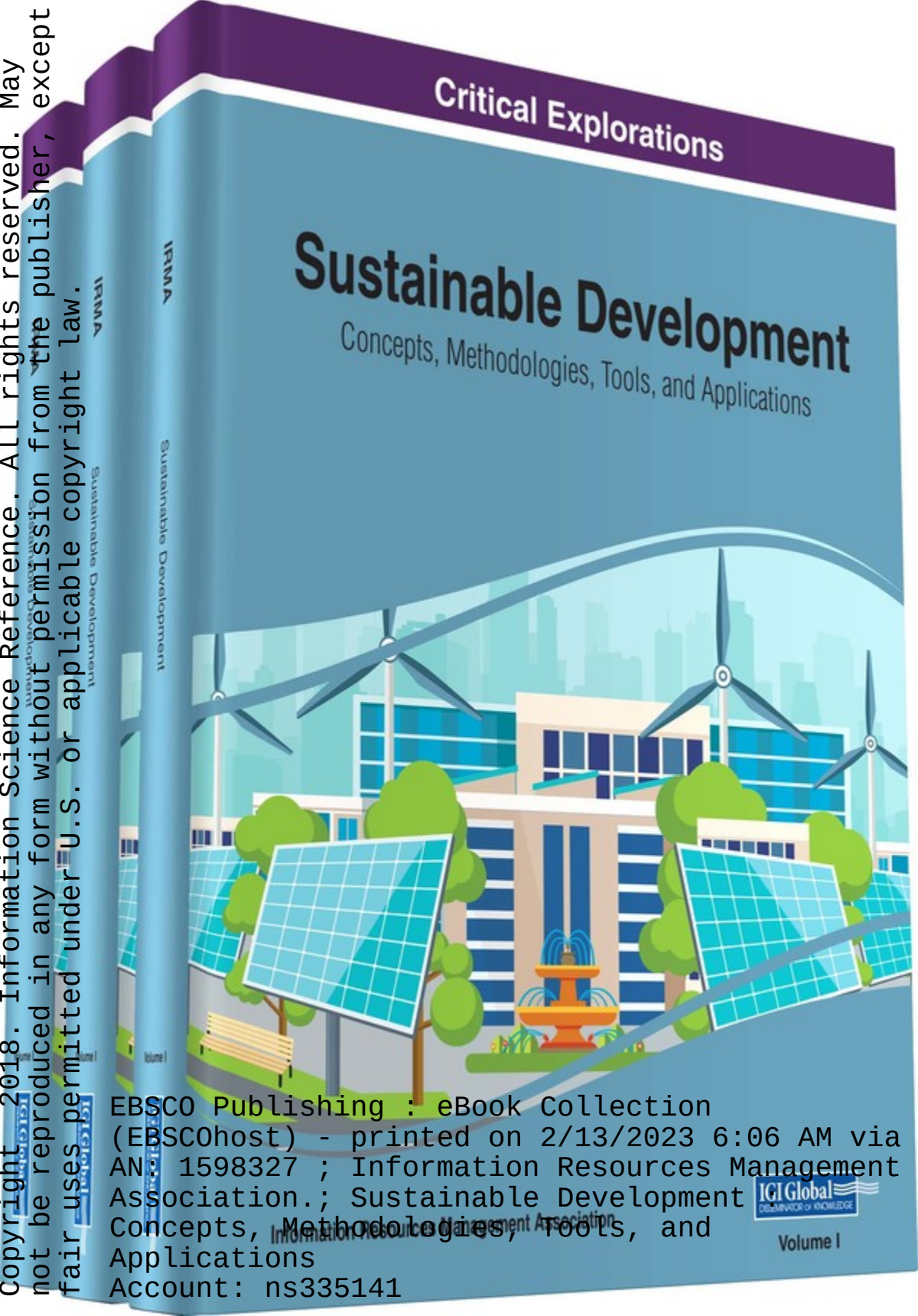


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Preface

The constantly changing landscape of Sustainable Development makes it challenging for experts and practitioners to stay informed of the field's most up-to-date research. That is why Information Science Reference is pleased to offer this three-volume reference collection that will empower students, researchers, and academicians with a strong understanding of critical issues within Sustainable Development by providing both broad and detailed perspectives on cutting-edge theories and developments. This reference is designed to act as a single reference source on conceptual, methodological, technical, and managerial issues, as well as to provide insight into emerging trends and future opportunities within the discipline.

Sustainable Development: Concepts, Methodologies, Tools, and Applications is organized into seven distinct sections that provide comprehensive coverage of important topics. The sections are:

1. Fundamental Concepts and Theories;
2. Development and Design Methodologies;
3. Tools and Technologies;
4. Utilization and Applications;
5. Organizational and Social Implications;
6. Critical Issues and Challenges; and
7. Emerging Trends.

The following paragraphs provide a summary of what to expect from this invaluable reference tool.

Section 1, "Fundamental Concepts and Theories," serves as a foundation for this extensive reference tool by addressing crucial theories essential to the understanding of Sustainable Development. Introducing the book is "Education for Sustainable Development: From Environmental Education to Broader Views" by Liz Jackson, a great foundation laying the groundwork for the basic concepts and theories that will be discussed throughout the rest of the book. Section 1 concludes, and leads into the following portion of the book, with a nice segue chapter, "Economics, Environmental Policy, Trade, and Sustainability" by N. Ghosh and A. Goswami.

Section 2, "Development and Design Methodologies," presents in-depth coverage of the conceptual design and architecture of Sustainable Development. Opening the section is "Role of HRM in Sustainable Organisational Development" by Fawzy Soliman. Through case studies, this section lays excellent groundwork for later sections that will get into present and future applications for Sustainable Development. The section concludes with an excellent work by P. Dhakal, "'Net' Social Change: Grassroots Empowerment for Sustainable Development."

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Section 3, "Tools and Technologies," presents extensive coverage of the various tools and technologies used in the implementation of Sustainable Development. The first chapter, "Renewable Energy Sources: Comparison of Their Use and Respective Policies on a Global Scale" by Mahmure Övül Arıoğlu Akan, Ayşe Ayçim Selam, and Seniye Ümit Oktay, lays a framework for the types of works that can be found in this section. The section concludes with "The Strategic Association Between Information and Communication Technologies and Sustainability: A Country-Level Study" by Sarah Jinhui Wu and Wullianallur Raghupathi. Where Section 3 described specific tools and technologies at the disposal of practitioners, Section 4 describes the use and applications of the tools and frameworks discussed in previous sections.

Section 4, "Utilization and Applications," describes how the broad range of Sustainable Development efforts has been utilized and offers insight on and important lessons for their applications and impact. The first chapter in the section is "Integration of Renewable Energy in Refrigerated Warehouses" written by Kostadin Fikiin and Borislav Stankov. This section includes the widest range of topics because it describes case studies, research, methodologies, frameworks, architectures, theory, analysis, and guides for implementation. The breadth of topics covered in the chapter is also reflected in the diversity of its authors, from countries all over the globe. The section concludes with "Sustainability Campaigns and Consumer Involvement: Effects of Altruism, Locus of Control, and Long-Term Orientation" by Zeynep Balanlı and Özlem Hesapçı, a great transition chapter into the next section.

Section 5, "Organizational and Social Implications," includes chapters discussing the organizational and social impact of Sustainable Development. The section opens with "Promoting Healthy Lifestyle for Sustainable Development" by Filiz Bozkurt and Ahu Ergen. This section focuses exclusively on how these technologies affect human lives, either through the way they interact with each other or through how they affect behavioral/workplace situations. The section concludes with "Supply Chain Social Sustainability and Manufacturing" by Mani V, Rajat Agrawal, Vinay Sharma, and Kavitha T.N.

Section 6, "Critical Issues and Challenges," presents coverage of academic and research perspectives on Sustainable Development tools and applications. The section begins with "Energy and Carbon Footprint-Aware Management of Geo-Distributed Cloud Data Centers: A Taxonomy, State of the Art, and Future Directions" by Atefeh Khosravi and Rajkumar Buyya. Chapters in this section will look into theoretical approaches and offer alternatives to crucial questions on the subject of Sustainable Development. The section concludes with "A New Barrier for the Future of Energy Market in Turkey: Internal Capital Adequacy Assessment Process (ICAAP)" by Esin Okay.

Section 7, "Emerging Trends," highlights areas for future research within the field of Sustainable Development, opening with "Sustainable Consumption Trends in the World in the Context of Green Economy and Sustainability" by Seda Yıldırım, Durmuş Çağrı Yıldırım, and Ayfer Gedikli. This section contains chapters that look at what might happen in the coming years that can extend the already staggering amount of applications for Sustainable Development. The final chapter of the book looks at an emerging field within Sustainable Development, in the excellent contribution, "CSR Strategies in Emerging Markets: Socially Responsible Decision Making Processes and Business Practices for Sustainability" by Claudia Ogrean and Mihaela Herciu.

Although the primary organization of the contents in this multi-volume work is based on its seven sections, offering a progression of coverage of the important concepts, methodologies, technologies, applications, social issues, and emerging trends, the reader can also identify specific contents by utilizing the extensive indexing system listed at the end of each volume. As a comprehensive collection of

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research on the latest findings related to using technology to providing various services, *Sustainable Development: Concepts, Methodologies, Tools, and Applications* provides researchers, administrators, and all audiences with a complete understanding of the development of applications and concepts in Sustainable Development. Given the vast number of issues concerning usage, failure, success, policies, strategies, and applications of Sustainable Development in countries around the world, *Sustainable Development: Concepts, Methodologies, Tools, and Applications* addresses the demand for a resource that encompasses the most pertinent research in technologies being employed to globally bolster the knowledge and applications of Sustainable Development.

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Section 1

Fundamental Concepts and Theories

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Chapter 1
Education for Sustainable Development:
From Environmental Education to Broader Views

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ABSTRACT

Education for Sustainable Development (ESD) is an important educational agenda at the international level, with significant implications for both formal and nonformal education. Though a relatively new topic in modern education, ESD frameworks have evolved and grown in number over the last few decades, from an early concern with education for development and environmental education, to more critical orientations that focus on the relationship between individual and social factors and between environmental and political factors contributing to challenges today for ecological sustainability and global development and flourishing. In this dynamic field, priorities may vary with social context, as a critical interrogation of the importance of place in education is considered fundamental to modern ESD frameworks. This chapter explores and assesses the development of ESD over the past few decades as a formal and nonformal educational policy and practice across world regions, before considering future directions for research and practice.

INTRODUCTION

In the last decade, Education for Sustainable Development (ESD) has become an important educational agenda internationally, with significant implications for both formal and nonformal education. However, as noted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) at the conclusion of its declared Decade of Education for Sustainable Development (2005-2015), at this time ESD faces many challenges to effective implementation across a wide variety of societies, both developing and developed, while there remains much uncertainty in the public and in educational communities about its aims, means, and significance. One of the main causes of the challenges for researchers and educators in

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this field is no doubt related to the wide variety of educational missions associated with the phrase, not all of which are mutually compatible, that have come to coexist across and within societies over time.

Part of this diversity of aims and meanings is related to the history of ESD. Originally, and still in some sense today, ESD has been a top-down approach to reform, wherein education is regarded as a tool for development in modernizing countries, as according to its use by global developmental and governance organizations, particularly UNESCO and United Nations Environmental Programme (UNEP). Yet as societies face different developmental challenges and opportunities, diversity rather than uniformity at the level of practice has been a natural result. On the other hand, ESD has also unfolded in everyday educational use in industrialized countries as a form of environmental education that focuses on the environment as an eco-system and the role of humans to conserve resources and decrease negative impacts on the natural world. Again, diversity in ecological contexts, risks, and possibilities create different grounds for such environmentally-based ESD, facilitating additional forms of diversity within environmental education (EE). From these beginnings, the term has further evolved and developed, to include critical political and educational orientations that focus on the relationships between individual, social, environmental, and political factors contributing to contemporary challenges for sustainability and local and global development and flourishing. Today, some eschew the terms "ESD" and "sustainability" as "empty signifiers" (Bengtsson & Ostman, 2013) in light of this plethora of educational meanings and practices attached to these terms. Among such critics include those who argue that social justice should be foregrounded in a holistic approach to EE, "ecopedagogy," and in related postmodern views.

This chapter explores and assesses the development of ESD over the past few decades as a formal and nonformal educational policy and practice across world regions. After giving a historical overview and survey of the field across contexts, it considers future directions for research and practice in ESD and related fields. Though the purpose of this chapter is not to take sides in debates traced out and explored, it does aim to give readers a clear view of potentially beneficial ways forward for effectively conceiving of and implementing ESD, through analyzing the challenges ESD faces at the practical level from a global view.

BACKGROUND

Some argue that the diversity of definitions and understandings of ESD across research and education contexts can be attributed to its early definition being given not by educational (or research) communities but actually by people within the policymaking field. Indeed, education for social development and environmental sustainability has its roots not in the educational community, but in larger social debates over environmental ethics which emerged in developed Western contexts in the 1960s and 1970s. Before this time, environmentalism consisted largely of land conservation, such as in the formal establishing and protecting of lands as modern public parks in western societies in the nineteenth and twentieth centuries. Yet as Light and Rolston note (2003), Rachel Carson's *Silent Spring*, published in 1962, heralded a new ecological consciousness in western societies, which rejected the liberal Enlightenment view of the natural environment as infinitely exploitable for human purposes. With the book notably increasing public awareness of the toll of pesticides on animals, plants, and human health, a critical and postmodern environmental movement emerged alongside peace and civil rights movements that argued for reorganizing of human life with greater consideration of the natural world.

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This consciousness of the social and biological worlds as component parts of a more holistically understood ecosystem thereafter emerged in the first place in educational imperatives of nonbinding international governance organization recommendations. The 1977 UNESCO conference on environmental education, organized in cooperation with UNEP in Tbilisi, Georgia, laid first groundwork for the educational concept of ESD (Sarabhai, Ravindranath, Schwarz, & Vyas, 2012). Known as the Tbilisi Declaration, the conference recommended the development of standards to guide EE at local, national, and global levels that was interdisciplinary in nature. Viewing EE as "the reorientation and dovetailing of different disciplines and educational experiences which facilitate an integrated perception of the problems of the environment," the declaration argued that EE must enable understanding of the "biological, physical, social, economic, and cultural aspects" contributing to our physical, "natural and built" environment (UNESCO, 1978, p. 25). It further specified that EE must equip people with "knowledge, values, attitudes, and practical skills" to resolve environmental problems, bridging divides between formal academic schooling and real-world action and behavior. It articulated "economic, political, and ecological interdependence of the modern world," and recommended that such EE was not only a responsibility of schools but also of the media and nonformal education, to cater to all ages and social groups within society.

This view of ESD, as an education focused on understanding the intertwining of social and natural worlds through formal and nonformal educational means remained influential since this foundational recommendation. The concept of sustainable development as requiring integrated thinking about economic and environmental domains was affirmed again by the United Nations (UN) General Assembly in 1987, which established the World Commission on Environment and Development (WCED; also known as the Brundtland Commission) in 1983. The Brundtland Commission defined sustainable development more succinctly as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," and appealed to the educational community in a general rather than specified manner, to increase social awareness of the need for sustainable development for the future (WCED, 1987).

In 1992, the United Nations Conference on Environment and Development at Rio de Janeiro, Brazil, aimed to operationalize ESD at a more practical level for the first time. Its Agenda 21, Chapter 36, argued for a program to systematically reorient education toward sustainable development, and it appointed UNESCO and UNEP to facilitate global revision of education for sustainable development across all societies and all levels of formal education (United Nations, 1992). However, even in this document, ESD was not envisioned exclusively or even primarily as a curricular or pedagogical program (Hopkins & McKeown, 2002). Rather, it framed ESD as a wide-ranging perspective on how to improve the world through education, recognizing education as a catalyst for more (and less) sustainable economic and political development in poor regions, for improvement of human rights as actualized capabilities for empowerment of previously disadvantaged groups (Sen, 1999), and more. In this broad view, developing wider basic educational access was regarded by UNESCO as a primary step in this global ESD project, as limited access to quality education is recognized by the UN and its subunits to hinder development (economic and political) in much of the world.

The next step, as discussed in Chapter 36 of the Rio Agenda 21, was to reform education across diverse contexts to align with social and environmental sustainable development (Hopkins & McKeown, 2002). Yet even here, definitions of ESD were given in a general rather than particular way in developing local curriculua, as in the 1977 and 1987 documents before it. This reforming and reorienting of diverse society's educational systems toward ESD implied in part a focus on *local* community needs

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and contextual considerations, rather than a borrowing of curricula, for example, from UNESCO. The document additionally emphasized an important shift from content knowledge to skills development in all types of education (formal and nonformal), to meet practical challenges effectively. Broader public awareness and training was also recommended.

Since 1992, UNESCO has thus led practices of defining, designing, and implementing ESD as a variety of formal and nonformal, locally appropriate and contextually specific programs of education, that focus on knowledge, skills, and/or values and perspectives seen to (or hoped to) that promote and enable sustainable development. Knowledge of ESD is understood as effectively trans- or inter-disciplinary, cutting across social, cultural, technical, political, economic, and ecological domains, while noteworthy skills include capabilities to deliberate and critically think alongside others to make effective action. A perspective oriented toward global peace, equality, and social justice is encouraged that is intergenerational, while human and biological diversity are held as intrinsically valuable, in line with the UN's larger ends. (Hopkins & McKeown, 2002).

In 2002 the UN again emphasized the significance of ESD as a global policy agenda, by tasking UNESCO with the 2005 launch of the 2005-2015 Decade of Education for Sustainable Development (DESD). Accepting this charge, UNESCO thereafter developed an International Implementation Scheme, with four thrusts and seven strategies for ESD that echoed the statements from the conference in Rio in 1992. The four thrusts include (1) improving basic education, (2) reorienting education toward sustainability, (3) increasing public awareness, and (4) providing training across sectors about sustainability (UNESCO, 2014, pp. 15-16). Rather than top-down implementation of a specific model program at the local level, the scheme's strategies included advocacy, consultation and ownership, partnership, capacity building, research and innovation, technology development and promotion, and (limited—in line with its authority) monitoring and evaluation.

In late 2014, as the UNESCO DESD came to its conclusion, UNESCO reported positively on the DESD, noting that a shift in public knowledge from ESD as formal curriculum to a broader understanding has resulted (2014). UNESCO has also reported (2012, pp. 28-31) that:

- Educational systems are responding more effectively to sustainability needs,
- Sustainable development and education agendas are converging,
- Political leadership with stakeholder and local involvement has productively grown,
- Holistic, comprehensive institutional approaches are increasing,
- Interactive, student-centered pedagogies are increasing,
- Nonformal and informal ESD is increasing, and
- Training that advanced sustainable development is increasing.

However, UNESCO has not described the DESD as an unqualified success. It goes on to note that significant challenges remain. In many countries, ESD is poorly implemented, due to the need for a holistic approach despite a lack of interdepartmental cooperation across different national and local government sectors (such as agriculture, economy, education, and so on). ESD is still not being effectively evaluated in many areas even as formal education, as formal education (schools) is as yet largely undergoing the reorientation process in most societies (UNESCO, 2014, p. 32).

Indeed, it becomes difficult to discuss practices of ESD generally at the global level, with a wide variety of contexts enabling diverse interpretations and priorities. Furthermore, despite UNESCO's observation that different contexts require different methods of reorientation and implementation, others argue that

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UNESCO tacitly supports a globalist, neoliberal view of education and sustainable development that undermines impactful ESD that truly encourages values of global diversity and social justice (Bengtsson & Ostman, 2013; Gonzalez-Gaudiano, 2005). When one breaks down ESD approaches by society and sector, no single essential type of ESD can be readily identified, leading to the claim that ESD is an "empty signifier…ridden with internal contradictions" (Bengtsson & Ostman, 2013, p. 481). Less provocatively, it is clear in surveying the field that wide discrepancies in interpretation and implementation are the norm, with differences being decipherable across societies based on the levels of educational development generally. In developing countries, nonformal education is more typical due to a common lack of high levels of formal education, while in developed societies strides are being taken toward a systematic curriculum, though again divergence rather than commonality can be seen. The rest of this chapter considers different approaches to ESD, focusing on teaching and/or learning related to sustainable development, rather than increasing educational quality and access for sustainable development. The next sections survey the extent of ESD geographically in formal and nonformal education, before considering matters of contemporary debate over meanings, values, and goals.

THE EXTENT OF ESD AROUND THE WORLD

Formal Education

According to UNESCO's DESD final report (2014, p. 83), 40% of the 70 countries that participated in the final assessment questionnaire describe their key reorientation of education towards ESD in terms of formal curricula, in primary and/or secondary education. Generally, most countries have some national/public education curricula dedicated to discussing environmental and/or sustainability issues, either with an integrated (interdisciplinary) approach, or within subjects such as social studies, science, and related areas. However, UNESCO goes on to report that most countries describe their efforts toward increasing attention to ESD as "in progress" rather than as implemented or achieved.

As a top-down approach initiated at the political level rather than educational level, substantive reorientation toward ESD in most countries is no doubt hindered by competing national-level goals for educational reform. In this context, as Hopkins and McKeown note (2002), interested individuals and non-governmental organizations (NGOs) may often "undertake the reorientation effort with either little or no government assistance" (p. 23). Relatedly, given the diverse national orientations toward centralization and regulation of the educational curriculum worldwide, a plethora of approaches, rather than one common method of reorientation, is the norm in many societies (Feinstein, Jacobi, & Lotz-Sistika, 2013).

In Europe, formal education in many countries has significant content on ESD today, owing to greater relative public commitments that have been observed there related to sustainability principles (UNESCO, 2014; Tilbury, 2002; Jucker & Mathar, 2015). Environmental education was called "an integral and essential part of every European citizen's upbringing" by the Ministers of the European Union in 1988, who focused on education as significant within their Fifth Action Plan for the Environment in 1995. Various organizations within Europe have thus helped reorient education formally toward ESD rather than those associated with the UN or global NGOs. In particular, the Organisation for Economic Cooperation and Development Environment and Schools Initiative Group (ENSI) has supported environmental education and related ESD programs with various aims in a wide variety of countries, including Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Italy, The Netherlands, Norway, Portugal, Scotland, Spain,

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Sweden, and Switzerland (Tilbury, 2002). Many European nations include ESD as a significant formal component of their national education policies and plans, with impacts felt widely regardless of whether their educational systems are centralized or decentralized. Challenges remain in Europe for ESD, related to effective implementation within societies system-wide given competing reform agendas (Jucker & Mathar, 2015); nonetheless, many countries in Europe provide instances of exemplary programs at the international level for ESD.

For instance, in Austria a strategy for ESD was developed in 2005 and 2006 that involved 400 stakeholders from formal, nonformal, and informal education (Rauch & Pfaffenwimmer, 2015). Central and regional support for ESD in formal education is supported by seminars for educational leaders and awards for school's ESD performance (Lechner & Rauch, 2014). Special programs to increase attention to ESD in higher education and technical and vocational education also exist and are being evaluated and reformed in an ongoing process. Such programs are common throughout Europe, for instance in the automotive sector in Sweden and in engineering in Poland (Leal Filho, 2010), to interrelate labor and sustainability practices. EE and ESD are also understood as separate and complementary tasks for education in Austria, to ensure both have a significant place in curriculum (Rauch & Pfaffenwimmer, 2015; see also Reti, Horvath, Czippan, & Varga, 2015).

Student-centered learning approaches are common in much of Europe and also reflected in ESD there at the classroom level. For instance, in classrooms in Italy teachers rely mostly on discussion and collaborative learning, wherein students are asked questions (such as what causes global warming or what is the greenhouse effect) and encouraged to reflect on their background knowledge in developing further understanding additionally informed by scientific views (Mason & Santi, 2006). Group discussion that facilitates argumentative practice wherein students "transform their personal beliefs into reasoned views" is also found to be more effective in such contexts than teaching to the tests in middle age groups, while the aim of ESD is conceptualized by many teachers in Italy as enabling students to develop empowered views (see also Andresen, Hogmo, & Sandas, 2015).

In Asia, formal integration of sustainable development topics into teaching of traditional subjects is not uncommon (UNESCO, 2014). However, given the highly academic orientation toward curricula in much of Asia and the related tendency toward teacher-centered and test-centered rather than student-centered education, emphasizing content over skills, it is likely that such curriculum appears as add-ons in many cases (Fien, 2002). Without ESD knowledge and skills integrated into assessments, the latter of which are often focused on knowledge in key disciplinary areas, it is likely students are not systematically or substantively focusing on ESD in formal education in many Asian countries.

As UNESCO notes (2014), where ESD is most successful in Asian formal education contexts is mostly likely in subjects that focus on student-centered and/or experiential learning, and interdisciplinary coursework. For instance, in Japan, Korea, Hong Kong, and elsewhere, experiential learning has increased in popularity. In these contexts, ESD projects focused on local sustainability issues may be easily and effectively implemented. As social sciences are frequently integrated across disciplinary areas in curriculum—for instance, in Hong Kong a recently required (2009) Liberal Studies subject includes environmental studies, global studies, and other social studies (Curriculum Development Council, 2007)—within such general studies subjects, ESD can easily be included.

However, as Asia in contrast with Europe does not yet place a major societal value on sustainability and environmentalism, without related teacher education via reformed pre-service and in-service teacher training, curriculum guidelines promoting ESD in formal education are unlikely to lead to effective classroom implementation there (Hopkins & McKeown, 2002). And indeed, across Asian countries

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(and elsewhere) such revision of teacher education is often piecemeal. UNESCO (2014, p. 92) reports that most countries described their integration of ESD into teacher education in 2013 as "in progress," in contrast to in 2005, when most only had an emerging interest. As Kwo (2011) notes, because most teacher education is normally provided through institutions of higher education, curricula for teacher education for sustainable development may be slow to change as this requires restructuring of programs overall, including their length and structure. Furthermore, as teacher education training (particularly in Asia) often focuses on teacher development of skills and techniques rather than content knowledge, there may be a hidden curriculum in such contexts which deemphasizes and devalues ESD. This hidden curriculum is further shaped by the ideally integrated, interdisciplinary nature of ESD curricula, as "something which officially is everybody's responsibility can in practice be nobody's responsibility" (Kwo, 2011, p. 47). Without explicit changes, ESD may not be effectively promoted in Asian contexts where top-down reform and monitoring for teacher accreditation is also increasingly the norm (Law, 2003).

Teacher buy-in is also necessary for implementation to take place, and such buy-in will depend upon teachers' current attitudes toward sustainability (Kwo, 2011). No generalizations about a region as large as Asia can be made with regard to teachers' attitudes. Rapid industrialization is seen alternatively across individuals in Asian societies as inherently positive or as problematic, with regard to sustainability. In highly developed and quickly developing Asian contexts anti-environmental attitudes among the general public have been clearly observed. Small-scale surveys of the public (Wong, 2011), stakeholders (Chan 2008; Hills, 2005) and educators in Hong Kong (Lee, 1997; Lee, Lam & Williams, 2009; Stimpson, 1997) reveal developing interest in sustainability education; yet they also indicate that many people tend to distinguish in their attitudes between political-economic and environmental concerns. Environmental problems are thus framed as apolitical, or not worth critically considering in light of political-economic needs. Whole-school approaches, as well as a focus on nonformal education, such as media campaigns and outside training, are therefore increasingly recommended (UNESCO, 2014).

African and Arab states have been the slowest to implement ESD reorientation in formal curricula generally (UNESCO, 2014). In many countries in these regions reorientation remains under review at the formal educational level by educational policy makers, while more progress is being made at the informal level. Given development challenges in many parts of these regions, ESD policies and programs are generally aimed more at the level of increasing access and quality of education, including primary education and early childhood education, rather than at the level of curriculum reform.

Across North and South America ESD incorporation in formal education is sporadic, with countries indicating different levels of commitment and progress toward reorientation. In Canada and the United States, ESD is not widely embraced socially or politically as compared with Europe, and within the two countries' their decentralized educational systems diversity of approaches and orientations is one result (Stevenson, 2002). In Latin America, environmental education and related developmental pedagogies have a long history within and outside of formal education. Many countries in the region, although not all, have what can be regarded as either substantive or implicit ESD curriculum at the formal level, in addition to much nonformal ESD activity (UNESCO, 2014).

In Australia and New Zealand environmental awareness is generally high and a variety of formal educational approaches are taken. Australia implemented a national action plan for EE and ESD in 2000 (Tilbury, 2004). Across states in Australia there is varying levels of curricular integration at this time. Notably, schools in Victoria have long had ESD as EE and developing appreciation for the natural environment, bird watching, and so on. This homegrown tradition provides fertile ground for implementation of more recent national ESD initiatives there (Gough, 2006). Similarly New Zealand's natural environment

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lends itself to outdoor "study abroad" education, wherein students visit the South Island for 15 days to meet leaders of conservation movements across the island (Cusick, 2008). Such field experiences as part of formal curricula are recognized there as enabling transformative education that promotes wellbeing of people and environments.

Nonformal Education

In some contexts ESD is more visible outside of formal education, in the spheres of nonformal education and training. In such cases it is led typically by NGOs rather than government departments or ministries. In UNESCO's final report on the DESD, it was found that most countries had made progress in the domains of adult education, public awareness campaigns and media, and other nonformal education programs. In many nations much of schoolchildren's ESD is provided by NGOs and related community groups, who may sponsor in-school or extracurricular activities or have their services used by the schools to learn about community and environmental issues in the local context. Adult community education that aims to be sustainable and develop local capacities is common in developing countries, and includes literacy programs, community business support, health education, and more. Public awareness campaigns by NGOs are found around the globe, such as Earth Day (UNESCO, 2014). Local groups may also spread awareness through performances and celebrations, websites, and television productions, depending on the context and the cultural and social appropriateness of various means.

In Asian developing contexts, nonformal community-based education for all members of society which is focused on sustainability and development is common. Community theatre and related artistic and dramatic groups often spread awareness while entertaining people in society, in countries including Vanuatu (Passingham, 2002) and Indonesia (Fuhker, 2002). These and related programs can be seen to help sustain cultural traditional understandings of the relationship between people and the environment against a modern, western exploitative view. In Africa, sustainability knowledge is increased by local groups who focus on the natural world through field trips and public education campaigns for living sustainably. Campaigns may focus on clean drinking water, waste management, disease prevention, alternative energy sourcing (such as solar power) and related local development challenges (UNESCO, 2014; Schreuder, 2002). The Peace Corps is highly active across much of Africa and Asia, where volunteers coming from the United States may work on projects in one or more of these fields to aid development, building wells, supporting health clinics, enabling and assisting with sustainable gardening, and more.

In contexts where formal schooling is well developed and standards of living are higher, such as in much of Europe, Australia, North America, and East Asia, nonformal education for ESD is typically related to formal schooling. In these regions, NGO activities may revolve around working with schools in partnerships to take young people out of classrooms and interact in communities and learn more about local environments. As mentioned above (in the case of New Zealand), field trips (or field days), organized camping, and volunteerism in disadvantaged areas are all common approaches. Experiential learning and service learning may be incorporated into ESD nonformal curriculum in these cases. In Canada and the United States, conservation of natural resources may be examined in particular (see Jickling, 2002).

In Latin and South America nonformal education has been viewed as key to development, and popular education movements there have been influenced by the Brazilian educational thinker Paulo Freire, who argued that all education should be community based, and involve praxis as a blend of learning for empowerment and social action (Freire, 1989; Misiazek, 2014). In postcolonial contexts in this region this framework has been taken up against academic schooling to involve local community members of all

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ages to take part in social development and reconstruction. Such education has had developmental as well as political connotations, and has also been connected to liberationist theology with a related emphasis on social justice. The pedagogical approaches associated with this form of ESD originating from Latin and South America have been to seen to impact educational approaches to ESD worldwide with regard to envisioning aims and methods, within or outside of formal education (Gadotti, 2009; Gadotti & Torres, 2009). These focus on critical thinking and critical empowerment of young and indigenous people, through dialogue, value sharing, and community problem solving activities. I now turn to the different models and approaches to ESD, and debates over values, meanings, and goals, in the next section.

CONCEPTUALIZING ESD: CONTEMPORARY APPROACHES

In terms of curriculum choices regarding aims, content, and teaching and learning practices, a wide variety of approaches is used today that go beyond a traditional academic model that focuses on environmental education. Varying emphases across approaches reflect different understandings of the causes and solutions to global sustainable development challenges. This section focuses on different pedagogies and curriculum for the formal sector, particularly for older students, in secondary and higher education.

The Traditional Model

The traditional approach to ESD focuses on knowledge accumulation, citing as the cause of sustainability challenges lack of awareness across populations (Scott & Gough, 2003). Knowledge is understood within such models as objective, factual, and scientific. The facts can straightforwardly tell us what to do in a variety of cases, as learning can directly lead to behavioral change (Vare & Scott, 2007). Scott and Gough (2003) describe this as a Type 1 approach, while Vare and Scott (2007) similarly describe this as ESD1 and as learning *for* sustainable development.

ESD1

As Vare and Scott elaborate (2007), in Type 1 or ESD1, behavioral change related to sustainability is caused directly by increased knowledge and understanding of the relationship between one's actions and behavior and sustainability challenges. Indirect impacts can also be made in the public's behavior through economic management of behavior based on social scientific understanding. In either case, the approach is centered on expert knowledge and the use of such knowledge.

Many people have assumptions about ESD underpinning Type 1 or ESD1. In a survey of higher education students in Canada (Wolf, Brown, & Conway, 2014), they found that most identified as communitarian or economist types. Communitarians, in their framing, view acting on knowledge of sustainability issues as every individual's responsibility, and the causes of contemporary challenges as adequately understood for individuals to take action. Economists in their research likewise think that data supports action, and that environmental scientists and economic and political researchers can determine what needs to be done and ensure that required changes are implemented across public and private sectors, respectively (Wolf, Brown, & Conway, 2014, p. 510).

Others describe the traditional ESD model of ESD1 as a *liberal* orientation, connecting commonplace ESD attitudes and understandings to the western Enlightenment view of human liberty, wherein

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humans attain freedom via the use of technology over the material world. This traditional model clearly has strengths. As Wapner writes (1996), "liberal environmentalism has been enormously important in identifying and containing many harmful activities. The Clean Air Act, the National Forest Management Act, and the Clean Water Act [in the United States] represent liberal victories." Additionally, as an orientation toward managing challenges, it is positive and optimistic about the potential of knowledge to create a better world and guide action, often at the individual level. For example, green consumption, the actions of individuals purchasing "green," more sustainable goods, can be seen to lead to personal empowerment of individuals to make a difference by acting on ESD knowledge against a backdrop of increasing uncertainty and risk in the environmental and political domains (Connolly & Prothero, 2008). Many specific examples can readily come to mind here, such as in the case of the production and use of energy-conserving lightbulbs, where knowledge and research can easily guide behavior that can clearly be seen to be more environmentally sustainable (see also Laessoe, Feinstein, & Blum, 2013).

Additionally, this traditional model, with its focus on content knowledge that students can learn, can be taught and assessed in straightforward ways. Knowledge can be imparted through books, lectures, discussions, or even films, online courses and websites, among other ways. Thus, in countries where teacher-centered pedagogies are commonly used (such as many Asian and African societies), reorienting curricula while using a traditional model of ESD does not imply such a comprehensive reform of teaching and learning to be successful. Content can simply be added to (or replaced within) the curriculum, with no major pedagogical changes required in such cases. Similarly, assessment of knowledge-based ESD can be simply designed to evaluate the impact of knowledge sharing on students as individuals and for other assessment purposes, such as for evaluating teacher effectiveness or program effectiveness. Quizzes, short answer questions, and the like can be used, as preferred in many contexts where more innovative alternative assessment modes are not as yet commonly appreciated today.

One particular program of assessment that has emerged to test sustainability knowledge at a global level in higher education is the UN Sustainability Literacy Test. This test was initiated by Jean-Christophe Carteron with funding and technical support from the Foundation for Sustainable Leadership of the Kedge Business School and DEGETEL, both based in France (Sustainability Literacy Test, 2013). Its senior advisory board includes the UNEP, the UN Department of Economic and Social Affairs, and UNESCO. As part of the Higher Education Sustainability Initiative, it aims to enable measurement of sustainability knowledge among diverse students of higher education, and measurement of higher education institutions' improvement and performance in teaching students for sustainable development (Sustainability Literacy Test, 2013). The test aims to measure students' knowledge using objective questions, in environmental, social, and economic realms. It therefore aspires to develop and test students on an international foundation of "minimal level knowledge" seen as valuable to students in higher education around the world. Questions are focused on "challenges facing society and the planet," and "organization's responsibility in general and on corporate responsibility in particular."

The promotion and use of such a test gives visibility to the importance of ESD and the role of higher education institutions in promoting sustainability at a global level, ambitiously aiming to become akin to other well-known and respected international standardized tests, such as the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMMS), the SAT U.S. College Admission Exam, and more. In societies where environmentalism is less common, the promotion and use of this test as a global indicator could develop a greater sense of urgency around educational reforms toward ESD, motivating people to learn more about sustainability concepts.

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Challenges to the Traditional Model

Despite the popularity and commonplace use of the traditional or ESD1 model today, many researchers and educators object to the exclusive use of this model, given several notable shortcomings. First, researchers contest availability of clear existing data to easily guide sustainable action in many areas of life. As Vare and Scott (2007, p. 195) note, ESD1 is inadequate by itself because "we can't measure success in terms of environmental impacts because this is an open-ended process; outcomes will depend on people's unforeseen decisions in future, unforeseeable circumstances." What constitutes the most useful knowledge depends on circumstances which are dynamic rather than static, across the world today and in the future.

Indeed, uncertainty about how knowledge can or should guide action can often be seen to reign in educational and public debates about sustainability today, against traditional ESD1 model ideals. In relation, whether humans should be seen as rational actors is essentially contested, as many argue that the evidence suggests that people often act against their own ultimate interests rather than toward them (Vare & Scott, 2007). Much research on green consumption suggests that people readily change some behaviors in more straight-forward areas, while not making changes in more complicated domains, where more impact can nonetheless be made (Wolf, Brown, & Conway, 2014; Connolly & Prothero, 2008).

Relatedly, the complicated nature of current sustainability challenges requires that people put trust in experts. These experts' views may be disseminated through mass media in better or worse ways, and may be presented in a provocative and exaggerated way, or as controversial, for media purposes. When it comes to individual decision making, there is no best practice for how to utilize such varying expert opinions. Uncertainty can thus reign over certainty. For green consumers, knowing whether it acceptable to purchase genetically modified produce, or how to weigh different options can be a nerve-racking, not straightforward, process. How to compare environmental risks to personal health risks, or weigh long-term versus short-term impacts of various personal decisions, is not easy for any individual to navigate (Connolly & Prothero, 2008).

Finally, critics of the traditional ESD model view it as significantly limited in its understanding of the relationship between individuals, political and economic forces, and the environment. As Maniates (2001) argues, American environmentalism over the last few decades has been limited to a focus on individual responsibility, over private or state responsibility, due to a lack of national NGO financing and the need for American NGOs to avoid confrontations with corporations and national entities that truly deserve responsibility for most significant and large-scale environmental and developmental challenges. As neoliberal models of private individual economic choice became popular which cast federal government as inferior and inadequate by comparison with corporations, "almost overnight, the responsibility for fundamental change in American consumption and production landed squarely on the backs of individual consumers" who are seen to more effectively "vote" through their consumer choices (Maniates, 2001, p. 40). In this ideological context, young people may be skeptical of social, non-corporate solutions, viewing them as idealistic within a framework that precludes an account of democracy and social responsibility of corporations (Maniates, 2001). Relatedly, American students have been found to suspect that people cannot learn or be persuaded of what they may believe they know themselves about sustainability challenges and the way to alleviate them, viewing others' lack of idealism thus as an intractable challenge (Wolf, Brown, & Conway, 2014). In the United States, young people perceive

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skepticism about human abilities to face sustainability challenges as the mainstream view (Wolf, Brown, & Conway, 2014), leading to a pessimistic view about collaboration for social change.

However, responsibility for sustainability challenges cannot rationally be put only upon individuals as private citizens, according to critics of the ESD1 model. Maniates (2001, p. 44) thus fears a downward spiral where cynicism will grow as knowledge increases given levels of public skepticism:

In the end, individualizing responsibility does not work—you can't plant a tree to save the world—and as citizens and consumers slowly come to discover this fact their cynicism about social change will only grow: "you mean after fifteen years of washing out these crummy jars and recycling them, environmental problems are still getting worse—geesh, what's the use?"

Wapner (1996) similarly writes,

Liberal environmentalism is so compatible with contemporary material and cultural currents that it implicitly supports the very things that it should be criticizing. Its technocratic, scientistic, and even economistic character give credence to a society that measures the quality of life fundamentally in terms of economic growth, control over nature, and the maximization of sheer efficiency in everything we do…Liberal environmentalism is unconcerned with reflecting upon who we are, our place in the global ecosystem, and our relationship with other species who also inhabit the earth.

In summary, the traditional ESD approach of ESD1 focuses on imparting knowledge to individuals, with the understanding that such knowledge, effectively disseminated, can lead people to change their behaviors and actions to align with what future sustainable development apparently can be seen to demand. While this has clearly been an effective approach in many instances and enables straightforward pedagogical practices and assessments of ESD teaching and learning, it is not without its limitations. People argue that a traditional academic model where knowledge is seen as politically impartial and unproblematically related to positive change through its dissemination at the individual level as inadequate given (1) the limitations of current knowledge, (2) factual and conceptual lack of clarity as individuals struggle to understand and act on expert views, and (3) the intertwined way that individuals alongside state and corporate actors actually bare responsibility for sustainability challenges. Others contend that ESD must focus not only on technical knowledge but also on skills, attitudes, and values and/or dispositions, if it is to have a positive impact.

Alternative Models

In contrast to the traditional ESD model of teaching and learning aligned with traditional, academic, teacher-centered views of education, many educators argue that ESD must relate to development of skills and changes in values, attitudes, and dispositions in order to have a truly positive impact. Various skills, values, and attitudes have been identified by such scholars and elaborated as educational aims.

Skills: ESD2

As mentioned previously, Vare and Scott (2007) argue that, while it is clearly essential as one part of ESD, ESD1 as a focus on content knowledge accumulation is unsufficient without attention to the fact that sustainable knowledge practices require a focus as well on student development of cognitive and interpersonal skills. In contrast to Type 1 ESD, which assumes the world's problems are basically

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environmental and can be solved through application of knowledge, Vare and Scott emphasize two additional types. They note that Type 2 identifies our problems as social rather than environmental. Type 3 "approaches assume that what is (and can be) known in the present is not adequate; desired 'end-states' cannot be specified. This means that any learning must be open-ended" (2007, p. 193). Arguing that Type 3 is also a useful way to understand the current situation that ESD responds to, they argue that ESD1 must be complemented by *ESD2*. ESD2 focuses on how learning itself can be sustainable, by building capacities of critical thinking that extend beyond current coin of expert knowledge. As Vare and Scott (2007, p. 194) write, "our long-term future will depend less on our compliance in being trained to do the 'right' thing now, and more on our capability to analyse, question alternatives and negotiate our decisions." Furthermore, they frame ESD1 and ESD2 not as linear learning models (with ESD1 occurring before ESD2), but argue that they should be viewed as a yin-yang (2007, p. 196).

The ESD 2 approach is often presented as a case for more liberal education (which it may well be) in opposition to ESD 1, which reflects a more limiting 'instrumental' view of education. Viewed from the Yin-Yang perspective, ESD 1 and 2 are complementary because people need to hear with the sustainability lobby and governments are telling us to do (through ESD 1) in order to have relevant subject matter to debate and test in our own contexts. ESD 2, although open-ended, cannot exist in a vacuum devoid of content.

Maniates (2001) similarly focuses on skills to ameliorate the harmful impact of consumeristic and individualistic thinking in the ESD realm, emphasizing particularly the need for a focus on imagination. He distinguishes his sense of the meaning and importance of imagination, from a "soft," emotional sense of new age earth-mother enlightenment, to instead emphasize the need to think more critically about what possibilities for social change are viewed as realistic versus idealistic within contemporary material and political contexts.

Political Perspectives

More radical alternative approaches to ESD highlight educational aims that are political and related to fundamental changes in values and perspectives of young people. Gruenewald's (2003) elaboration of a *critical pedagogy of place* aims to join educational movements he labels as "critical pedagogy" and "place-based education." Critical pedagogy, Gruenwald notes, has its roots in Freire's (1989) pedagogy of the oppressed framework, which places student empowerment, in light of students' local community needs, at the heart of educational invention. Education should not be dictated by educators or policymakers according to Freire's influential approach, but should be developed dialogically by students and teachers, working together as democratic equals. Educational labor should help improve students' worlds and lives; to do this, teachers must release some of their traditional power to students, in developing curriculum and teaching methods. This is an inherently critical and political kind of education, as it is presumed in this approach that the world needs changing, and that education therefore has a function of social and material reconstruction.

Ecological place-based education similarly intends to engage students in their physical and social worlds in a direct way, taking the student outside the traditional formal classroom, and enabling students to take part in their worlds and interact within them productively (Gruenwald, 2002). As in critical pedagogy, the context of education thus plays a role in developing teaching and learning activities. While critical pedagogy invites student action to transform students' world, ecological education has

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traditionally encouraged conservation. By joining the two approaches, Gruenwald argues, students can develop a critical orientation toward sustainability, realizing that informed, democratically developed changes are needed, while students must simultaneously work to sustain that which supports flourishing in the future (2002).

Gruenwald's critical pedagogy of place represents a kind of locally oriented eco-pedagogy project, that gives less attention to the notion of students as potential actors on a global stage. However, other educators have developed related conceptions of eco-citizenship, as a form of global citizenship oriented toward grappling with complex global challenges with environmental and social (often economic) implications. Wolf, Brown, and Conway (2009) argue explicitly for what they describe as *ecological citizenship*. As they note, such a view of citizenship is distinct from how citizenship is normally conceived, in that there is no legal status of the eco-citizenship concept, or rights associated with it, and therefore no objective determination of what makes one such a citizen. However, as citizenship is also understood in political theory to have moral and social responsibilities, it is apt for highlighting our interconnection and interdependence with one another at a global level regardless of nationality, and our duty to act to decrease harm and increase good internationally.

Bengtsson and Ostman (2013) that ESD should be seen as practices of meaning making in the context of politics and global inequality. Rather than accept dominant, popular and hegemonic meanings of development, sustainability, and globalization which complement neoliberal, market-driven, globalist approaches, Bengtsson and Ostman (2013) note that ESD should be involved with deconstructing meanings at different levels and developing alternative articulations based on location, perspective, and subjectivity. By implication, refinement and reclaiming of these terms in ways that may be more locally empowering is an educational aim.

Wapner (1996) similarly argues that educational values must be dramatically reoriented toward a global environmental level, within an "ecological politics." Wapner cites Aldo Leopold in describing an ethic of environmentalism wherein all humans are fellow citizens, "which included plants and animals as well as other people, and the community as a whole" (1996). In terms of practices of teaching and learning, similar to Gruenwald's critical pedagogy of place, Wapner argues that teachers can build bio-regional awareness by involving students in understanding local ecosystems through visits, making needed connections between their everyday lives and those of diverse others (human and animal) in their community. As caring should be extended beyond the nation-state to help improve life more holistically, Wapner goes further however to recommend teachers highlight holistic senses of community over nationalistic ones in ESD education. Finally, Wapner encourages participatory ecological practice, embracing citizenship within an ecological politics as requiring personal efforts, connecting the personal to the political, to develop better understanding of how one's own actions can make a difference (1995).

ESD as Developing Global Civic Values

Relatedly, others emphasize ESD as a new way of understanding the world and one's relationship and responsibilities to it. Within such framings, ESD is about developing globally sustainable values and caring understandings of the relationships between self and other living creatures in the world. Gadotti (2008) argues for education for sustainable *life* rather than sustainable development. Gadotti (2008, pp. 23-24) summarizes such a movement towards education for sustainable life as having the following goals:

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1. **Global Thinking:** In an era of information…there is no need to accumulate information. But it is vital to know how to think….We must educate so that people understand that we have only one home.
2. **Feelings:** Human beings are the only creatures who ask about the sense of life. We must educate to feel, to care, to take care and to live every moment of our lives making sense. We are humans because we feel, not only because we think.
3. Our identity on the Earth as a vital human condition. Our common destiny is to share life on the planet with others…
4. **Planetary Awareness:** Understanding that we are interdependent. The Earth is a single nation and we, the people on Earth, are its citizens. We don't need passports. Nowhere on the Earth should we be considered foreigners. Separating the world into the First World and Third World means dividing it so it can be ruled by the most powerful…
5. **Understanding:** We must educate for human ethics rather than for market ethics…
6. **Voluntary Simplicity and Quietness:** Our lives need to be guided by new values: simplicity, austerity, quietness, peace, serenity, listing, living together, sharing, discovering and building together…

Gadotti points here to radical reorientation of values and perspectives through education in this approach to ESD as education for sustainable life. Other global citizenship educations similarly focus on developing values and understandings of a global community for global sustainable development and well-being. Amartya Sen (1999) and Martha Nussbaum (2001) have advanced capabilities approaches to education, which hold that societies have responsibilities to educate the world for living together with greater equality and collaboration. Such capabilities can inform ESD, as the basic goal of increasing meaningful educational access around the world, as well as for revising pedagogies for global citizenship needs in developed societies. Nussbaum's capabilities in particular can be seen to interrelate with Gadotti's (2008) conceptualization of education for sustainable life. They include (2001, p. 416-417):

1. **Life:** Being able to life to the end of a human life…
2. **Bodily Health:** Being able to have good health…
3. **Bodily Integrity:** Being able to move freely from place to place…having opportunities for sexual satisfaction…
4. **Senses, Imagination, and Thought:** Being able to use the senses, to imagine, think and reason—and to do these things in a "truly human" way…
5. **Emotions:** Being able to have attachments to things and people outside ourselves; to love those who love and care for us…
6. **Practical Reason:** Being able to form a conception of the good and to engage in critical reflection about planning of one's life…
7. **Affiliation:** Being able to live with and toward others, to recognize and show concern for other human beings…
8. **Other Species:** Being able to live with concern for and in relation to animals, plans, and the world of nature…

Nussbaum argues that global citizenship must be prioritized by countries because the problems faced are global. She further argues that such citizenship must be fundamentally compassionate. Hytten (2009) likewise argues that education must help people to develop compassion, care and empathy toward others

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globally, by focusing on the root causes of global problems rather than on symptoms of social problems. Thus Nussbaum and Hytten see it as a political project within civic education to develop concern for others at the global level, with development of requisite cognitive skills, alternative understandings of the world, and different values and emotional dispositions. Caring is also the focus of much work in global citizenship education. Though focusing primarily on her work on interpersonal caring in educative relations, lead caring theorist Noddings (1999) has described concern for more-distant others' sufferings as the "foundation of justice."

Return from Feelings to Skills in Alternative Approaches to ESD

Although feelings are emphasized in many of the approaches to ESD highlighted here, some argue that such emotional education has grave risks. Zembylas (2008) notes that students experiencing empathy and compassion regarding others' trauma or suffering in such critical political or related educational projects can unfortunately also lead to an inappropriately sentimental reaction by students, who want to do and be good people despite of (and in relation to) their experiencing unfair advantage and privilege over others. In this response, students are prone, particularly in observing cases of global underdevelopment and poverty, to orient themselves to suffering using a 'deficiency imaginary of development' (Jackson, 2014a). According to the deficiency imaginary, people are missing something which other people—student volunteers, for instance—can provide. This sentimentality can thus create a naive assumption that once an empathy gap is bridged, problems of a structural nature can easily be solved (Zembylas, 2008). Compassionate models of citizenship realized as international volunteerism, seemingly celebrated in some of Noddings's work (2003), can thus lead to ideologically fueled development work, whose outcomes are actually more indeterminate for the so-called subjects of aid (Cook, 2012). The response is doubtlessly one of emotional concern and care, but the result is far from appropriate and effective.

With regard to ESD more generally, Maniates notes how the focus on personal change in such civic education models inappropriately presumes individual responsibility. People may feel morally committed to the earth through such education, but can hardly heal the planet by changing personal consumption (Jackson, 2015). In ESD it has also been observed that students across diverse countries feel gloomy, pessimistic, and guilty, but not sure how to respond appropriately to these feelings, or to environmental challenges (Morris, 1996; Fein, Sykes, & Yencken, 2002; Gruenewald, 2004). As Fein, Sykes, and Yencken (2004) notes, "it is not so much a question of creating anxiety during environmental education. The problem is more [one of] how to handle the anxiety and worry which students already feel." Though care and emotions toward others nearby and distant is emphasized in models of global citizenship for living together and sustaining the planet, ESD research suggests that students need problem-solving skills to understand sustainability challenges and realize the need to work effectively with others, given the scale of challenges. Developing right emotions, about others or the planet, is not crucial. Cognitive skills are required to empower people to help others (today and in the future). Thus some theorists have extended this work into more cognitive and rational directions.

Engster (2005) has incorporated care theory into explorations of how to consider and treat people across the world. He echoes Noddings' original theory of care by characterizing it as attentive, responsive, and respectful. Attentiveness is a kind of active-listening orientation toward others, which entails considering needs or causes of dilemmas below the surface in seeking to understand others' situations, in line with views such as Hytten's, that compassionate global citizens should address causes, not symptoms, of social injustice. Responsiveness relates to the appropriateness of a reaction. Engster takes an example

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from Noddings (2002) of the flood of donations of food and clothing to Afghanistan after an earthquake, when what was needed were building materials (see also Gallwey & Wilgus, 2013). Respect is recognition that one is an end in their own right, with their own worldview, and not an extension of oneself.

For Engster, human interdependency justifies a duty to care. As he (2004) writes, "since all human beings need care and claim the right to be cared for when in need, and more generally depend upon the caring of others to sustain not only our own lives but also human life and society, we must logically recognize the rights of others to make claims upon us for care when they need it, and should endeavor to provide it when we are able to do so without significant danger to ourselves." Sigal Ben-Porath (2008) argues in parallel that the fact of global interdependency justifies a global ethics of care as a practice of interacting with international others with attentiveness, responsiveness, and respect. Although Ben-Porath concedes it may seem strange to discuss caring of social entities such as nation-states, she elaborates that "caring relations among groups refer broadly to the common understandings they have about possible ways to perform caring acts. The way the other is portrayed…and the self-understanding of each group as related to its role with the other…generates the basis for the relationship among the groups" (2008, p. 5).

To incorporate emotional learning into education that aids development, Chouliaraki (2010) argues for a "post-humanitarian communication" style that enables more meaningful interrelations of people globally across divisions of power. Understanding emotions not just sociologically but economically, "this style acknowledges that compassion fatigue lies not so much in the excess of human suffering that transcends individual capacity to feel for or act on it, but rather in the excesses of discourses of morality around which we are called to organize our feelings and action towards suffering" (Chouliaraki, 2010, p. 120). Similarly Leighton describes empathy as "a limited resource that we need to use wisely" (2011, p. 226; cited in Jackson, 2014b). These ideas are empirically grounded, in media theory, in Chouliaraki's (2008) observation that emergency news discourse—unlike other types of news stories about development and aid—can produce a moral demand for action, based on fragile and incidental, rather than systemic, historical, connectivity to distant others. Such discourse can potentially bolster one's sense of cosmopolitan spirit in responding to distant others' needs, without begging painful questions of historical-causal intergroup relations, or drifting into sappy and patronizing sentimentality. Developing a better objective future is a desire binding social groups in disparate conditions, while in emergency conditions, there are fewer emotionally or psychologically pesky problems of power, politics, and resistance to the status quo.

Summary

In sum, a variety of different perspectives exist on ESD as teaching and learning, with some focused on a traditional curriculum which is teacher-centered and focused on knowledge dissemination and accumulation, while others focus more on skills, feelings, dispositions, and civic and moral values and responsibilities. Within this latter group, diversity of orientations is evident, as well as different prioritization of the importance of emotional versus cognitive and rational education for sustainable living and development at local and global levels.

What emerges most clearly in examining the kinds of contemporary ESD approaches taken today from a global and comprehensive view is the diversity of aims, values, and methods used. Such diversity can be seen to follow from the understanding that ESD must fundamentally be contextualized within concrete settings rather than accepted as recommended from the top-down. Local reorientation of ESD, which is encouraged by UNESCO in the implicit acceptance of a student-centered view of education (see also UNESCO, 2007), implies that ESD education should unfold with consideration of the options

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and one's own educational context, as what works best will depend not only on expert knowledge but on the background knowledge of learners, community context, and more. The claim can be made that ESD teaching and learning should not only be knowledge-based, but should also meaningful engage and enhance students' skills, deeper level understandings, dispositions, moral attitudes, and more. However beyond this general statement, research is ongoing in this area about what approaches work best based on context, as not all students, communities, and environments around the world are alike.

CONCLUSION

ESD as a trend in conceptualizing and enhancing environmental and sustainable knowledge and know-how has changed dramatically over the years. Originally, it was seen not as a teaching and learning trend or area of content knowledge. In contrast to today's understanding, in its first few decades of emergence, in the 1970s and 1980s, it was viewed instead as a means toward using education for development generally. At that time, it was also understood by advocating political bodies that ESD could unfold as curriculum, based on sustainability principles and environmental knowledge. However, the original aim was merely to use education to drive development, thus implying a focus mostly on developing countries where capacity building was needed in aid of modernization and industrialization.

A global perspective on the current state of ESD which stems from this historical background reflects that a variety of activities are still held as appropriate for ESD across diverse world regions and contexts, beyond traditional classroom teaching and learning. In Africa and parts of Asia and the Middle East, educational access and quality enhancement is still a primary goal. Adult literacy training and other community services to increase capacities of local people in the same regions are thus typically included under the basic umbrella of ESD in these same parts of the world. Media and public awareness campaigns are often also common in these areas, and around the globe more universally, signaling that ESD is not just about classroom disciplinary development, but about all members of society becoming encouraged to take part in positive global change.

At the level of curriculum, a similar diversity of approaches and impacts can be seen from a global survey of the extent of ESD in formal education. In formal education, ESD is most prevalent in secondary education, where it may be part of general studies curriculum, social studies education, or science and environmental education. It may be a standalone topic or integrated in other areas; additionally, it can be part of a whole-school reorientation to ESD, which includes consideration of a hidden curriculum. In this domain, recycling campaigns, the values of educators the use of school resources (as examples) may all be considered part of ESD in the formal education system. Indeed, research shows that without awareness of this hidden curriculum, ESD may be less effective however it is to be formally included, particularly as educator interest, commitment, and "buy-in" to ESD, ideally formed through pre-service and in-service teacher training, is seen as critical to successful integration.

Comparing countries, one can see major discrepancies in terms of integration and/or orientation of curriculum toward ESD. Some of this can be seen to relate to different stages of development of different societies, as typically those countries that are more focused on ESD as basic educational access will have a less systematic inclusion of ESD principles in their curriculum. However, even in Europe, Asia, and the Americas the methods and significance of inclusion of ESD in curriculum vary from country to country. Indeed, some scholars have argued a national-level analysis of ESD is unhelpful due to the vastly different structures of education across different countries, enabling a wide variety of practices

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across societies based on difference in regulation, accountability, curriculum development practices, and other matters (Feinstein, Jacobi, & Lotz-Sisitka, 2013).

ESD as educational practices can be further broken down in relation to various aims and objectives that educators and researchers argue for as components of ESD. Traditional models of ESD focus on content knowledge, which can be easily assessed, and lead in many cases to educational practices seen as culturally sustainable today, as many countries still prefer teacher-centered, academic education in formal education. Such knowledge is seen as productive for instructing people about what they should do, as well as developing societal structures that encourage and discourage particular behaviors and actions among the public based on social science principles.

As discussed here, such a traditional approach to ESD as knowledge, as in Type 1 and ESD1 approaches, can clearly be seen as having a direct impact on people's behaviors, particularly in areas where individuals can make clear positive changes in their behavior toward sustainability, such as in consumption of resources. However, others critique this model for focusing on knowledge at the neglect of skills development, when ESD knowledge must itself change over time in relation to dynamic circumstances. Additionally, not all knowledge is clear in its implications for individuals' actions, in a complex, expert-driven domain where personal and environmental risk often appears alarmingly close at hand. Furthermore, critics argue that such a depoliticized view of knowledge emphasizes individual consumer choice at the cost of understanding how large-scale environmental destruction is not actually conducted by individuals, but by states and corporations. Political and social change should be enacted according to this view of ESD knowledge; such change requires that ESD develop people's skills to think, act, and work together interpersonally in an interdependent global setting, rather than just act as individuals.

Therefore, others argue that ESD in formal education must not focus only on knowledge accumulation, but also on skills, attitudes, understandings, dispositions, moral and civic responsibilities, and emotions. ESD2 is thus seen as a complement to ESD1, as we must apply skills to interpret knowledge which does not by itself tell us how to proceed in concrete circumstances. Imaginative, creative, and critical thinking are also emphasized by thinkers who believe environmental problems require radical changes in perspective and awareness that current views of ESD, sustainability, development, and globalization, are politically framed, rather than neutral. ESD should thus deconstruct views critically in classroom settings.

More radical views include a critical pedagogy of place, dedicated to changing the world around the classroom, and various views of global ecological citizenship. A wide variety of these latter views can be readily identified, which focus holistically on changing student understandings of themselves in the world, emphasizing connections and interdependence with others species and life around the world regardless of political borders. These approaches emphasize relationships and the production of positive feelings toward others worldwide, such as caring, compassion, empathy, and related feelings. They also call on people to develop a moral sense of civic duty toward the planet and all other living creatures, developing a critical, deeply felt commitment to helping the world develop more sustainable living patterns.

These latter views also have their limitations and challenges for implementation. Emotional education can be challenging and can also risk developing cynicism, guilt, and despair among students, given the complex relationship between individual actions and global challenges. When one realizes the critical systematic features of global sustainable development challenges, one may develop many feelings, but not necessarily a sense of empowerment. In this context, researchers have reoriented such emotional education toward a rational sense of global duty connected to civic responsibility. Post-humanitarian views also encourage an understanding of relationality that may be less deeply felt at an emotional level,

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but more promising when it comes to the impact of understanding on behavior, recognizing that emotions in ESD are also scarce resources that should be enhanced sustainably.

Today no single path among these options is held by researchers or UNESCO as the single best practice for ESD. After all, ESD that is aligned with best educational practice will interrelate with communities at hand to be sustainable, and the local environments they live in. In some cases, increasing basic education so as to enhance local capabilities and capacities for development will be most urgent, while in other cases increasing ESD more systematically in the formal curriculum will be an important goal. For others, developing an appropriate curriculum in terms of aims and objectives that reflect local interpretations and perspectives as intertwined with global sustainability challenges is a worthwhile agenda. For this latter group, further developing the field of research knowledge on best practices for ESD as teaching and learning can additionally fuel future ESD, as practices must be grounded in particular contexts with an eye to making an impact on change, in order to be effective. As ESD becomes more firmly integrated into curriculum worldwide in the future in relation to countries' professed mutual aspirations, how to better integrate ESD formally at policy and pedagogical levels will remain important questions to ask while our understanding of the heart of sustainable development issues also continues to unfold.

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KEY TERMS AND DEFINITIONS

Decade of Education for Sustainable Development: An initiative of the United Nations, led by UNESCO practically, for promoting Education for Sustainable Development around the world in formal and nonformal education from 2005-2015.

Education for Sustainable Development: An umbrella term that captures formal and nonformal education initiatives that aim to provide people with knowledge, skills, attitudes, and/or training for sustainable development.

Education for Sustainable Development 1: A traditional model of Education for Sustainable Development, that prioritizes disseminating and using knowledge from various disciplines in order to enhance sustainable development.

Education for Sustainable Development 2: An alternative orientation to Education for Sustainable Development, that prioritizes skills and attitudes people need to continually gather, analyze and make decisions collaboratively based on values and new information and situations of the unforeseen future.

Environmental Education: Education about learning about place, ecology, and the natural environment. Often has a place-based component and explores local forests, rivers, and other natural features.

Nonformal Education: Education that takes place outside of formal schooling.

Sustainable Development: Economic, political, and/or cultural development that meets the needs of the current generation without risking the needs of future generation.

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Chapter 2
Sustainability Evaluation of IT/IS Projects

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ABSTRACT

Sustainability is without doubt one of the most important challenges of our time. How can one develop prosperity without compromising the life of future generations? Companies are integrating concepts of sustainability in their marketing, corporate communications, annual reports and in their actions. Information technology (IT) and information systems (IS) provide organizations with the ability to change and improve business processes to better support sustainable practices. IT/IS evaluation methods should therefore reflect this ability and include criteria for the assessment of sustainability aspects of IT/IS projects. However, IT/IS evaluation methods are today still dominated by the economical perspective that resulted from the infamous IT productivity paradox. This paper aims to broaden the perspective on IT/IS evaluation, by exploring the integration of indicators that reflect the concepts of sustainability into IT/IS evaluation methods. Based on an identification IT/IS evaluation methods and an overview of frameworks for sustainability indicators, an analysis is made of the inclusion of the indicators and principles of sustainability assessment in IT/IS evaluation methods. The analysis will conclude that integrating sustainability considerations in IT/IS evaluation requires far more than a set of additional criteria to be considered.

INTRODUCTION

Sustainability is recognized by the United Nations as one of the most important challenges of our time (Glenn and Gordon, 1998). How can we develop prosperity without compromising the life of future generations? The pressure on companies to broaden its reporting and accountability from economic performance for shareholders, to sustainability performance for all stakeholders has increased substantially (Visser, 2002). Proactively or reactively, companies are looking for ways to integrate ideas of sustainability in their marketing, corporate communications, annual reports and in their actions (Hedstrom et al., 1998; Holliday, 2001).

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The growing concern about sustainability and the preservation of our planet is increasingly being recognized by the information technology (IT) and information systems (IS) disciplines. CIOs identify 'Green IT' as an important strategic technology (Thibodeau 2007), but the 'green' aspects of IT go beyond the technology. Given IT's functional ability to improve, change and reinvent business processes, it can also be an important contributor to more sustainable business practices (Kazlauskas and Hasan, 2009). However, this 'Greening by IT' perspective, is not reflected in IT/IS evaluation methods, as these methods tend to focus predominantly on an economic perspective. Probably fuelled by the much quoted 'IT productivity paradox' (Brynjolfsson, 1993), researchers and practitioners have been challenged to proof that IT/IS brings economic value to the organization. And although many evaluation models have been developed that also include other variables than Return on Investment (Renkema and Berghout, 1996), the debate on the contribution of IS seems to be dominated by the economic perspective (Silvius, 2010).

This paper explores the integration of indicators that reflect the concepts of sustainability into IT/IS evaluation methods. The paper will present a brief overview if IT/IS evaluation methods and an exploration of frameworks for sustainability reporting and evaluation. The paper will then analyze how these two concepts, IT/IS evaluation and sustainability, fit, and make a number of observations on the similarities and differences of the concepts.

IT/IS EVALUATION

Through research and in practice, a substantial number of evaluation methods to assess the contribution of IS/IT to business performance was developed. After considering over 50 evaluation methods Renkema and Berghout (1996) grouped these methods into four categories: Financial methods, Multi-criteria methods, Ratio methods and Portfolio methods.

Financial Methods

The financial methods consider the valuation of an IT/IS investments as an economic issue for which it is irrelevant whether the investment is in IT or in any other resource. As long as the effects of the investment are understood, calculating the value of it is merely a financial technicality (Silvius, 2010). However, in reality capturing value is not quite that straightforward. Financial valuation methods all have assumptions and limitations. Table 1 provides an overview of these valuation methods.

The limitations of these financial methods to capture the more qualitative aspects of IT/IS value and impact led to the development of other methods.

Multi-Criteria Methods

Multi-criteria methods are a reaction to the problems of capturing the full value of IT/IS investments in just financial metrics. These methods aim to identify different relevant aspects of value and risk in order to enable a thorough discussion and an informed discussion (Frisk, 2007). The most influential method using multiple criteria is Information Economics (Parker et al., 1988). This method is suited for evaluating a single project as well as a portfolio of projects.

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Table 1. Overview of Financial valuation methods (based on Silvius, 2010)

Valuation Method	Qualities	Limitations
Return on investment	Easy to calculate Easy to interpret (a simple percentage) In line with the financial administration	Outcome sensitive to amortization method Ignores the time-value of money Ignores risk
Pay-back period	Quite easy Intuitively coping with risk	Ignores part of the revenues Simplistic, does not determine value
Internal Rate of Return	Includes the time-value of money Easy to interpret (a simple percentage) Based on cash-flows	Complex Not in line with the financial administration Ignores risk Multiple outcomes, or none, possible
Discounted Cash Flow / Net Present Value	Includes the time-value of money Based on cash-flows Copes with risk	Complex Complex to interpret Not in line with the financial administration Not conclusive in case of projects with different durations
Economic Value Added	Includes the opportunity value of money In line with 'shareholder value'	Value calculation based upon one of the other methods Not in line with the financial administration
Real Options Valuation	Includes optimality and managerial flexibility in investments	Complex Complex to interpret Data often not available Not in line with the financial administration
Game theory	Includes market developments Adds a strategic perspective	Data often not available Not in line with the financial administration

Information Economics identifies assessment criteria in two domains: business (IT/IS demand) and IT (IT/IS supply). Criteria in the business domain are: Return in Investment, Strategic Match, Competitive Advantage, Management Information, Competitive Response and Organizational Risk. Criteria in the IT domain are: Strategic Information Systems Architecture, Definitional Uncertainty, Technical Uncertainty and Infrastructure Risk. The importance or 'weight' of the different criteria may not be equal. Management therefore has to decide upon a weight factor for each criterion.

Based upon the set of criteria and weight factors each project or investment is given a score on all of the criteria. It is crucially important that the scores are underpinned in this more objective way in order to create acceptation for the results of the evaluation process.

The results of the evaluation process can be presented in a graphically attractive way. The scores on the criteria Return in Investment, Strategic Match, Competitive Advantage, Management Information, Competitive Response and Strategic Information Systems Architecture, are totaled to a score representing the 'value' of the investment. The scores on the criteria Organizational Risk, Definitional Uncertainty, Technical Uncertainty and Infrastructure Risk, add up to a total 'risk' score. Combining the two scores in a two-dimensional graph provides management with a concise overview of the investment portfolio.

An important quality of multi-criteria methods is that they allow for the evaluation of value and risks that are hard to quantify in monetary terms, such as Strategic Match, Competitive Advantage, Management Information, Competitive Response, Organizational Risk, etc. A critique on the methods is that they lack objective measurement of these criteria in the projects that are evaluated.

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Ratio Methods

Different from the financial and multi-criteria methods are ratio methods not aimed at evaluating a specific investment or project, but at finding the 'right' level of total IT/IS costs in an organization. This level is expressed as a ratio, e.g. IT costs / total revenue or IT costs / employee. The outcome of these ratios should be considered relative to the same ratios at competitors or for one organization in time. Lower or higher scores on these ratios than comparable organizations are not per-se right or wrong, but should give reason for investigation and discussion.

The most prominent author on ratio methods is Paul Strassmann. He developed sophisticated ratios for specific industries. Based on his research he remains sceptical about the value of IT investments. Strassmann states that "For 55% of U.S. firms the computer budget exceeds their economic value-added." and "The "right" level of spending for computers reflects the bureaucratic characteristics of a firm, not revenue or profits." (Strassmann, 1997). A limitation to the applicability of the ratio methods, however, is the availability of data required for the ratios.

Portfolio Methods

In 1981 F. Warren McFarlan suggested to analyze and manage IT/IS investments and projects in terms of revenues and risks using portfolio theory, as was done in the financial world (Warren McFarlan, 1981). 'Portfolio theory' referred to the 'modern portfolio theory' as developed by Markowitz (Markowitz, 1952). Although appealing, the use of this insight did not really take off until the Clinger-Cohen Act. This Act states that the management of IT in US government institutions 'must reflect a Portfolio Management approach … and decisions to terminate or make additional investments are based on performance much like an investment broker is measured and rewarded based on managing risk and achieving results'.

With its appeal on portfolio theory, the Clinger-Cohen Act aimed to bring transparency to IT/IS costs and benefits. When applying portfolio theory to IT projects however, some issues may occur regarding the scalability of the investments, the tradability of the investments, the unique character of some investments, the exchangeability of benefits, the unfamiliarity of project risks, etc. Although the difference in characteristics between financial investments and IT investments does imply limitations to the applicability of portfolio theory, some useful insights could be derived (Van Rossum and Silvius, 2006).

An important insight in portfolio theory is the understanding that the value of an investment will be influenced by other investments or assets in the portfolio. In other words, investment decisions are not taken in isolation. Whereas all other evaluation methods study the value of an investment as an autonomous value, portfolio methods study value of investments in conjunction to other investments and assets. An insight that appeals to the common sense when considering architectural aspects. Portfolio theory also points out the importance of having a structured process in place for the continuous evaluation of the total portfolio of IT/IS investments and projects.

THE ROLE OF IT/IS IN SUSTAINABILITY

Societal concerns about the balance between economic growth and social wellbeing has been around as a political and managerial challenge for over 150 years (Dyllick and Hockerts, 2002). Propelled by the World Commission on Environment and Development (1987) and the 1992 Rio Earth Summit, the

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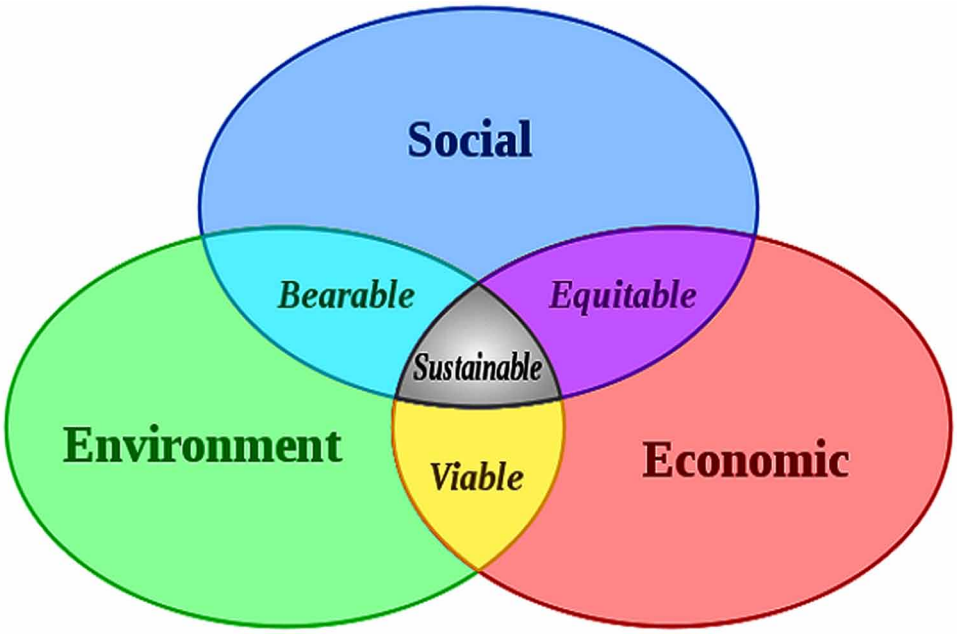
opinion that none of these three goals, economic growth, social wellbeing and a wise use of natural resources, can be reached, without considering and effecting the other two, got widely accepted (Keating, 1993). With this widespread acceptance, sustainable development became one of the most important challenges of our time.

Sustainability in the context of sustainable development is defined by the World Commission on Environment and Development (1987) as "forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs". This broad definition emphasizes the aspect of future orientation as a basic element of sustainability. This care for the future implies a wise use of natural resources and other aspects regarding the environmental footprint. However, sustainability requires not just an environmental "green" perspective, but also a social one. Elkington (1997), recognizes this in his 'triple bottom line' or 'Triple-P (People, Planet, Profit)' concept (Figure 1): Sustainability is about the balance or harmony between economic sustainability, social sustainability and environmental sustainability (Elkington, 1997).

In the debate on sustainability and IT/IS, a commonly used term is 'Green IT'. As was stated in the introduction, however, a distinction can be made between 'Green IT' and 'Greening by IT', more commonly referred to as 'Green IS' (Kazlauskas and Hasan, 2009; Watson et al., 2010). In this distinction, Green IT refers to the energy efficient utilization of IT equipment and Green IS to the use of IS to enable more sustainable business processes (Boudreau et al., 2008).

The environmental impact of IT/IS has been subject to discussion. The promise of a decreased environmental footprint because of paperless offices and tele-working has been opposed by claims of increased power consumption and hazardous waste because of the use of IT needed to operate the systems. Because of this diversity of direct and indirect indicators, the overall effect of IS/IT on environmental sustainability is not easy to determine. Plepys (2002) concludes "The discussion on what the role is of IT and,

Figure 1. The Triple-P concept of sustainability



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particularly, Internet for sustainability is still going on and will hardly reach any definite conclusion, as the environmental impacts of the new technologies will depend on how they are used".

The concepts of sustainability mentioned above suggest that in the debate on the sustainability aspects of IS/IT, not just the environmental effects should be considered, but also the social effects of IS use. The United Nations (UN) concluded that IS has the ability to be a powerful enabler of social sustainability and contributor to development goals, because of its unique characteristics to dramatically improve communication and the exchange of information to strengthen and create new economic and social networks (United Nations Development Program, 2001).

In some parts of the world, IT/IS is contributing to revolutionary changes in business and everyday life. In other parts of the world, the lives of people have hardly been touched by these innovations. If people in developing countries are unable to acquire the capabilities for using IS, they will be increasingly disadvantaged or excluded from participating in the global information society. The social and economic potential of these new technologies for development is enormous, but so too are the risks of exclusion (Mansell, 1999). Economic research suggests a positive correlation between the spread of IS and economic growth (Siegel, 2003). IS can contribute to income generation and poverty reduction. It enables people and enterprises to capture economic opportunities by increasing process efficiency, promoting participation in expanded economic networks, and creating opportunities for employment.

SUSTAINABILITY INDICATORS

Crucial for developing more sustainable business practices is the ability to evaluate the sustainability aspects of different policies and projects, as well as to monitor progress. Or, as Jain (2005) argues: "The ability to analyze different alternatives or to assess progress towards sustainability will then depend on establishing measurable entities or metrics used for sustainability". The most frequently used instruments in this context are frameworks or sets of sustainable development indicators (SDIs), both as a way of measuring and evaluating (proposed) actions, and as a way of communicating this information (Bell and Morse, 2003).

Many organizations have developed frameworks of indicators for this goal. In fact, the literature on these models is a veritable jungle of different approaches and numerous case studies (Olsson et al, 2004). The International Institute for Sustainable Development (IISD) maintains an online directory of SDI initiatives. This directory includes more than 600 initiatives at national and international levels by governments, non-governmental organizations (NGOs) and individuals. It can therefore be concluded that the use of SDI as an evaluative tool is still very much in its infancy (MacGillivray, 1995, Bell and Morse, 2003) resulting in more questions than answers. What should be measured and what could be excluded? What are the most effective indicators? How should they be organised? And how can the indicators be communicated?

The following section gives an overview of some of the most influential frameworks for SDIs.

Natural Step Framework

One of the first initiatives to bring scientific principles to the assessment of sustainability was by Swedish scientist Karl-Henrik Robèrt. Robèrt coordinated a consensus process to define and operationalize sustainability. At the core of the process lies a consensus on what is called 'the Natural Step framework'.

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The Natural Step Framework is a holistic framework which helps organizations to integrate sustainability principles into their business strategies. It provides a tool for developing a shared vision, shared identity and shared goals among departments and along supply chains. Foundation of the Natural Step Framework is the principle that a company should try to reduce its negative impacts on the biosphere while enabling humans to fulfil their needs. It stimulates companies to re-think production processes and product design and to find innovative alternatives for achieving their business goals. The framework provides a good basis for both awareness raising as well as strategy development.

IISD Dashboard of Sustainability

The IISD is a Canadian-based, public policy research institute, dedicated to advancing sustainable development. The IISD developed a sustainability 'dashboard' that "illustrates the complex relationships among economic, social and environmental issues" (International Institute for Sustainable Development, 2012). This Dashboard of Sustainability is intended for decision-makers and others interested in sustainable development. It is based on the Millennium Development Goals indicators for developing countries. These indicators help define Poverty Reduction Strategies and monitor the achievement of the Millennium Development Goals.

WBCSD Measuring Impact Framework

The World Business Council for Sustainable Development (WBCSD) is an organization of companies that joined forces in order to create a sustainable future for business, society and the environment. The WBCSD argues that "sustainable development is good for business and business is good for sustainable development". This view is supported by some economists that state that, contrary to the popular belief that sustainability requires a trade-off of economical and environmental/social benefits, it is possible for the concepts of sustainable development and competitiveness to merge if enacted wisely (Esty and Porter, 1998).

The WBCSD developed a framework, the Measuring Impact Framework, to assess the contribution of business to the economic and broader development goals in the societies where business operates. It is designed to help companies understand their contribution to society and use this understanding to inform their operational and long-term investment decisions, and have better-informed conversations with stakeholders.

The Measuring Impact Framework includes a 4-step methodology to help companies in any industry operating in any part of the world to measure, assess and manage their impacts on society. In the application of the methodology, an organization should adapt it to the specific company strategy and development context in which the business operates;

UN Global Compact Framework

The United Nations (UN) Global Compact (2010) is a framework of ten universally accepted principles, developed by the UN and a number of large corporations. It covers the areas of human rights, labour, environment and anti-corruption. Participating companies agree to comply with these principles. They can use the framework as a platform for disclosure. This initiative has been created because the UN realized that businesses are primary drivers for globalization and can help ensure long-term value creation

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that can bring benefit to economies and societies all over the globe. In the absence of global regulations, this voluntary code of conduct has been developed, hoping to stimulate companies to more sustainable business practices.

UNCSD Indicators of Sustainable Development

Following the 1992 Rio Earth Summit, the UN Commission on Sustainable Development (UNCSD) started the development of the 'Indicators of Sustainable Development'. This resulted in a set of 134 indicators of sustainable development. Country case studies and further discussion in the UNCSD led to the rejection of a framework in lieu of "themes" and a more comprehensive set of 'core' indicators.

The third, revised set of the UNCSD indicators was finalized in 2006 by a group of experts from developing and developed countries and international organizations. This third edition of the indicator set is based on the previous two (1996 and 2001) editions, which have been developed, improved and extensively tested. It contains 96 indicators, including a subset of 50 core indicators. The guidelines on indicators and their detailed methodology sheets are available as a reference for all countries to develop national indicators of sustainable development.

ISO 26000 Core Subjects and Issues

As a response to businesses' growing interest and the increasing number of sustainability-related institutions and frameworks, the International Organization for Standardization (ISO) launched ISO 26000, a comprehensive guideline on social responsibility, to help companies introduce more sustainable practices. ISO 26000 is a guideline on social responsibility that is designed for all types of organizations. ISO 26000 summarizes seven social responsibility 'core subjects': Organizational governance, Human rights, Labour practices, The environment, Fair operating practices, Consumer issues and Community involvement and development. These core subjects are further broken down into 'issues', specific themes or activities a company should work on in order to contribute to sustainable development.

GRI Sustainability Reporting Guidelines

The Global Reporting Initiative (GRI) is a non-profit organization that pioneered the world's most widely used sustainability reporting framework, the Sustainability Reporting Guidelines (SRG). Companies can use the SRG to indicate to shareholders and consumers their economic, social and environmental performance. GRI's objective is to facilitate sustainability reporting for companies and thereby stimulate them to operate more sustainably. The SRG framework consists of an extensive set of indicators, from which companies can select a set that is relevant to their operations or industry.

Dow Jones Sustainability Indexes

The Dow Jones Sustainability Indexes (DJSI) are not a reporting tool, but a family of indexes evaluating the sustainability performance of the largest 2,500 companies listed on the Dow Jones. They are the longest-running global sustainability benchmarks worldwide. The DJSI is based on an analysis of cor-

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porate economic, environmental and social performance, assessing issues such as corporate governance, risk management, branding, climate change mitigation, supply chain standards and labor practices. It includes general as well as industry specific sustainability criteria.

From the above overviews of SDI frameworks, it should be concluded that, although many organizations have offered meaningful lists of indicators, consensus on how to measure and assess sustainability has not emerged yet. A recurring structure in many frameworks is the Triple-P concept mentioned in section 3. However, some frameworks, for example ISO 26000, adopt a completely different structure and also different perspectives. Many specialists actually question whether or not a common list is even possible, given the wide variety of conditions and the differences in values in different contexts.

In the so called Bellagio principles, a set of overarching principles for the assessment of sustainability are formulated, thereby suggesting that a truly 'universal' framework to measure sustainability may be illusive. The Bellagio principles are (International Institute for Sustainable Development, 1997):

Principle 1: Guiding Vision and Goals

Assessment of progress toward sustainable development should:

- Be guided by a clear vision of sustainable development and goals that define that vision.

Principle 2: Holistic Perspective

Assessment of progress toward sustainable development should:

- Include review of the whole system as well as its parts.
- Consider the well-being of social, ecological, and economic sub-systems, their state as well as the direction and rate of change of that state, of their component parts, and the interaction between parts.
- Consider both positive and negative consequences of human activity, in a way that reflects the costs and benefits for human and ecological systems, in monetary and non-monetary terms.

Principle 3: Essential Elements

Assessment of progress toward sustainable development should:

- Consider equity and disparity within the current population and between present and future generations, dealing with such concerns as resource use, over-consumption and poverty, human rights, and access to services, as appropriate.
- Consider the ecological conditions on which life depends.
- Consider economic development and other, non-market activities that contribute to human/social well-being.

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Principle 4: Adequate Scope

Assessment of progress toward sustainable development should:

- Adopt a time horizon long enough to capture both human and ecosystem time scales thus responding to needs of future generations as well as those current to short term decision-making.
- Define the space of study large enough to include not only local but also long distance impacts on people and ecosystems.
- Build on historic and current conditions to anticipate future conditions.

Principle 5: Practical Focus

Assessment of progress toward sustainable development should be based on:

- An explicit set of categories or an organizing framework that links vision and goals to indicators and assessment criteria.
- A limited number of key issues for analysis.
- A limited number of indicators or indicator combinations to provide a clearer signal of progress.
- Standardizing measurement wherever possible to permit comparison.
- Comparing indicator values to targets, reference values, ranges, thresholds, or direction of trends, as appropriate.

Principle 6: Openness

Assessment of progress toward sustainable development should:

- Make the methods and data that are used accessible to all.
- Make explicit all judgments, assumptions, and uncertainties in data and interpretations.

Principle 7: Effective Communication

Assessment of progress toward sustainable development should:

- Be designed to address the needs of the audience and set of users.
- Draw from indicators and other tools that are stimulating and serve to engage decision-makers.
- Aim, from the outset, for simplicity in structure and use of clear and plain language.

Principle 8: Broad Participation

Assessment of progress toward sustainable development should:

- Obtain broad representation of key grass-roots, professional, technical and social groups, including youth, women, and indigenous people - to ensure recognition of diverse and changing values.
- Ensure the participation of decision-makers to secure a firm link to adopted policies and resulting action.

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Principle 9: Ongoing Assessment

Assessment of progress toward sustainable development should:

- Develop a capacity for repeated measurement to determine trends.
- Be iterative, adaptive, and responsive to change and uncertainty because systems are complex and change frequently.
- Adjust goals, frameworks, and indicators as new insights are gained.
- Promote development of collective learning and feedback to decision-making.

Principle 10: Institutional Capacity

Continuity of assessing progress toward sustainable development should be assured by:

- Clearly assigning responsibility and providing ongoing support in the decision-making process.
- Providing institutional capacity for data collection, maintenance, and documentation.
- Supporting development of local assessment capacity.

These principles provide guidance in the analysis of the impact of integrating sustainability indicators in IT/IS evaluation, as reported in the next section.

ANALYSIS

When confronting the methods of IT/IS evaluation identified in section 2 with the overarching Bellagio principles derived from frameworks of sustainability indicators, a number of observations can be made.

Integrating Sustainability Indicators Suggests a Multi-Criteria Approach

The principles Holistic Perspective and Essential Elements, prescribe for sustainability evaluation the use of more perspectives than just the economic perspective. Most frameworks of sustainability indicators adopt the triple-P concept and some frameworks take an even more holistic view. This suggests that by definition an IT/IS evaluation approach based solely on the economic perspective is inadequate for capturing the sustainability aspects of IT/IS.

From the four groups of methods identified by Renkema and Berghout (1996), the multi-criteria group of methods seems most appropriate to include the multiple perspectives that the concepts of sustainability imply.

Inclusion of Sustainability Indicators Makes Good Sense

Multi-criteria methods for IT/IS evaluation, like Information Economics, typically include an indicator for the contribution of IT/IS to the strategy of the organization. IT/IS evaluation therefore links to strategy (Silvius, 2010). And as more and more companies are integrating statements about sustainability in their strategy (Hedstrom et al., 1998; Holliday, 2001), inclusion of sustainability indicators in IT/IS

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evaluation makes sense. In the Bellagio perspectives this link is captured in the principle Guiding Vision and Goals, that prescribes that assessment of sustainability aspects should be guided by a clear vision of sustainable development and goals that define that vision.

A Universal Model for Evaluating (Sustainable) IT/IS is Illusive

The recognition in the Bellagio principles that a sensible and meaningful set of sustainability indicators is context specific, and that consensus should be sought on the level of principles rather than specific indicators, suggests that a 'one size fits all' approach to IT/IS evaluation may not be viable. This is also recognized by principle Practical Focus that stated that standardizing of measurement should be sought wherever possible, thereby suggesting that this is not always possible. For organizations this would imply that working with a universal 'business case' model, which most organizations do in order to be able to compare IT/IS investments and projects, actually does not lead to optimal decision making.

Including Sustainability Assessment Expands Scope

The logical 'unit of analysis' of IT/IS evaluation is the organization that uses the technology or systems or invests in them. This scope is based on economical reasoning and the concept of ownership. IT/IS should bring benefits to the economical unit that invests in, pays for or owns the technology or systems being assessed. In sustainability assessments, however, the sphere of influence is not limited to economical units or ownership. This is covered in the Bellagio principles Holistic Perspective and Adequate Scope. The principle Holistic Perspective mentions that assessment of sustainability should include a review of the whole system as well as its parts. The principle Adequate Scope prescribes that assessment of sustainability aspects should define the space of study large enough to include not only local but also long distance impacts on people and ecosystems.

Including Sustainability Assessment Implies Equality of Time

The economic perspective, that is so dominant in all IT/IS evaluation methods, values short term effects more than long term effects. This principle is most visible in the discounting of future cash flows. In economic theory an immediately cash flow holds more value than a future cash flow, thereby emphasizing the value of short-term benefits. However, social impacts or environmental degradation because of business decisions, may not occur before the long-term. Also this aspect is mentioned in the principle Adequate Scope, that states that assessing sustainability should adopt a time horizon long enough to capture both human and ecosystem time scales thus responding to needs of future generations as well as those current to short term decision-making.

Sustainability Assessment Implies Continuous Assessment and Institutional Capacity

The Bellagio principles Ongoing Assessment and Institutional Capacity prescribe an institutionalized, repetitive and iterative process to assess sustainability aspects. In IT/IS evaluation, this aspect is covered in some of the IT/IS evaluation methods, most explicitly in the concept of portfolio management. Portfolio management suggests a continuous process of monitoring, measuring, evaluating and selecting

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investments or assets. In fact, also project management methodologies like Prince2 include a continuous re-assessment of the business case of the project. Assessing sustainability, however, goes even further than this and suggests that the technology or system at hand is also continuously assessed during its exploitation. This could be compared with the 'business case management' in the post-implementation phase of a project.

Sustainability Assessment Implies Openness and Broad Participation

The Bellagio principles Openness, Effective Communication and Broad Participation prescribe how stakeholders are informed and engaged in the assessment of sustainability aspects. These principles touch upon the way assessments are performed. And although these aspects are not explicitly covered in the IT/IS evaluation methods, the graphical representations that are included in the Information economics methodology do facilitate participation of and communication with key stakeholders and decision makers. It is, however, debatable whether these formats and techniques are an adequate operationalization of the principle Openness.

CONCLUSION

Sustainability is one of the most important challenges of our time. How can we develop prosperity, without compromising our wellbeing or that of future generations? More and more companies recognize this and take responsibility for their role in this challenge. IT/IS can make a contribution to the sustainable development of organizations. It therefore makes sense to include an assessment of sustainability aspects in the evaluation of IT/IS. And although some considerations of sustainability can be found in the various methods of IT/IS evaluation, it has to be concluded that the integration of sustainability indicators in IT/IS evaluation is just in its infancy.

In a contribution to the understanding of sustainability considerations in IT/IS evaluation, this paper confronted the principles of sustainability assessment with the different methods of IT/IS evaluation. This analysis did not result in a set of additional criteria to be considered, but in a set of observations that form a foundation to reconsider IT/IS evaluation methods. These observations are:

- Integrating sustainability indicators suggests a multi-criteria approach.
- Inclusion of sustainability indicators make good sense.
- A universal model for evaluating (sustainable) IT/IS is illusive.
- Including sustainability assessment expands scope.
- Including sustainability assessment implies equality of time.
- Sustainability assessment implies continuous assessment and institutional capacity.
- Sustainability assessment implies openness and broad participation.

The implications of these observations may be far fetching, as their impact suggests a far more holistic and elaborated perspective on IT/IS evaluation than the infamous IT productivity paradox. The operationalization of this holistic and elaborated evaluation perspective, however, is still subject to further research.

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Chapter 3
Economic Growth, Sustainable Development, and the Role of Markets

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ABSTRACT

This chapter tracks the long path that Development Theory has traversed over the last century. Its origin traces back to the notions of economic growth and development and eventually reached a stage where governments and academics are more concerned with more holistic notions of development than merely growth. Sustainable development has become the most important notion of the day and provides a more comprehensive definition of development, linking ecological services and quality of life with economic growth. Such a paradigm shift in less than a century is no less than a revolution. Expectedly, this shift has been marked by cognitive dissonance, bitter debates, and scholastic antagonism. This chapter traces the story of how the road has been traversed and the shift achieved. It highlights the various theories of economic growth and development and focuses on the debates among economists that have helped the discipline traverse this long way. Finally, this chapter talks of markets. While it has often been understood that markets can promote economic growth, this chapter further emphasizes how markets, under enabling conditions, might be the right catalysts to promote sustainable development.

THE DAYS OF CLASSICAL POLITICAL ECONOMY…

With political economy evolving out of the writings of Adam Smith and David Ricardo, the scope of economics as a discipline got defined in the confinements to find and explain the "nature and causes" of economic development. The scenario is neither so simple nor so comfortable for modern economists; it has always been considered a maverick field; lurking somewhere in the background but not really thought of as "real economics"—rather an amalgam of sociology, anthropology, history, politics, and all-too-often, ideology.

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Though it has often been claimed that economic development as a branch of economic science emerged only in the '50s, there is no doubt that the notion of development existed even in the classical economic thought processes. The recognition of development economics as a discipline over the past 50 years earmarked the changes in our understanding of development. The wealth of experiments so far has revealed that there are clearly no sure-fire formulas for success; if there were, there would have been many more success than what there are today. Economic theory has, in fact, evolved to account for both successes and failures.

Nonetheless, few of the greatest economists actually ignored it outright. The Classical School, starting with Adam Smith, was concerned with "economic development." However, their notion of economic development was quite different from what is defined as development today by development theorists. This difference gets reinforced in Smith's *Wealth of Nations*, and Ricardo's *Principles of Taxation*, and goes on *till* Schumpeter's classic *Theory of Economic Development* (1911). The German Historical School—and its English and American counterparts—could very well be deemed as part of development economics. It was thoroughly geared towards the theory of economic growth.

However, the primary focus of economic research remained confined to developed nations till the 1930s. It was Colin Clark's quantitative study in 1939 that made economists realize that most of humankind did not live in an advanced capitalist economic system. Yet, the early concern was still Europe; namely, post-war European reconstruction and the industrialization of its eastern fringes as exemplified by the pioneering article of Paul Rosenstein-Rodan in 1943 and Kurt Mandelbaum's book in 1947. It was only some time after the war that economists really began to show their concerns for Asia, Africa, and Latin America.

To this end, decolonization was an important catalyst. Faced with a plethora of new nations whose standards of living and institutions were so different from the European way of life, modern development theory—by which we mean the analysis of not only growth but also of institutions that could induce, sustain, and accelerate growth—began in earnest to change its focus and rearrange its referential. After the Second World War, academes began to think of ways and means of effectively dealing with poverty and destitution that heavily weighed upon two-thirds of the human race (Pakdaman 1994).

The post-war formation of the United Nations and its attendant agencies, such as the World Bank, the IMF, the ILO, and various regional commissions, provided an impetus to the shift in focus and perceptions. The commissioning of numerous studies by these institutions led to the emergence of a non-academic strand of development theory.

POST-WAR PERIOD: STAGE THEORY OF GROWTH AND CAPITAL FORMATION

Post-war development was primarily looked at from the viewpoint of growth and capital formation. Even before that, developing nations looked at development primarily as a process of industrialization. This resulted in the concept of a Third World consisting of Latin American, Asian, and African countries, which were to be mostly viewed as "underdeveloped" countries. It was believed that they were in the early stages of development; and with time, they would be able to transcend the various stages. This was contingent upon the way the in which capital was being formed, industrialization was taking place, and GDP growth occurred.

This thought culminated in the "stage" theory of development, made famous by Gerschenkron (1962) and Rostow (1960). The stage theory assumes certain "linearity" in the development patterns of

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economies, and argues that "underdevelopment" in some of the economies will be converted to "development" over time. A few Asian, African, and Latin American countries lagged behind the developed nations as for time. Interestingly, to view development, capital formation, and technological change as linear functions of time is an assumption that is reductionist, and which does not incorporate social and political variables that might result in differential and varying growth trajectories.

However, the role of capital formation as a crucial component that accelerates development was not only recognized by Gerschenkron and Rostow, but also by Nurkse (1953) and Lewis (1955). Early Keynesians, such as Kaldor and Robinson, attempted to call attention to income distribution as a determinant of savings and growth. Even modern Marxists like Maurice Dobb (1951and 1960) focused on the formation of savings. And even orthodox Marxists have had no conflict on this issue. Lewis and even Keynesians have argued that savings can be manipulated through government intervention (Singer 1950, Myrdal (1957)]. Thus, government involvement—whether by planning, socio-economic engineering, or effective demand management—was regarded as a critical tool of economic development.

POST-WAR MARXIST THINKING

A number of emigrant economists in Britain, influenced by their personal experience of late industrialization in Central and Eastern Europe, developed plans for the post-war transformation of underdeveloped regions. The contributions of Michael Kalecki, Kurt Mandelbaum, Joseph Steindl of Oxford University, and Paul Rosenstein-Rodan of the Royal Institute of International Affairs laid the basis of development economics as a formal sub-discipline. These Central European economists were more familiar with Marx than with Keynes, and the success of the Soviet five-year plans played a significant role in their approaches to developmental planning. It is well known that Kalecki's (1955 and 1956) model of an economy with under-utilized resources of labour and capital was similar to Keynes', but presented in Marxist rather than the more familiar Anglo-Saxon analytical categories. In fact, Kalecki's contribution to planning for economic development deserves to be widely acknowledged.

Newly formed economies like India also followed the planning processes, as was done by the USSR, and their growth models were based on the Soviet experience. It was generally accepted that the state must play a central role in economic transformation because the private sector was either dominated by landed and commercial oligarchies with vested interest in the status quo or was simply too weak and disorganized. The degree of state involvement in the economy varied across countries, but basic public infrastructure and its financing was universally undertaken by the state, which was accompanied by some form of long-term economic planning. In the first three post-war decades, countries were able to privilege domestic agriculture and industry by discretionary access to credit and foreign exchange, subsidies, and a variety of protective commercial policies. The principal of sovereignty regarding natural resources, and more generally the sovereign right of nations to formulate fiscal, monetary, commercial and all other aspects of government policy, was not questioned, although in practice it was often violated.

This was the time (first three post-war decades) when the new orthodoxy emerged around the notion of balanced growth with the works of Lewis and Nurkse. However, it never took much time for an antithesis to emerge in the notions of "unbalanced growth" with the works of Hirschman (1963, 1981) and Streeten (1959). They are of the view that balanced growth is not possible as the theory assumes that a modern sector should be superimposed on an old and traditional one. In the process, the "balanced

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growth" theory loses its focus from the processes of change, which, in fact, should have been the real focus of development theory.

NEOCLASSICAL GROWTH THEORY

Neoclassical development theorists have emphasized the important role that international trade plays as a substitute for low domestic aggregate demand. They argue that governments should act as facilitators to promote international trade between economies. In the process of positioning the economy on an autonomous, sustained-growth path, the government has to remove barriers to international trade in commodities. Comparative advantage, combined with the Hecksher-Ohlin theorem, can then take care of the rest. Subsequent amendments to this position require the removal of price distortions in domestic factor and commodity markets ("getting prices right"); this is in addition to the list of government actions that is required to induce suitable movements of factors among sectors, encourage the adoption of appropriate technology, and increase capital accumulation. In this view, domestic and international liberalization programmes suffice to bring about sustained economic growth and structural change.

Many economies have revealed considerable faith in this framework and have relied extensively on export-oriented growth. This has been the main characteristic of Southeast Asian economies and present-day China. To a certain extent, even developing economies like India and Brazil have also subscribed to this thought process. Interestingly, export facilitation in many of the Southeast Asian economies resulted in pegged exchange rate regimes and free international mobility of capital. Although phenomenal economic growth has been achieved, yet there have often been problems of capital flight caused by the lowering of interest rates as currencies were devalued to promote exports. Hence, in developing economies like India, which proposes to go for full capital account convertibility in recent years, words of cautions have always been forwarded to "go slow" on this front—whether it is right or wrong remains the concern of a broader debate.

FROM ECONOMIC GROWTH TO ECONOMIC DEVELOPMENT

Capital formation remained an important component of growth for centuries, and even today, its importance remains undiminished. However, over time, its connotation has changed. T.W. Schultz (1963 and 1971), and was the first to recognize the need for "human capital" formation, as an important appendage to physical capital formation. This led to an emphasis on education and training as pre-requisites of growth and the identification of the problem of "brain drain" from the Third World to the First.

Lewis (1965) and Singer (1965) also subscribed to Schultz's thesis. Their argument was focused toward social development as a whole, which could be brought about by education, health, fertility, etc. Improvement in human capital thus began to be considered as a necessary pre-requisite for economic growth. In this view, industrialization, if it came at the cost of social development, could never be self-sustaining.

According to Singer (1965), "…Development is growth plus change," and "…change is not only economic but also social and cultural" (Singer 1965: 5). He pointed out that growth had not resolved the problem of poverty, and suggested "poverty-biased" policies to affect the lives of the poorest. Till this time, all arguments, even those in favour of development, were growth-centric.

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The growth-obsession of development theory received a huge jolt when Seers (1969) published a seminal essay where development was construed as a social phenomenon rather than merely being defined in the reductionist mode of per capita income growth. Development, in Seers' opinion, involved the movement toward the social goals of poverty reduction, employment, and equality.

Myrdal (1968) also supported Seers' views. In his presidential address at the 11th Conference of Society for International Development at New Delhi, Seers (1969) presented a more succinct statement of development with distinction: "…It is very slipshod for us to confuse development with economic development, and economic development with economic growth" Seers (1969:2). Haq (1971: 6) was galvanized by Seers' call to redefine economic development, when he stated, "…We were taught to take care of our GNP as this…[would] take care of poverty. Let us reverse this and take care of poverty as this will take care of GNP".

Thus, structural issues, such as dualism, population growth, inequality, urbanization, agricultural transformation, education, health, and unemployment, began to be reviewed on their own merits, and not merely as appendages to an underlying growth thesis. Eventually, there was an emerging debate on the very desirability of growth, which was led by the extremely provocative publication by Schumacher (1973) where he argued against the desirability of industrialization and inscribed the merits of handicrafts economies.

The social positions of development became even more prominent with the adoption of Human Development Index (HDI) as a somewhat rough measure of development by academics and multilaterals in the 1990s. The HDI measures life expectancy, literacy, education, and standard of living for countries worldwide. This provides an indicative measure of the impact of economic policies on the quality of life. The index was developed in 1990 by Amartya Sen, and Mahbub ul Haq with help from Gustav Ranis of Yale University and Meghnad Desai of the London School of Economics. Ever since its development, the United Nations Development Programme uses it as a standard measure for categorizing development of a nation in its annual *Human Development Report*. Though a "vulgar measure", as described by Sen because of its limitations, it nonetheless brings forth the broader aspects of development than the per capita income measure it supplanted, and provides a pathway for researchers to delve into the wide variety of detailed measures contained in the Human Development Reports. Even other multilaterals like the World Bank have started focusing their attention on social attributes like poverty. As a result, whether in policy making or in academic research, social variables began to be factored in and became an integral part of development economics.

Yet, the debate between growth and development continued and took a new twist in the late 1980s and became more prominent in the 1990s when the very sustainability of economic development was being questioned by environmentalists because of grave concerns about the growing environmental crisis. Environmental pollution was seen as an externality of "mindless" developmental policies. The question that loomed large was: Growth? At what cost?

SUSTAINABLE DEVELOPMENT

Around three and a half decades ago, a group of academics known as the Club of Rome put forth the "limits to growth" theory, predicting disaster for humankind unless natural resource–depleting economic and technological progress were abandoned. Such pessimistic calls were, indeed, extreme in nature. However, the global recognition of the linkage between environment and development came as late as

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1980 when the International Union for the Conservation of Nature (IUCN) published the *World Conservation Strategy* and used the term "sustainable development."

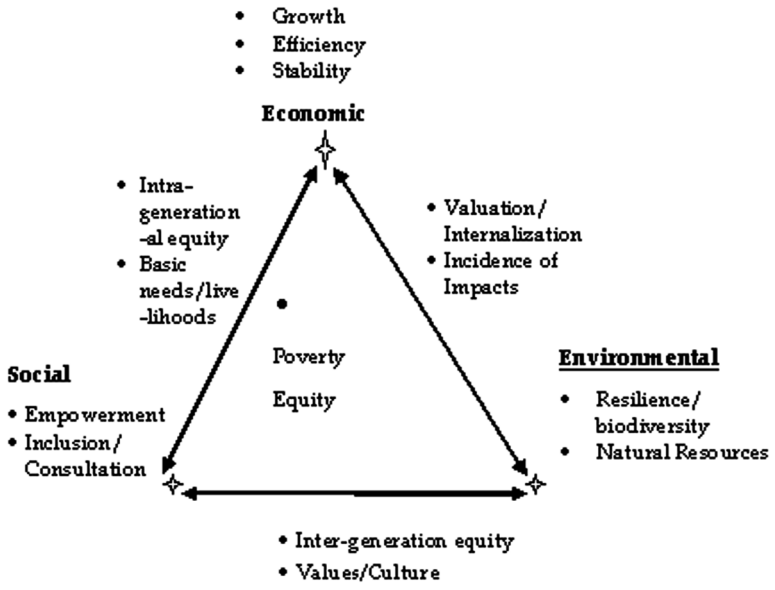
The concept came into general use following the publication of the 1987 report of the Brundtland Commission—formally the World Commission on Environment and Development (WCED). Set up by the United Nations General Assembly, the Brundtland Commission coined what was to become the oft-quoted definition of sustainable development: Development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" [WCED (1987)]. This definition, despite being lauded as the first formal attempt to delineate sustainable development, has met with a lot of resistance and cognitive dissonance.

However, there is a misconception that sustainable development is all about environment and ecology. There cannot be anything more disastrous than conceiving such a reductionist scope of this notion. Rather than focusing solely on environmental issues, sustainable development policies broadly encompass three areas: economic, environment, and social. In support of this, several United Nations texts, most recently the 2005 World Summit Outcome Document, refer to the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection.

Among many subsequent definitions, the sustainable development triangle in Figure 1 shows one of the widely accepted explanations proposed by Munasinghe (1992) at the 1992 Earth Summit in Rio de Janeiro.

All the available documents of sustainable development acknowledge the interlinkages between the three domains, and have argued that environmental changes (e.g. in ecosystem services like food production and water purification) influence economic growth in the short and the long run, institutions, and culture (Munasinghe 1992, Munasinghe and Reid 2005). Changes in social values and behaviour

Figure 1. Elements of sustainable development
Source: Munasinghe and Reid, 2005



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influence economic development and environmental management. And critically, economic growth and distribution of wealth and welfare influence both social and ecological attributes.

Sustainable development, eventually, led to the recognition that life support systems that are crucial to human development are given by nature and can be finite, diminishing, yet replenishable at times. In the context of non-replenishability, there is an utmost need to look for alternative sources so that the exploitation of such resources is diminished. It also gave recognition to the fact that a given stock, composition, and productivity of society's capital—natural, man-made, and human—can contribute toward meeting basic human needs in a sustained manner over time, but only up to a maximum limit (Sengupta and Sinha 2003).

Yet, the debate still rages. Despite various attempts to define "sustainable development", in terms of pathways, values, indicators, goals, practice, etc., yet a clear, fixed, and immutable definition remains elusive [Kates et al (2005)]. It has also led some to infer that sustainable development is an oxymoron: "development" and "sustainability" cannot be reconciled. Verily, Kates et al (2005: 20) state, "… Sustainable development draws much of its resonance, power, and creativity from its very ambiguity…its malleability allows it to remain an open, dynamic, and evolving idea that can be adopted to fit these very different situations and contexts across space and time. Likewise, its openness to interpretation enables participants at multiple levels, from local to global, within and across activity sectors, and in institutions of governance, business, and civil society to redefine and reinterpret its meaning to fit their own situation… Despite this creative ambiguity and openness to interpretation, sustainable development has evolved a core set of guiding principles and values, based on Brundtland Commission's standard definition to meet the needs, now and in the future, for human, economic, and social development within the restraints of life-support systems of the planet."

Hence, no ambiguity can deter one from concluding that sustainable development is probably one of the most powerful and holistic thought process that has enriched the development discourse, by challenging the reconciliation of what apparently seems to be the "irreconcilable trinity" of economic growth, social development, and environmental sustenance, thereby providing opportunities for a healthier and sustainable future.

IS SUSTAINABLE DEVELOPMENT OPPOSED TO ECONOMIC GROWTH?

Sustainable development has sometimes been treated as a notion emerging from the communistic thought processes, and sometimes as a tool used by antagonistic ecological activists. Both of these are widespread misconceptions about the notion. Rather, the notion is much more objective than being treated as inclined toward a particular tradition. The concrete challenges of sustainable development are at least as heterogeneous and complex as the diversity of human societies and natural ecosystems around the world. Unfortunately, both socialistic thought processes and ecological antagonism have used the notion as a powerful tool to talk against economic growth, and this has even deterred many market-oriented thinkers to adopt this notion. It needs to be remembered that sustainable development is not opposed to economic growth or development; rather, it talks of sustaining the process of growth and development over generations.

On the contrary, the relationship between economic growth and indicators of air and water quality indicates that growth does not always contribute to environmental degradation. The connection is highly

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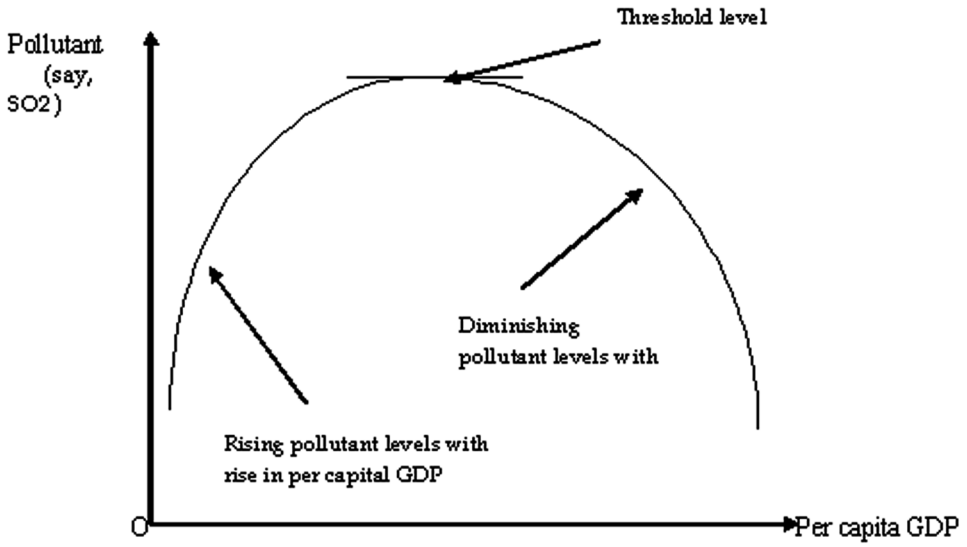
dependent on income levels: there seems to be a U-shaped relationship between income and environmental quality.

This statement in favour of reconciliation of growth and ecological sustainability is best reflected in the Environmental Kuznets' Curve (EKC). EKC presents a relation between various indicators of environmental degradation and income per capita. In the early stages of economic growth, degradation and pollution increase, but beyond a threshold level of per capita income the trend reverses, so that at high-income levels economic growth leads to environmental improvement. The turning point varies according to the pollutant. This implies that the environmental impact indicator is an inverted U-shaped function of per capita income, as presented in Figure 2. EKC is named after Simon Kuznets (1955), who hypothesized that income inequality initially rises with per capita GDP and then falls as economic development proceeds beyond a threshold level.

The EKC concept emerged in the early 1990s with Grossman and Krueger's (1993) path-breaking study of the potential impacts of NAFTA and Shafik and Bandyopadhyay's (1992) background study for the 1992 World Development Report. However, the idea that economic growth is necessary for environmental quality to be maintained or improved is an essential part of the sustainable development argument promulgated by the WCED (1987). However, EKC is an empirical phenomenon, despite research papers on the topic being inflicted by weak econometrics.

In the context of the EKC, it is easy to interpret that the levels of suspended solids and toxic metals in air and water increase rapidly as incomes approach middle income levels but then decrease. The link between income and pollution arises because the composition of output changes with growth in favour of newer, cleaner technologies. EKC also presents a powerful statement on the political dimension of the economy-ecology linkage. Because of better education and awareness, citizens in higher income economies articulate their demands for a cleaner environment, in a more effective manner than those

Figure 2. The environmental Kuznets curve



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in lower income nations. Hence, it is the concern of "environment" as a "good" being featured in the "utility bundle" of the consumer that acts as a prime driver in the scheme of things.

On the other hand, the convincing statements made by Munasinghe (1992 and 2005) and the recently published Millennium Ecosystem Assessment (2005 a) on ecosystem services affecting economic behaviour reveal that ecological services and economic development cannot be dissociated or disintegrated, and that the causality flows from both directions.

Developing countries have often perceived pollution abatement as being opposed to their development aspirations. An implausibly high level of technical progress in energy use would be needed if these were to result in the stabilization of emissions. Incidentally, in consonance with the EKC phenomenon, most developing countries are still well below the peaks of their pollution so that global environmental damage is likely to increase substantially before it declines. Does that imply that growth needs to be sacrificed for that? Rather sacrificing on growth would aggravate the problem, accelerating population growth, slowing the adoption of cleaner technologies and frustrating the development of democratic institutions. Pollution tends to be related to population, and population growth is inversely related to income growth. Higher average income and output levels are only good for the environment when associated with policies that lessen demographic pressures by reducing personal risk and the need for large families. Improvements in the security of employment, education and training, pension policies, social security and the employment of women are especially important.

Measurement of environmental costs and benefits is a key first step to the development of appropriate policies. The failure of current estimates of net national product to account for the depreciation of environmental resources amounts to imputing this depreciation to be zero, biasing investments and technological choices. If full account were taken of environmental depreciation, profits and national output would be lower. In Costa Rica, for example, it is estimated that the depreciation of forests amount to around 10 percent of GDP and over a third of gross capital accumulation. Biases like this have severe consequences everywhere, but are particularly pernicious in poor countries where small fluctuations in income or growth levels can spell the difference between famine or survival. Small changes in techniques of measurement, production and lifestyle are likely to prove sufficient to preserve the options for future generations. Investments in environmental maintenance are likely to lead to barely significant declines in income growth (under 1 per cent) in the short-term; longer term, they should facilitate more rapid and globally equitable development. Policies which facilitate growth and lead to the appropriate pricing of natural resources provide the basis for enhanced environmental management. The establishment of a pricing structure for natural resources which reflects their true value will also be invaluable. The failure to price natural resources, such as water, at their economic cost means that degradation of natural resources by present generations may undermine the basis for future economic growth.

Trade liberalization offers a particularly powerful impetus to growth and is entirely compatible with sustainable development. Indeed, trade distortions are a primary explanation for environmental degradation, as shown by the the high dependence on subsidised dirty fuels in China and Eastern Europe. To the extent that trade policies may have an adverse effect on the environment, it is up to governments to initiate policy changes. Improved minimum standards and global cooperation for environmental management are a vital step to ensuring that the benefits of economic growth may more quickly and effectively be reflected in an enhanced environment. Not only is growth sustainable, but it is a necessary condition for improved environmental management.

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THE ROLE OF MARKETS

From the discussion so far, it is clear that from the viewpoint of policymaking, a development path that is "sustainable" should also take into consideration institutions that will be conducive for greater participation of citizens at various levels. One of the critical elements that have been implicitly pointed out in this debate is the crucial role of market mechanism. Unfortunately, the role of market in sustainable development has not received much attention, and rather, in many cases, the same has been criticized by communist groups. Therefore, it is only pertinent here to talk of a few market phenomena that have emerged and might prove conducive for sustainable development.

Trading in Ecosystem Services: A Market for Nature

It has often been argued that ecosystems services should be viewed as natural capital; investment in which can prove more effective than that of the built capital to deliver key services. "As an example, consider the case of flood control. One can address floodwaters through built capital, such as engineered works (e.g. construction and maintenance of dikes and levees) or through natural capital, such as landscape management (e.g. restoration of wetlands in flood plains). In some instances, perhaps many, landscape management may prove a better public and private investment strategy for providing flood control, once one accounts for the positive externalities of improved water quality, wildlife habitat, and recreational amenities." (Salzman 2005) Many solutions have been proposed to halt environmental degradation and reverse the downward trend in ecosystem services. Some have been successful, while others have failed. An assessment of response strategies undertaken by the Millennium Ecosystem Assessment (2005b) highlighted the potential of market-based strategies to mitigate the degradation of ecosystem services.

At one point in time, it was thought that nature is endowed with resources in abundance. Anything that is supplied in abundance eventually has no value, and no market. However, over time, with human intervention in the working of the environment, there has been degradation and depletion of the resources. With the decline in their *supply*, a traditional response has been to turn to governments for continued supply of ecosystem services, through regulations, cost sharing, and other related mechanisms. This is what has been done for public goods and utilities so far. The status of the ecosystem is really a cause for more serious concern than that of public goods and utilities. The Hardin-initiated parable of "Tragedy of Commons" demonstrates how free access and unrestricted demand for a common, natural resource dooms the resource through overexploitation. This happens, as none of the beneficiaries from the resource are willing to take up the responsibility of restoration and maintenance, because the individual cost of doing so is perceived to be much higher than the benefits that accrue. According to the Millennium Ecosystem Assessment (2005a) "If current trends continue, ecosystem services that are freely available today will cease to be available or become more costly in the near future. The higher costs that primary users may face will be passed downstream to secondary and tertiary industries and will transform the operating environment of all businesses."

Since monitoring and regulation of the ecosystem services is difficult and expensive for the government, the need for creating markets and market values assumes importance. Ecosystem services affect the well being of individuals and the performance of firms. Yet, this is rarely reflected in the financial incentives that ecosystem participants get. Typically, those who reduce ecosystem services do not bear all the costs they impose on others, nor those who supply such services are rewarded for the benefits they

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provide to others. In the absence of non-existent markets, allowing participants to act in their own private interest can result in fewer ecosystem services than is optimal for the society as a whole. Markets work well at providing rewards, and hence, markets are a way of encouraging resource managers to properly manage natural resources by offering them incentives.

When one looks at the value chain of any marketed commodity, one realizes that goods extracted from ecosystems have long been traded in markets (i.e. can be bought and sold at established prices). The services provided by ecosystems have been used for just as long, but have remained beyond markets and largely unpriced. The open access problem, whereby resources with poorly defined or undefined property rights (including forests, water, or grasslands), if not regulated in their use, can be accessed by all and used until exhaustion. But just as in any market, an emerging scarcity can make them tradable.

There have been establishments of markets for ecosystem services, and as argued by many, payments for ecosystem services can help in rural poverty alleviation and the process of conservation simultaneously (Uddhammar and Ghosh 2006, Ghosh 2007). Economists have also been instrumental in devising tools like environmental valuation to assess the value of the benefits accrued to human civilization by the environment (e.g. Costanza *et al* 1997, Chopra and Adhikari 2004)]. This has often helped in devising rules of compensation for environmental damages that cause economic losses to backward communities (e.g., Ghosh and Shylajan 2005).

Some of these ecosystem market-based initiatives include the establishment of carbon sequestration offsets, tradable development rights, tradable quota systems, eco-labeling and environment certification, and bio-prospecting. A brief synopsis of these processes is given below.

Market-Based Mechanisms for Ecosystem Services

- *Carbon sequestration offsets* encourage landowners to conserve natural vegetation and to reforest land by providing a market that allows them to be compensated for their costs and the profits they forgo.
- *Tradable development rights* are marketable rights awarded to landowners in areas reserved for conservation. These rights can be sold to owners of land in development areas to satisfy requirements that they hold a certain number of credits before gaining permission to develop the land.
- *Tradable quota systems* have been applied to a number of areas including fisheries management. Quota systems are a means of dealing with over exploitation by allocating quotas to individual fishers so that the sum of the individual quotas does not exceed the carrying capacity of the fishery. These quotas can be traded between groups of producers, or individually.
- *Eco-labelling and environmental certification* have gained significance particularly in natural resource extraction and management. These schemes are often voluntary, and are often created by private agents in the market. They seek to increase incentives for environmentally sound production by enabling consumers to differentiate between production techniques, product qualities, or producing organizations.

The recent expansions of markets for other environmental services suggest that they may rapidly become a central point of sustainable development financing, representing tens of billions of dollars annually within the next 10 to 15 years. All these moves toward markets have been triggered by two major drivers that include conscious national environmental policy movements towards market-based instruments, and rising demand for environmental goods and services from public authorities, private entities, and

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consumers. On the one hand, there are new public regulations along with the establishment of market-based instruments, and on the other, it has become quite lucrative and fashionable for private players to show initiatives toward efforts of biodiversity protection. Consumer demand for derivatives of healthy ecosystems in the form of organic foods, fair trade products, and eco-tourism has also increased over time. Its positive incidence on human health and overall welfare is also being steadily documented.

Water Markets

Rosegrant and Binswanger (1994) suggest that water markets provide a flexible and efficient way to allocate water while at the same time providing incentives that are beneficial for water users. When water savings can be traded, they provide extra income to farmers, while pricing leads to a reduction in income. They also suggest that markets lead to the highest value use of water. As shown by Holland and Moore (2003) in the context of the Central Arizona Project, a restrictive market mechanism on groundwater resources could result in inefficient solutions. According to Hearne and Easter (1995), markets should be recognized as providing a means of allocating water according to its real value, thereby leading to efficiency gains and conservation. Gardner and Fullerton (1968), and Marino and Kemper (1999) suggest that markets can provide a means to allocate water according to its opportunity cost, resulting in efficiency gains.

Holden and Thobani (1996) talked of tradable water rights as an approach to resolve water shortages and promote investment. They expressed that a system of tradable water rights combined with effective institutional arrangements can solve many of the problems related to allocation that administered solutions fail to deal with. In another instance, Chile's National Water Code of 1981 established a system of water rights that were transferable and independent of land use and ownership. The most frequent transaction in Chile's water markets is the ——renting of water between neighbouring farmers with different water requirements (Gazmuri 1992).

Cases and analyses have widely been documented on physical market transactions of water all over the world or transactions of tradable water rights. Markets range from being formal to informal. Informal water markets are found in India (Saleth 1997), Pakistan (Bandaragoda 1998, Meinzen-Dick 1997), Chile (Hearne and Easter 1997), and Mexico (Thobani 1997). Transactions are typically small-scale and local, selling surplus water to neighbouring farmers or towns (Johansson 2000, Bosworth *et al* 2002). Formal markets involve buyable and sellable water rights, permanent and seasonal transfers or transactions between sectors and jurisdictions. Examples exist for the western US (Colby 1998), California (Howitt 1998), Texas (Griffin 1998), and Spain (Garrido 1998). It is claimed that the most advanced form of tradable water rights exist in the Murray-Darling Basin in Australia, with seasonal and permanent states of diversion entitlements (Bosworth *et al* 2002).

Virtual Water Imports

A recent concept that has emerged in literature on water resource policy is virtual water (Allan 1993, 1994, 1996, 1997, 2003;, Jobson 1999); Hakimian (2003); Hoekstra and Hung (2002); Wickelns (2001)]. The water "embedded" in agricultural commodities is called "*virtual water*". It requires about 1,000 tonnes [cubic metres] of water to produce a tonne of wheat; about 16 times this volume to produce a tonne of beef. This water is sourced from freshwater or from soil water. In other words, virtual water is the volume of water needed to produce a commodity or service (Jobson 1999). The concept is particu-

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larly impressive in the way it ameliorates water scarcity over vast distances (Merrett 2003). It enables non-water self-sufficient economies and river basins to meet their strategic food needs (Allan 1997). This is, thus, a classic example of Ricardo's generic concept of comparative advantage. Products with extensive consumptive use of water, if imported, entail import of *virtual water*. Economies like Israel have tried to balance their water budget in that manner. Japan is the world's biggest importer of virtual water (Oki et al. 2003)]. Japan's needs are provided by the U.S. and Australasia by providing grain for consumption by humans and livestock. Apart from food grains, virtual water is present in commodities whose productions require water, e.g. hydropower, etc. (Jobson 1999).

Virtual water stands as one of the demand-side management options for water resources, which has often been argued as the crux of the new paradigm of water resources management. It has often been thought that the primary reason for water conflict is scarcity of the resource, thereby making the issue of scarcity the fundamental concern worldwide by creating the rationale for managing water demand.

Some Comments on These Emerging Markets and Sustainability

Market institutions make the common man understand the value of the services that the ecosystem provides to the economy as a whole, the incidence of economic activity on the ecosystem, and finally, its possible repercussions on the quality of life. This dictates the supply-side phenomenon of an economy, including human health, welfare, and eventually, labour markets. At the same time, trade in ecosystem services has the potential to become the new growth industry. Areas and projects where such trade is possible are likely to generate significant secondary benefits, such as eco-tourism, with multiplier effect on incomes and employment. The potential for synergies among various initiatives therefore are plenty. Not only can an economy fulfill its obligations under the various environmental conventions to combat desertification, biodiversity degradation, and global climate change, but the possibility also exists to engage various rural communities in formal market transactions, reducing thereby the extent and magnitude of poverty.

CONCLUDING REMARKS

Development theories have transcended various disciplinary barriers for finally arriving at the concept of sustainable development from the notion of economic growth. Sustainable development, by all means, is an all-encompassing notion involving parameters of human health, labour, education, industrialisation, and demand-side factors along with the recognition of the contribution of nature to the economy. Such a paradigmatic shift to a holistic concept of development from a reductionist notion in less than a century is no less than a revolution.

The "quality of life" indicators (see Oswald 1997), rather than simply growth, have increasingly become important for governments and academics, as disciplines are being transcended. As the biophysical constraints of land, soil, and water put an upper limit on the carrying capacity of nature, there is the utmost need to develop institutions like markets to manage the limited resources efficiently, ensure equity in the distribution of these resources, and allow substantial time for replenishment of the resources, and find alternatives to guarantee sustainability. This would simultaneously require a trans-disciplinary knowledge base[1], public action, and design of appropriate macro and sectoral policies. More critically,

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the entire discourse of public policy needs to be viewed in the wider context of inclusive development, including those of future generations.

There is no doubt that one of the biggest catalysts in this phenomenon is the market. Ghosh (2011) has talked of how markets can help in cooperative behaviours and therefore bridge the "ingenuity gap"[2] between the developed and the developing nations. With the emergence of more and more markets and therefore cooperation over natural resources, scholars have increasingly recognized that increasingly cooperation over natural resource use and management is on. Even governments have been including local communities to offer eco-tourism benefits, which is another form of market creation leading to cooperative behaviour and mutual benefits. Cooperative behaviours have emerged in the use and management of forest resources. Local communities have been increasingly involved in forest management through institutions of joint forest management in India, Bangladesh, Nepal and Bhutan.

Worldwide, ecosystems markets are being developed with this notion. While carbon trading and clean development mechanisms (CDMs) are important interventions to bridge the chasm between the rich and the developing world, it seems that these institutions will only be enhanced over time, with more sophisticated instruments for trading. These initiatives have been helping the poor, as also the cause of species conservation, thereby reducing the frequencies of community–government conflicts in the developing world. Water markets at informal levels have helped in resolving water conflicts to a large extent, and have been conducive to promote local level developments. Unfortunately, while we note a lot of cases of cooperation at international levels over transboundary waters, international water markets are not yet in vogue. Cooperation over water at international and within national boundaries are exemplified by the cooperation of the seven states of Western US over the Colorado River, and the treaty over the Indus waters between India and Pakistan. However, the potential for international water markets to promote sustainable development at broader regional levels is immense. The last chapter in this volume talks of how a South Asian water futures exchange can help in resolving water conflicts at an international as well as at national levels in South Asia. There is therefore little doubt that a policy toward sustainable development can substantially reduce the inequalities in the economic, environmental, and social sectors, and one can never ignore markets and market-based instruments as important forces in helping attain that goal.

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ENDNOTES

1. Sustainomics has been suggested by Munasinghe (1992) as a trans-disciplinary knowledge base emerging out of knowledge of economics, ecology and society.
2. To understand the determinants of social adaptation to scarcity, Homer–Dixon defines "ingenuity" as society's ability to supply enough ideas."

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Chapter 4
Implementing an Interfaculty Elective "Sustainable Development":
An Intervention into a University's Culture Between Organized Scientific Rationality and Normative Claim

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ABSTRACT

A university is a place of organized scientific rationality, but as a social institution it is also committed to future generations. Therefore, it can be argued that universities should act as "models for sustainability". It is thus not sufficient to spend public funds efficiently in achieving their educational mission. Beyond that, the social and the environmental effects of their actions also have to be considered. Having this in mind, the status quo of sustainability in research, teaching, and administration at the Alpen-Adria University Klagenfurt in Austria was examined in 2010. Results showed that although important approaches and several internationally acknowledged contributions in research and teaching do exist, at the same time a concise and focused strategy for these actions is missing. However, there was some commitment that a coherent strategy would strengthen our University. The major challenge is that a system based on individual freedom in research and teaching needs to intervene in order to create, implement and live such a strategy. The conception and implementation of an interdisciplinary elective open for all Master and PhD students seemed to be a first appropriate step to implement sustainability

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at the University across disciplinary and structural borders. To increase general acceptance of such an intervention and to cause impacts towards sustainability at the university as a whole an interfaculty approach was chosen. The corresponding processes and challenges are described in this chapter.

ORGANIZATION BACKGROUND

This chapter describes the developments of the Alpen-Adria-University Klagenfurt, and milestones in the field of Sustainable Development (SD). The University founded in 1970 for "Educational Sciences" evolved into an institution with five different disciplinary approaches: three conventional faculties (Cultural Studies, Economics and Business Administration, Informatics), one inter- and transdisciplinary Faculty and a School of Education. The rather young university - compared to other universities in Austria (the University of Vienna was founded in 1365) - focused from its very beginning on linking research and teaching to its relevance in societal practice. The IFF-Faculty for interdisciplinary studies (founded 1979 by six Austrian universities as an inter-university institute for interdisciplinary approaches in research and education) has always played a very specific role. It became a faculty at Klagenfurt University in 2004. This faculty bundles scientists from different disciplines around a societal problem together with the parties involved. Their work is based on intervention oriented approaches in research and teaching such as group dynamics, action research, intervention research and others. From very early in the 1990ies ecological problems have been seen as a huge social and cultural challenge, leading to specific approaches to the concept of sustainability internationally as accepted in science and politics, such as *social metabolism* and *social ecology* or the *cultural sustainability* approach and the concept of *intervention research* as well as approaches of *Education for Sustainable Development* (ESD).

Therefore it was no surprise that the Alpen-Adria University Klagenfurt earned the *Sustainability Award* commissioned by the Austrian Federal Ministries of Sciences and Environment for its IFF-Faculty for Interdisciplinary Studies in 2008[1]. As a consequence Renate Hübner and Franz Rauch, the initiators of the submission, were authorized to research the status quo of sustainability throughout the whole university in research, teaching and organization. An investigation based on the approach of Intervention Research (Heintel, 2005; Hübner, 2012; Krainer & Lerchster, 2012) of the status quo of sustainability at the University (Hübner, Hadatsch & Rauch, 2010) made many initiatives and approaches[2] also in other faculties and administrative areas visible. At the same time it showed that these initiatives were not linked with each other and existed without a unifying or at least joint strategy. This, even though the development plans of the Alpen-Adria University Klagenfurt since 2006 have included sustainability as highly relevant from a social and cultural science perspective, as the following milestones prove:

2005: Implementation of a Master's program in social and human ecology;
2006: Implementation of an In-Service University Course and a network "ESD – Innovation in Teacher Education";
2007: Implementation of a professorship for environmental history;
2007: Implementation of an Institute of Intervention Research and Cultural Sustainability;
2008: Winner of the Sustainability Award (category "communication and decision processes") of the Federal Ministry of Science and Research as well as the Federal Ministry of Agriculture, Environment and Water management for IFF-Faculty of Interdisciplinary Studies;

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2009: Examination of the status quo of sustainability in research, teaching, and administration at the University of Klagenfurt;
2011: Implementation of sustainability within the strategy process of the University of Klagenfurt as one of the future inter-faculty core research areas and assignment to design and implement an inter-faculty elective "Sustainable Development";
2012: Again winner of the Sustainability Award of the Federal Ministry of Science and Research as well as the Federal Ministry of Agriculture, Environment and Water management (category "regional cooperation");
2014: Again winner of Sustainability Award (category "students initiatives").

The corresponding processes while implementing the milestones are characterized by an attitude of partnership and open discourse about different conceptions of sustainability, this also holds for the case described in this chapter, the conception and implementation of the Interfaculty Elective "Sustainable Development," initiated and financed by the IFF-deanship and led by the authors of this case study.

SETTING THE STAGE

The Underlying Understanding of Sustainable Development as an Attitude

This chapter describes the understanding of Sustainable Development which was and is the basis of our work, especially with regard to sustainable development at and by the Alpen-Adria University Klagenfurt. As with human rights, sustainable development (SD) may be regarded as a regulative idea (Kant, 1787). Such ideas do not indicate what an object consists of but serve as heuristic structures for reflection. They give direction to research and learning processes. In terms of sustainability this implies that inherent contradictions, dilemmas and conflicting targets need to be constantly re-negotiated in a process of discourse between participants in each and every concrete situation (Minsch, 2004). This means a great challenge but also offers considerable potential for enhancing innovative developments in education (Tschapka, 2012).

Education for Sustainable Development (ESD) originated in the context of worldwide discussions concerning the complex correlations between environmental change and people's living conditions. The idea of ESD has been implemented as the UN decade of "Education for Sustainable Development" (2005-2014) and aims at fostering education and learning processes as driving forces for change to create a broad basis for sustainable development (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2006).

Based on the understanding of education in the tradition of enlightenment, the link between sustainable development and education can be described as follows: Sustainable development is integral to the general mandate of education: its humanistic aim emphasizes the self-development and self-determination of human beings as they interact with the world, their fellow humans, and themselves (Rauch, 2004). Ideally, ESD thus enables the next generation to establish a reflective and responsible society that respects natural and ecological constraints. ESD fosters the capability of individuals as well as of society to rethink and develop the values, principles and practices necessary to respond effectively to current and future challenges (Stoltenberg, 2010).

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Over the last few years the ESD concept has been extended to higher education. In conclusion of their analysis of sustainable university research and development Beringer and Adomßent (2008) conclude that Sustainability in Higher Education – conceived as institutional, systems-level sustainable university research and development – remains an emerging field involving philosophical reflections, theoretical-conceptual analysis, empirical research, theorizing as well as knowledge mobilization and capacity building. Transdisciplinary research projects promise rich opportunities to grow higher education as the catalyst for a sustainable global society. Although the question as to whether this signals a fundamental shift of policy and practice remains still unresolved (Sterling & Scott, 2008).

In its new research framework program, Horizon 2020, the European Union identified six major current and future challenges (European Commission, 2011, p. 5):

- Health, demographic change and wellbeing;
- Bio-economy (food security, sustainable agriculture, marine and maritime research);
- Energy (secure, clean and efficient);
- Transport (smart, green and integrated);
- Environment (Climate action, resource efficiency and raw materials);
- Inclusive, innovative and secure societies.

These challenges are directing current and future research and sustainable development will be an overarching objective of Horizon 2020. Thus, thinking and acting in a sustainable way requires not only disciplinary knowledge and openness for approaches within other disciplines, but also a specific political and moral attitude as a citizen of planet earth. From this requirement two main questions arise regarding education in general as well as learning and teaching Sustainable Development:

- Which methods of teaching and studying are adequate to fulfil these requirements at university level?
- How can the teaching of sustainable attitudes and approaches be implemented into the university system?

To sum up with regard to implementing SD in the university's culture one has to see clearly that ESD lies between the contradictory contexts of being a concept of organized scientific rationality on the one hand, and of being a social and normative concept, committed to future generations, on the other. This turned out to be the challenge of our project on an SD elective.

CASE DESCRIPTION

Starting Processes: Sensitive Moments in a University's Culture

Starting a project which shall intervene in a social system, means starting a social process that needs broad acceptance of the people involved or concerned. Therefore intervention research pays close attention to the initial phase of such projects (Heintel, 2005; Hübner, 2012). The most important steps are related to composing the team and to enabling the individuals who hardly know each other to grow together. However, there is little experience of interventions in the own systems. Therefore, we had to be

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even more sensitive about how to start this process. Personal contacts in all faculties and on a very open draft of how the elective could look like with different alternatives built the initial situation. Interested scientists of all faculties were identified and invited to develop the elective.

In the end the teaching team included eight representatives of the four faculties (Cultural Sciences, Business Administration & Economics, Technical Sciences, and Interdisciplinary Research and Education). The idea was to guarantee interdisciplinarity across faculty borders. This cooperation between the participating departments is a new approach for the Alpen-Adria University Klagenfurt which is expected to result in a wider scope and understanding of the facets of sustainability for both students and researchers/teachers. Furthermore, the development of a learning community as the core element of a new learning culture among students and among the core teaching team, can also be seen as an innovation: students and researcher/teachers work out relations and options for actions jointly and reflect on these actions as well as on the learning process, thus following Bateson's concept of first and second order learning (Bateson, 1972) or ESD following Vare and Scott (2007).

In comparison to 'traditional' university classes, additional competences have to be taught, such as the competence to critically question our modern information society, and/or social competences such as self-esteem, self-determination, individual initiative, and general participation capability. Furthermore, the capability of handling different concepts and contradictions and managing conflicts are seen to be important competences when it comes to Sustainable Development (Rauch, 2008). These concepts are not only part of the content of the elective, but can also be seen as learning opportunities for the teaching team at the University as a whole.

Finally and crucially, the elective takes into account an aspect which is all too often neglected in the SD-discourse: the cultural dimension (Heintel, 2007). SD concerns not only educational processes and processes of research and technological innovations, but also includes cultural reorientation and changes in consumption and production patterns (Der Rat von Sachverständigen für Umweltfragen [SRU], 1994). However, the cultural dimension needs practical and thematic contextualization to identify the differences between sustainable and non-sustainable patterns, for which "mobility and modern nomadism" had been selected as overarching subject for 2012/13.

An Interfaculty Approach and a Leading Faculty

The working hypothesis is that the idea of Sustainable Development benefits from interdisciplinary education through including the discussion of different theories, competences and methods. The implementation of the SD elective is a first trial to involve all faculties at the University in a single course. The interfaculty team should have at least one person from each faculty who is interested in such a new cooperation. This team should work on the concept and implementation as well as be part of the staff of the elective. Co-operation between faculties is still not usual, but at the same time it is crucial for the success of such a heuristic educational approach. Furthermore, it can be regarded as a new approach in Education for Sustainable Development (ESD) and thus also means an intervention in the teaching and studying culture of the university.

The development of the course is based on the assumption that – in order to practice and 'live' sustainable approaches – sustainability requires a (collective) process of (re)searching and developing (Rauch & Steiner, 2013). As such it needs a basic understanding of the social system. The teaching format aims at fostering the willingness for fundamental rethinking as well as at enhancing competence for reflective and sustainable actions. This interfaculty co-operation between the participating departments (mathemat-

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ics, jurisprudence, economics, geography, sociology, intervention research and cultural sustainability, as well as instructional and school development) is seen as both a challenge and an innovative approach: it results in a wider scope and understanding of the facets of sustainability for both students and teacher (Dawe, Jucker & Martin, 2005), whereby the teaching team does not understand sustainability only or simply as a rational issue to be lectured and understood, but rather as an attitude towards life.

Thus, the course also serves as a model in which scientists from different disciplines and different faculties have to converge. Consequently, sustainability is approached from manifold perspectives (which possibly or even probably results in different outcomes for individual research progress). This may and hopefully will open up new pathways for the development of the university, especially within its learning and research culture. This is seen as a prerequisite for sustainability in teaching and research. To recap, we understand the project of developing an interfaculty elective on sustainable development as an intervention into the university system. This is taking place on different levels: interdisciplinary teaching, research, administration, and transdisciplinary cooperation.

Basic Contents of the Elective on Sustainable Development

Due to the wide diversity of topics it is important to have a clear listing of issues which are considered as necessary basics for sustainability. To have sustainable impacts, these fundamental basics have to be more than factual knowledge of a specific topic. The basics can be understood as the theoretical concept or matrix of the elective, the foundation for any further thematic differentiation drawn on and profiting from the manifold disciplines represented by the teachers and students participating. The basic contents of the "Sustainable Development" elective are:

- What does SD mean? Multiple facets and history of the term.
- SD and time: understanding time processes.
- Sustainable systems and growth.
- SD as coping with antagonisms (contradictions).
- SD and system-compatible thinking and acting.
- Philosophical and epistemological basics.
- SD, self-organization and non-linear dynamics.
- SD in different social conditions.
- Communication, reflection and learning (as an/the overarching theme).

These contents require inter- and trans-disciplinary approaches and consequently a mix of teaching methods: lectures, literature review, and joint investigation of practical examples (inquiry-based learning). Further teaching designs can be used (lecture courses, book presentations, project reflections, faculty research days).

Structural Principles and the Character of the Intervention

The notion of intervention can be distilled into one fundamental effect, namely the introduction or making accessible of a different point of view (Grossmann, 2007; Willke, 2005). An intervention is, in this sense, not a direct command to take action, but a process for the generation of awareness, which arises from the gaining of reflective distance to exactly those relationships in which one is a participant (Paul-

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Horn & Krainz, 2009). The development of this course is thus based on the assumption that – in order to practice and 'live' sustainable approaches – sustainability requires a collective process of re-searching and developing. As such, it depends on the respective cultural setting for which a basic understanding of the social system is needed.

Sustainable teaching stimulates orientation knowledge and systems knowledge (the former offers orientation in a modern world undergoing an increasing differentiation), providing inspiration for innovation and exploration (Schneidewind, 2009). Additionally it fosters discussion in interdisciplinary teams and offers fertile ground for a reflexive, participative and activating method of teaching.

The teaching format aims at enhancing the willingness to reconsider according to the metanoia principle: systems' thinking requires the willingness to change one's mind fundamentally (Ossimitz & Lapp, 2006; Senge, 1996), while simultaneously increasing the competence for reflection and sustainable actions. Sustainability thus has to be approached from different angles, which in turn fosters different outcomes for the individual and gives impulses to work in specific disciplines, too. This might open up new pathways for the development of the university, and particularly its learning and research culture. Corresponding innovations in the overall university culture need specific interventions in the system of teaching and studying within any given discipline. But there are also questions that go beyond disciplinary knowledge. Here lies the advantage of the elective SD, it offers a learning environment where disciplinary, as well as interdisciplinary questions can be discussed. Therefore, the elective is structured according to the principles of inquiry- based learning (Anderson, 2007) and problem-based learning (Schneider, 2006; Wildenburg, 2006). It is crucial that teaching is guided by research. The following basic decisions result from these considerations and build the framework for the elective:

- SD encompasses thinking and acting by identifying and reflecting contradictions.
- Projects gain practical and social relevance by focusing on one general topic per year, for which research topics and research questions are to be defined and studied. The results are discussed with representatives of non-academic practice (Topic for the first year: Mobility and modern nomadism).
- Self-organization of students.
- Reflection on everyday theories as well as disciplinary approaches and paradigms.
- Establishment of a learning community (both students and lecturer(s) are learners).
- The content, structure and effects of the course themselves follow the principle of resource-oriented thinking and acting.

Students have to fulfill different tasks that support the mutual learning process. Students attending the elective already hold a Bachelor degree in a certain academic subject, which builds the disciplinary basis for further inquiry. Orientation in a discipline supports learning and understanding in the interdisciplinary discourses on sustainable development in the elective.

By discussing their ideas with the teachers as well as with partners from working practice (industrial and public management, NGOs etc.) the students define research questions and methodology, write and discuss text reflections, organize and conduct small research projects in groups, followed by public presentations. In addition, students work on selected topics in small groups to discuss sustainability from ecological, economical, geographical, juridical, psychological, sociological and educational points of view with the aim of working out contradictions and consistent aspects that are important for all students of the course. The results of these group works have to be documented and prepared to inform other

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students about the essential outcomes and to support the contribution of further scientific or didactic discourses on the subject.

In terms of a sustainable use of intellectual results, future students that attend the elective can build on the existing work of previous generations of students. The form of presenting the results will be chosen regarding perceivability (presenting the results in a comprehensible form for outsiders), economy (limit economic effort for the creation of the end products) and sustainability (practicability for science and teaching). The goal is to find a balance between the individual experience-based learning and the production of durable "products" that communicate the main results. Evaluations are made on the basis of feedback-comments that help students to identify their strengths and weaknesses and give them the chance to improve within the course.

The elective was intended to be implemented in several Master's and Doctoral programs across faculties and disciplines. It is seen as crucial that teaching in that elective should be guided by research. Therefore the teaching team decided to construct the elective as a research workshop ("Forschungswerkstatt"), that being the learning environment most adequate for the formation of a learning community. This idea cannot be realized in a single semester, therefore the course was held over two semesters. This turned out to be an additional challenge for the university's culture: one course has to be within one semester, something which goes beyond is called "curriculum" and immediately has a different status. This was a inhibiting for the accreditation of the course for the students' study programs.

CURRENT CHALLENGES FACING THE ORGANIZATION

The multiple organization-related challenges were caused by unforeseen simultaneous processes within the university as well as by structural and other cultural circumstances, like the value of team work, interdisciplinarity or skeptical positions which consider the sustainability concept to be not scientific enough.

1. **Context of New Curricula – Reduction of Free Electives:** Currently the University is going through a process of re-structuring its curricula and study plans. On the one hand, this is paving the way for the implementation of the elective. On the other hand, this process brings unforeseen changes: The amount of free electives of all Master's Programs has been reduced from 10% to 5% (6 ECTS[3]). Due to this the elective (with 12 ECTS) is now too large for these study programs. Nevertheless, due to the complexity of SD the core team decided not to change the concept in the expectation that there will be sufficient students interested in attending the elective.
2. **Potential Competition – Pleasant and Irritating at the Same Time:** Overlapping with our project the Faculty of Management and Economics planned for the same time a disciplinary module on "Environment and Energy" within their curricula, in which cooperation beyond the faculty was not on the agenda. For our elective this might have led to fewer students from economics-oriented studies and inhibited the interdisciplinary approach as well. On the other hand, such a progress in offers of sustainability-relevant courses is overall to be welcomed and could enrich the whole process of implementing SD at the University.
3. **Sustainability – A Plastic Word with Normative Touch Disturbs in a Culture of Rationality:** The concept of sustainability is viewed and understood in different, often controversial ways. This is due to the fact that sustainability has many facets, each of which cannot easily be claimed to be wrong or right, as this is a question of perspective. Whilst such a multi-perspective approach towards

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sustainability is a major challenge for teaching as well as for learning, it offers huge potential for self-referential studying: sustainability builds on curiosity and a strong interest in interdisciplinary exchange – both of which at the same time have to be taught. However, critics claim that – instead of being multi-faceted – the term sustainability is merely vague and obscure, and hence without scientific value.

4. **Work in Teams and Across Disciplines - Not as Highly Valued as Individual Work in the Current University's Culture:** Personal commitment, bottom-up initiatives and memberships of the Alpen-Adria University Klagenfurt in university networks are a necessary, but not a sufficient condition for the successful implementation of an elective on sustainable development. Structural obstacles are evident which cannot be easily overcome, while strong individual dedication is not sufficient. At the University Klagenfurt co-operation between faculties is still not usual. As stated above, the teaching team assumes that sustainability requires constant rethinking and the willingness to question existing paradigms, concepts, methods and last but not least scientific 'beliefs'.
5. **The Practice – First Experiences:** The first course started in October 2012 with almost 30 students from studies across all faculties. Five interdisciplinary groups could be formed; most of the students had little experience with team work in courses and which turned out as a key burden. Almost all eight teachers have been present during all blocks, many of them experiencing team-teaching for the first time which in some mirrored the students' situation. More of two thirds of the students were lost after the first semester. Challenges are located on many levels, e.g. on the level of emotions, theoretical approaches, self-organization and assignments between the presence phases. All in all the tasks seemed to overburden a majority of the students. Those who finished the course learned a lot as they reported.

SOLUTIONS AND RECOMMENDATIONS

Lessons Learned

Pedagogical innovations are always unique, depending on the institutions involved, the region, historical paths and the educational culture in which it is embedded and last but not least on the acting personalities. Therefore we prefer to describe our experiences that the project was an intervention in our university's culture during the three years from the initial idea for the SD elective up to the finalization of the first course at the university. In gradually opening up the dominant university culture with regard to SD we have so far learnt the following lessons:

- **The Teaching Team as Multipliers:** By building an interfaculty teaching team we aimed at initiating a broad process at the university. Thereby, the elective should itself become self-referential, i.e. Sustainable Development is applied to itself. This, in turn, might establish a learning process that goes beyond disciplines. Inter-disciplinarity is known as key issue in researching and teaching sustainability. However, one should be aware that finding an approach for transcending faculty borders in order to organize a collective process is an invidious, wicked problem. It appears to be the norm that a basic contradiction exists between an organization and creative individuals. On the other hand we know from organization theory that the organization is sensitive to creative networking (Grossmann, Lobnig & Scala, 2007). Every educational organization, and above all a

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university, has to find its own solutions to address this issue. Hierarchies at universities have to be seriously considered and the support of top-level staff is crucial. However, awareness can be raised by effective publicity (media presentations etc.)

- **Attractiveness Through Experiments in Teaching:** Such an interfaculty concept can also be attractive for those university teachers who are not primarily oriented towards sustainability but interested in innovative teaching and learning methods, and new settings.
- **Societal Requirements Placed on Universities:** The process of implementing SD (at least in part) at the Alpen-Adria University Klagenfurt started in 2005 when it was mentioned in the development plan, thus it has been running now for more than eight years. However, the question still remains: How can SD be brought into existence at the university as a place of organized rationality? Closely related to this question is the one of how the collective process of decision-making takes place within the university. After all, due to its systemic characteristics like freedom of research and teaching, a university cannot be led and managed like a business enterprise. This directly contradicts the new policy of introducing full economic autonomy into the university system. However, at the same time society's requirements and expectations are growing – that can help to implement SD in a university.
- **A Certificate to Overcome the ECTS-Corset:** The teaching team implemented a "Sustainable Development" certificate which requires 20 ECTs, 12 ECTs coming from the elective described in this article and 8 ECTs from a pool of seminars which deal with sustainability from interested colleagues across all faculties. With this certificate sustainability should be more visible and attractive for students.
- **Joint Writing of a Scientific Paper:** The joint writing of a paper for the conference "Leuphana Sustainability Summit 2012" in Germany has been a very interesting and valuable process of communication which has strengthened the teaching team through its common reflection on the process and its barriers in the conception phase. During the discussions of the paper relevant issues have been identified which had to be resolved for the implementation of the elective.
- **Financial and Mental Support:** Due to its long tradition with research-led teaching and problem-based learning, the IFF had got the lead for developing sustainability as an interfaculty core research field. Therefore the process was financially supported by the IFF-Faculty of Interdisciplinary Studies (one should not underestimate for instance the improving effect of financing accommodation and beverages for meetings in order to support team-building processes). Furthermore, the personal backing of its deanship strengthened the work and the project team and in cases of organizational difficulties solved the irritations caused by the project intervening in the university's culture and structures.
- **Self-Evaluation:** The internal evaluation of the pilot course by a colleague interviewing most of the participating students and the teaching staff helped a lot in going beyond a superficial understanding of the course's successes and weaknesses. It became a very useful basis for revising the second course which will start in the academic year 2013-14.

Answering Our Questions

Thus the process of implementing SD has been running now for more than 9 years. However, the question still remains: How can SD as a normative and holistic idea further be brought into existence into university's reality despite of its character of organized scientific disciplinized rationality?

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In reflecting the first sub-question about teaching methods in the light of some current empirical literature (Bray, 2008; Ellis & Weekes, 2008) we decided that the teaching and learning methods to be chosen within the elective SD have to be based on the following principles: inquiry-based learning, problem- and research-based learning, building of learning communities, SD seen from different disciplines. Through that the elective contributes to fulfilling the requirements of ESD in higher education, while helping students to gain important theories, competences and methods to meet the demands of the present time and to ensure a future that is worth living.

To answer the second initial question - how can the teaching of sustainable attitudes be implemented into the university system? - it can be stated that the implementation process of an interfaculty SD elective needs strong support by top-level staff. Understood it as a regulative idea, the concept of SD contains both arbitrariness and a normative demand. Due to these features a permanent reflection process is necessary. This is why the implementation process of the elective is being scientifically supported and evaluated.

The development and implementation of the elective SD at the Alpen-Adria University Klagenfurt can be seen as another attempt to use the innovative potential of the SD-discourse. This potential concerns not only the conceptual and theoretical dimension, but also organizational challenges of development in accordance with new governance and the advancement of teaching and research cultures at the university.

The implementation process of this elective, based on a new type of cooperation among research and teaching team from all four faculties, turned out to be a challenging intervention not simply an innovation at course level. In order to implement Sustainable Development as a regulative idea across the university as a whole, faculty boundaries must be transcended on both management and structural levels. Its acceptance in all master programs of the university represents a serious challenge for the coming years.

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ENDNOTES

1 In 2012 the Alpen-Adria University Klagenfurt got the Sustainability Award again; this time for the development of networks in education all over Austria (Rauch 2013).

2 Obviously, there exists a multitude of implicit concepts of sustainability. These concepts were deduced from twelve qualitative interviews with researchers from all four faculties and representatives of management and administration. We regard it as one of the key strengths of our elective to make these (and other) implicit concepts explicit and to include these – partly controversial – understandings of Sustainable Development in our teaching (please also refer to the section 'lessons learned').

3 European Credit Transfer System is a standard for comparing the study attainment and performance of students of higher education across the European Union and other collaborating European countries.

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Chapter 5
Interdisciplinarity in Sustainability Science: Challenge or Opportunity?

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ABSTRACT

Over the last few decades, Sustainability Science (SS) has gained momentum and emerged in the academy with an extraordinary performance in knowledge production and contributions to the research and publications enterprise, growth in academic programs at the undergraduate and graduate levels, creation of centers/laboratories, and formation of scientific communities, networks and associations. Increasingly, terms like integration, collaboration and bridging of fields and disciplinary boundaries are in the forefront of conversations and/or debates. The key question addressed by this review essay is this: Is interdisciplinarity in Sustainability Science a challenge or opportunity for educational institutions and local communities in the 21st century? Considering the recent momentum in educational advancements and institutional progress, the study outlines relevant literature on interdisciplinarity in SS; synthesizes recent thinking and developments in SS and attempts to address what challenges and opportunities people across the globe face in sustainability education and research and in the development of academic programs and sustainable communities. When scientists, policy makers, academics get together as teams, partners and collaborators they are likely to be engaged in interdisciplinary work and possibly doing sustainability research, policy development and problem-solving to deal with the pressing demands and challenges of the 21st century society. In this context, it is urgent in science and society to seek solutions to major sustainability problems such as climate change and one way to address that is by doing interdisciplinary work in Sustainability Science.

INTRODUCTION

This paper focuses on interdisciplinarity in Sustainability Science (SS) and explores the phenomenal rise of academic programs on SS and their likely influence in sustainable community development. As Frodeman (2011) once wrote: '…the age of disciplinary knowledge may be ending, but the true shape

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of interdisciplinarity, and the essential characteristics of sustainability are as yet unknown (p. 111). With the topical currency of interdisciplinarity and SS, the key question addressed here is this: Is interdisciplinarity in Sustainability Science a challenge or opportunity for developing educational institutions and local communities in the 21st century? By contending a parallel narrative through an interpretative lens, as informed by the literature germane to interdisciplinarity and SS, this article is centered on three key aspects. *First*, it examines key perspectives on interdisciplinary thinking in current knowledge production beyond the traditional single disciplinary approach to systematic inquiry. Here, "systematic inquiry" means careful examination or investigation of a problem from a scientific, scholarly, professional or technical way to build new knowledge in a field or discipline (Wylls, 2003). *Second*, it discusses the trends in the growth of Sustainability Science in terms of academic program development in educational institutions (i.e., universities and research centers). The evolution of Sustainability Science (SS) is examined as an international science, an emerging field and vibrant forum linking disciplines across natural, physical and social sciences through the lens of academic program development in educational institutions across the globe. *Third* is to explore how interdisciplinarity in SS in a comparative context, relates to efforts toward building community sustainability. Broadly, the prospects for 'interdisciplinarity' are promising. As Frodeman (2011) claims, the term has become an idea embraced by almost every university's strategic plan and seen as a boom industry with a growing academic community. It crosses and bridges disciplinary boundaries (interdisciplinarity) and makes knowledge more pertinent to non-academic actors (transdisciplinarity). Increasingly, the growing interest is on the "how" rather than the "why" of interdisciplinarity in knowledge production, not only in creating new and additional knowledge but also in finding solutions to pressing societal and environmental issues (Lele & Norgaard, 2005). When scientists get together as teams, partners and collaborators, they are engaged in interdisciplinary work and possibly doing sustainability research to deal with the changing demands and challenges faced by society in the 21st century. But first, what do we mean by 'interdisciplinarity'?

WHAT IS 'INTERDISCIPLINARITY?'

Interdisciplinarity has, over the years, attracted scientists from the social and natural sciences to other areas of research practice. In early times, great minds during the scientific revolutions in 17th Century Europe like Isaac Newton and Robert Boyle made discoveries that dealt with every kind of interdisciplinary challenge (Merton, 1938). The principle of interdisciplinarity means an integration of theories, concepts, techniques and data from diverse bodies of knowledge (Porter et al., 2006; Rafols & Meyer, 2010). Since the 1970s, there has been an exponential growth of publications, a variety of networks and wide discussions of the concept (Klein, 1990). As Klein noted, the interdisciplinarians have yet to establish a common identity because they were still in a state of social and intellectual marginality. Interdisciplinarity is seen to challenge the academic status quo as it 'represents an innovation in knowledge production- making knowledge more relevant, balancing incommensurable claims and perspectives, and raising questions concerning the nature and viability of expertise (Frodeman, 2010, xxix). By the 1990s, a majority of people from various fields and disciplines were immersed with interdisciplinary research. By "interdisciplinary research" means "... a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge… to solve problems whose solutions are beyond the scope of a single discipline" (NAS, 2004 p. 2).

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As Klein (2010) identified, there are three widely cited labels in the typology, namely: multidisciplinary, interdisciplinary and transdisciplinary. Invariably, terms associated with 'interdisciplinarity' are integrating, interacting, linking, blending and intermeshing within the typology of the interdisciplinary spectrum (Klein, 2010). In terms of intellectual capital, increased borrowing across disciplines, unified/ holistic perspectives and mixing of genres in epistemological sense have put pressures on conventional disciplinary anchoring. In the 21st century, interdisciplinarity is one of the most inspiring of human pursuits- making connections to build new knowledge (NAS, 2004). However in the literature, a lack of agreement on its meanings indicates there is no universal definition of the terminology. This has been a recurring issue in the discourse where both terms of interdisciplinarity and integration have been used interchangeably when considering different viewpoints to problem solving, producing knowledge or finding new knowledge. Earlier, Kockelmans (1979) pointed out that we used the term loosely for describing all types of crossings between or among disciplines, glossing over the subtle differences between multi-, inter- and transdisciplinarity. It is different from other concepts because "multidisciplinarity" has been argued to have little or no effect to analyzing data sets, applying approaches to knowledge production in the environment and other fields (Frodeman, 2011 p. 106). We think collectively about complex problems and often it needs crossing boundaries both horizontally (across disciplines) and vertically (across experts, policymakers, practitioners, and the public (Klein 2004; Lele & Norgaard, 2005).

In the real world, there are at least two major categories or disciplinary blocks, one is the natural sciences and the other is social sciences. When interdisciplinarity is used to include scholars from both blocks, it is taken that all sorts of crossings between and among disciplines are possible and it is likely that scholars use multi-, trans- and interdisciplinarity in one way or the other (Lele & Norgaard, 2005). More recent research landscape show prospects of interdisciplinarity in problem solving, partnership building and use of novel methods and new technologies. However, researchers face disincentives and barriers in a world dominated if not highly influenced by traditionally discipline-based academic institutions that range from funding challenges to new modes of research organization (NAS, 2004). Indeed, there is a need for meaningful interaction given an array of interdisciplinary texts through bodies

of speeches, conference papers, institutional reports and working papers, reviews, articles and a number of books (Klein, 1990). In this age of knowledge society in the 21st century, there is a growing community producing knowledge that crosses and bridges disciplinary boundaries (Frodeman, 2011). It calls for a holistic view of theories, concepts, techniques and methods from a wide variety of disciplines (Rafols & Meyer, 2010). If knowledge production is an engine of the 21st century society, it is essential to look beyond current disciplinary anchoring by tapping potential opportunities offered by interdisciplinarity as an inherently inclusive, integrative and fundamental approach to current thinking. More importantly is the assertion that the academy needs theoretical and institutional changes which Frodeman (2011) calls beyond a disciplinary social epistemology. After all, there are world problems that need not be confined to a single discipline for finding solutions since collaborations are required to bring together experts from different disciplines to address major problems that cut across any discipline and field.

Today, the proliferation of studies from medicine to engineering indicates the power of combining disciplinary knowledge in interdisciplinary ways. It is employed in research marked by an integration of different approaches or methodologies whether narrow (chemists and chemical engineers or wide (natural scientists working with social scientists or humanities) (Frodeman & Mitchum, 2007; Klein, 2010). Recent "hot topics" in the current research landscape are interdisciplinary: from nanotechnology, genomics, neuroscience to bioinformatics and terrorism. Many innovative research triumphs are results of interdisciplinary inquiry and collaboration such as the discovery of the structure of DNA and laser

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eye surgery (Beckman, 2005). If we are to meet the present day challenges and the changing place of knowledge in society, it is critical to recognize the limitations of disciplinary structures and then explore the promise of interdisciplinarity especially in dealing with pressing societal and environmental problems. Accordingly, the 20th century knowledge production has been under pressure from information technologies to demands for greater accountability, hence the attention given to interdisciplinarity to address this crisis in the current century. Despite a variation in 'texts' and publications, the problem-focused research have made scholars and actors increasingly engaged with interdisciplinary research. As Lele and Norgaard (2005) put it, researchers from different disciplines could study the same phenomenon but vary with their explanatory models as well as underlying assumptions. Often interdisciplinary work operates as teams whose membership is premised on shared interests, relevant expertise and knowledge and willingness to collaborate with, between and among other disciplines. Shared interests are seen to translate into a research plan with predetermined bridges between the disciplines. What best describes situations like these lie on the differences in methodological orientations, variation in problem definition, or broad range of solutions to a phenomenon. Yet, what is interesting for a group of scholars and actors is to work in an integrative way of thinking and working while recognizing differences in disciplinary backgrounds.

Emphasis has been placed on 'thinking collectively about complex problems by crossing boundaries both horizontally (across disciplines) and vertically (across experts, policymakers, practitioners and the public)' (Klein, 2004; Lele & Norgaard, 2005). While it may not be a panacea to challenges of knowledge production, the idea of interdisciplinarity has a place in the 21st century culture of knowledge society (Frodeman, 2011). In recent times, the growth of scientific and technical knowledge has prompted scholars to join teams and groups from varied disciplinary backgrounds for addressing the world's major problems that require broad, if not deep knowledge from different perspectives and disciplines. In current scholarship, interdisciplinarity has invariably been linked with problem-solving (Frodeman, 2011; Klein, 2004; Lele & Norgaard, 2005). There are problems of global importance with practical and major consequences such as global climate change and poverty that can be addressed through interdisciplinarity in sustainability research- possibly through creative integration, exchange and sharing of knowledge. The sustainability landscape indicates the need for combining knowledge from diverse expertise and practice of interdisciplinary inquiry. Despite the explosive growth of databases and information networks in our present day knowledge society, the recurring question of methods and methodology for operating concepts in the real world, remains.

Concerns for attaining sustainability are commonly debated within a broad range of possible solutions relating to interdisciplinarity in the academia. SS is seen at best, to be instrumental in finding solutions to real-world and place-based problems in efforts towards sustainability transition (Kates 2010). A focus on interdisciplinarity is relevant to sustainability science as a step in the right direction since it involves solving problems from a variety of disciplinary lens. As Frodeman (2011) puts it, "interdisciplinarity needs to be placed within an environmental context linking future knowledge production to the concept of sustainability" (p. 106). Establishing the relationship between interdisciplinarity with sustainability requires that some application of current methods and techniques particularly in second generation environmental issues such as climate change be considered and applied. Current environmental research are concerned with global debates on climate change deemed to provide useful insights in problem analysis and better understanding of associated issues from sea-level rise to significant atmospheric impacts. The next section discusses sustainable development and the sustainability idea before a discussion of Sustainability Science.

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SUSTAINABLE DEVELOPMENT AND THE SUSTAINABILITY IDEA

In hindsight, since appearing in the United Nations Brundtland Report 'Our Common Future', the concept of sustainable development (SD) has gained much attention from various disciplines with many adopting its definition from the World Commission on the Environment and Development (WCED) (1987). The roots of the word 'sustainable' is said to go back to the ancient Romans when it meant to be capable of being maintained in existence without interruption or diminution (Engleman, 2013). Many authors recognize SD's extraordinary rise as it pervades agendas of governments, corporations, civil society, educational and research programs across the globe (Bettencourt & Kaur, 2011; Redclift, 2006; Komiyama & Takeuchi, 2006). As a concept, it is associated with economic and ecological sustainability, resource conservation, protection of biological diversity and sustainability of cultural and community life. SD concepts remain unclear if it has progressed into a scientific discipline with its agenda of integrative theory and applied science or generate a new interdisciplinary synthesis across fields (Bettencourt & Kaur, 2011). The central thesis of WCED is deemed to have brought new quality to the environmental discourse and continues to shape sustainability discussions today. In policy and academic circles, the WCED definition below of 'sustainable development' is the most widely cited and more exhaustive (Shao Li & Tang, 2011; Zhao, 2011; Redclift, 2006).

…development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (WCED, 1987, p.8)

This canonical definition from the 1987 Brundtland Commission cites three elements: the environment, futurity and social equity for present and future generations (Pearce, 1993; Brand, 2010). By interpretation, its meanings have been subject to academic debate from how needs are met by generational differences (present and future) and how they are defined by varied cultures and societies. Though there are several debates on definitions in the environment and development literature, the SD concept has been deemed a term of contradiction, imprecise, blurred and vague (Glavic & Lukman, 2007; Shao et al., 2011; Quental, Lourenco & Nunes da Silva, 2011). As a normative term, it is useful as an approach to development as it can be an orienting vision to foster broader participation, consensus and appropriate to human inhabitants of this planet. As a concept, SD has referred to with extraordinary rise and success and central to the mission of research laboratories and universities worldwide (Bettencourt & Kaur, 2011). Why? As a moral imperative, it is a call to build healthy economies, influence planning policy and environments, and to improve the quality of life now, and in the future (Hopkins, 2013; Turvey, 2007). It has become a popular paradigm and subject of a series of debates but widely adopted as a goal by several countries and supported by almost everyone (Goodland, 1995; UNDP, 1996). The idea of sustainability is rooted in human cultures, more importantly the North American indigenous cultures (Engelman, 2013). In modern times, Engelman writes that sustainability took root in the work of George Parkin Marsh in the 1860s and 1870s with anthropogenic forces competing with natural forces to alter the Earth itself. From Marsh to later writers, it is asserted that human actions and decisions will affect the sustainability of present and future generations with respect to natural resources, the economy and the environment. Although publications of all sorts on sustainability have mushroomed, some claim its inherent ambiguity, others refer to it as an oxymoron that has 'come of age' but with questions about its future (Kajikawa, 2007; Redclift, 2006; Parris & Kates, 2003; Daly, 1996). Still others stressed how it could be applied for decision-making and management, advocacy, consensus building and research,

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and analysis (Parris & Kates, 2003). Another definition of SD concerns the improvement of the quality of human life while living within the carrying capacity of supporting ecosystems (Daly & Cobb, 1989). What has been postulated in the academy is the parallel analysis of economic and social development being compatible with the preservation of the essential condition of human existence (Haberl et al., 2011). As a concept, it was deemed an intellectual answer to reconcile the conflicts and interests on the environment and economic growth (Quental et al., 2011). While the application of SD is argued to be embryonic (e.g., Kates & Parris, 2003; WRI, 2003 p. 145), attention to the environment has become central to national and international laws and institutions with regard to sustainability for more than 40 years (Quental et al. 2011). SD is an intellectual answer for reconciling conflicting goals between environmental protection and economic growth (Quental et al., 2011; Scheor, Wolfgang & Jurgen-Friedrich, 2012). In the environment and development lexicon, it has become a popular expression if not agreed to, and accepted by almost everyone worldwide.

The concepts, methods and approaches associated with the sustainability idea are undoubtedly useful that demand a diverse range of academic disciplines to carry out sustainable development work. Since the 1970s, the sustainability narrative has been called with urgency as a global problematique in the 21st century (Adams, 2006; Uskokovic, 2008). This is not surprising because academic discussions have raised the world's attention to a couple of fundamental issues, the first on environmental degradation and the second on the need for economic growth to alleviate poverty and these two issues are often intertwined when ranking global issues. Goodland (1995) outlined sustainability in three streams from social, economic to environmental sustainability where the latter is about maintaining environmental assets and not depleting natural resources. As well, SD and sustainability are taken as ethical concepts that seek desirable outcomes, given social and economic decisions to be made (Adams, 2006). Yet, in some cases, the rhetoric of SD is sometimes ignored in practical decisions and the term 'sustainable' is loosely applied that it can be taken as 'development as usual'. At the UN Millennium Summit in 2000, sustainability was among the eight Millennium Development Goals and one of the many examples where it can be used for divergent ideas with its worldwide popularity. Though some could argue about its lack of clarity and precision, one thing is sure, it brings people together (from various disciplines and sectors of society) for the sake of development and environmental concerns; so the debates and arguments on SD and sustainability will undoubtedly remain. Next is a brief discussion of the origins and definitions of 'Sustainability Science.'

ORIGINS AND MEANINGS OF SUSTAINABILITY SCIENCE

With a phenomenal interest in the sustainability idea to address the complex anthropogenic challenges on development and the environment, Sustainability Science has gained momentum as evidenced by progress in institutional developments and academic publications as mirrored in new journals, conferences, research projects and educational advancements (Bettencourt & Kaur, 2011; Wiek et al., 2011). The discussion in this section briefly tracks the origins and definitions of SS that bridges the knowledge gap between science and society to address the socio-cultural gaps on 'sustainable policy development and implementation' (Sanusi et al., 2013; Jerneck et al., 2011). From practical lens, SS is not entirely new; it is considered very much a part of ancient history within traditional wisdoms and/or indigenous knowledge and has long been part of human civilization (Sanusi et al., 2013). Since the 1980s, publications in the field has produced an unusual geographic footprint worldwide and characterized by scientific collaboration generating new interdisciplinary synthesis across fields (Bettencourt & Kaur, 2011). Ini-

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tially, SS was highlighted at the World Congress "Challenges of a Changing Earth 2001" in Amsterdam by the International Council for Science (ICSU). Perceived as an international science policy project, it was said to be consolidated in the World Summit on Sustainable Development in Johannesburg in 2002 (Jerneck et al., 2011). The question is this: Is Sustainability Science a concept, an emerging field or new discipline that integrates arts and science or simply 'science' in its own terms?

The concept of SS was floated by Simonelli (1994), Hirch and Ghiderella (1994). In advancing SS as a concept, Hirsch and Ghiradella's (1994) work on Sustainability Science has been influential to feminist scholars like Londa Schiebinger (1997) supporting the idea of a socially responsible science such as ones responsibility toward nature and culture (Broadhead & Howard, 2011). As a concept, sustainability science is applied by those who are engaged in addressing (and correcting) environmentally destructive ways- scientifically and in practice (Broadhead & Howard, 2011). What is reflected in the literature is a changing relationship between science and society (for instance, in terms of well-being of society) (Lubchenco, 1998; Cortner, 2000; Blackstock & Carter, 2007). Indeed, SS has, over the last few decades, emerged as a vibrant field of research and innovation (Clark, 2006). As a research field, it makes scholars rethink the interactions of domains and scales such as nature and society (Jerneck et al., 2011; Hornborg & Crumley, 2006; Schellnhuber, 1999).

SS is recognized as a new science since the 1990s when the International Council for Science (ICSU) studied science and technology links for sustainable development (Komiyama & Takeuchi, 2006). It has been envisaged to harness 'science' toward sustainability and strengthening dialogue between science and society (Clark & Dickson, 2003; Jerneck et al., 2011). The literature suggests that what comes to light when redefining the functions, mandate and scope of scientific inquiry is this: Sustainability Science focuses on the needs and values in society while preserving the planet Earth's life-support systems (Kates et al., 2001; Backstrand, 2003). With this new momentum of SS from a science perspective, it has become part of the global discourse on SD closely linked across a range of disciplines and has reached out to, and from a world of problem-solving streams (Sanusi et al., 2013; Clark, 2006). The word 'science' in SS is somehow caught in a 'cross-fire' of two opposing camps in terms of how the word 'science' is interpreted. One is to look at 'science' as a major tool of the ideology driving industrialization, modernisation and the modern economy. The other looks at 'science' toward knowledge production and technology development as well as long-term management of resources. In exploring the nature and place of 'science' in Sustainability Science, some authors argue it is a 'set of principles by which sustainability knowledge is built' (Sanusi et al., 2013). The science of sustainability is deemed to require collaboration between perspectives and integration of theory, methods and approaches toward scientific rigour without which SS begs the question whether it has indeed become a field of science? Several scholars have advanced the idea of science towards sustainability; adopting convergence of multiple sciences and a holistic approach that advocates cooperation and integration of the social and natural sciences (Jager, 2009 a, b; Weaver & Jansen, 2004; Clark & Dickson, 2003). The argument is to promote a convergence, not a fragmentation of the sciences, of humanities and social sciences approaches values and perspectives together with natural sciences. As an ancient wisdom in practice from a long time in terms of the history of knowledge generation, some scholars may prefer the use of sustainability studies instead as the use of 'science' in SS could invite a debate in the compartmentalization of knowledge (Sanusi et al., 2013).

'What is sustainability science?' To Sanusi et al. (2013), the question may not be answered easily and with the sheer lack of a universal and precise definition, they argue is not actually a weakness in conceptual terms. Sustainability Science is defined in several ways after its introduction in the academy but it should be reiterated that specific academic fields, sub-fields and disciplines have their own standards for validity, vocabulary, principles and modus operandi that make it difficult for 'those outside the

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discipline' to give a thumbs up to interdisciplinarity in sustainability science. According to Schoolman et al. (2011) some authors argue that SS is a distinct field where there is collaboration among researchers, policy makers and stakeholders with the purpose of learning from each other without worrying about the traditional disciplinary boundaries (Kates et al., 2001; Komiyama & Takeuchi, 2006; Ostrom, 2009; Characklis et al., 2011). As Kates et al. (2001) put it, 'It seeks to understand the character and interactions between nature and society, and to provide the knowledge needed to pursue paths that can meet human needs while preserving life-support systems of the planet' (p. 394). As the field matured, it was accorded a 'room of its own' in the Proceedings of the National Academy of Sciences (PNAS) in early 2005 (Clark, 2007). With the surge in SS publications and programs being developed, it has received increased academic attention but not to the extent of its interdisciplinarity as a subject of inquiry, and this is indeed an intellectual challenge in theory and practice. As Schoolman et al. (2011) indicated, '…the extent to which SS has lived up to its interdisciplinary ideas has, so far, not been the object of systematic inquiry.' Referred to as 'something 'intellectually exciting and practically compelling', Clark and Dickson (2003) viewed it as: "… not yet an autonomous field or discipline, but rather a vibrant arena that is bringing together scholarship and practice, global and local perspectives from north and south, and disciplines across the natural and social sciences, engineering and medicine." Most commonly, SS is described to be interdisciplinary; a field concerned with the relationship between nature-society system, the scope of work for which is 'ambitious' (Frodeman, 2011). Schoolman et al. argue that the '…principle of interdisciplinarity with respect to integration of theories, concepts, techniques and data from diverse bodies …is equally crucial to the study of sustainability.' The place of interdisciplinarity in SS is critical to understanding the conceptual foundations and practical underpinnings of sustainability as a whole. An important dimension of SS is the breadth and scope of publications in geographical and thematic sense. Based on the work of Bettencourt and Kaur (2011), a large corpus of publications in SS during the period 1974-2010 were analyzed which consisted of about 37,000 distinct authors of more than 20,000 papers from 174 countries and territories and 2, 206 cities worldwide. From that study, SS is noted to have grown exponentially with the first rate of growth seen in the late 1980s and continued to accelerate in recent times. An unusual feature of SS literature is the broad (geographic) distribution of contributions internationally, not only from countries with traditional strength in science but elsewhere from the developing world (Bettencourt & Kaur, 2011). In summary, Bettencourt and Kaur concluded that:

- As a field, SS has evolved as a collaboration network unified with a giant cluster of 'co-authorship' around 2000;
- The field is growing exponentially after the late 1980s-1990s when it accelerated its pace of growth to present levels and widely distributed internationally with a strong presence not only in the US, Europe and Japan but also elsewhere;
- With the substantial rise in publications, principal national centers and many smaller universities and laboratories contribute and have a presence in the field, given author affiliations and geographic distribution of publications, both in developed and developing countries;
- The spatial distribution of publications is a regionally diverse field with different contributors by type and form both from the social sciences and the natural sciences, including biology and engineering;
- The existence of a young and fast-growing unified scientific practice of sustainability science bodes well for dealing with humanity's greatest scientific and societal challenges.

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Though others defined SS as a 'new discipline without a discipline', if structured along the lines of disciplinary- based categories of knowledge (Sanusi et al., 2013), SS is however claimed as a 'new academic discipline' with over a decade of collaborative research, publications and educational advancements are evident through the Alliance for Global Sustainability with the Massachusetts Institute of Technology, the Swish Federal Institute of Technology in Sweden (Komiyama and Takeuchi 2006). In Asia, Japan's University of Tokyo formed the Integrated Research System for Sustainability Science (IR3S) with a nationwide research network. As Komiyama and Takeuchi (2006) claim, there is great opportunity to advance SS as a new discipline as welcomed by scientific and academic circles worldwide.

SUSTAINABILITY SCIENCE: CHALLENGE OR OPPORTUNITY?

Is 'interdisciplinarity in sustainability science' a challenge or opportunity? Today, SS has posed some challenges as well as opportunities as it evolved as a concept to a vibrant field, then emerged as a 'new discipline'; but still others see it as a 'new discipline without a discipline' while some consider it a scientific discipline (Komiyama & Takeuchi, 2006; Clark, 2007; Sanusi et al., 2013). As the debate continues, there are challenges and opportunities that deserve attention to understand the progress of SS from the perspectives of interdisciplinary thinking and pervasiveness in the agendas of various institutions including governments, higher education and research programs worldwide as discussed in this section.

Challenge # 1: Interdisciplinarity and Researching Sustainability Challenges

First, interdisciplinarity is deemed crucial to researching sustainability, given a sense of urgency for its practice to deal with global economic, social and environmental issues. Scholars have already explored this concept in systematic inquiry for doing sustainability research (Schoolman et al. 2011). Though insights of one discipline is valuable to a government agency or stakeholder group, Frodeman (2011) argues that creating interdisciplinary knowledge for transdisciplinary reasons could be valuable in improving the production and use of knowledge itself. There are sustainability challenges that Sustainability Science itself faces. One of the sustainability challenges concerns the *modus operandi* of natural science which operates 'under paradigms that strive for scientific objectivity, reduced uncertainty, and scientific agreement as epitomized by the bottom line consensus on climate change' (Oreskes, 2004). To Jerneck et al. (2011), advocates of SS who are firmly grounded in the natural sciences are seen to be less theoretically or methodologically versed in justice, politics, power and critical research in the social sciences. If the aim in sustainability science is to foster a 'coherent interdisciplinary system of research planning and practice' there must be equal, not less room for research rooted in the social sciences and humanities that calls for the basic assumptions of modern society in question' (Jerneck et al., 2011). If we aim to address global sustainability challenges, Jerneck et al. argued it is unlikely it could be understood or solved solely from one side (the natural sciences, medical or engineering sciences) so equal efforts must be exerted toward addressing the challenges from other ontologies and epistemologies.

Challenge # 2: Knowledge Integration and Interdisciplinarity in SS

The next challenge involves knowledge integration and interdisciplinarity in SS. Achieving knowledge integration from across disciplines is a challenge in sustainability science due to institutional and organizational impediments in the conduct of interdisciplinary research (Fujikaki et al., 2000; Bercher &

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Trowler, 2011). Based on a growing literature, SS is a clear 'object of interest' (Kajikawa et al., 2007) considering that less than a decade ago, it was not yet an autonomous field or discipline but a dynamic arena that brought together scholarship and practice from north and south and disciplines across the natural and social sciences and others such as engineering and medicine (Clark & Dickson, 2003). Is SS integrative of knowledge across disciplines? Already, there are studies and investigations of the empirical validity of interdisciplinarity within sustainability research (Schoolman et al., 2011; Kajikawa, 2008; Adams, 2006; Kastenhofer & Rammel, 2005).

In his account of the state of knowledge production in the early 21st century, Frodeman (2011) stressed the limitations of single disciplinary structures; pointed out the 'promise of interdisciplinarity' from the standpoint of the university that must adapt to changing social demands and conditions and called for the need to take a broad perspective to a wide range of solutions the society faces, not through one discipline. Interdisciplinary approaches to knowledge need to be based in a fundamental way through single disciplinary knowledge and should be placed within an environmental context, linking future knowledge production to the concept of sustainability (Frodeman, 2011). As Frodeman clarified in linking interdisciplinarity to sustainability, it will need a reformulation of the underlying assumptions in the 21st century university- that is, make knowledge production sustainable, not just aim for more or additional knowledge and examine the question of what counts as academic rigor. In brief, interdisciplinary approaches to research and education will mean an integration of different disciplinary approaches to methodologies, not narrow ones (e.g., chemists and chemical engineers); or wide (natural scientists working with social scientists or humanists) interdisciplinarity (Frodeman & Mitcham, 2007; Klein, 2010). What this knowledge integration requires is a synthesis of theory and practice for finding solutions to complex problems or major sustainability challenges. In much of the literature, SS is articulated as a field concerned with problem-solving and overcoming challenges, not by single disciplines it employs (Clark, 2007; Jerneck et al., 2011, Wiek et al., 2011). New ways of integrating knowledge across the natural and social sciences and the two cross-cutting approaches of critical and problem solving research could be achieved by studying major sustainability challenges such as climate change, biodiversity loss; depletion of marine fish stocks, land degradation, water scarcity and global ill- health (Hotez et al., 2007; Broadhead & Howard, 2000; Cox, 1981). Next are opportunities posed by interdisciplinarity in SS.

Opportunity # 1: Interdisciplinary Knowledge Production

Knowledge production is seen as a driving engine of the current century society or knowledge society in general. As Frodeman (2011) puts it, 'the 20th century research university combined a Kantian belief in disciplinarity, a Humboldian commitment to linking research and education and academic autonomy; and a Cartesian allegiance to infinite knowledge production.' Blackstock and Carter (2007) viewed SS to be integrative for bridging disciplinary perspectives toward new understandings based on the creative interaction of multiple perspectives (p. 344). As an opportunity, SS gains from multiple forms of knowledge production and it is not simply interdisciplinary but engaged in conceptualizing why, how and by whom science is practised (Blackstock & Carter, 2007). While there are pressures upon traditional divisions of knowledge, increasingly what is sought is more crossing of disciplinary boundaries, collaboration and working in a variety of holistic and unified perspectives commonly labeled to be 'interdisciplinary' (Klein, 1990; Lele & Norgaard, 2005; Frodeman, 2011). With the limitations already identified in existing disciplinary structures and the potential of interdisciplinarity to enhance university research to adjust to changing demands and challenges, the need to examine SS and how it is linked

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with interdisciplinarity is compelling. Of utmost significance is to place SS within the context not only of environmental sustainability but within sustainability science in future knowledge production. Over the last few decades, scholars have tried to address the question of interdisciplinarity as an 'object' of systematic inquiry', particularly in sustainability research (Schoolman et al., 2011). Linking interdisciplinarity to sustainability science requires a review of the nature of sustainability research and the academic programs being developed in the 21st century (Sanusi et al., 2013; Clark et al., 2011; Frodeman, 2011).

Opportunity # 2: Problem Solving of Sustainability Challenges

In past efforts to address complex questions, we turn to interdisciplinarity to tackle broad issues, solve problems beyond the scope of a single discipline and attain unity of knowledge, whether of limited or grand scale (Klein, 1990). A wide range of actors and sectors are attracted to interdisciplinarity with a goal for achieving key sustainability objectives and answering complex issues concerning the environment and development. Since anthropogenic influences in the world's life support systems are critically unprecedented in human history, it is recognized to address sustainability in 'interdisciplinary rather than disciplinary ways' (Jenerck et al., 2011). As Jerneck et al. (2011) asserts, an integrated approach (to research) involves different disciplinary perspectives and grounded in problem-solving and critical approaches where epistemological reflexivity is essential for successful interdisciplinary dialogue. As an important opportunity for problem-solving of major sustainability issues, this approach is critical to sustainability science in terms of research because the Earth's major problems from the perspectives of both the environment and development could not be solved by just one sector or discipline alone (Dale, 2004). Researchers like Kajikawa (2008) considered the triple aspects of economic growth, social well-being and natural systems for promoting interdisciplinarity in sustainability research which demands active interdisciplinary participation. Multi-stakeholder decision- making and pressing solutions to global issues like climate change and world poverty are inherently interdisciplinary and transdisciplinary in approach- the latter for making knowledge accessible to non-academic actors. As a problem-solving activity, it needs novel methods and techniques and expertise from people across disciplines and sectors from both the natural and social sciences. To move beyond a disciplinary social epistemology, academics and practitioners in interdisciplinary and sustainability work must recognize the inadequacies of the existing regime of knowledge because there is an unprecedented level of knowledge integration required to deal with pressing issues today. With traditional disciplinary boundaries, scholars argue that the academy without interdisciplinarity is too specialized, lacking societal relevance and lost the larger purpose of things (Frodeman, 2011).

Interdisciplinarity in sustainability science is relevant to the conduct of results evaluation in programs and projects concerned with sustainability- the evaluation of outputs, outcomes and impacts (OOI) called singly as results demand holistic, integrative and complex coordination of databases, methods of assessment and synthesis to arrive at a particular level of sustainability. The idea of interconnectedness and interrelationships is vital when doing sustainability research and sustainable development in the same way that interdisciplinarity is seen as an integration of theories, concepts and techniques from various bodies of knowledge (Schoolman et al., 2011; Rafols & Meyer, 2010). Even more important is the idea of applying approaches that are integrative of knowledge in terms of outputs, outcomes and impacts from sustainable development work. Analyzing their complex systems of phenomena requires an interdisciplinary inquiry and exchanges between and among fields as it has been demonstrated in academic publishing and record of collaborations across disciplines over time (Schoolman et al., 2011).

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Opportunity # 3: Academic Program Development in Sustainability Science

The opportunity to develop Sustainability Science as an emerging new discipline is evident in academic and scientific circles worldwide (Komiyama & Takeuchi, 2006). The significant institutional momentum over the past few years in educational (scientific and academic) advancements in the US, Europe and Japan has been recognized and the interdisciplinary research style in SS has been examined (Clark, 2003; Kajikawa, 2008; Khagram et al., 2010; Clark et al., 2011; Wiek et al., 2011; Sanusi et al., 2013). With the growing number of academic programs in sustainability, especially Sustainability Science, there is a proliferation of international events, sustainability courses, growth in research and publications and academic societies on sustainability (Wiek, 2011; Bettencourt & Kaur, 2011; Sanusi et al., 2013). Primarily, the emergence of academic programs on sustainability is associated directly with the urgency of solving complex environmental issues and anthropogenic challenges (Kates et al., 2001; Komiyama & Takeuchi, 2006; Sarewitz & Kriebel, 2010). At the local level of cities, the contributions to publications is a key dimension of SS growth with evidence of collaboration networks, strong productivity and well-connected research centers with a global reach from Washington D.C to London, Tokyo, Canberra to Cape Town, South Africa (Bettencourt & Kaur, 2011). A few years ago, progress in SS is mirrored in the rise of undergraduate and graduate academic programs in sustainability and being a 'new discipline', this clearly indicates the promotion of SS at the university platform. Examples of such programs around the world can be found in the US from Arizona University to Harvard University; Lund University in Sweden; Maastricht University, The Netherlands; Technical University of Catalonia, Barcelona, Birmingham Initiative on Sustainability Sciences, UK; University of Tokyo and the United Nations University in Japan, and the Lakehead University in Orillia, Canada. In the US, the Sustainability Science Program at Harvard University's Kennedy School is the hub for teaching, research and interventions on sustainable Development (Sanusi et al., 2013). In Japan, there are several teaching and research centers on SS including:

- Center for Sustainability Science (Census), Hokkaido University,
- Ritsumeikan Research Center for Sustainability Science,
- Institute of Sustainability Science, Kyoto University,
- Institute for Sustainability Science, Osaka University,
- Graduate Program in Sustainability Science, University of Tokyo,
- Graduate Program on Sustainability Science, Ibaraki University,
- Institute of Advanced Study on Sustainability, United Nations University.

Apart from university-based initiatives in sustainability education and research at both national and smaller universities and laboratories, there are activities and programs carried out internationally by the UN agencies and non-governmental organizations level such as the United Nations mega-conferences, Decade for Education for Sustainable Development, UNESCO's science and sustainability activities and alliances (e.g., Alliance for Global Sustainability) and Academic Leadership for Sustainability by the Salzburg Academy (Sanusi et al., 2013). Already, scholars have noted efforts to provide useful knowledge for solving the very practical but highly complex problems such as climate change and often required fundamental advances in our conceptualization and understanding of coupled human-environment systems (Clark, 2006). At Harvard University's Center for International Development, their Sustainability Science Program has set out goals for advancing the 'basic understanding of the dynamics of human-environment

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systems, to facilitate the design, implementation and evaluation of practical interventions that promote sustainability in particular places and contexts' (CID, 2010). There are other global initiatives in terms of policies, multi-party agreements, research networks from the Tailloires Declaration of Presidents for a Sustainable Future, to the Sustainable Development Solutions Network to the global-meta network led by the United Nations University concerning SS (Sanusi et al., 2013).

Opportunity # 4: Sustainability Science in Building Sustainable Communities

The exponential and extraordinary rise of SS in sustainability education, research and teaching brings more meaning at the community level since attention to sustainability in many places is about meeting the urgent human needs, improving quality of life and doing research on the complex dynamics of human-environment systems. In understanding the relationship between the environment and development for shaping nature-society interactions and applied problem-solving at the bottom level of governance, i.e., the community, the benefits gained from education, research, policy development and publications permeates different levels of development-national, regional and area and community. Regardless whether SS is a field, a 'new discipline' or scientific discipline, it is fast growing, and diverse that recently turned into a 'unified scientific practice' (Bettencourt & Kaur, 2011). At this point, an important opportunity is how SS can contribute toward shaping communities into 'sustainable communities' to ensure solutions to complex environmental issues such as water crises, land degradation and biodiversity loss. If one is to view SS from its role to promote applied problem-solving and education, the ultimate gains could be generated by such communities, whether in the developed or developing world.

The literature indicates there is no universal definition of 'sustainable communities' (Rogerson et al., 2011). From a local perspective, the dilemma is not the lack of, or absence of a definition but the variation in context and how a community is viewed. In the 1990s, an international social movement on community sustainability has emerged (Innes & Booher, 2000). The concept of 'sustainable communities' was used in Agenda 21 following the sustainable development model in the UK and elsewhere (UN (a), 1996; UN (b), 1998; ODPM, 2003). The tendency has been to move from its narrow focus of environmental sustainability in the 1960s towards a more holistic recognition of the environmental, social and economic principles of sustainability and the roles communities play (Agyeman, 2005; Marsden & Hines, 2008). Hempel (1998) defined it as a 'community with economic vitality, ecological integrity, civic democracy and social well-being to foster a high quality of life' (p. 48). In the past, sustainable communities are labeled in various ways- as green cities, eco-cities, sustainable cities, eco-communities and livable cities. They can be any type of neighbourhood, town, city or region. Past studies referred to the garden city movement (Howard, 1898); bio-regional planning and design (Geddes, 1915); spaceship Earth idea (Fuller, 1969); resilient ecological communities (Holling, 1973); and architectural visions of neoliberal towns and healthy cities (Van der Ryn & Cathorpe, 1993). From the nineteenth century to the present, progress in creating 'sustainable communities' has been deemed patchy and challenging even with the objective to transform a community into a place desirable to its residents with better (if not the highest) quality of life. The idea of 'sustainable communities' can be grouped into different types, including communities defined from the perspective of policy and planning, resource management, quality of life, integration of social, economic and environmental dimensions and local governance. Or, it could mean a community that is continually adjusting to meet the social and economic needs of its residents while preserving the local environment (Bridger & Luloff, 2001). The goal towards a better quality of life, maintenance of nature's ability to function overtime and revitalizing natural resources

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are commonly applied and such communities represent the successful integration of four key objectives, namely: ecological integrity, economic security, high levels of quality of life and citizen empowerment. Roseland (1998) stressed the potential and economic dimensions of community sustainability relative to growth management, urban ecology and environmental planning. What a 'sustainable community' needs is an integrative approach to transforming communities through an interdisciplinary process of incorporating the goals and principles of environmental sustainability and a holistic planning system that considers the environment, the economy and society. These communities develop economically, socially and environmentally, respecting the needs of future generations succeeding now. The key is to find lasting, rather than temporary, solutions to major problems. Broadly, sustainability draws from three popularly cited 'pillars' of the environmental, economic and social sciences to articulate three positions. It can be argued that engaging in sustainability research must be more interdisciplinary than disciplinary and that the three pillars of interdisciplinarity require the active involvement of various disciplines to achieve sustainability in local areas, country, or region. As we experience an extraordinary growth of SS over the last few decades with an agenda of integration, scientific collaboration and a scenario beyond single disciplinary anchoring to connect knowledge and practice, the promise of sustainability from an interdisciplinary and community context is here.

CONCLUSION

Obtaining impetus from progress in current literature, this article placed interdisciplinarity in Sustainability Science through a parallel narrative and interpretative lens and considered the challenges and opportunities in SS facing the 21st century society. Having reached its momentum that could pave the way toward a sustainable society, the juxtaposition of interdisciplinarity with sustainability science is not simply an academic exercise that explores 'what interdisciplinarity is but adds to the conversation on what can be derived from the founding of SS whether it influences the creation of academic programs, build an intellectual enterprise on sustainability through research and publications, form professional associations, networks and so on. Arguably, interdisciplinarity is crucial to researching and teaching sustainability, whether in the developed or developing countries. With a revisit of interdisciplinarity and the roots of SS, the review essay found the profound gains from collaborative networks, scholarship exchanges, publications and research in efforts to find creative solutions to major environmental, economic, and social development issues- all valuable to enhance sustainability in our home planet called Earth. Overall, interdisciplinarity in Sustainability Science reflects a dynamic conjunction that may help to determine the direction, content and shape of local communities; provide a balanced and bright future concerning the economy, the environment and society. In the 21st century, the value of interdisciplinarity is not limited to the classroom and the substantive and substantial growth of Sustainability Science will stay as an intellectual phenomenon confronting some challenges yet offering more opportunities. Although the future of SS may not be contingent upon a generation who will live up to its interdisciplinary ideals in its entirety, the key is to push for collaboration, networking and building skills and research competencies to shape sustainable communities for tomorrow, today.

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Chapter 6
Economics, Environmental Policy, Trade and Sustainability

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ABSTRACT

Sustainability has to be measured by different tools of valuation. Furthermore, the philosophy behind environmental policy making also decides the way sustainability is perceived and measured in a society. Moreover, in a growing globalized world, trade regimes and routes also impact the social, economic and environmental segments of sustainability of trade partners. This chapter makes an attempt to outline these notions to bring a larger clarity on the subject of sustainability.

Sustainability is a concept which is quite broad ended. It is because of this researchers working on the domain of sustainability can link it with economic, environment, governance and social aspects. Researchers from the discipline of economics trained particularly by the mode of neoclassical thinking often relate sustainability concept to the framework of valuation. According to this school, an essential tenet of sustainability has to deal with how to value the resources all around us. Valuation is done mostly through monetary accounting of these resources which gives the people a sense that any resource poses a certain value which is incommensurable. However this view can be contested. In a ways the origin of this kind of thinking can be traced back to a quote by Hicks (1946) when he said that:

The purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves.

But the world today has moved far forward than this and the principles of these income calculations from resources are widely contested now. But the objective of this chapter is not to elaborate on those debates: it will instead aim through to take the readers through some of these income accounting practices that are largely applied in measuring resources and in its further association to the concept of sustainability.

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Therefore, the chapter first starts with some of the natural resource accounting practices and thereafter moves towards the broader context of international trade and sustainable development which also forms the essential blocks of sustainability. Trade and sustainability connections are observed because today the world has become integrated. Income streams of countries are coming through exports of goods and services. With the growing dependence of countries on each other and south south cooperation measures between developing countries, dependence of these countries (for whom sustainability concerns are extremely important in comparison to developed countries), it is essential to explore some of the facets of trade and sustainable development interlinkages to understand the future of these developing countries. The next sections of this chapter make an effort to take the reader through these facets.

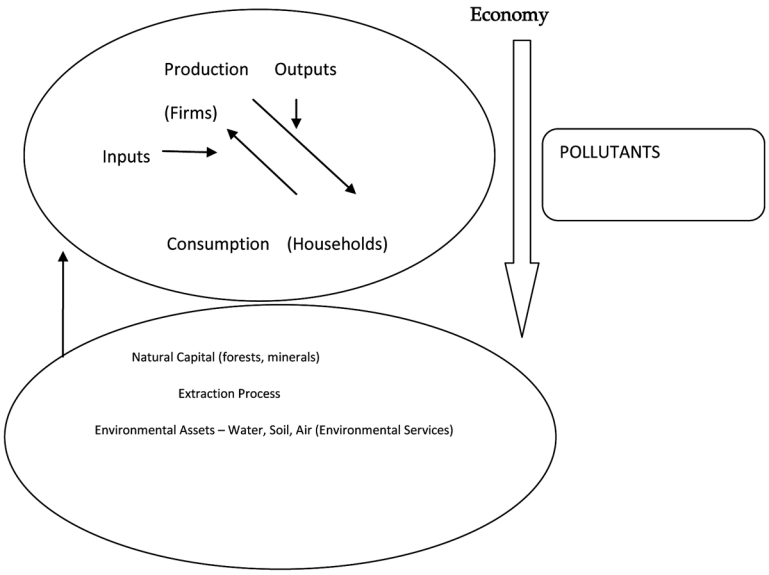
NATURAL RESOURCE ACCOUNTING

Conventional SNRA (Systemic Natural Resource Accounting)

This system of accounting creates a statistical framework by which the total value of the final output produced across sectors of the economy is estimated and maintained. Further, in this framework, the details of distribution of the factor incomes producing such a value of an output is also provided along with the final expenditure made within the economy on a particular year. Thus within this framework an attempt is made to understand the effects of economic policy measures on different sectors, institutions and the factors involved in those sectors. Hence within this framework, households, firms will be interacting with each other in Figure 1.

But to understand this flow between each element of the economy, it is essential to value resources which flow across the firms and households. Thus, at this juncture it is essential to ask the fundamental question of why there is a need to value and account for natural resources (Hardin, 1968)?

Figure 1. Economy-environment interactions



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There is a need to value resources because there is a need to understand the impact of economic growth on degradation of natural capital. In order to understand such a degradation it is essential to know the value of the natural capital. Developing countries which have started to grow late might not have the adjustment factors to understand the depreciation of natural capital. Moreover, value of natural resources are often not included within the national wealth. Neither are they assessed by indicators of environmental quality. Thus there is a major need to create and put in place proper frameworks to initiate valuation of resources within an economy. Such a valuation framework will have to imbibe the following measures:

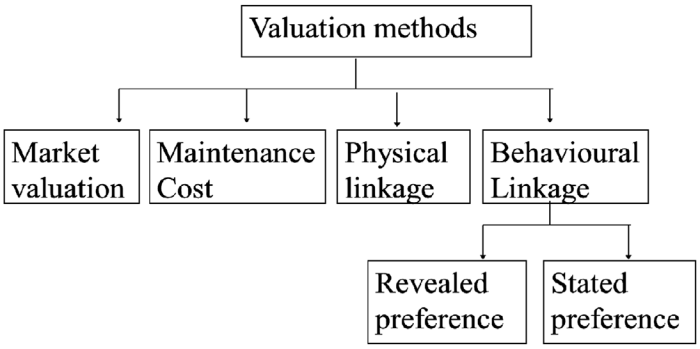
VALUATION TECHNIQUES

The first step of the framework will have to deal with the preparation of physical accounts. Such a preparation will have to measure the extent of natural resource depletion and enhancement within the economy of the country. As a part of this, a value of the stock of minerals, forests, air, and water has to be assessed. Further, the extent of degradation of the value of such resources has to be measured. In order to do that a series of measures have to be implemented. Those measures will include – collection of data related to physical account of all natural and environmental resources. This has to be followed by a valuation of all these resources and further interlinkages between the economic, human development and the degradation of the value of these resources has to be done. Once this is done, the degradation of the value of these resources has to be reflected within the national income of the country. Such an adjustment has to come by reducing or adding the value of the natural resource degradation/upgradation to the national income of the country that has been generated owing to economic growth. Essential aspect of all these calculations is the creation of a physical account of the stock of natural and environmental resources. Changes in the stock will indicate the level of resource depletion and enhancement. In order to do that the following equation structure is followed which is:

Opening stock + Quantity changes (economic use/other reasons) = Closing stock

After the physical accounts are estimated, the value of such resources are estimated. Values of resources are estimated through the following techniques which are represented by the schematic structure in Figure 2.

Figure 2. Monetary valuation



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While calculating the value of resources, the following overarching framework is kept in mind. Pictorial representation of the framework is given in Figure 3.

Hence the total economic value is a sum total of use and nonuse value. This use and non - use value are measured by using the following techniques:

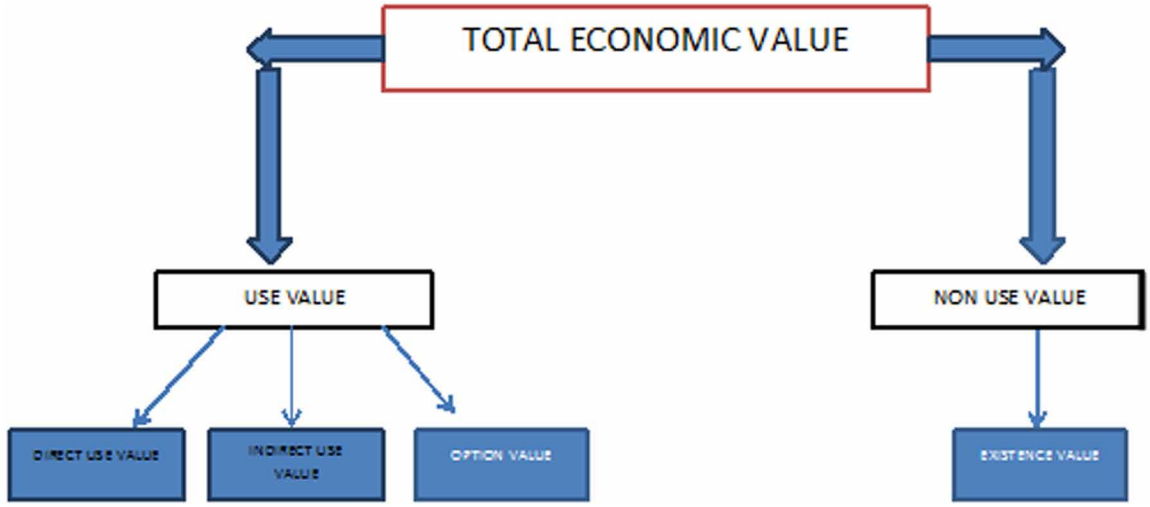
Market Valuation

In the market valuation technique, all resources are visualized as non produced fixed assets. For valuing these non produced fixed assets, market prices used in the market transactions of non produced fixed assets are used as surrogate conversion factor to estimate the corresponding monetary value of such a non produced fixed asset. However, if market prices are not available then market price of similar assets which can be comparable to these assets are used. In monetary valuation exercise of these assets, the rental or lease value of assets play an important role. In order to value the resource, the prices of the extracted goods, service generated by these natural assets are estimated. Once such an estimation is done, the value is reduced by the cost or expense incurred to extract such an amount of resource. Then the total stream of value of the resource over its entire life time is calculated and a present discounted value of the resource is found out. These kinds of techniques are applied in the case of net price methods of estimating the value of resource which principally follows the below mentioned equation structure:

Net Price Method (Vt) = (pt – Ct) Rt (where Rt – Volume of proven reserve, pt – average market value per unit of the resource, Ct – per unit cost of extraction, development, exploration)

However, a net price method operates within a neoclassical framework and in many cases are far away from the complexities of resource degradation challenges faced by developing countries with abundant resources. This is because a net price method assumes that the price of natural resource in a perfectly competitive market rises at the rate of interest of alternative investment offsetting the discount

Figure 3. Definition of economic value Adapted from D. Pearce, et.al., Introduction to Environmental Economics, 1996



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rate. Therefore it assumes that the price of natural resource is equivalent to the rate of return earned by the money put in to extract the resource when that money is put into a bank (Hotelling, 1931). The framework is reductionist as it assumes that the return given by a bank within a perfect competitive set up is the value of resources without internalizing the vast range of future impacts on the economy, ecology, society that are created by such a resource extraction process. Hence the value of the resource is explained by a rental value which is called as *Hotelling Rent and explained as – (pt – Ct) (where pt – average market value per unit of the resource, Ct – per unit cost of extraction)*

Another way of valuing the resources is through replacement cost based methods. In the replacement cost methods, value of the resource is based on the incremental annual unit cost of adding and replacing reserves into the reserve base. The other method of valuation of the resource is through depreciation method. In this depreciation method, difference in the value of the resource stock at the beginning and end period is taken as the value of the resource. The revenue from the sale of resources is also taken as the value of the resource. In this method, the revenue calculated is based on the present value of annual net revenues from the sale of resources considering the lifespan of the resource. One essential aspect of this discounting technique is the calculation of the discount factor which is generally based on the banking rate of return on any financial resources invested or kept in bank. Once the discount factor is calculated it is used in coming up with the discounted value of the income generated from the sale of resources after considering the life span of the resource. A similar approach is taken in user cost valuation method, where the net income from the revenues of the sale of an exhaustible resource is taken as the value of the resource (Devarajan & Fisher, 1981). In calculating the net income, investments made from the revenue arising from sale of resources is deducted. Discount rates after considering the life span of the resource is used to arrive at the net income. The income measures of resource valuation is based on realized income data and doesnot internalize the preference pattern of the people of society who depends or might depend on the resources.

In order to internalize the preference pattern within the valuation techniques, contingent valuation measures are used. Some aspects of such a valuation measures is highlighted below:

CONTINGENT VALUATION

In a contingent valuation technique, the people are asked specific questions on how they value a certain resource. As a part of these questions, the people are asked about their goals, aspirations, political causalities and how they impact the value of the resource. Many times, the people are also asked about how much they are willing to pay for consuming a certain amount of resource. Essentially, the users of the resource or who can be impacted from the degradation of the resource are given an alternative situation of the resource provision and thereafter they are asked to state a value that they are ready to pay for such an amount of resource. Sometimes the question that they are asked is as follows:

what is the most you are willing to pay for a certain amount of clean water? Or are you ready to incur a cost Rs. X for getting one bottle of clean water?

Within the questions a certain amount of monetary value is embedded and stated which is being asked to the respondents. The value comes from various relevant market prices. In case the value and cost number is not given and open ended question is asked, it can then result in an overvaluation and

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undervaluation of the resource if the respondent is not well aware of the real tangible benefits of the existence of the resource. So it is always better to use closed questionnaire. Another technique that is used for valuing resources is called – "Hedonic Estimation Technique".

HEDONIC ESTIMATION TECHNIQUES

In hedonic estimation technique, questions are asked about how property prices can increase if a clean natural resource is provided. Thus using increase in property prices as a proxy, the incremental value of any resource (say trees, clean air) is calculated. Generally, these estimations are done through questionnaire based techniques.

Strong sustainability is determined by the preservation of today's resources without compromising the needs of future generation. In order to do that, it is critical to measure and value today's resources so that the importance of preserving it future is established. From that background principle, all these above valuation measures are carried out. Once they are valued they should be also reflected within the national income of the country. This therefore means that the net value of the resources owing to the economic growth path of a country should be reflected into the accounting exercise of the gross domestic product of a country. Once that is done it will give rise to green GDP. Thus by this way the natural accounting techniques will be integrated with the national income accounting and a recognition will be given to a sustainable growth i.e. a growth which not only takes into account of GDP but also reconciles the impact of such a growth process within the mainstream GDP oriented economic growth thinking.

Thus the integration process will involve the following measures:

Estimation of the value of gross domestic product (GDP), environmental service, environmental damage and defense expenditure. Once it is done the following measurement of a GDP should be worked out that takes into account of the environmental services and damages in the following manner:

gGDP = GDP + Environmental services - Environmental damages - Defensive expenditure

Once the gross domestic product is estimated, it should be followed by an estimation of the net domestic product in which the gross value of the domestic product will be reduced by consumption of fixed and natural capital. Thus from this estimation, net wealth generated from the economy of the country can be estimated. Net wealth of the economy will be a summation of

Net financial assets + Net man-made tangible assets + Net natural tangible assets

One aspect that has to be kept in mind is each of these elements that contribute to the net wealth can only be estimated if extensive data is available. All man made tangible assets, natural assets have to be valued using certain types of valuation techniques. Some of the challenges that can be faced with respect to the estimation are as follows:

- Availability of data,
- Disagreement over the appropriate unit of measurement,
- Disagreement on the rate of discount,

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- Problems of aggregation,
- Treatment of defensive expenditure,
- Choice of method and comparability of results.

Measures coming out of the green GDP (g GDP) can guide the policy makers on how the country has performed in her growth path. Further that will indicate what value of environmental and natural resources are left for the future generation of a country. Essentially, valuation of the environmental and natural resources will indicate the need to take measures to create a sustainable growth path. Once these measures are provided by the planning commission or statisticians working with the central planner of a country, then specific measures and policy framework has to be laid out by the policy makers to address the sustainability concerns (that will be indicated by the numbers provided by statisticians).

However, the question is once these numbers are obtained by the planners, on what basis an environmental policy should be made.

Primarily, within the literature of environmental policy making two kind of theoretical principles are embedded. The principles follow either – a) Coasian or b) Pigovian stream or a c) mix of both.

Under the Coasian framework (Coase, 1960), an environmental pollution or a natural resource degradation happens at a decentralized level. So many times a centralized policy making and its implementation to tackle a decentralized environmental or natural resource degradation problem might not be feasible. Therefore, it is feasible and pragmatic to create property rights on natural and environmental resources. Once the rights are well developed, the negotiation to demand the environmental rights and tackling of the environmental challenges should be done through decentralized negotiation between the polluters and the people, communities who are or can be affected from such pollution. This will therefore help in reducing the transaction costs of implementing measures to address the environmental and natural resource degradation challenges in a big developing country with a lot of variations within the communities at the decentralized level (Ostrom, 1990).

The other framework is the Pigouvian school of thought in which the markets through direct, indirect taxes sends the signal to the polluters that they have to pay if they pollute. And their payment will be further distributed to the affected communities. In this framework, subsidies can also be given to clean technologies of production to create a sustainable production that can create a better a pollution free environment for future will less pollution and wastes.

In countries which have democracy with a wide diversity of culture amongst the local population and communities which are or can be affected by the challenges of environmental degradation and pollution, often determination and implementation of strong property rights can become a challenge (Baumol & Oates, 1960). When people within the community are also not well aware of their rights and future implications of any pollution on the community, then the Coasian stream of implementation might not be the right approach. Further, when the markets are distorted by fragmentation and information asymmetries are existing within the market, a Pigovian regime might not work in such a case.

It is with this background for certain specific situations and in certain context, a command and control regime through enforcement of law can be an alternative. Within India too, a command and control regime has been operational to address the challenges of environmental and natural resource degradation. A quick glimpse of the history in India suggests that within India, way back in 1972 a national committee of environmental planning and coordination was established. The 42nd constitution amendment act of 1976 had an article 48A which declared that the states have the right to protect and save environ-

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ment. This in a way was a kind of Coasian framework, where the law was used to establish the right of protecting environment by the communities. *As a follow up to this, several legislations were passed which were - Clean Air Act 1970, Wild Life Act 1972, Water Act 1974, Forest Act 1981, Environment Act 1986*. Water Act of 1974 led to the formation of state and central pollution control boards. The duty of the state pollution control boards have been to regulate and oversee that the standards of pollutant concentrations in any production processes are maintained. Further audits of any production process is done by the Ministry of Environment and Forest. The view point was that public health should not be affected from any production process. Further a continuous reporting of these activities has to be done by the state pollution control boards to the central pollution control boards.

All these measures have a contribution in maintaining the environmental aspect of sustainability for a country like India. However, a larger review of the global literature shows that various instruments have been used across the world to maintain the environmental domain of sustainability. A tabular representation of the findings is stated in Figure 4.

Some of the tenets of the command and control measures with respect to emissions in India are mentioned below:

1. Source specific effluent and emission standards are valid for point sources of pollution,
2. Ambient concentration standards are developed for non point sources.

CPCB, SPCB are supposed to implement these standards as set by the legislations within India. Most of the times, the emission standards are of the following types:

Figure 4. Country specific measures

Country	Type of Measure	Facets	Implications
China	Preferential grid price for desulphurized power generation	Monitoring mechanisms in place	savings for the power industry due to lower pollution levy payments reduction in environmental damage from power generation
South Africa	a levy on water effluent as part of its evolving water pricing strategy largest emitters are taxed highly to create strong incentives to reduce effluent loads	Has cost recovery and revenue raising component tax/levy on effluent discharged to the environment	Reduction of effluent loads over a certain concentration
Thailand	retail (pump) price of unleaded gasoline 0.3 (USD 0.012) per litre less than that of leaded gasoline	government agencies, representatives of oil companies, and automobile manufacturers were involved in making this pricing strategy target dates for implementing key actions, and continual monitoring and follow-up evaluation	Reduction in use of leaded gasoline
Brazil, Chile, Ecuador, Venezuela, Netherlands, Thailand and Singapore	landfill tax, waste generation tax, waste treatment and disposal tax	waste management by urban bodies	Reduction in waste generation
OECD Countries			

Source - T E R I. 2011, Environmental Fiscal Reforms in India: Where and How? New Delhi: The Energy and Resources Institute. 184 pp. [Project Report No. 2009RD03]

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1. Concentration based (suspended particulate matter not to exceed permissible limit),
2. Equipment based standard (for control of sulphur dioxide emission),
3. Load/ mass based standard (for industries like urea).

Thus in order to maintain sustainability, the legislations and acts have given power to CPCB, SPCB to examine the process. In case an industry is polluting, it has to obtain certificates from boards for production. Further, in case of non compliance, penalties will be imposed on the industry. Both the command control and market based instruments have certain advantages and challenges. Those advantages and challenges are outlined below:

Limitations of the Existing CAC Measures

- *Source specific standards dependent on technology or performance,*
- *No incentives to opt for cleaner abatement technologies,*
- *Penalties for noncompliance are unrelated to the compliance costs,*
- *Fines are not linked to quantity, quality of emissions,*
- *Problems in enforcing laws.*

MARKET BASED (ECONOMIC INSTRUMENTS)

Demerits

- Allow little flexibility: Tend to be high cost, ruling out variation in technology deployed.
- Freeze on development of technology; no incentives to exceed target pollution levels.
- Leakages due to bargaining between parties.

Merits

- Wide application across countries and sectors leading to substantial experience.
- Effective in implementation or attaining goals.
- Useful when environmental concern is highly damaging or irreversible.

ADVANTAGES OF ECONOMIC INSTRUMENTS

- Flexibility, market driven, Cost effectiveness.
- Revenue raising.
- Incentive for environmentally friendly behavior.
- Resource conservation.

Having laid to the advantages, challenges of the various environmental policies, an interconnection between such policies is attempted. The framework shown in Figure 5 is adapted from Sterner (2003).

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Figure 5. Types of environmental policies Source: Adapted from Sterner 2003

Using markets	Creating markets	Direct provision	Environmental regulations	Engaging the public
Environmental taxes and charges	Property rights and decentralization	NRM or waste management programmes managed by the government	Standards	Education/ awareness
User charges	Tradable permits and rights		Bans	Information disclosure
Subsidy reduction	International offset systems		Permits and quotas	
Deposit refund schemes			Zoning	
Targeted subsidies				

In the above sections, therefore an attempt is made on how valuation of resources contributes to environmental policy planning of a country which is a key to ensure the environmental domain of sustainability without compromising the needs of the future generation of a country. The implementation of the plan needs to have a strong basis of environmental policy. Further, the policy has to be implemented through legislations and market based instruments to address the environmental domain of sustainability. However, sustainability also has the domain of income. Emphasis and focus on the sustainability of any country has to ensure that enough income is generated for future generations and further they are distributed properly so that people at the marginal segments of a country earns income and gets money to live a healthy and happy life. One way, in which all countries in today's globalizing world earns income for herself is through the trade in goods and services. Merchandise trade in goods and trade in services gives a country net export revenue if the export revenue income is greater than the import outflows of the country. Thus a picture of sustainability will not be complete if the connections between "Trade and Sustainability" is shown for the developing and other countries which are following a path of growing income and development. Next few sections aim to bring forth such a connection between "Trade" and "Sustainability".

TRADE AND SUSTAINABILITY

The discussion on "Trade and Sustainability" often centres around the terms "Trade and Sustainable Development" It is because, sustainable development entails a development of a country that emphasizes on the need of balancing the economic, environment and social aspects, needs of a country. Sustainability

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also highlights the same importance. Therefore, essentially a discussion on "Trade and Sustainability" is actually a debate on how "Trade" of a country can balance the environment, economic and societal needs which are critical in the development path of a country. Next sections, will subsequently attempt to explore these connections.

Within today's global perspective, trade and sustainable development discourse is put forward through the following focus lenses – a) how trade can be a catalyst to the economic growth of countries, b) how can trade lead to higher demand for better environmental amenities and services in the society which thereafter can affect the environmental policies and social welfare and finally c) how can trade impact social indicators like – employment, gender empowerment.

These intuitive relationships cater to environment, economy and social dimensions of sustainable development. All the subsequent sections aim to expand these interlinkages.

Section 1 starts with trade and environment aspects followed by trade and growth, trade and its effect on society in the subsequent sections 2 and 3.

Section 1: Trade and Environment

Debates on trade and environment came to forefront in 1971 and in the entire debate the ideology which was highlighted was trade between countries should not suffer owing to environmental concerns.

Discussions on trade and environment issues came to the forefront in 1971 (Industrial Pollution Control and International Trade by GATT). During this time, main concern was that trade should not suffer because of environmental concerns. However over time that discourse has got reversed and use of non tariff barriers for getting market access through environmental and health protection instrument has become common in many countries. Context of sustainable development entered into the trade regime through the exceptions article XX embedded within the GATT principles. These principles were mentioned in the original GATT text which mentioned the importance to be sensitive to the fact that trade should not happen between countries by impacting human, animal and plant health. Notion of sustainability and protection of human, plant life got introduced to the principles of trade negotiations. In order to substantiate and consolidate the principles by which trade should happen, a plurilateral standards code was developed in 1979. The standards code brought out the principle that no country can be prevented from taking measures to safeguard and protect plant, animal and human health. Though in the trade context, sustainability principles came in this way, the word sustainable development was coined during 1992 United Nations Conference on Environment and Development (UNCED) at the summit of Rio De Janeiro. Agenda 21 of the Rio Summit mentioned of an action programme for promotion of sustainable development. Parallely, there were ongoing discussions of Uruguay Round during 1986 – 1994 which overlapped with debates on sustainable development raised by UNCED. While all these were happening, subcommittee on Trade and Environment of the WTO preparatory committee picked up the view points on sustainable development. This was manifested in the preamble of WTO after the Uruguay round was concluded.

Thus, sustainability was legitimized within WTO through the paragraph 1 of WTO in 1994. It stated that expansion of trade in goods and services will balance the needs of sustainable development through carrying a global trade regime which will be sensitive to environmental protection. Paragraph 31 III legitimised that by suggesting the essence of reducing the tariff and non tariff barriers on environmental goods and services: though the definition of environmental goods and services has not still become clear even now. The definition of environmental goods and services has remained vague, open and it

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has entailed a wide range of equipment and services that can "measure, prevent, limit and bring in corrective action to reduce environmental damage to water, soil, air and ecosystem. Therefore majority of these goods have spread across a wide range of sectors that include – architecture and design, consulting and management, chemicals. Owing to this large definitional ambit of these goods and services, it has been seen by developing countries as a ploy of developed countries to create market access of a wide range of their products. Many times, instead of sustainability being the main focus of concern, the trade negotiations in environmental goods and services have been loomed by market access interests of companies of developed countries which has been vehemently protested by the developing country groups.

Growing interest of the developed countries for environmental goods market can be buttressed by Figure 6.

Figure 6 highlights that most of the largest environmental corporations who are operating in the environmental goods market are from Germany, France, UK, US and Japan. U.S controls 33% of the global market of environmental goods and services which grew by more than 15% during 1996-2002, and was estimated at US $652 billion in 2005. Major part of the production of these goods are happening in the developed countries. In the last five years or so a saturation has started showing in the environmental goods market of developed countries whereas the market size and demand for these goods and services in the developing countries is gradually growing. The companies from developed countries have shown competitive edge in the production of environmental goods and services as they started innovation, production of these goods and services in mid 70s which finally matured by 90s. Developed countries were higher on the development ladder in comparison to the developing countries and therefore a conciousness, awareness and demand for these goods and services matured earlier in these countries in comparison to the developing countries. Formulation of stringent environmental standards and regulation and their

Figure 6. Environmental Goods Market (in US$ billion) Source – http://www.ebiresearch.com/Global_Environmental_Market_Datapack

Region	2003	2004	Growth	2003 Exports	2003 Imports
US	228.7	240.8	5.3%	24.7	21.9
Western Europe*	172.4	180.0	4.4%	37.5	30.2
Central & Eastern Europe	11.8	13.0	9.7%	0.3	3.8
Japan	96.1	98.8	2.8%	16.9	5.8
Rest of Asia (India)	33.6 (3.96)	38.0 (4.67)	13.1% (17.4%)	1.3	9.4
Mexico	4.1	4.4	9.1%	0.05	1.64
Rest of Latin America	11.0	12.1	10.3%	0.2	4.4
Canada	16.0	16.5	2.9%	1.65	2.13
Australia/ New Zealand	9.6	10.1	5.3%	1.8	1.1
Middle East	8.3	9.4	13.6%	0.1	2.2
Africa	4.6	5.5	19.4%	0.0	2.1
Total	*596.0*	*628.5*	*5.5%*	*85*	*85*

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implementation within developed countries also led to the formation of a strong environmental goods and services industry within the developed countries. Countries of South, South East Asia and Asia Pacific started later and now since they are catching up the developed countries the market and demand for these environmental goods and services has started expanding. Role of environmental regulation and policies are also playing a key role in this market expansion of environmental goods and services within the developing countries. Some more analysis will be required over time to find out how the growing expansion of the market of environmental goods and services and the trade in such goods, services have contributed to the sustainability, sustainable development of the developing countries where signs of such expansions are being shown.

Historical trend and data shows that trade has created both mpositive and negative effects on the environmental aspect of sustainability. These impacts of trade on environment has been channelled through a) Scale effect, b) Structural effect (risk of pollution havens), c) Product and Technology effect and d) Regulatory effect.

Within the parlance of scale effect, as trade between two countries have expanded and grown, the size of the GDP of countries has increased leading to a rise in environmental pollution. In Structural Effects as trade has expanded between countries, polluting industries have been shifted to developing countries where the goods have been produced by generating pollution and wastes. The finished product has been further sent back to the developed countries. This has been evident for the leather and textile industry of India where the goods have been produced by environmentally polluting wet blue process and the product has been exported back to the developed countries for final value addition to convert it to a high value added good for consumption within the developed country market. Strutural effects have also been observed in large amount of FDI that has gone into energy intensive pollution generating industries (mining, quarrying, petroleum, coke, chemicals, chemical products, rubber, non metallic mineral products, metals and metal products) of developing countries. Table 1 shows that though FDI stock in the mining, quarrying, petroleum, coke, petroleum and nuclear fuel industries of developing countries has grown to a larger extent: the stock for chemicals, rubber, plastics, non metallic mineral, metal and metal products has grown to a larger extent in developed countries in comparison to the developing ones.

Table 1 indicates that FDI from developed countries have gone to energy intensive and pollution generating industries of mining, quarrying and petroleum industries of developing countries where resources are available and the cost of production and extraction of these resources are low. But in effect, these FDI s' have created local wastes and environmental externalities for local communities. The production and extraction process has not happened by means of a clean technology though trade theorists for a long time have been saying that trade in goods and services can create clean technology transfers from developed to developing countries and can help in the reduction of environmental pollution in developing countries. Regulations can be created guiding and protecting environmental and ecosystem resources that can be dampened from production of certain goods that are traded. Trade can help in protecting environment unlike the structural effect of trade where it has a negative effect on environment owing to trade between two countries. Moreover, trade is largely being done through shipping routes. Merchandise trade through shipping generates global bads like carbon emissions that can impinge upon the environmental domain of sustainability. Discussions all around are targeting the ways of reducing these emissions which are going to increase in the near future. The European Commission estimates suggests that by 2020, emissions from the shipping will be the highest contributor to the global carbon emissions within the category of transportation. Hence, trade expansion through the shipping route

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Table 1. Inward FDI stock in 1990 and 2008

	Developed Countries			Developing Countries			World		
	1990	2008	% change	1990	2008	% change	1990	2008	% change
Mining, quarrying and petroleum	157.33	854.24	442.98	24.49	192.63	686.67	181.81	1109.20	510.08
Coke, petroleum products and nuclear fuel	55.91	88.78	58.80	3.37	43.36	1185.00	59.28	136.21	129.77
Chemicals and chemical products	134.15	703.31	424.27	50.62	159.13	214.38	184.77	869.86	370.79
Rubber and plastic products	14.25	61.05	328.33	2.03	8.59	322.28	16.29	71.33	337.99
Non-metallic mineral products	17.72	128.89	627.55	3.15	17.86	467.34	20.86	154.13	638.75
Metals and metal products	54.47	294.94	441.51	16.42	42.18	156.87	70.89	365.67	415.84
Total of above six industries	433.82	2131.21	391.27	100.08	463.74	363.37	533.90	2706.39	406.91
Total inward FDI	1698.26	11788.57	594.16	383.53	3384.94	782.58	2081.78	15491.18	644.13
% share of above six industries	25.54	18.08		26.09	13.70		25.65	17.47	

Note: Figures are in Billion USD unless mentioned separately
Source: World Investment report 2010

can hurt the environment and global commons like a clean air and can hinder strong sustainability by creating adverse effects on future generation owing to today's actions. So the critical question which the world faces today is - 'it is possible to restrict trade without restricting development and balancing the needs of the environment, climate'?. This question is becoming more pertinent day by day as the global trade regime has moved more towards an – 'intra industry trade' regime in which countries are importing (leading to emission through shipping while the import happens) same type of goods with different varieties to cater to preference of a section of population though another variety of the same product is produced within the importing country itself. Hence even if India produces a particular type of apple, it will still import certain type of apple from New Zealand to cater to the needs, preferences of Indian consumers. Consumer demand and larger heterogeneity of preferences of consumers within a market are leading to the flourishing of the intra industry trade leading to emissions and hurting the environmental aspect of strong sustainability by effecting the future generations. Thus, consumption and variety preference of an individual and environmental implications of importing goods to meet those preferences are contradicting to each other viz. objective of trade promotion on one hand and the saving of emissions from trade promotion. Our future generation which are moving towards a consumerist lifestyle can create a larger demand for intra industry trade leading to an enhancement of these contradictions posing larger challenges to sustainability. To counter this, countries have to take a consensual decision on how they balance the lifestyle needs of the vast consumer segments with the fallouts that those demands can create on global commons like availability of a clean air. One way can be through taxing imports that create larger emissions and for which domestic substitutable goods are available by also creating safeguard mechanism so that such bans do not have any impact on the economy and society of the countries engaged in the trade relationship.

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Next sections highlight the interlinkages between trade and growth, society that can have implications on the economic, social aspects of sustainability owing to trade.

Section 2: Trade and Growth

Trade can create income, growth and if that income can be distributed to the communities for their development then it can lead sustainable development (Dollar & Kraay, 2001). The classical theories suggest that comparative and absolute advantage acts as an incentive for countries to trade which thereafter can generate income for them and lead to development. Neoclassical trade theorists also pose similar views. But in today's world, trade is rather efficiency, scale economy driven and it has a strategic element into it. Any decision of trade is driven by a countries larger political and strategic framework of building up foreign relations. Factors like efficiency, scale economies, strategic aspects of foreign relations change over time and economic gains from trade can also vary over different points of the way a country moves along. It also depends on how the country positioned in the growing discourse of globalization and openness to trade. However, econometric studies have not been able to prove this hypothesis empirically. Studies by Dollar and Kray (2001)[1] shows that post 1980 globalizers and are developing countries have grown faster than non globalizers. In this study, globalizers have been defined as the top 30% of the countries in terms of their trade to GDP ratio between 1975 – 1995.

With respect to this definition, the non globalizers are actually more globalized with respect to trade to GDP ratio and tariff barriers. This perplexes us then what is the actual definition of a globalizer. Global history of trade shows that manufacturers from United States of America have enhanced tariff protection in goods produced by competitors from Europe though U.S never had any comparative advantage. This is quite in contrast to the theory of comparative advantage and the established theory of comparative advantage driven trade. Natural resources, consumer goods were always allowed in the United States market whereas in high tech technological goods like computers, aircraft United States maintained a monopoly and sustained their trade in these products. Thus, technology played a pivotal role in generating income through trade for United States and its final distribution to the people for their sustainable development. Thus many developed countries as early globalizers have not played a responsible role in instrumenting trade as a potential tool to create sustainable development of countries which are down in the ladder. This kind of action becomes more evident when one comes to know of the fact that today United States which is an early globalizer collects larger tariff revenue from Cambodia than Singapore which is higher in income ladder than Cambodia. United States buys more value of goods from United Kingdom than from Indonesia but Indonesian exporters pay more tariff revenue to United States than what Britain does. Similarly Bangladesh pays more to United States than Spain in terms of tariff revenue. These anomalies within the global trade regimes hint that anomalies exists and the trade regime is not in reality generating income and leading to its distribution in a fair way as ideally it should be as mentioned by the WTO principles. Moreover, the trade regime between developed and developing countries is not therefore leading to a larger generation and distribution of income to the developing countries to create equity between countries and promote future strong sustainability of these countries. Thus a lot needs to be done to create income, eradicate inequality and foster the development of society of developing countries which are engaged in trade with developed countries. However, before some concrete conclusions are made, it is a prerequisite to see what trade has done to the social elements of sustainability of some of the developing countries who are and will grapple with the challenges of strong sustainability

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in future. The following section precisely attempts to do that by exploring the interlinkages of trade on society, inequality and trade in services and its effects on sustainable development.

Section 3: Trade and Its Effect on Society

Trade can impact on gender empowerment, livelihoods, inequality and employment which can contribute to its effect on the social aspect of sustainability. This is elucidated by Ghosh (2003)[2] who points out that in export-oriented manufacturing and semi-industrialized sectors of developing countries, trade liberalization and global outsourcing has led to a jump in women's share of paid employment[3]. Some of the South Asian countries have witnessed this phenomenon. In these countries, though owing to trade a restructuring of work force has happened leading to demand for labour from a woman, financial status and bargaining power of women for wage revisions has not improved. The bargaining power has not improved and women are expected to work in inferior conditions earning lower wages than male counterparts and more vulnerable to the risk of job losses[4]. Trade liberalization and increased commercialization of the agriculture sector has had an increased negative effect on women employment (Cagatay, 2001)[5]. One of the reasons behind this is particularly in South Asian countries, many women act as unpaid family workers, landless labourers or marginal farmers engaged in subsistence land farming (Joekes,1999). Another area through which trade has been aimed to address the social aspect of sustainability is through the Geographic Indications which comes under the WTO Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).[6] Geographical Indication (GI) for a good is linked to the climate, geography of a particular region that gives it a special character leading it to earn a premium on such goods. Thus it is believed that if communities in such geographical locations are associated with production of such goods, they will also benefit from such a premium and it will contribute to their livelihood and development. Thus the first issued GI was for wines and spirits which was linked to the soil and geographical factors of a particular place in France. But since then the concept of GI has got diluted and now GI has been claimed for items like rice, tea, coffee, honey, handicrafts and even muga silk. Many of these products have no exact relation with the geographical route of the product but rather associated with a specific skill. If the premium earning is more linked to a particular skill then training and capacity building of the people might be required. In absence of that, even with traditional cultures, practices, some of the communities might not be able to earn the premium from these goods. Thus the possibility of communities earning a premium from these goods is conditional on in certain cases whether the communities have adequate skill to produce a good. This has no connection with the geographical specificity of a good. Therefore one could not say with surety that a geographical indication will always bring in a premium and larger earning for communities leading to their development. One essential facet to attain such a development is through reduction of inequality. The next section aims to explore the association between "Trade and Inequality" which can cater to the economic and social domain of sustainability.

TRADE AND INEQUALITY

In order to explore this association, the first question to ask is whether trade between two countries can bring a change in income distribution and can impact inequality. However, whether it will increase or decrease inequality is not substantially proven as there are views on both sides. Papers by Paul Krugman

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throw some light on this fact. It suggests that way back in 1980s, there was a rise in inequality within the U.S. economy. This was because owing to a rise in trade, there was a high growth of import of labour intensive goods from low wage countries. There was a demand for exporting large skill intensive high end technological goods which created demand for high skilled labour. Wages of educated, skilled labour went up and a rise in inequality was observed between high and low skilled workers. The labour intensive goods were imported from developing countries and high end technological goods were exported which demanded high skills.

Thus there was a change in the relative price of the skilled and unskilled labour leading to a rise in inequality within the U.S. economy. But this is a story of a developed country. One has to ask what was the effect of such a trade on developing countries of South. Data[7] of North South trade during 1990s show that effect of such trade on inequality levels of trade partners was modest. Soon the shift of analysis switched to how trade created outsourcing of services in the developing countries and raised the levels of inequality in the developed countries with rise in income of educated skilled workers with a subsequent fall in the income of the less educated workers.

Therefore it is important to analyse whether trade in goods and services contributes to the social goals of inequality reduction, enhancement of quality of life and generates sustainable development for the trade partners. The next segment looks on how trade in certain important services like health and tourism can promote and generate sustainable development.

TRADE IN SERVICES AND SUSTAINABLE DEVELOPMENT

Sustainable development of a country can be affected through trade in services (e.g., health and tourism services) by bringing a change on employment and livelihoods of local community through trade.

Growth in tourism trade which is very common in many developing countries could have an impact on the sustainable development of local people by generating more income. For example, post 2003 tourist arrivals have gone up to a large extent in India owing to the incredible India campaign and driven by many proactive state policies. In this regard, Kerala, Rajasthan have played an active role in promoting tourism in their state.

Local communities have been tapped and engaged in promotion of local cultural heritages. They have been exposed to global tourists and revenue from tourists has trickled down to the communities leading to income earning of communities through state driven policies.

Similarly, trade in health service is important in Indian context. Many south-east Asian developing countries and some developed countries are engaged in this trade with a developing country like India. However does this mean that an enhanced trade in tourism sector, health services sector has led to an overall development of the people of India by improving their quality of living, life.

The picture is not so clear in many regards because one cannot say that trade in health services in India has improved the basic quality of life indicators of the people of India. It gets validated when we observe that though Kerala performs well in terms of Infant Mortality Rate (14), many large states of India like U.P, Madhya Pradesh, performs ridiculously in IMR (Infant Mortality Rates) indicators.

U.P in 2000 accounted for 20% of the infant deaths. This picture is true although India's trade in tourism and health services have gone up. In 2002, India earned more than US $ 60 million exporting IT enabled services for the health sectors in developed countries. Most of the trade gains have occurred in medical billing and transcription. During 1998 – 2006, India was amongst the highest recipients of

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H1A and H1B visas in U.S. Large outflow of health professionals from India has taken place due to pull factors of wage differentials, infrastructural conditions and push factors like lack of recognition.

But at the backdrop of all this, basic needs of access of common people of India to doctors is an unresolved issue although trade in health services has increased. According to Adkoli[8] (2006) there has been one Indian doctor for every 1325 Americans in U.S whereas it has been one Indian doctor for every 2400 Indians in India. So although trade has improved in health and tourism services, it still questionable that how far such trade gains have resulted in improvement of sustainable development of people of India by bring better quality of life for them.

CONCLUSION

Thus this chapter leaves us with a question of whether at the backdrop of globalization, trade can bring in better quality of life for future generation. However, it brings out clearly the role of an environmental policy in ensuring better quality of life. A sound environmental policy can address myriad of environmental challenges that can be faced at a decentralized local level in a vast country with large cultural differences. In order to come up with a sound environmental policy, there is a need to find out and assess the value of the natural resources as much as possible as not all values like the biodiversity, cultural and aesthetics value associated with certain natural resources might not be assessed. These valuation can be done through the means of various techniques that were mentioned in this chapter. In a way, all these techniques should show how the country is creating a footprint on natural resources. Once this is done it can indicate how the country is performing in terms of its impact on sustainability. Further, another channel through which this impact can happen is by means of trade.

Trade can impact the social, environment and economic domains of sustainability within the developing countries though in today's context negotiations on trade has seen a conflict between the developed and developing countries. While, the developed countries are pushing the trade agenda in specific products and sectors mostly with a market access philosophy, often their interests have gone against and have been pushed in a way which hamper the social, economic and environmental aspects of these developing countries. The more the world becomes integrated, globalized these concerns will increase. It is therefore, important for the developing countries to have strong domestic environmental policies and governance regimes which protect the sustainability needs of these countries even when the countries open up in terms of trade. In order to address the future needs of these developing countries it will be imperative to take these measures. Only then, the vision of strong sustainability will be attained and realized by these countries in the long run.

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3 However, evidences from East Asian countries seem to suggest that there has been a decline in women's employment in this sector during the 1990s (Joekes 1999).

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Section 2

Development and Design Methodologies

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Chapter 7
Role of HRM in Sustainable Organisational Development

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ABSTRACT

This chapter explores the role Human Resource Management plays to support sustainable organisation development by controlling and managing valuable resources including employees of the organisation. The chapter presents the concept of sustainable organisation development as vital and important requirement to survive the competition in the current financial era. This chapter explains that sustainable development could enable organisations to overcome current market problems as well as achieve their goals. The chapter proposes that HRM can play a crucial role in developing strategic leadership and management capabilities and thus promote economic, social and environmental forms of sustainable development.

INTRODUCTION

Sustainability from the environmental point of view is seen as activities that are friendly to the environments (BusinessDictionary.com 2014). Sustainable development means that organisations have to capable to create a development and able to keep it as on-going or continues process. Sustainable organisations have to be able to create development that will meet the current demands, without diminishing future opportunities to fulfil their needs (Vollenbroek, 2002).

Recent, high economic growth and fluctuating market conditions may lead to a complex working situation. This means the role of human resource management HRM need to find solutions to the questions of: How to deal with relationships between and with employees? and how to manage the firm's sustainable development?

This chapter explains the key responsibilities of HRM and in particular the critical role of HRM in organizational sustainable development. Organisations could formulate their creative strategies in order to act more effectively and efficiently in their operations (Zandee, 2011).

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Sustainable organisational development definitions appear to be associated with the relationship between organisation, society and environment. Spooner and Kaine (2010) describe sustainability in businesses as the 'triple bottom line (TBL)', where economic, social and environmental issues are integrated.

Sustainability of an organisation has traditionally been viewed as the three E's being Economic, Environment and Equity. New definitions include the three P's being people, profit, and planet. According to Bowersox, et al (2013) "organisational sustainability can ultimately be refined into the following four dimensions being environmental, social, education, and economic."

1. Environmental Sustainability

Environmental sustainability includes conservation, usage reduction, and efficient business practices (Bowersox, et al 2013). It is noted that public's awareness of environmental issues has been recognized earlier by Drumwright (1994) who proposed that "The deterioration of the environment over recent decades has drastically increased the public's awareness of environmental issues". This type of awareness can either help or hinder a firm's position in the market depending on the firm's ability to manage potential environmental impacts within their functions. This view was also supported by Elkington (1998), who argued that "If we fail to address the wider political, social and ethical issues, the backlash will inevitably undermine progress in the environmental area". In addition, Porter and Linde (1995) also noted "Greening the supply chain can save resources, eliminate or reduce waste, and improve productivity and competitive advantage at the same time". Other scholars such as Bowersox et al. (2013 pp. 403) argue "There is growing belief that under specific circumstances, firms can increase their profits by adopting environmentally sustainable practices".

2. Social Sustainability

Traditionally social sustainability has received less corporate attention compared to environmental issues. In recent times Corporate Social Responsibility (CSR) has emerged as a tool for addressing ethical sustainability include employee relations, community involvement, and ethical business practices (Bowersox, et al 2013). Social sustainability is the economic, legal, ethical, and other expectations that society has of organisations at a given point in time. According to Elkington (1998 pp. 85), "the degree of trust between a corporation or industry and their external stakeholders is likely to be a key factor determining their long-term sustainability". This is particularly pertinent to a firm's ability to operate in a socially sustainable manner, however, following global headline-grabbing events such as the 2012 Bangladesh garment factory tragedy that drew major attention to well-known brands and the extent to which they were, or were not, managing their business in a socially sustainable way. Elkington (1998) highlights that social issues are so relevant to the firm's survival regardless of its position within the value stream (either from a customer or supplier perspective).

3. Economic Sustainability

There are two elements relevant to economic sustainability; namely internal management and external management. However, economic sustainability can be viewed as "The ability of desired performance to be maintained over time" (Bowersox et al. 2013 pp. 48). According to Min and Galle 2001 (p 1222-1238) "Cost concerns are the most serious obstacle for taking environmental factors into account in

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the purchasing process". This demonstrates that firms may prioritise economic performance over environmental performance if the cost of sustainability is prohibitive to pursue. Therefore firms can't be considered truly sustainable in according with the triple bottom line theory if such trade-offs amongst sustainability measures creates an imbalance.

4. Educational Sustainability

Educational sustainability aims at ensuring the workforce is properly trained. Educational sustainability could prepare staff for an effective succession plans by ensuring the workforce is able to replace departing employees in the future. Approaches to addressing educational sustainability include employee relations, talent development, and collaboration with the supply chain (Bowersox, et al 2013).

BENEFITS OF ORGANISATIONAL SUSTAINABILITY

According to Perrot (2014), the key benefits as a result of being involved in sustainability actions may be:

- Improved organisational reputation and image;
- Cost savings;
- Competitive advantage;
- Employee satisfaction, morale and retention;
- Innovation;
- New sources of revenue or cash flow;
- Effective risk management; and
- Enhanced stakeholder relations.

Additional benefits lies in performance improvement under sustainability programs. To address the extent to which firm performance improvement could be affected by sustainability, it is important to view the firm's sustainability from one single dimension, i.e. either economic or environmental perspectives. This approach is supported by Elkington (1998) who noted, "*Companies aiming for sustainability need to perform not against a single, financial bottom line but against all the triple bottom line*". Therefore, argument is provided that interdependence exists amongst the triple-bottom-line dimensions of economic, social and environmental sustainability, and that one-dimensional approaches to sustainability, i.e. an approach that focuses on environmental parameters disconnected from other social concerns, can be counterproductive to overall sustainability goals. (Matos and Hall 2007, p. 1087).

Further work by Zandee (2011) suggests that the organisational development in the context of sustainability could be divided into three main segments:

1. The first segment integrates the shared value of business and society.
2. The second segment looks at the application of organisational internal continuous improvement.
3. The third segment deals with organisational sensitivity in terms of sustainability of the organisation and its environment.

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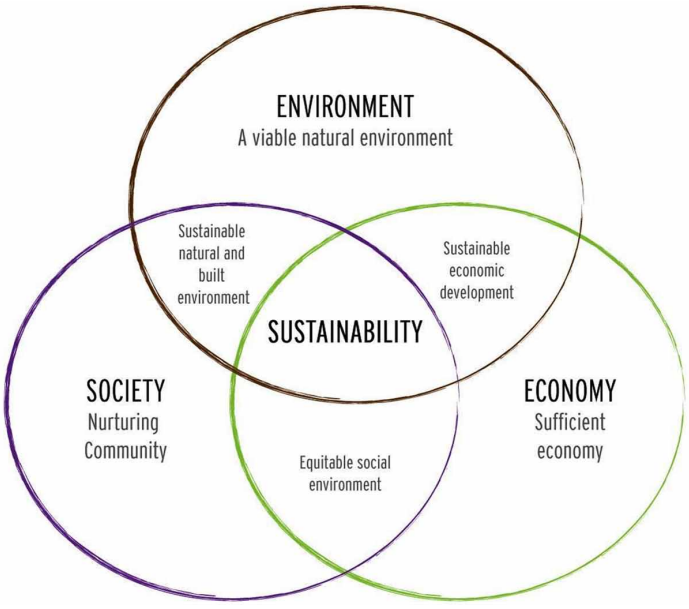
The earlier work by Gladwin et al. (1995) focused more on human development by introducing the term 'sustaincentrism' as an effort to attain human progress in an inclusive, affiliated, equitable, prudent, and secure manner. Therefore, human resource management may be considered as an organisational driver with a special role to achieve sustainable organisational development.

The significance of sustainable developments has growing rapidly in response to growing national and international concern about protecting the environment (Avery, 2005; Elkington, 2004). Since the Kyoto Protocol, environmental sustainability has gained worldwide attention. However the society and business community are now more concerned with the impact of environmental issues. Even the investment community interest in tracking sustainability related performance of firms has increased. That is why many global organisations are now re-strategizing for sustainability against the *Triple Bottom Line* (TBL) standards (Spooner and Kaine, 2010). As such, multi-national organisations have increasingly started to shift focus from economic and organisational growth to sustainable and balanced practices (Ardichvili, 2012).The following diagram (Figure 1) illustrates the relationship between environmental protection, social fairness and cohesion and economic prosperity.

Building a Sustainable Organisation

Building a sustainable organisation involves overcoming a number of challenges. Some of these challenges are due to the complexity in applying social sustainability in global organisations. In such case the organisational development need to address issues of social, environmental and sustainability reporting, as an extension of the financial reporting model as prospective source of "value creation" is the challenge faced by global and local organisations (Gray 2007). The building of sustainable organisation requires developing a number of appropriate strategies that embed sustainability in all or most of its processes.

Figure 1. Relationship between environmental protection, social fairness and cohesion and economic prosperity (Torugsa et al, 2012)



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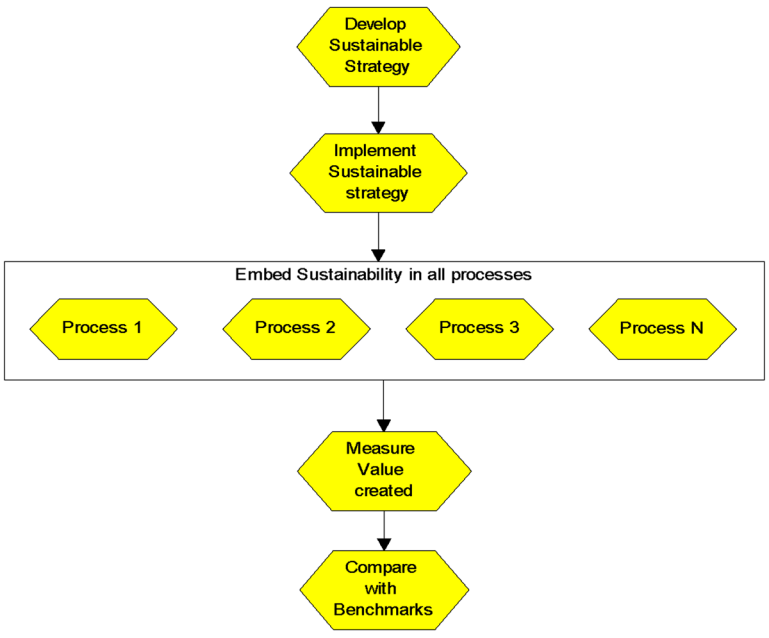
Figure 2, developed after Klettner, Clarke, and Boersma (2014), clearly illustrates that the process incorporates social responsibility and organisational development into the core business processes

Strategic Role of HRM in Sustainable Organisational Development

Corporate and environment sustainability can be attained through sustainability of human resources in current competitive environment. HRM has a prime role to play in adopting organisational development sustainability. This approach require strategically investing in employees who can offer the potential to develop a competitive advantage which eventually leads to long term sustainability of the organisation. Hence a strong focus is needed to build human resources and capabilities by implementing strategies to develop skills in them for long term.

HRM could face complex task in making sure that there will be appropriate staff within the firm to drive the sustainable development. Therefore, one of the HRM main responsibilities is to make sure that the organisation employs the right candidates to run the business. A number of scholars such as Mabey *et al.* (1998), Ellinger *et al.* (2002), and Soliman and Spooner (2000) emphasised the HRM role in their stamen "*employees are the organisation's internal sources that could create a sustainable competitive advantage for the organisation*". In other words, failure to recognise the value of human resource could lead the business into an unfortunate situation. To avoid being in this situation, HRM may have to fully understand the current employees' ability to drive the sustainable development. Therefore the organisation should conduct thorough evaluation regularly. Evaluation managers could also learn reasons behind any decline in the employee's ability to drive the sustainable development. Soliman (2011a) emphasized the critical role of the leader to drive the innovation. Similarly leadership to drive the sustainable development need to be effective leadership for transformation into a truly sustainable organisation.

Figure 2. Building a sustainable business



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Leadership for Strategic Transformation into Sustainable Organisational Development

Strong and effective leadership is required when undertaking transformation to sustainable organisation. Change is usually associated with some form of resistance. The degree and strength of this resistance will be dependent on the leaders driving the change, and managing the implementation of sustainable programs.

Graetz (2000) describes instrumental and charismatic leaders are those that can inspire a shared vision and personally communicate the future with clear and honest answers to the what, why and how questions. Not only must the goals be emotionally compelling to all employees but they must know how they will contribute to achieving those goals (Soliman, 2011b).

Identifying sustainability issues is usually the first step to undertake by the leadership. This may require consulting widely across the organisation and investigating how these limiting factors are effecting each business function will enable leaders tailor and implement changes that have the greatest value to all those involved. The transformational leadership also has the task of ensuring that the goals related to sustainability can be accommodated into the HRM strategies (Barton et al 2000). The infrastructure should support learning, sharing, and knowledge management. HRM can contribute towards this by focussing on four key areas:

1. **Policy and Procedures:** HRM need to execute a new set of roles as knowledge facilitator, human capital steward, and a builder of sustainable development (Lengnick-Hall and Lengnick-Hall, 2003). This role facilitates learning and development, creating environment which supports knowledge creation, sharing and dissemination. These roles should complement an organisations sustainable development process by enhancing their ability to work across different organisational, national and international boundaries; helping employees to demonstrate their skills in problem solving across environmental, socio-political, technical and economic factors and enable staff and employees to demonstrate and replicate self-renewing behaviour.
2. **Employees-Management Relationships:** HRM can contribute towards creating a better environment by building relationships with managers, employees, customers, suppliers and distributors and linking them more directly towards the organisation's value creating process (Ulrich and Smallwood, 2003). A positive relationship building role by HRM should empower employees by helping them to think across boundaries, work across expanded markets and value chains, form and establish new relationships, demonstrate outstanding communication skills, become adaptive and flexible to restructuring and dynamic changes and sustainable development.
3. **Competence Development:** HRM should recognise and direct intellectual employees towards developing a compact set of key strengths, capabilities and competencies (MacDonald, 2003). Along with long range planning and long term strategy development, HRM should also develop a short term strategic approach to address the dynamic environmental problems. In addition to this short term strategy, firms also need to think about constant renewal and revitalisation for long-term sustainability. Thus HRM can create and develop capabilities that can generate wealth by investing in this intellectual capital and maintain an allegiance to sustainable imperatives.
4. **Learning:** HRM can significantly contribute towards sustainability by strongly emphasising on developing employees to achieve organisational sustainable development change. Employees' collective knowledge provides a useful tool for the HRM function to sustain organisational development

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by directing towards capturing, using and re-using employees knowledge (Soliman and Spooner, 2000). HRM can serve in building quality, creativity, problem solving skills and employee development (Yahya and Goh, 2002) and thus play a pivotal role in nurturing and sustaining learning focus by identifying sources of employee knowledge, facilitate continuous learning, and by developing an understanding of the mediators who facilitate sharing of knowledge and make the information available to employees (Soliman, 2011c).

THE SUSTAINABLE DEVELOPMENT LEADERSHIP FACTOR

Leadership has always been the key factor for any firm in its success and competitive advantage as different attributes of leadership help in increasing the firm performance (Soliman, 2011a). The perspective of leadership has been changed and the new theories emphasize the relationship-oriented view which reflects both the leader and the follower. It also acknowledges that followers may influence leader decision making (Kouzes & Posner, 2004). There are different theories which describe the leadership characteristics but actually it's a process through which individuals or groups should get influenced and achieve goals in their respective work domain. Moreover, leader is the person who shows a vision of future and the path to achieve that vision when targeting a set of shared goals (Hogg et al., 2003). The theories related to leadership are generally describe the role of leader as an individual which is helping the society or organization in leading in different areas such as sustainable organisational development (Bowersox & Closs, 1996; Lambert et al., 1998a, b).

Transformation Leadership and Sustainable Organisational Development

Transformational leadership is the form of leadership in which leader transform the follower's moral and gives motivation through various mechanisms (Soliman, 2014). Doing this the performance of the followers is increased to the level which was not expected if there would not have been the influence of transformational leadership. Transformational and transactional leadership styles are contrary to each other. Transactional leaders doesn't aspire for changes in the system and also do not develop long term relationship rather they try to control their followers behaviour by giving rewards against performance for which the goals have been set by the leader. There are three behaviour patterns which is always visible with the transformational leadership (Avolio et al., 1999; Hater & Bass, 1988; Howell & Avolio, 1993):

1. Inspiration in which leader articulate a clear vision that shows a path of attaining that vision and set sustainable development measures assist in achieving a desired future.
2. Intellectual stimulation in which leader motivates his followers in creating something innovative and creative which should solve complex sustainable organisational development and various business problems.
3. Individualized consideration in which leader see what kind of training is require for the followers to increase their skill and show how to utilize the skills of followers in the correct way.

Transformational sustainable development leader tend to have clear purpose and mission. The followers and the leader have a shared set of values which is established between them which fives a sense of purpose. Leaders articulate a vision which gives a clear indication of improved sustainable organisational

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development in the future also depicts as an inspirational behaviour. The new ideas needed for the sustainable organisational development are usually created and implemented by the staff of the firm. Sustainable organisational development leaders usually know that the followers are having different skill set and that not every follower in the organization is skilled and that some may need training to upgrade their skill.

According to Chaleff (2003) and Kelley (2004), there are four key behaviours that describe the domain of transformational followership. These key behaviours are:

1. Critical Thinking,
2. Assuming Responsibility,
3. Collaboration, and
4. Commitment to Organizational Success.

The above key behaviours could make followers to behave in a transformational style. Transformational sustainable organisational development followers use their skills to think critically in bringing better changes in the inter-organizational process. They could be pro-active in taking responsibilities to make the sustainable development process successful.

They are usually highly commitment to creating strong relationships with sustainable organisational development leaders and also with other members of the organization. Once the leader set the goal, the followers follow the directions and aligned their goals with it.

Strategies for Implementing Sustainable Organisational Development

HRM needs to address and facilitate the strategy for sustainable organisational development from three Perspectives:

1. **Rationale Perspective:** HRM needs to address and facilitate the human component of through:
   a. Gaining employee commitment by clarifying corporate motivation and sustainability involvement.
   b. Educating Top management on the business implications of sustainability. HR team can be instrumental by creating commitment and developing awareness in the top management team.
   c. Establishing roles sustainability champions (Lee Scott at Wal-Mart).
   d. Accommodating regulatory changes (Kyoto Protocol);
   e. Supporting these sustainability causes in their role as supervisors.
2. **Conceptual Framework Perspectives:** A conceptual framework helps organisations set up a sustainable model which fits its strategy by focusing and limiting perception and actions. HR professional by working with top management can simplify their scheme on sustainability which eradicates any ideological views and preconceived notions. HR can also create sustainable teams by developing a mental model which can increase the effectiveness (Rentsch and Klimoski, 2001). The values ingrained in this guiding model should be in sync with the values of the firm's culture. For example, a new CEO would face roadblock if he attempts to promote TBL strategy in an established organisation which focus exclusively on increasing stakeholder's value. HRM can contribute here by building a culture which not only fits but also nurtures the sustainability efforts of an organisation.

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3. **Directional Perspective:** The HR team can contribute by leading, coaching and advising. The advisory roles should help the top managers to decide the best employee who fits to lead the role of sustainability and where this function should be housed in the organisation's structure. The next role would be to serve as advisors to the selected leader and allow him to frame his own team from the respective functionalities and thus promote collaboration (Osland, 1994).They also need to ensure that leaders and cross-functional teams have the desired set of skills, change management techniques and global leadership training programs if they are needed to deal with cross-country efforts.

According to Ulrich cited in Brewster et al. (2011), "To create a sustainable organisational development, the role of HRM should be able to reflect the following five points in its strategy":

1. HRM needs to be able to travel with constant speed and dexterity into the market in order to control and foresee the changes. This can be achieved by eliminating bureaucratic processes of governance to enable rapid decision making and removing unnecessary processes.
2. HRM needs to create a brand for the organisation firm in order to attract consumer and other associated brand. The reputation and identity of the firm is depends on employees' actions and organisation human resource policies, experienced by two dimensions of reputation such as customers and investors."
3. HRM should serve as a customer interface to analyse data on consumer behaviour, needs and business processes as a feedback of performance management.
4. The company must have talented staff with superior competence and commitment. This not only makes the company an attractive workplace to the current staff but also helps other employees or prospective staff to dedicate energy into the company's performance.
5. Empowering innovation and learning. Companies should create and support a culture of inquisitiveness and innovation. Staff should be encouraged to be innovative.

Other areas that need attention include resource allocations and assigning accountability. Employees need to be well equipped, information required needs to be made available the network should be connected. Employees need to be empowered by means of assigning accountability. This helps create environment where employees feel they own the company and hence perform to their best capacity and ability. It should be noted that the process of sustainable organisational development also leads to enchaining the corporate memory in relation to sustainability (Soliman, 2014). This in turn should support the ability of the organisation to be a *Learning Organisation*.

Role of "Learning Organisation" in the Sustainable Development

The transition into a sustainable organisation could change the role that learning and knowledge management play within an organisation and between organisations comprising the supply chain. An increasing number of organisations are transforming from traditional knowledge monopolies to networks characterised by an increasing degree of interdependency and knowledge sharing and learning organisation. In addition the transformation into sustainable organisation may add further complexity in managing the sustainability knowledge and in turn the may lead difficulties in pursing the learning organisation concept.

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Given that the ability to continuously adapt to a changing business environment and remain competitive depends on the willingness of all partners, it becomes a requirement that firms should be committed to implement holistic knowledge management and learning concepts across the entire firm.

The "Sustainable Learning Organisation" Concept

The concept of a learning organisation has been the subject of extensive research and debate since early 1990s and has its roots in the studies related to organisational learning in the 1960-1970s (Yeo, 2005). The "learning organisation" represents an entity that continuously learns and transforms, while "organisational learning" refers to a process of developing learning in organisations (Yeo 2005).

There have been numerous attempts to define a learning organisation (Peterson, 2002). Senge (2000) describes learning organisations as organisations that have developed knowledge management systems enabling them to constantly adapt to the changing environment based on learning particularly about sustainability. Seemann et al. (2000, p. 92) propose that learning organisations are characterised by "explicit management efforts to build intellectual capital in support of the firm's strategy". The implementation of the learning organisation concept is considered as enhancing the intellectual capital of the firm that contains both tacit and explicit knowledge of employees about sustainability.

As knowledge acquired by individuals often stays with them, the individuals are the learning entities (Örtenblad, 2001). Thus, the success of organisational learning is contingent upon the collective cognitive processes of individuals and requires personal capability and a supportive organisational culture that is characterised by commitment, trust and co-operation. What is expected of effective organisational learning is an observable shift in the extent to which individual behaviour, attitudes, knowledge base and specific skills change to meet organisational sustainability goals.

Effective knowledge management and organisational learning are considered crucial for developing a sustainable competitive advantage for an organisation (Skyrme, 2000). Organisations that have control over their knowledge or intellectual capital are widely considered to be more capable of responding to market threats and opportunities effectively and efficiently (Peterson, 2002).

Integration of Knowledge Management and Sustainability

The effectiveness of integration with sustainability in the organisation is dependent on the degree and the timeliness of information sharing between the sustainability participants (Soliman, 2013). It is therefore critical that sustainability participants extend their internal knowledge management systems and processes to include external entities and customers. This task requires an organisation to consider all knowledge-based systems that exist and to comprehensively map their knowledge management chain and its critical elements to ensure the required knowledge can be created, captured, organised, accessed and used in an effective and efficient manner (Soliman & Spooner, 2000).

Maqsood et al. (2007) argue that embedding the principles of knowledge management throughout the entire firm could facilitate sustainability and provide substantial competitive advantage. This requires the organisation to work collaboratively to develop a combined knowledge strategy that supports the idea of acting as an integrated entity rather than acting as separate participant. Such a knowledge strategy should aim at reducing fragmentation and adversarial relationships that may exist between participants in order to improve the overall productivity of the firm. Implementation of cloud system has shown to

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be a factor assisting this strategy (Soliman, 2014). Thus integrating the cloud system with the process of developing the sustainable organisation may lead to benefits as discussed below.

According to Bowersox, et al (2008, p. 7), information, product, services, financial and knowledge these are the five critical flow of sustainable organisational development where value result come from. Such values are economic value, market value and relevance value. According to Baily, et al. (2008, p 18), value needs to be expressed in terms of total lifetime costs not "sticker" price, should consider possible business productivity and performance improvement and take into account potential value from areas such as:

- Innovation & Preferential Access to New Technology.
- Service, Responsiveness and Delivery.
- Quality.
- OH & S Related Improvements.
- Risk Reduction / Management / Avoidance.

Benefits of Integrating Sustainability with Other Functions

The benefits of integrating sustainability with other functions, such as increased responsiveness, inventory reduction, shorter product development cycles and lower transactional costs, could enhance the concept of the learning organisation with integrated sustainability practices (Peterson, 2002). A firm that exhibits high levels of trust and commitment between its participants in terms of sustainability knowledge creation and sustainability knowledge sharing can be seen as a "sustainable learning firm". Peterson (2002, p. 1331) defines a sustainable learning firm as an "integrated firm that has an added dynamic, agile ability to learn from and respond to changing market environments". Similarly, Mason-Jones & Towill (1999) argued the key distinction of sustainable learning firm is the capacity to simultaneously feed the end-user or market information to all participants through highly effective knowledge transfer mechanisms and tight co-ordination of information flows.

One of the key pre-requisites and benefits of sustainable learning firm is the fair distribution of returns among participants underpinned by reciprocal relationships and well-designed incentive structures (Peterson 2002). A fair distribution of returns from knowledge co-creation and sharing activities must be supported by an appropriate incentive scheme. Such an incentive scheme should take into account risks faced by each supply chain participant and provide each with an adequate and competitive reward for contribution to collective knowledge management.

Organisations aiming at embedding learning culture in their integrated sustainable learning firm may also benefit from practicing knowledge sharing networks comprising partner organisations, with a focus on developing common goals, holding joint planning sessions and performance reviews, and initiating employee rotations and secondments between entities. Such initiatives may generate enhanced levels of trust, commitment and interdependence between member entities, thereby contributing positively to the overall functioning of a sustainable learning firm.

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INFORMATION SHARING IN THE SUSTAINABLE ORGANISATIONAL DEVELOPMENT

Information is the most important aspect in the integration mechanism. Due to availability of information in the system all the members attached to the sustainable organisational development like internal and external members can exchange information in a timely, responsive and useable format. There is always an encouragement from leaders for the followers to innovate new processes so as to benefit the entire supply chain, this happens when there is a sharing of information across all members. Continuous improvement is usually a practice among the sustainable organisational development followers by using their critical thinking skills in creating a profitable sustainable organisational development which benefits every member attached to that chain. In holding all the things together in a sustainable organisational development communication plays a pivotal role. Through consistent communication between different partners in the sustainable organisational development trust and relationship is maintained and the satisfaction increases with the increase in the quality of communication. Transformational sustainable organisational development leaders always try to maintain a healthy environment of informal communication for better alignment of thoughts and they also seek feedback from time to time so as to keep the process streamlined without any error resulting in better effectiveness and efficiency in the sustainable organisational development.

The effectiveness of a sustainable organisational development is measured by the achievement of the goals that the leaders have set for the followers. There has to be some kind of structure which should be formed by the sustainable organisational development leaders and followers in measuring the performance of the sustainable organisational development i.e. how effective and efficient is the sustainable organisational development. Greater availability of information results in more efficient operations, better customer service and cater to changing customer demand patters. The leader and the followers should develop an informal communication in the sustainable organisational development as this will create a better relationship among the members and also strengthen the bond as inter-organizational integration. The big ambitious goals and rewards always keep the transformational sustainable organisational development leaders and followers to work in an environment where there is lot of emphasis on innovation in the current system and also it increases the collaboration between the members of the sustainable organisational development. This is usually achieved through integration.

CONCLUSION

This chapter examined the importance of trust and commitment between supply chain participants as a pre-requisite for successful implementation of knowledge management systems that span entire firm. The chapter also combined the concept of a learning organisation with integrated sustainability to analyse and describe key added capacities and characteristics inherent in sustainable learning firm.

HRM should tailor its functions to incorporate sustainable developments. This chapter argues that HRM play a crucial role in managing employees to help the organisation creating a sustainable development. The main role of HR management is not only to manage the recruitment process to find the right people to join the company, but also to provide training, controlling and monitoring the employees to achieve sustainable development. Therefore apart from the processes and practices in the organisation that drive vision, management approach also needs to be restructured especially when multiple perspec-

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tives and stakeholders are concerned. Thus HR can play a crucial role in developing strategic leadership and management capabilities and thus promote economic, social and environmental forms of sustainable development.

Leaders of sustainable development must consult widely or run the risk of negative out comes and undermining from subordinates as well as other leaders within the organisation. The introduction of Information Technology and Cloud Systems require a driver that has a full understanding of the overall requirements of the organisation and can deliver alignment with cross functional areas. Groves (2006) has found that theoretical and empirical studies have linked the relationship between a leaders emotional competencies, including self-awareness, emotional expressivity, self-monitoring, and empathy, and a range of important leadership outcomes.

There is a distinct interdependence exists amongst economic, social and environmental sustainability, but as Hahn (2009) argued "A tri-dimensional approach can prove to be difficult in cases where trade-offs exist between any of the three dimensions". A multi-dimensional approach such as triple bottom line is in itself a challenge of sustainability. The challenge for firms is to embed policies that focus on the triple bottom line that will stand the test of time, supporting long term objectives, and preventing any of the three pillars of sustainability being abandoned at the expense of another, i.e. economic priorities outweighing others, thus plunging the firm into a single or double bottom line focus.

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KEY TERMS AND DEFINITIONS

Economic Sustainability: Can be viewed as the ability of desired performance to be maintained over time.

Educational Sustainability: Includes activities used to prepare staff for an effective succession plans by ensuring the workforce is able to replace departing employees in the future.

Environmental Sustainability: Includes conservation, usage reduction, and efficient business practices.

Ethical Sustainability: Includes employee relations, community involvement, and ethical business practices.

Social Sustainability: Includes Corporate Social Responsibility (CSR) and other issues of social concern resulting for the activities of the firm.

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Chapter 8
Significance of Cultural Dimensions in Urban Planning Process for Sustainability of Pilgrimage Towns in India

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ABSTRACT

This chapter raises the significance of integration of cultural attributes in the urban planning process for sustainability of pilgrimage towns. It identifies the spatial connotations of cultural practices, processes and events to review synergies between culture and urban planning. Two Indian pilgrimage towns of Vrindavan and Haridwar with congruent cultural context but diverse urban setting have been examined. Eight significant diverse attributes of both case studies are discussed for examining linkages of cultural dimensions with urban planning, and sustainability of indigenous urbanism of Indian pilgrimage towns. Recent policy initiatives in India envision an increasing inclusion of cultural and heritage aspects in urban development, but are constrained by paucity of empirical spatial research on Indian pilgrimage towns.

INTRODUCTION

The sustainability debate increasingly focuses on urban development and sustainability is being considered unattainable without achieving sustainable urban development (UN-HABITAT, 2002). Further, Sustainable Development Goals (SDG's) adopted in the 2030 Agenda for Sustainable Development at the United Nations Sustainable Development Summit includes making "cities inclusive, safe, resilient and sustainable" as a goal (UN, 2015). At global scale, UN-Habitat summarizes climate change, gaps in energy supply, food security, changing demographics, size of cities and towns, income inequality and managing the cultural diversity as critical issues facing urbanism. In context of developing countries,

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additional challenges of urban growth, urban informality, growth in peri-urban areas, linking of green and brown agendas and institutional and professional capacity building are identified issues to be addressed (UN-HABITAT, 2009). Emergence of alternative paradigms of urban development with greater inclusivity is envisaged in response to homogenizing influence of globalization in the developing countries.

With a shift in goals and emergent challenges, urban planning praxis and theory explore alternative urban and spatial planning paradigms. The attributes of sustainability imperative are variously interpreted in urban planning domain, and diverse approaches to achieve urban sustainability include conceptualization of eco-villages, eco-cities (Register, 1987) and eco^2 cities (Suzuki, Dastur, & Moffat, 2010); new urbanism (Talen, 2013) and sustainable urbanism (Farr, 2008); compact cities, green cities and resilient cities amongst others. Simultaneously, in response to globalization the place-based factors of local contexts are assuming significance in urban and spatial planning paradigms (WHO, 1999) (UN-DESA). Embedded in the local discourse, culture has emerged as a significant local, place-based determinant in urban planning process necessary for achieving sustainable urban development. UNESCO has initiated preparation of a 'Global Report on Culture and Sustainable Urban Development' for negotiations in the post 2015 Agenda which aims to provide guidelines and recommendations aimed to foster culture-based urban sustainable development initiatives at the international, national, regional and local levels (UNESCO, 2015). Significantly, the SDG's have adopted 'inclusive and sustainable urbanization' and to 'protect and safeguard the world's cultural and natural heritage' for making cities resilient and sustainable (UN, 2015) amongst other adopted goals. However, presently the linkage between cultural heritage and sustainable urbanization to make cities resilient and sustainable is tenuous and its progress is confounded by abstractions in definitions of both culture and sustainability, insufficient empirical evidence and a near absence of integrated conceptual framework (Parr, 2000). This chapter examines this gap through an exploratory study situated in context of pilgrimage towns in India.

Pilgrimage towns in India are characterized by high visitations of pilgrims, which stress the prevailing environmental services and result in degradation of built environment. The need for pilgrimage infrastructure results in urban growth; which, in absence of appropriate planning regulations, threatens cultural and environmental sustainability of the pilgrimage town (Shinde, 2012). Culture-led and event based urban regeneration strategies have been identified as a key theme for urban regeneration (Singhal, McGreal, & Berry, 2013) A recent Government of India scheme - Heritage City Development and Augmentation Yojana (HRIDAY) - recognizes the need to undertake strategic and planned development for sustainable development of heritage cities in India. Most of the cities shortlisted for the scheme involve an element of sacrality and attract pilgrims at varying scales. The scheme envisages to "preserve and revitalize soul of the heritage city to reflect the city's unique character….and facilitate inclusive heritage linked urban development" (Ministry of Urban Development, Government of India, 2015).

This chapter explores the relevance of identifying place-specific cultural characteristics and establish the need for its embedding in urban planning process at pilgrimage towns in India; fundamentally premised on significance of culture for sustainable urban development. The links between cultural characteristics - values, aspirations, activities, processes and patterns of a place, and urban planning are examined at two Hindu pilgrimage towns – Vrindavan and Haridwar - to predicate the relevance of culture to sustainable urban planning at pilgrimage towns in India. The case study towns exhibit congruence in terms of their religious significance, well-regarded sacredness, riverine geography and primacy of pilgrimage - and divergence in terms of presiding deity and associated rituals, cultural vitality, demographic patterns, urbanization trends and urban scale of the town. Briefly, the two selected case-study towns have convergent cultural backgrounds but divergent urban context.

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The inter-linkages between culture, urban planning and sustainable urban development are gleaned from a review of available literature and inquiries during personal visits to the case-study towns. Synthesis of the information contributes towards emergence of a conceptual approach towards theoretically establishing the role of culture in urban planning process for sustainable urban development. The conceptual approach requires additional empirical data for its affirmation, and may have methodological synergies with investigations at similar Hindu pilgrimage towns in India, viz. Varanasi, Mathura, Rishikesh, Chitrakoot etc.

The chapter is organized in four sections wherein Section 1 provides a context to the theme being investigated. Section 2 reviews the inter-relationship between culture, sustainability and urban planning which provides a theoretical narrative supporting inclusion of culture as a major determinant of sustainable urban development. Section 3 briefly reviews distinctive characteristics of Indian urban conditions and pilgrimage towns to contextualize the case studies in a place-specific milieu. It also presents a review of two case study pilgrimage towns in India focussing on their cultural characteristics and synergy with urban planning. Section 4 includes discussions and conclusions, wherein an analysis and interpretation of two case studies lead to identification of attributes for examination of the inter-linkages between culture, urban planning and sustainability.

THEMATIC INTER-LINKAGES BETWEEN CULTURE, URBAN PLANNING AND SUSTAINABILITY

Development divorced from its human or cultural context is growth without a soul. – (Our Creative diversity, UNESCO 1995)

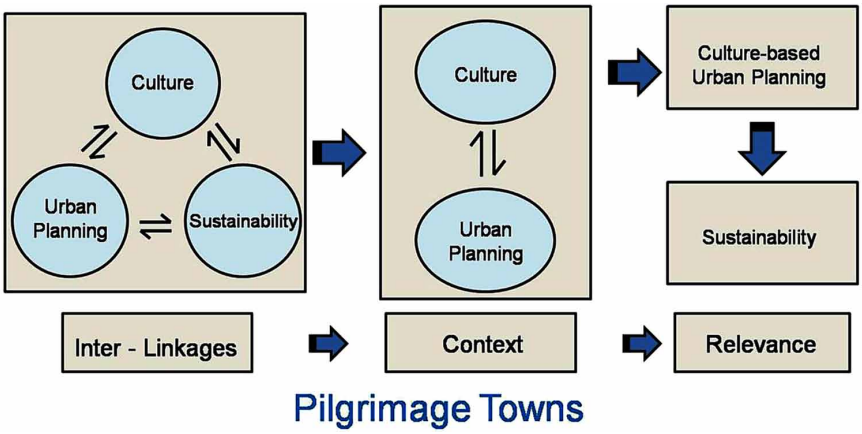
Multiple interpretations of culture necessitate a broad conceptualization of the embodied meaning in context of this study. Accordingly, culture is perceived as a 'way of life' and a way of living together (UNU-IAS and IICRC, 2002), as a generic nomenclature for 'diverse set of activities and pursuits' (Sen, Culture, freedom and independence, 1998) that embodies the following aspects:

- Values and aspirations of the community, or linked to the place;
- The processes and mediums through which the values and aspirations are received and transmitted;
- The tangible and intangible manifestations of these values (Hawkes, 2001);
- Uniqueness of each culture, sensitivity towards the differentiation and respect for it also encourages cultural diversity and heterogeneity (Sen, 1998) (Nadarajah, 2007).

These following sub-sections explore the inter-linkages between the three concepts of 'culture', 'urban development' and 'sustainability', to deduce its implications for urban planning at Hindu pilgrimage towns in India. The theoretical linkages between the three concepts are established by a review of cross-sectorial development literature (Figure 1). Sustainability as conceptualized in the Brundtland Commission Report focuses on the environment and ecological strategies to ensure inter-generational parity. The three recognized pillars of sustainable development include economic development, social justice and ecological responsibility; though their weightages vary and are largely determined by the local context and philosophy driving development. The three pillars are in dialectical tension, and in praxis, sustainable development appears as a shifting adjustment among them (Hawkes, 2001). Earlier,

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Figure 1. Thematic linkages between culture, urban planning and sustainability



the prime determinants were the economic development and its environmental implications, with little consideration of cultural aspects, which was considered as included in the social criteria. The linkage of culture with either sustainability or urban planning and development is still an emerging area of research; with nebulous and meagre structured information available from either global research or praxis (Duxbury & Jeannotte, 2010) (Nadarajah, 2007).

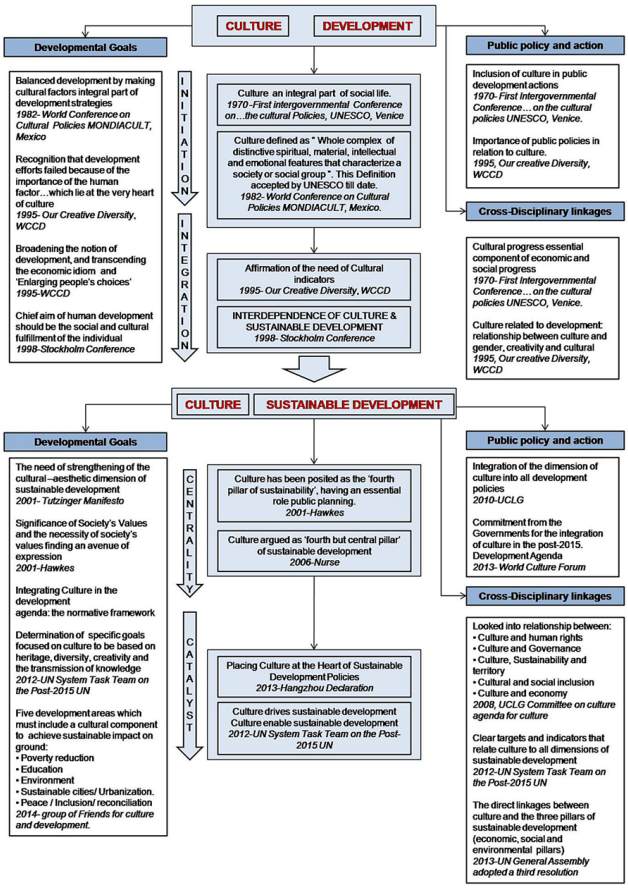
Culture, Development, and Sustainable Development

The inclusion of culture in development is examined from existing literature and structured under three broad themes of development goals, public policy and action and cross-disciplinary linkages (Figure 2). Evidently, the role of culture first gained recognition in the development realm (Bandarin, Hosagrahar, & Albernaz, 2011), and later progressively gathered increasing acceptability in sustainable development domain. Increasing emphasis on human-centric development paradigms led to initiation and progressive integration of culture in sustainable development discourse, and latter sustainable development frameworks. As evidence of increasing theoretical significance, culture is advanced as the 'fourth pillar of sustainability', and its centrality as a catalyst, driver and enabler (UNESCO, 2013) for sustainable development is being acknowledged. The inclusion of culture for sustainable development is supported based on its relevance for:

- "Human capacity expansion" (Sen, 1990), and increasing emphasis of development towards 'enlarging people's choices' (World Commission on Culture and Development, 1996);
- Social and cultural fulfilment of an individual (UNESCO, 1998) perceived as objectives of human development
- Strengthening the cultural-aesthetic dimension of sustainable development (Tutzinger Manifesto, 2001);
- Emphasis on the significance of society's values, and the necessity of its finding an avenue for expression (Hawkes, 2001) and
- Cross-sectorial linkages with disaster resilience and climate change, social development, economic development, peace & reconciliation, environmental sustainability, sustainable urban development (UNESCO, 2013) (UN, 2014), poverty reduction and education (UN, 2014).

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Figure 2. Increasing inclusion of 'Culture' in 'Development' and 'Sustainable Development' discourse



This research envisages culture as a repository of knowledge that helps a society to mediate challenges and positions culture as a resource, capital and capacity inherent in a local situation (Mercer, 2002).

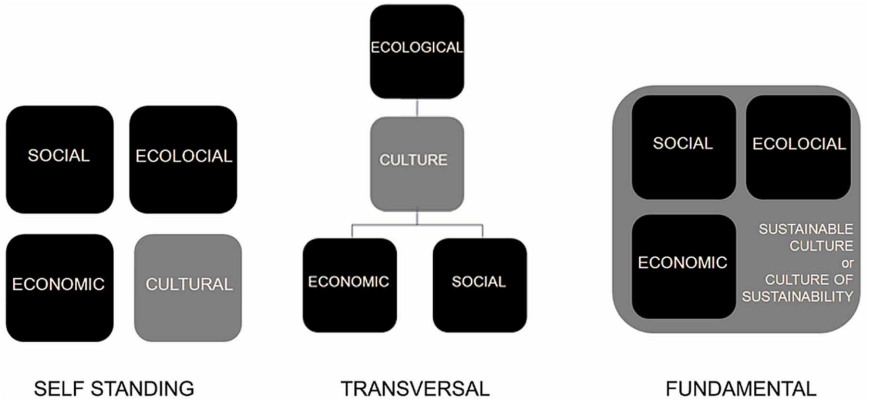
The proposal for inclusion of culture as the fourth pillar of sustainability has led to a theoretical conceptualization of its critical relevance to the prevailing paradigm of sustainable development. This has included positioning of culture as a fourth pillar vis a vis other three pillars in the sustainable development paradigm. Accordingly, three conceptual possibilities of engaging culture with the existing sustainable development framework are conceptualized (Soini, 2013) as below:

- **Self-Standing:** Culture as the fourth pillar of sustainability
- **Transversal:** Culture as a catalyst in sustainable development
- **Fundamental:** Culture as a new paradigm of sustainability (Figure 3).

Concurrently, a wider role of culture in sustainability is also being advanced in the urban development discipline, wherein culture is seen as an invaluable tool for sustainable urban development (UNESCO, 2015).

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Figure 3. Three approaches on role of culture in global sustainable development (Roders, 2013).



Urban Planning and Sustainable Development

Brundtland Commission's report – Our Common Future –places the issue of sustainable development at the core of urban policy and planning concerns (World Commission on Environment and Development, 1987). Complementary assertions of centrality of sustainability to the urban development processes (Berke, 2002) and sustainability initiatives centring on building sustainable cities (Yanarella & Levine, 1992) are indicative of conceptual connect of sustainability with the urban. Yet concentration of urban population and its quest for economic growth has substantial adverse implications of environmental degradation, resource depletion, deteriorating ecosystems and climate change (Dixon, 2011) and the urban planning process grapples for appropriate sustainable responses. In this context, Global Report on Human Settlements focuses on need of a new perspective for urban planning, and begun differently by setting the goal of sustainable urbanization as liveable, productive and inclusive cities, towns and villages (UN-HABITAT, 2009).

Inquiry into antecedents of contemporary urban planning paradigms reinforces need for emergence of new perspectives to deal with contemporary sustainability challenges. The concept of sustainability is historically considered intrinsic to the process of urban planning with implicit theoretical linkages. It has been established that urban settlements were perceived holistically as constituents of a larger eco-system by Alberti, Marsh 1865, Olmstead and Vaux 1887, Patrick Geddes 1915, Mumford 1968, Lynch 1981, McHarg 1969, Jacobs 1961 etc., an aspect that has well been documented by Spirn (2012) for the Anglo-American context (Spirn, 2012). Evolution of contemporary urban planning practices traces its roots in the concepts of modern urban planning in Western Europe in latter 19th century, primarily as a response to the Industrial Revolution. Urban development was perceived as an exercise in design and physical planning of human settlement with complex social, economic or political matters eluding it. At earlier stages, urban planning focussed on improvement of liveability criteria in its spatial territory, and harboured a fixation for the visual. The urban planning concepts of the industrial towns gradually spread the globe through processes of colonialism, market expansion and intellectual exchange; and embedded itself into local planning practices at dispersed location and diverse contexts (UN-HABITAT, 2009). Progressively, urban planning focussed on automobile-centric transportation, landuse and zoning based on spatial segregation of usages, and design standardization. Cities and settlements conforming to

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these urban planning principles were devoid of cultural diversity in response to the local place, values, and context; and alienated the people from their habitat. Tracing these antecedents in the Indian urban experience, Menon strongly advocates professional engagement with specific complexities of traditional Indian urbanism as both a socio-cultural construct and technical entity (Menon, 1999).

In response to this context, "New Urbanism" gained prominence as an alternative to traditional US suburban design in the 1980's. It was presented as a model for sustainable urban development to address wider concerns as placeless sprawl, environmental deterioration, loss of agricultural lands and wilderness and erosion of society's built heritage. Offering spatial planning solutions, it strongly advocated the principles of: i) compact development for preservation of environmentally sensitive areas; ii) infill development to revitalize city centres; interconnected streets friendly to pedestrians and cyclists; iii) mixed land uses rather than single-use pods; iv) discreet placement of garages and parking spaces to avoid auto-dominated landscapes; v) transit-oriented development (TOD); vi) well-designed and sited civic buildings and public gathering places; vii) the use of building and street and building typologies to create coherent urban form; viii) high-quality parks and conservation lands used to define and connect neighbourhoods and districts; and ix) architectural design that shows respect for local history and regional character (Ellis, 2002). Though the sustainability criteria attracted professionals in addressing wider urban planning concerns, evidently the solutions continued to focus on issues concerning the visual urban form. The social, cultural and economic dimensions of sustainable development were either relegated or simply considered beyond the scope of the movement (White & Ellis, 2007).

It becomes important to explore the nature of urbanization and contextualize its wider inter-linkages at varying scales - metropolitan, small urban centre, town, and their surrounding rural area. Mostafavi expands the context of the urban in 'Ecological Urbanism' - a framework that deals with these complex economic, political, social and cultural perspectives through conjoining of ecology and urbanism (Mostafavi, 2010). Sustainable urban development and management is identified as a critical aspect influencing sustainability and crucial to quality of life of people (UN, 2015). As urban development focuses on sustainability, the planning process is required to meet not only the challenges of urban design but also many other social, environmental, economic, health and climate issues.

Culture, Urban Development, and Sustainability

In recognition of cities as active players for promotion of sustainable development and the significance of the urban context therein, culture is increasingly imagined as a key tool for sustainable urban development (UNESCO, 2015). In beginning of 2000, the Kanazawa Initiative examined the role of culture in building sustainable cities at four different Asian countries. The research involved empirical exploration into the nature of urbanization and its linkages with sustainability from a local culture perspective in different cities. Recognition of the varying urban contexts, and sensitivity to the diversity led to evolution of four culture-centric approaches for sustainable urban development (Nadarajah, 2007) that focussed on:

- Internal cultural transformation approach;
- The multiculturalism and enlightened localism approach;
- The urban cultural identity approach;
- The cultural mode of production approach.

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The inter-linkages between culture and sustainable urban development are nebulous in contemporary urban context ((Rana & Piracha, 2007) (White & Ellis, 2007), and requires additional evidence and empirical data for its affirmation. The conceptualization has been recently enunciated and theoretical frameworks or methodologies for conducting research are emergent only. Further empirical research supported by evidence-based case studies in diverse contexts will significantly contribute to establish culture as a tool for sustainable urban development. Examination of the role of culture in urban planning and its relation to sustainable development is emerging as a key area of investigation. In this background, cultural mapping is emerging as a mode of enquiry and methodological tool for diagnosing potential role of culture in the urban planning processes (Evans, 2015). In practice though, culture is seldom used as a key urban development variable, and is characteristically referred in its intersections with other key (economic, environmental, social) development variables.

CHARACTERISTIC INDIAN URBANISM AND PILGRIMAGE TOWNS

Indian urban conditions are characterized by abundant diversity that results from a combination of multiple planning processes and spatial overlapping - vernacular, indigenous urbanism, formal planned and extra-legal 'pirate modernities' (Sundaram, 2010). They distinctly exhibit spatial juxtaposition of the planned and the un-planned (extra-legal) activities in, as theorized - 'static city' and 'kinetic city' respectively (Mehrotra, 2008) (Gupte, Mehrotra, & Shetty, 2010). The static city is usually permanent whereas kinetic city is impermanent, in a realm outside the planning framework, and usually extra-legal. Un-planned activities are a formidable presence in Indian urban conditions and are normally ignored or not included in the formal planning process (Roy, 2009). Largely manifested in the interstitial spaces of a city – road edges, slums and informal settlements the un-planned is constantly in a state of adversarial relationship with the planning process. The need of urban planning to negotiate contrasting urban conditions of neat suburban developments and heterogeneous traditional settlements, city of 'haves' and 'have-nots', automobile and the bicycle etc. has been emphasized (Menon). It is essential to closely assess the nature of Indian urbanism situated in the larger Indian background characterized by heterogeneity, plurality and multiculturalism.

These generic conditions appropriately describe the urban conditions for Indian pilgrimage towns. Both the case studies are constituted of the traditional core of the city, which is culturally vibrant, dense with high numbers of pilgrim visitations and inadequate hygiene and infrastructure. Pilgrimage related activities related to rituals, practices, and ritual offerings like flowers and prasad, accommodation, fooding and transportation, function largely at the periphery of the mainstream planning, informally and extra-legally. However, an inquiry into the indigenous urbanism as manifested in these sacred spaces offers an opportunity of its use as catalysts to revitalize the civic environment. A relevant approach for study of Indian heritage (traditional pilgrimage) towns from a cultural perspective has been postulated in the 'Architectural Knowledge Systems' (Thakur, 2002) that approaches study of Indian historic towns in a people-time-place continuum framework; thus implying an assimilative and holistic enquiry into the anthropological, historical and the geographical narrative of the city. The emergent Indian Cultural Landscape (ICL) is termed as the 'intellectual landscape' - a repository of knowledge, where collective memory, information and imagination shape the landscape (Thakur, 2011). Accordingly, the place may be conceived as an overlay of cultural layers in a temporal perspective, which may be unpeeled distinctively for each settlement.

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Pilgrimage has had a long tradition and continuity as large civil society movement for religious/ spiritual experiences in the Hindu tradition of India (Singh, 2013). The number of pilgrims has increased manifold due to improvement in the communications and transportation system over time. Massive influx of pilgrims coupled with poor environmental infrastructure, lack of hygiene, weak governance apparatus, inadequate awareness, capacities and capabilities of the citizens or governance authorities creates problems related to health, safety and experiential aspects at the pilgrimage town. The resulting transformations are socially and environmentally detrimental for the pilgrimage town and diminish the quality of experience of the pilgrims (Shinde, 2012). Unless timely planned sensitively, the pilgrimage towns fail to offer any significant experience to pilgrims or a liveable quality of life to the residents; the town loses meaning for people and ceases to be sustainable. Aware that religious beliefs and traditions are the raison d'etre of pilgrimage towns; the following section investigates the potential role of culture in urban planning process for sustainable urban development through case studies of two Hindu pilgrimage towns. The methodology includes literature review, observations and unstructured interviews conducted at case study towns to identify cultural characteristics in its intersections with the urban planning, and inter alia sustainability of the urban development process.

Case Study of Vrindavan

Vrindavan is a small town in District Mathura within the administrative division of Agra - a city situated in Western Uttar Pradesh. Administered locally by a municipality, Vrindavan has a population of around 63,000 people distributed in 25 wards. A proposal to include seventeen more villages within the jurisdiction of Vrindavan municipality and its potential upgrade to a level of Municipal Corporation also emerges from information gathered locally during a field visit.

Notionally at centre of the sacred geography of Braj Kshetra (region) circumscribed by 84kos (252kms), Vrindavan is believed to be the place where Lord Krishna spent his early childhood. The cultural identity of Vrindavan is embodied in its religious values being a *dham* – abode of God (Brahmachari, 2011), and an eternal home to the divine Radha-Krishna who are perceived as a living presence in Vrindavan. Lost to the world as a Vrinda (Tulsi) vana (forest) on banks of River Yamuna until Sixteenth century, Vrindavan re-emerged when visited in by Chaitanya Mahaprabhu and Vallabhacharya, famous Vaishnava gurus and proponent of Bhakti movement (Entwistle, 1987). Mahaprabhu and later his disciples – the Chhat (six) Goswamis (priests), physically construed the entire town driven by divine inspiration, vision, consciousness and memory of its association with events in life of Lord Krishna. Largely because of its associative sacredness, Vrindavan soon became a leading centre of pilgrimage, Vaishnavism and Vaishnava learning. Intrinsically steeped in the metaphor of Radha-Krishna, the spiritual culture is the wellspring of many performing art forms like painting, sculpture, theatre, music, braj bhasha (language) poetry and dance. 'Raas Lila', the divine dance signifies unison of God with his devotees and related allegories are favourite themes of prominent classical dance forms all over India. Over six million pilgrims visit the sacred town of Vrindavan annually (Shinde, 2012) which acts as a testimony to the universal significance of the intrinsic cultural values associated with the place.

Vrindavan's spatial growth was predominantly guided by the Goswamis, who as religious heads exercised considerable influence over happenings in the town and region. Contemporary Mughal, Rajput and Jat patrons generously extended donation of land parcels and funding for establishment of Vrindavan as a spatio-cultural-religious town from neighbouring territories. The growth expanded outwards from banks of river Yamuna. Temples, temple precincts, ashrams, dharamshalas (charitable rest houses),

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ghats (stepped bathing places along rivers) and princely estates were constructed with considerable architectural elegance, skill and craftsmanship. In accordance to the traditional and scriptural knowledge, considerable significance and reverence was attached to natural elements such as vanas (sacred groves), kunds (man-made water tanks), river Yamuna and sacred hills.

Architectural appurtenances were evidently employed to enhance beauty and utility of kunds, riverfront, and community-protected groves, forests and hills. The built fabric comprised of considerable architectural heritage (Figure 4) and ritual symbols are largely encompassed within a 10km pradakshina path (circumambulatory route), and part of the inscribed area is declared as a heritage area. The traditional ecological beliefs, sanctity of river Yamuna, and recognition of value and conservation of architectural heritage have been intrinsic to the way of life of the residents'. These values can be potentially leveraged to direct urban planning initiatives for addressing challenges posed by ecological imbalance, environmental degradation, obsolescence of built fabric and deterioration of quality of life of residents.

Collective memory, community values and beliefs underpin the temporal activities of the town, leading to distinct activity patterns and urban morphologies. Faith-driven residents or pilgrims converge at specific temples or river ghats for darshan of deities and/or ritual performances at varying periodicity. Extremely populated during the festivals, events and auspicious cycles of visitation, movement between the significant activity nodes and landmarks usually follow a pattern. Tradition of daily parikrama (circumambulation) along the pradakshina path is also a regular activity with many residents and pilgrims visiting Vrindavan. Pilgrimage movements along these networks present a livelihood option to the residents who develop trade and services' establishments. A mixed landuse pattern emerges with a rich mosaic of activities that impart vibrancy to the place, and simultaneously congests meagre spatial capacity available. Awareness of the temporal spatial patterns of human ritualistic activities and movements at a local area level becomes a significant consideration for urban planning interventions.

Lord Krishna is believed to permanently reside at Vrindavan, and the people reinforce His Grace and living presence by organizing community events and activities regularly. Colloquially Braj is known for celebrating more festivals than days in a year. The festivals, fairs and events are organized at varying scales ranging from a local to global scale and attract participation accordingly. The major congregation amongst others are the annual festivals of Janamashtmi and Holi with a national catchment, recitation of

Figure 4. Built heritage of considerable architectural merit at Vrindavan: the Yamuna riverfront



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Srimad Bhagavatam katha (scriptural discourse) with a regional catchment, and sankirtan (congregational singing of devotional songs with music accompaniment) at local level that occurs daily. The community activities – participants include local populace and visiting pilgrims - are of profound cultural significance for perpetuation of traditions known to contribute positively to the well-being of the community. Temporal patterns of participatory community activities and the imperative to provide accessibility, sufficiency, safety and hygiene for continued enactment of these activities are key considerations for evolving urban planning strategies (Figure 5 & 6). Urban planning in accordance to the existing patterns

Figure 6. Congregational activities at temples



Figure 5. Temporal spatial patterns of pilgrimage activity as at streets leading to temples with prasad shops



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of the community and the pilgrims activities reduces conflicts, and enables not only an enhanced quality of life for the residents but improves the pilgrim experience as well.

Vrindavan has a population of sixty three thousand people in the 2011 census, and a thriving pilgrimage-based cultural economy with about six lac visitors annually. Though most of the earnings accrue to religious actors and institutions, the pilgrimage activity also supports several allied activities, some rooted in traditional cultural economy. The allied activities include carving of stone statues, mukuts (crowns) and decorative clothes for deities, sanjhi and local cuisine amongst others (Figure 7 & 8). Presently, the production is undertaken usually in households informally at disjointed locations. Aggregation of the production activities through spatial planning may foster innovation by peer learning, economies of scale and better connect with the demand side. Thus, mapping of the processes and practices of cultural economy and assessment of its potential to generate sustainable livelihoods is an important component of urban planning initiative.

Numerous NGO's and community-based organizations related to tradition-based cultural domains have emerged to address divergent issues in Vrindavan. These issues primarily include revitalization of the holy river Yamuna and its ghats, conservation and restoration of built heritage, facilitating and promoting pilgrimage and community activities, propagation of traditionally community activities like sankirtan, Srimad Bhagavatam katha, revitalization of pradakshina path (circumambulation route), innovation and promotion of local arts and crafts, veneration and protection of cow and promoting traditional cow-based economy. A few of these organizations are crucibles of local practices and repositories of traditional knowledge; and are immense resource for cultural mapping and interpretative efforts. Local spiritual leaders and influential citizens, with urban development concerns usually place-based and local, patronize numerous significant organizations. A few enjoy easy access to the decision makers and exercise considerable influence on the residents and non-residents from across the globe. The significant

Figure 7. Spatial patterns of production and access to cultural products as decorative clothes for deities



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Figure 8. Mukut (crown) making for deities



numbers and outreach of these organizations presents a medium with a high capacity for mediation of local issues with official urban planning process. The participation of these organizations in urban planning framework can impart considerable insights in arriving at development objectives of local community in response to the needs and aspirations of their communities. There is a serious disquiet over the sporadic urban development in response to endogenous triggers and an inclusion of all stakeholders in the development process can potentially render the framework sustainable.

To sustain and enhance the rich cultural and historical significance through urban and spatial planning process, Uttar Pradesh Urban Planning and Development Act, 1973 mandates the Development Authorities for preparation and implementation of the master and the zonal plans. Vrindavan is regulated by the Master Plan 2021 that recommends the conservation of ancient religious, cultural and archaeological buildings, areas and precincts. The master plan delineates a heritage zone that includes built heritage and the cultural precincts in view of specific cultural considerations (MVDA, 2009). The heritage zone falls in the municipal area, and under the administrative jurisdiction of the municipality. Special development controls and guidelines are recommended in the building byelaws for physical development in the heritage zone. Zonal plans are mandated to include specific spatial recommendations for development of site plans and use/activity plans for achieving objectives envisaged in the master plan. The zonal plans for Vrindavan are not yet formulated, and thus the objectives envisaged in the master plan are under achieved.

The Vrindavan Eco-city project highlighted the people's concern about protection of cultural and traditional values (Kulshrestha, 2007); and field interactions reveal a real desire for engagement with the cultural aspects by the authorities as well. However, the role of the state witnesses a multitude of implementation agencies (Shinde, 2012), wherein overlapping responsibilities and jurisdictions are barriers in holistic fulfilment of objectives envisaged in master plan. Coherent action is also constrained by a lack of capacity and expertise in the prevailing planning system to evolve context specific urban

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planning strategies. Vrindavan Eco-city project concluded that a participatory approach to planning and development appeared replicable.

It is thus gleaned that richness of traditions and cultural practices finding expression through the urban planning process is circumvented due to disregard of the cultural dimension in implementation tools viz. master/zonal plan, urban planning laws, planning regulations and conflicting institutional responsibilities. It is also implicit that culturally aware state, institutions and citizenry, conscious of traditional values accorded to the river Yamuna, hills forests, sacred groves, water bodies, temples etc.; are better positioned to imagine potential contribution of indigenous urbanism towards contemporary urban development. A cultural orientation is required for capacity building of individuals and institutions to understand and sustain the embedded patterns of urbanism as cultural expressions, and leverage them as catalysts to advance a sustainable urban development trajectory.

Case Study of Haridwar

Haridwar is an ancient tirtha, a sacred geography and one of the seven sacred cities that offer moksha (salvation) according to the Skandpurana. The region is known as Kedarkhand – the abode of Kedar (Lord Shiva); and the legendary association is reinforced by the presence of Daksha Mahadeo's temple at Kankhal (near Haridwar), earlier known in legends as Prajapati Daksha's capital. As suggested by the Puranas, Haridwar is the site for Bhagirathi's penance, which led to the descent of (river) Ganga. An event of immense cultural significance in the national consciousness, a sketch depicting the descent of river Ganga was enshrined in the Indian Constitution reinforcing its significance. Earlier known variously as Mayapur, Kapilasthana, it is called Har-dwar (gateway to Shiva) by the Saivites and Hari-dwar (gateway to Vishnu) by the Vaishnavites. Puranas and Mahabharata confirm the sanctity of Haridwar, and as a paramount pilgrim destination, its appeal has been non-sectarian and supra regional.

The importance of Haridwar centres on sacrality and reverence accorded to river Ganga that finds frequent mention in the scriptures. Devotees address the river as Ganga Maa (mother) and venerate her. The river is identified as an embodiment of sacredness, and its holy water is known to offer moksha – freedom from the cycles of birth and death. River Ganga descends to the plains at Haridwar flowing between two hills – 'neel' and 'bilwa', and is also known as the 'Gangadwar' - dwar (gateway) to a network of sacred pilgrimage spots in the Himalayas – Kedarnath, Badrinath, Gangotri and Yamunotri. Natural scenic beauty, enchanting ghats, picturesque sites, Sivalik forests, mandirs, ashrams and akharas have long been a primary attraction for pilgrims and travellers. Haridwar is a centre for traditional learning and ayurvedic knowledge, is home to erudite scholars and sanyasis of many orders. It also hosts Kumbh mela (fair) - a religious event of utmost national significance - every twelve years, with an approximate 30-50 million pilgrims visiting Haridwar during Kumbh mela in 2010. Kumbh mela is organized in an area equivalent to 130sq.kms extending much beyond Haridwar.

Situated at the right bank of river Ganga, Haridwar was earlier an area of wilderness that attracted pilgrims primarily for religious activities. It was known as 'Tapovan' - a meditational retreat - and scarce physical growth or development maintained its serenity. The sanctity attracted many seekers and devotees to the place, and livelihoods were organized strictly on basis of Vedic tenets. Mayapur – earlier prevalent name of Haridwar - was known as a riparian settlement and River Ganga was considered sacrosanct and worshipped. The physical location of earliest Mayapur is uncertain and is conjectured by findings from archaeological remnants, interpretation of texts and descriptions left by travellers. Rituals were conducted in 'purnyashalas' (charitable establishments) at Haridwar constructed by the wealthy patrons or kings

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and resided at ashrams or dharamshalas at Kankhal or Jwalapur located close to Haridwar. Core of the traditional town at its present location is believed to have developed over ruins of an earlier settlement, though scarce evidences are available of the antiquity and architectural heritage.

Morphologically, Haridwar has evolved along the river Ganga on the land at its right bank and the adjacent 'Neel' parbat (hill). The growth of the town is guided by constraints in the availability of land, being bound by presence of river Ganga and 'Neel' on opposite sides. The spatial patterns in the traditional core area evolved linearly in response to its geography (Figure 9), and ritual and pilgrimage cycles; with the riverfront comprised of ghats assuming significance as hub of the town. Importantly, main worship and ritual areas developed along the riverbank and supporting livelihoods emerged within this area. Dharamshalas (charitable rest houses) were built along the river, and provided independent ghats and ritual bathing areas for the residents. Consequently, a mixed land use emerged at the traditional pilgrimage core that supported residential, commercial and religious activities. The number of pilgrims and their ritual and non-ritual activities exhibit variations in magnitude based on three temporal cycles i) The daily performance, ii) Performances during the auspicious occasions and festivals and iii) Every six years during the Kumbh/Ardh-Kumbh festival.

The cultural identity of Haridwar as a traditional centre of ritual-pilgrimage converges around river Ganga (Figures 10 and 11), and now mutated to a populous, physically dense, amorphous urban settlement with juxtaposition of varied activities – ritual, pilgrimage, livelihoods and trading in same urban space. The core pilgrimage area is proportionately insignificant to the spatial expanse of the town, and experiential aspects of the pilgrims' are qualitatively diminished. The unplanned transformations of built fabric, change in usages and activities, and lack of environmental services in the core ritual-pilgrimage area results in an unsustainable physical environment leading to gentrification from the traditional core.

Figure 9. Linear morphological spatial growth along the river visible at riverfront of River Ganga at Haridwar



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Contemporary urban development subsumes the indigenous patterns of urbanism, and traditional identity of Haridwar as a pilgrim town is being progressively obliterated.

Presently, Haridwar town is headquarter of Haridwar district and is comprised of three tehsils. The current population of Haridwar urban agglomeration exceeds three lacs in 2011 census and continues to exhibit significant growth rates. Current developments include housing and commercial development at the periphery of the core area, and an industrial estate in proximity; resulting in heterogeneity of activities compounded with diluted emphasis on traditional ritual-pilgrimage based activities.

Pilgrimage is prime cultural activity that contributes to the local economy. Religious actors and organizations benefit directly by the economic support and donations by the pilgrims, whereas immense indirect benefits accrue to other stakeholders in catering to pilgrims' requirements of accommodation, travel etc. Religious tourism and other tourism activities have also proliferated. Other heterogeneous economic activities like manufacturing have also developed; hence, direct benefits of cultural economy are relegated to relative insignificance. It is significant however, that cultural products are symbols to link memories to a place; and its high associative value be favourably considered to promote spatial provisions in urban planning.

Prominent NGOs, community based organizations active in the cultural domains focus on varying issues of making the Ganga clean, facilitating performance of traditional rituals, promotion of afforestation and conservation of forests, protection of natural heritage – flora and fauna, and protection of built heritage. Few large social and quasi-religious organizations are involved in research and synthesis of aspects related to traditional knowledge and local practices, and are potential resources for cultural mapping. Most organizations view the contemporary urban development as driven more by concerns of economic development that is evidently at crossroads with the cultural values of society. They stress on

Figure 10. Cultural identity of Haridwar as a pilgrimage town centred on River Ganga exemplified by ritual bathing in River Ganga



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the critical need for mechanisms to integrate the embodied knowledge of the community, and mediation of cultural and traditional practices in the urban planning paradigm.

The urban and spatial planning processes to sustain the rich cultural and historical heritage of Haridwar are mandated through formulation of Master Plan. Additionally, 'A City Development Plan (CDP)' focussing on the municipal area in Haridwar was prepared under the ambitious Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2007. The Haridwar Master Plan 2025 recommends cognisance of cultural aspects related to the historic-religious aspects of Haridwar in framing objectives for its future urban development. The vision statement of CDP Haridwar envisages it as a 'city of Hope, faith and Spirituality…an international destination of pilgrimage and tourism, in keeping with its rich cultural heritage' (GHK International, UK, 2007). Concurrently, Haridwar is identified as a potential site for urbanization and industrial growth due to availability of flat terrain in the hilly state of Uttarakhand. The urban planning and development strategies and policies are more reactive to existing urban situation with negligible evident efforts to centre-stage cultural aspects despite recognition of their primacy for urban growth.

To reinforce traditional identity in this transformed scenario, potential contribution of indigenous spatial patterns evolved through traditional spiritual-pilgrimage based cultural activities needs understanding as an important consideration in urban planning domain. Identification of activity patterns corresponding to the local activities and events and its inter-linkage with activity nodes emergent spatial patterns and the temporal variations are imperative for facilitation of traditional ritual-pilgrimage activities that are critical for reiteration of cultural identity of people. In view of the identified development objectives and context of accelerated urban growth, it is critical for urban planning initiatives at Haridwar to recognize the significance of the cultural values inherent in the city, spatial patterns of cultural activities, architectural heritage and ecological aspects of physical growth.

Figure 11. River Ganga being venerated as a symbol of purity



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DISCUSSIONS AND CONCLUSION

This chapter explores potential of cultural characteristics of a place to inform urban planning domain for evolving sustainable trajectories of urban development for pilgrimage towns in India. Theoretical linkages between the three variables gleaned from literature advocates inclusion of cultural aspects in urban planning considerations as critical for sustainable urban development – a learning well advised for sensitization of planning professionals. Integrative frameworks to empirically evaluate potential contribution of culture to urban planning may be theoretically situated in existing frameworks for examining contribution of culture to a wider development processes.

UNESCO has developed an analytical framework to explain and quantify how culture contributes to development processes, wherein direct references to urban planning processes are absent. It identifies twenty-two indicators from seven dimensions to elucidate on linkages between culture and development; and data is being generated in seventeen countries (UNESCO, 2011). Spain has developed a strategy for culture and development cooperation, which identifies a theoretical framework to include principles, approaches and concepts guiding the cooperation. It also envisages regulatory, institutional, methodological, instrumental and implementation frameworks within the scope of its strategy (AECID, 2007). Information from similar such interventions need to be cumulated to deduct its potential linkage to the urban planning and potential impact on sustainability issues. Paucity of empirical studies focussing on potential contribution of culture to the urban planning and sustainability domains renders formulation of integrated cooperation strategies elusive. Conducting empirical field studies and gathering evidence of inclusion of cultural dimensions in urban planning process to produce a sustainable development trajectory offers substantial research opportunities in varying urban and cultural contexts.

In contemporary Indian urban scenario, Jawaharlal Nehru National Urban Renewal Mission (JNNURM) initiated by the Government of India in 2005 conveys the intent to engage with Indian urbanism, and included urban planning interventions within its scope indirectly. Significantly, the criteria for selection of the towns eligible for funding under JNNURM scheme included cities/urban agglomeration of religious, historic or tourist importance. It is noticeable that a supplement Heritage toolkit (JNNURM, 2006) was prepared as an afterthought in cognisance of the specific cultural requirements for preparation of the City Development Plan (CDP) envisaged in the scheme. Similarly, a recent Government of India scheme - Heritage City Development and Augmentation Yojana (HRIDAY) - recognizes the need to undertake strategic and planned development for sustainable development of heritage cities in India. Two above schemes convey implicit priority accorded by the Government of India to engage with indigenous urbanism at heritage cities.

This chapter attempts to bridge theoretical gaps in examining potential contribution of culture to urban planning processes for achieving a trajectory of sustainable development by initiating a conceptual approach to advance the intent. Timely in the context of recent Government of India schemes (HRIDAY), a study of these linkages is confounded by challenges faced in engagement with indigenous Indian urbanism characterized by hybridity, plurality and informality. Empirical studies exploring the linkages between three variables viz. culture, urban planning and sustainable urban development in Indian cities are extremely rare, and sketchy where available.

This study examines the linkages to assess conceptually the potential role of culture in urban planning process at two existing pilgrimage towns in India – Vrindavan and Haridwar - and its influence on sustainability. Prime cultural characteristics of both the case studies are closely linked to their homogenous Hindu identity, and in being significant pilgrimage destinations. The primacy of deities - Krishna in Vr-

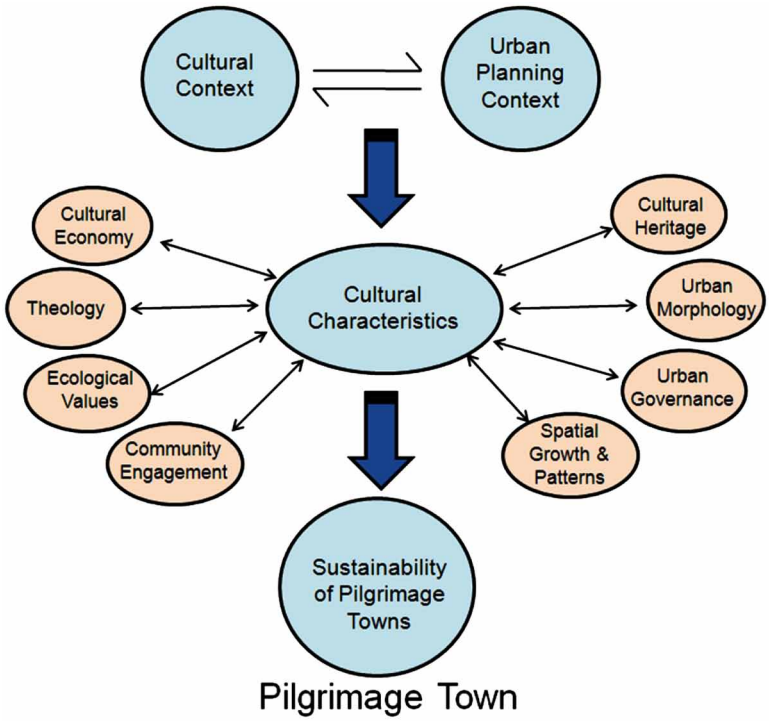
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indavan and Ganga in Haridwar – result in diversity of beliefs, rituals and activities. Religious and ritual activities are raison d'etre of pilgrim towns - hinging on Parikrama (circumambulation) and visitations to temples in Vrindavan, and on a holy dip in river Ganga at Haridwar. The legends of Lord Krishna's life have found expression in various cultural forms viz. dance, drama etc. which are performed and participated en-masse by the community and visitors in Vrindavan whereas Haridwar was predominantly known for being a taposthali steeped in asceticism.

The diversity of the belief system and concomitant activities, varying geographical settings, activity nodes and their inter-linkages resulted in evolution of varying spatial and morphological patterns at the two towns. Keeping in perspective the diversity in the manifest natural, urban and cultural contexts and variance in their interface with the urban planning and sustainability domains, the study evolves a conceptual approach for inclusion of culture characteristics leading to sustainable urban development of pilgrim towns.

The case studies identify eight diverse attributes significant for examination of the linkage between the cultural dimension of pilgrimage towns with urban planning and sustainable urban development. The identified attributes are urban morphology, spatial growth, theological values, ecological values, urban governance, community engagement, cultural heritage and cultural economy (Figure 12). Prima facie, the case studies also reveal that the inter-relation between the three variables is itself not static; and temporal, positional and structural transformations therein can be analysed through careful analysis of the eight attributes. Similarly, in spite of broad similarities in cultural attributes of the case studies, the inter-relationship varies in its causality at the two towns. Accordingly, inclusion of culture in urban

Figure 12. Attributes reflecting linkages between culture, urban planning and sustainable development



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planning domain anticipates advancing a flexible framework for sustainable development, wherein the dynamic inter-relationships between variables continue on the sustainable trajectory.

Case studies at Vrindavan and Haridwar reiterate the need of additional research and empirical evidence to examine the ingenious urban linkages with other Hindu pilgrimage towns like Varanasi, Rishikesh, and Mathura etc. to establish a spectrum of indigenous urbanisms and establish conclusively inter-linkages between culture, urban planning and sustainable development.

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Chapter 9
Application of Soft Computing Techniques for Renewable Energy Network Design and Optimization

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ABSTRACT

Energy operation can be characterized by its complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network has provided the great flexibility for energy transformation and transportation; meanwhile, it presents a complex task for conducting agile energy dispatching when extreme events have caused local energy shortages that need to timely be restored. One of the useful methodologies to solve such a problem is soft computing, which conducts collaboration, association, and complementariness of the different techniques that integrates them. The applications and developments of soft computing have amazingly evolved in the last two decades. Many of these applications can be found in the field of renewable energy and energy efficiency where soft computing techniques are showing a great potential to solve the problems that arise in this area. In this chapter, several soft computing techniques are briefly introduced. Then the methodology framework and implementation procedures are presented to demonstrate the application of artificial neural networks and curve fitting for renewable energy network design and optimization, which has the capability to handle restoration during extreme and emergency situations with uncertain parameters.

INTRODUCTION

Nowadays energy supply is characterized by its diversity, including traditional energy such as fossil fuels, nuclear power, as well as renewable energy such as solar, hydroelectric, geothermal, biomass, and wind energy. It involves a complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network does provide the great flexibility for

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energy transformation and transportation; meanwhile, it presents a complex task for conducting agile energy dispatching when extreme events have caused local energy shortages that need to be restored timely. The design and optimization of energy network needs to investigate the environment impact of current power plants in order to replace the fuel combustion method with renewable energy facility and integrate the consideration of the energy restoration during the emergency situation of regional shortage.

The energy network optimization actually involve a lot of factors such as climate change trend, regional energy demand forecast and regional environment impact assessment of traditional power plant operation with fuel combustion. The modeling and optimization to reversely determine the dynamic emission rate and search for the optimal energy restoration is always a high nonlinear multi-objective MINLP (Mixed Integer Nonlinear Programming) problem, which is difficult to solve with current deterministic MINLP solvers. Thus, the solving algorithm of multi-objective genetic algorithm (MGA) will be a good choice. MGA can directly obtain Pareto frontier of the raised two objectives from all possible patterns under different optimal scenarios. Furthermore, since the entire local area might be investigated, the whole region needs to be partitioned into a large number of grid cells and energy condition and its impact of each cell will be calculated. Thus, the optimization will involve lots of simulations, causing the simulation duty during the optimization is very heavy. All these operations are full of uncertain situations.

Facing these challenges, decision makers often encounters various uncertainties that inevitably influence the performance of a being designated energy dispatch plan. The uncertainties can upset the optimality and even the feasibility of the dispatch plan. Thus, quantitative analysis on the impact of uncertainties is of great significance for the study of energy network optimization. Technically, a viable approach is to conduct a full evaluation of the effects of uncertainties based on all their possibilities. This will provide decision makers a complete roadmap of the space of uncertainty parameters. Through this way, the objective function and the optimization parameters are represented as functions of uncertainty parameters (i.e., parametric programming); meanwhile, the regions in the space of the uncertainties characterized by these functions can be obtained. Therefore it is very useful for the stake holders to apply spatial and temporal predictive analysis techniques during the optimization of energy network operation. Among them, the soft computing techniques and artificial neural networks can be adopted to achieve the above purpose.

SOFT COMPUTING TECHNIQUES

Soft computing is a term applied to a field within computer science which is characterized by the use of inexact solutions to computationally hard tasks such as the solution of NP-complete problems, for which there is no known algorithm that can compute an exact solution in polynomial time. Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind. In computer science and related fields, artificial neural networks (ANNs) are computational models inspired by animals' central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition. They are usually presented as systems of interconnected "neurons" that can compute values from inputs by feeding information through the network. These techniques have a very wide application (Ganesan, Elamvazuthi, Shaari, & Vasant, 2013; Elamvazuthi, Vasant & Ganesan, 2013; Vasant, 2013; Ganesan, Vasant, & Elamvazuthi, 2013; Ganesan, Elamvazuthi, Ku Shaari, & Vasant, 2013)

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With the help of information technology, the spatial and temporal data are more than ever before. The environment monitoring for weather forecasting are typical spatial and temporal data. They have brought bring new challenges and opportunities to the research area of data analysis and intelligence solution. More predictive patterns should be identified from the integration of space and time dimensions in order to solve real-world problems. In real world, massive data volume are always available with uncertainty, complex relationship, and system dynamics. Spatial and temporal analysis has become one section of data mining (Fayyad, Piatetsky-Shapiro & Smyth, 1996). It has become interdisciplinary research field of computer science (ACM SIGKDD, 2006; Clifton, 2010; Hastie, Tibshirani & Friedman, 2009). which apply computation to identify and predict patterns from available large data sets. The applied methodologies or techniques include artificial intelligence, statistics, predictive analysis, information technologies, machine learning, and database systems (ACM SIGKDD, 2006). It aims to extract information from a data set and transform it into an understandable structure for further use (ACM SIGKDD, 2006). Besides data analysis, spatial and temporal analysis system also needs to integrate database, data management, data pre-processing, modeling and interpretation, complexity assessment, post-processing, visualization, and real time updating (ACM SIGKDD, 2006). All these are combined together computer decision support system. The tremendous information in the present age requires more accurate and comprehensive awareness in real time to enhance decision making. The critical part is to identify the particular points of area where critical decisions may be made, where the future may be predicted, and where the decision makers' abilities to manage their organizations may be enhanced.

The fast progress in the research has made the advanced techniques available for predictive analysis integrated with forecasting, modeling, and time series characterization, presenting identified patterns interactively, and finally, validating analytical models using real-world historical data which can be used for a range of applications ranging from intelligent alarms to monitoring and interpretation of trends in marketing systems. This convergence of interdisciplinary techniques for attuning adaptive models to specific application domains has brought the state of practice closer to the goal of developing models that are both predictive and explanatory. In order to support the prediction and analysis, a lot of techniques for regression analysis has been developed, such as the linear regression and ordinary least squares regression. The performance of regression analysis depends on the data generating process. The assumptions are made about this regression process. Regression models for prediction are often useful even when there are a lot of available data information. During the baby period of regression, it was called only "least squares"(Legendre, 1805; Gauss, 1809;Guass, 1821 & 1823; Mogull, 2004) Legendre The method is applied to solve the problem of determining from astronomical observations, the orbits of bodies about the Sun (mostly comets, but also later the then newly discovered minor planets).Afterwards, the regression techniques have been developed by multiple persons (Mogull, 2004; Galton, 1989; Galton, 1877; Galton, 1885; Yule, 1897; Pearson, Yule, Blanchard & Lee, 1993; Fisher, 1922; Fisher, 1954; Aldrich, 2005; Rodney, 2006). Due to their effort, regression methods are still at the status of active research. In recent decades, there appears new methods to handle robust regression, correlated responses, time series and growth curves, curve regression, image regression, graph regression, complex data objects, missing data, nonparametric regression, the predictor variables with error, more predictor variables than observations, and causal inference. On the other hand, the development of modeling with uncertainty is also very fast. It is very useful to make a full-scale evaluation of the effects of uncertainties based on all their possibilities. This will provide decision makers a complete investigation of the space of uncertainty parameters. Through this way, the objective function and the optimization parameters are represented as

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functions of uncertainty parameters (i.e., parametric programming); meanwhile, the regions in the space of the uncertainties characterized by these functions can be obtained. In the field of parametric programming for handling uncertainties, Gal and Nedoma (Gal & Nedoma, 1972) developed an algorithm to solve multi-parametric linear programming problems based upon the Simplex algorithm. Acevedo and Pistikopoulos (Acevedo & Pistikopoulos, 1999) extended the field of parametric programming to address multi-parametric mixed-integer linear programs, and Dua, Bozinis and Pistikopoulos (Dua, Bozinis & Pistikopoulos, 2002) made significant contributions in the area of multi-parametric mixed-integer quadratic problems. Acevedo and Salgueiro (Acevedo & Salgueiro, 2003) presented a novel algorithm for the solution of convex multi-parametric nonlinear programming problems. More studies have also been reported in this area from Acevedo and Pistikopoulos (Acevedo & Pistikopoulos, 1997a; Acevedo & Pistikopoulos, 1997b); Ryu, Dua, and Pistikopoulos (Ryu, Dua & Pistikopoulos,2004); Jia and Ierapetritou (Jia & Ierapetritou, 2006a & 2006b); Verderame and Floudas (Verderame & Floudas, 2009). Therefore the combination of temporal and spatial analysis techniques with modeling under uncertainty will definitely extend the capability and capacity of energy network optimization.

APPLICATION OF SPATIAL AND TEMPORAL ANALYSIS FOR RISK ASSESSMENT, OPTIMIZATION AND DECISION MAKING ON ENERGY NETWORK OPERATION

The design and optimization of energy network operation needs to predict the potential demand trend, integrate the consideration of the energy restoration during the emergency situation of regional shortage and investigate the environment impact of current power plants in order to replace the fuel combustion method with renewable energy facility and. These will always involve large scale data and information systems. The application of spatial and temporal analysis for energy network operation will definitely helps to achieve these targets. The detailed description of their potential application will be provided as below.

Prediction of Energy Demand

Right now the techniques of modeling to predict or forecast energy demand has been available. According to Energy Demand Forecast Methods Report provided by California Energy Commission(California Energy Commission, 2005), in order to develop energy policies that conserve resources, protect the environment, ensure energy reliability, enhance the state's economy, and protect public health and safety, the Energy Commission is directed by Public Resources Code (PRC) Section 25301 to conduct regular assessments of all aspects of energy demand and supply. These assessments serve as the foundation for analysis and policy recommendations to the Governor, Legislature, and other agencies in the *Integrated Energy Policy Report (Energy Report)*. The Energy Commission's demand forecasting methodology features a variety of different models that follow into three large groupings: annual electric and natural gas consumption models and an electric hourly load model by sectors (or types of consumers). In most sectors, the Energy Commission's methodology attempts to simulate individual energy use decisions as they pertain to end use energy services. Examples of energy services are the comfort derived from a heated home, the clean dishes from a dishwasher, the illumination from a light fixture, and the evaporation of water from pulp in a paper making machine. Energy in the form of natural gas, electricity (or

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other fuels) operates machinery to produce the service derived. Therefore, energy demand is a derived demand, not a direct one. End use energy consumption estimates can be developed from the application of analytical engineering techniques and econometric techniques for extracting information from customer use data. Early generation end use models were developed using largely engineering methods. As better data became available, disaggregate econometric techniques were incorporated. The advantage of end use modeling over other forecasting techniques is the ability to explain more fully how energy is actually used and factors affecting change in energy use. For example, the Energy Commission staff uses models involving different levels of end use detail to characterize the manner in which efficiency programs affect both energy requirements and peak demand.

Besides each state's development of its specific forecast model based on its own situation, United States Energy Information Administration (United States Energy Information Administration, 2009) also provides national wide standard modeling system, the National Energy Modeling System(NEMS). According to United States Energy Information Administration (United States Energy Information Administration,2009), the National Energy Modeling System (NEMS) is a computer-based, energy-economy modeling system of U.S. through 2030. NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS was designed and implemented by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE).

NEMS is used by EIA to project the energy, economic, environmental, and security impacts on the United States of alternative energy policies and different assumptions about energy markets. The projection horizon is approximately 25 years into the future. The projections in Annual Energy Outlook 2009 (AEO2009) are from the present through 2030. This time period is one in which technology, demographics, and economic conditions are sufficiently understood in order to represent energy markets with a reasonable degree of confidence. NEMS provides a consistent framework for representing the complex interactions of the U.S. energy system and its response to a wide variety of alternative assumptions and policies or policy initiatives. As an annual model, NEMS can also be used to examine the impact of new energy programs and policies.

Energy resources and prices, the demand for specific energy services, and other characteristics of energy markets vary widely across the United States. To address these differences, NEMS is a regional model. The regional disaggregation for each module reflects the availability of data, the regional format typically used to analyze trends in the specific area, geology, and other factors, as well as the regions determined to be the most useful for policy analysis. For example, the demand modules (e.g., residential, commercial, industrial and transportation) use the nine Census divisions, the Electricity Market Module uses 15 supply regions based on the North American Electric Reliability Council (NERC) regions, the Oil and Gas Supply Modules use 12 supply regions, including 3 offshore and 3 Alaskan regions, and the Petroleum Market Module uses 5 regions based on the Petroleum Administration for Defense Districts.

Baseline projections are developed with NEMS and published annually in the Annual Energy Outlook (AEO)(United States Energy Information Administration, 2009). In accordance with the requirement that EIA remain policy-neutral, the AEO projections are generally based on Federal, State, and local laws and regulations in affect at the time of the projection. The potential impacts of pending or proposed legislation, regulations, and standards¾or of sections of legislation that have been enacted but that require implementing regulations or appropriations of funds that have not been provided or specified in

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the legislation itself¾are not reflected in NEMS. The first version of NEMS, completed in December 1993, was used to develop the projections presented in the Annual Energy Outlook 1994. This report describes the version of NEMS used for the AEO2009.1 The projections produced by NEMS are not considered to be statements of what will happen but of what might happen, given the assumptions and methodologies used. Assumptions include, for example, the estimated size of the economically recoverable resource base of fossil fuels, and changes in world energy supply and demand. The projections are business-as-usual trend estimates, given known technological and demographic trends (United States Energy Information Administration, 2009).

NEMS can be used to analyze the effects of existing and proposed government laws and regulations related to energy production and use; the potential impact of new and advanced energy production, conversion, and consumption technologies; the impact and cost of greenhouse gas control; the impact of increased use of renewable energy sources; and the potential savings from increased efficiency of energy use; and the impact of regulations on the use of alternative or reformulated fuels(United States Energy Information Administration, 2009).

In addition to producing the analyses in the AEO, NEMS is used for one-time analytical reports and papers, such as An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook,2 which updates the AEO2009 reference case to reflect the enactment of the American Recovery and Reinvestment Act in February 2009 and to adopt a revised macroeconomic outlook for the U.S. and global economies. The revised AEO2009 reference case will be used as the starting point for pending and future analyses of proposed energy and environmental legislation. Other analytical papers, which either describe the assumptions and methodology of the NEMS or look at current energy markets issues, are prepared using the NEMS. Many of these papers are published in the Issues In Focus section of the AEO. Past and current analyses are available at http://www.eia.gov/oiaf/aeo/otheranalysis/aeo_analyes.html.

NEMS has also been used for a number of special analyses at the request of the Administration, U.S. Congress, other offices of DOE and other government agencies, who specify the scenarios and assumptions for the analysis(United States Energy Information Administration, 2009). Some recent examples include:

- *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*,[3] requested by Chairman Henry Waxman and Chairman Edward Markey to analyze the impacts of H.R. 2454, the American Clean Energy and Security Act of 2009 (ACESA), which was passed by the House of Representatives on June 26, 2009. ACESA is a complex bill that regulates emissions of greenhouse gases through market-based mechanisms, efficiency programs, and economic incentives.
- *Impacts of a 25-Percent Renewable Electricity Standard as Proposed in the American Clean Energy and Security Act*,[4] requested by Senator Markey to analyze the effects of a 25-percent Federal renewable electricity standard (RES) as included in the discussion draft of broader legislation, the American Clean Energy and Security Act.
- *Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues*,[5] requested by Senator Sessions *to* analyze the environmental and energy efficiency attributes of diesel-fueled light-duty vehicles (LDV's), including comparison of the characteristics of the vehicles with those of similar gasoline-fueled, E85-fueled, and hybrid vehicles, as well as a discussion of any technical, economic, regulatory, or other obstacles to increasing the use of diesel-fueled vehicles in the United States.

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- *The Impact of Increased Use of Hydrogen on Petroleum Consumption and Carbon Dioxide Emissions*,[6] requested by Senator Dorgan to analyze the impacts on U.S. energy import dependence and emissions reductions resulting from the commercialization of advanced hydrogen and fuel cell technologies in the transportation and distributed generation markets.
- *Analysis of Crude Oil Production in the Arctic National Wildlife Refuge*,[7] requested by Senator Stevens to access the impact of Federal oil and natural gas leasing in the coastal plain of the Arctic National Wildlife Refuge in Alaska.
- *Energy Market and Economic Impacts of S.2191, the Lieberman-Warner Climate Security Act of 2007*,[8] requested by Senators Lieberman, Warner, Inhofe, Voinovich, and Barrasso to analyze the impacts of the greenhouse gas cap-and-trade program that would be established under Title I of S.2191.
- *Energy Market and Economic Impact*s of S.1766, the Low Carbon Economy Act of 2007,[9] requested by Senators Bingaman and Specter to analyze the impact of the mandatory greenhouse gas allowance program under S.1766 designed to maintain covered emissions at approximately 2006 levels in 2020, 1990 levels in 2030, and at least 60 percent below 1990 levels by 2050.

Therefore, it can be seen that the spatial and temporal analysis techniques have already been widely used to develop regional wide or even national wide energy modeling system. They really help to predict the potential demand under different scenarios of uncertain situations.

Energy Network Restoration Under Emergency Situation (Cai, Zhao, & Xu, 2012)

In recent years, the increasingly frequent occurrences of extreme events, such as U.S. southern storm and tornado (2011), Japan earthquake and tsunami (2011), and India power shortage (2010), have rang the world an alarm on reexamining whether current rescue policies are effective or efficient enough for a speedy recovery of the suffered areas. These disasters have caused tremendous damages to local areas in terms of economy, people's health and safety, transportation, as well as the energy and the living infrastructures. To restore the functionality and capability of these damaged systems, the recovery of energy system is one of the most important because all the other recovery operations have to be supported by enough available energy. On the other hand, if the local energy shortage caused by a disaster cannot be effectively restored, the local areas will be at risks of rescue delay, widespread power outages, economic losses, and even public safety threats. Therefore, the recovery time minimization of a suffered energy network system should be a top priority of an emergency rescue plan. On the other hand the climate change, population increasing and demand forecast have presented an increasing trend of energy demand. However, the high energy demand will always cause regional energy shortage.

From the literature survey, the reported work on local energy shortage and management problems has been studied. The contribution includes policy making of normal management (Bellarmine & Arokiaswamv, 1996), energy operation in buildings (Meier, 2006), economic impact from energy shortage (Sanghvi, 1991), energy shortage solution by economic lever function (Heffner, Maurer, Sarkar & Wang, 2010), typical technology proposal of renewable energy utility (Kainkwa, 1999), and energy system optimization for reduction of environmental impact (Berredo, Ekel, Martini, Palhares, Parreiras & Pereira, 2011). However, there is still lack of study on decision marking support for energy dispatch optimization under emergency situations. Conceivably, this is not a trivial task, because it involves multiple types of energy

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(traditional energy and renewable energy), different energy shortage modes (e.g., short of energy source materials or incapable of energy transformation or transportation), and various energy dispatch scenarios (e.g., energy dispatch from one place to another place, 1→1for short; or possibly 1→n, n→1, and n→n) based on the available infrastructure of local energy dispatch network.

Nowadays energy supply is characterized by its diversity, including traditional energy such as fossil fuels, nuclear power, as well as renewable energy such as solar, hydroelectric, geothermal, biomass, and wind energy(United States Energy Information Administration, 2013). It also involves a complex network system composed of energy generation, energy transformation, energy transportation, and energy consumption. The network does provide the great flexibility for energy transformation and transportation; meanwhile, it presents a complex task for conducting agile energy dispatching when extreme events have caused local energy shortages that need to be restored timely. Conceivably, any type of dispatched energy under certain emergency condition has its own characteristics in terms of availability, quantity, transportation speed, and conversion rate and efficiency to other types of energy. Thus, different types of energy should be dispatched through a superior plan. For instance, energy sources such as petroleum or coal can be directly transported to a suffered area; meanwhile, they can also be converted to electricity in a source region and then sent to the suffered area through an available electricity network. Sometimes, even the transportation of the same type of energy may have different alternative routes for selection, which needs to be optimally determined from the view point of the entire energy dispatch system.

Environment Impact Assessment for Power Plant Emission (Cai, Wang, & Xu, 2013)

According to the Environmental Protection Agency's (EPA) 40 Code of Federal Regulation, malfunctions refer to any "sudden, infrequent, and not reasonably preventable failure of air pollution control equipment, process equipment, or a process to operate in a normal or usual manner"(United States Environment Protection Agency, 1982). "Gaussian Plume Model" is an approximate analytical method for point-source emissions for calculation of air pollutant concentration in the downwind area (Bowman, 1996;Turner, Bender, Pierce & Petersen, 1982;Griffiths, 1994; Halitsky, 1989;Slade, 1986; Seinfeld, 1986; Hanna, Briggs & Kosker, 1982; Turner, 1979;Turner, 1994; Pasquill, 1961; Pasquill, 1974; Church, 1949;Goldsmith & Friberg, 1976). Even though inverse modeling methods based on Gaussian plume models have been reported (Hogan, Cooper, Wagner & Wallstrom, 2005; Jeong, Kim, Suh, Hwang, Han & Lee, 2005; MacKay, McKee & Mulholland, 2006), they are generally used to estimate emission rates of point sources in an average long-time period based on measurements from multiple monitoring stations. In practice, the dynamic emission profiles can be very useful. For example, it can help schedule multiple plants' activity to minimize regional air quality impacts (Cai, Wang & Xu, 2013).

APPLICATION DEMONSTRATION

For the purpose of vivid illustration of the potential application of spatial and temporal predictive analysis in energy network operation research, two virtual cases have been included here. However, the attention should be paid that the handling of the real world problem of energy network will definitely involve regional or national wide scale of data system, which is much more larger than the provided virtual cases. Furthermore, the latest Annual Energy Outlook(United States Energy Information Administration, 2013)

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can be referred to as the application result of the spatial and temporal predictive analysis technique to predict energy demand. Therefore the virtual case illustration has been omitted in this part.

Energy Network Restoration Under Emergency Situation (Cai, Zhao, & Xu, 2012)

An energy network is composed of three cities (A, B, and C). The infrastructure of city A is currently experiencing energy shortage. The other two cities (B and C) are not affected by the event and thus are able to provide energy and source materials to support city A. By following the first two stages of the proposed methodology, the energy initial conditions of this case study are summarized in Table 1, which gives all the parameters used in the energy dispatch model.

Beside the listed parameters, the efficiency of electricity transportation is approximated as 0.95, suggesting 5% loss during electricity network transmission; the hourly energy consuming index is 0.05, suggesting 5% of the available inventory energy will be consumed from the network. Meanwhile, there

Table 1. Given data of the case study

Description	Parameter	Energy Source	Unit	*i* / *j*		
				A/B or C	B/A or C	C/A or B
Electricity Conversion Efficiency from Other Energy Sources (*k*: electricity)		*l*: Petroleum Oil	MWh/Barrel	0.55	0.51	0.62
		l: Natural Gas	MWh/Million ft^3	0.12	0.125	0.11
		l: Coal	MWh/Short Ton	1.5	1.2	1.6
Hourly Electricity Generation Limit from Source Materials (*k*: electricity)		*l*: Petroleum Oil	MWh/hr	75	65	90
		l: Natural Gas	MWh/hr	500	400	600
		l: Coal	MWh/hr	50	40	45
Hourly Limit of Transportation Input from City *j* to City *i*		*k*: Petroleum Oil	Barrel/hr	0.03	0.03	0.03
		k: Natural Gas	Million ft^3/hr	0.2	0.2	0.2
		k: Coal	Short Ton/hr	0.01	0.01	0.01
		k: Electricity	MWh/hr	0.05	0.05	0.05
Hourly Limit of Transportation Output from City *i* to City *j*		*k*: Petroleum Oil	Barrel/hr	0.03	0.03	0.03
		k: Natural Gas	Million ft^3/hr	0.2	0.2	0.2
		k: Coal	Short Ton/hr	0.01	0.01	0.01
		k: Electricity	MWh/hr	0.05	0.05	0.05
Required Energy Inventory Amount for City *i*		*k*: Petroleum Oil	Barrel	400	426	493
		k: Natural Gas	Million ft^3	500	700	600
		k: Coal	Short Ton	314	346	396
		k: Electricity	MWh	1600	1550	1600
Hourly Energy Supply for City *i*		*k*: Petroleum Oil	Barrel/hr	27.45	29.25	27
		k: Natural Gas	Million ft^3/hr	135	180	225
		k: Coal	Short Ton/hr	27	22.5	27
		k: Electricity	MWh/hr	0	0	0

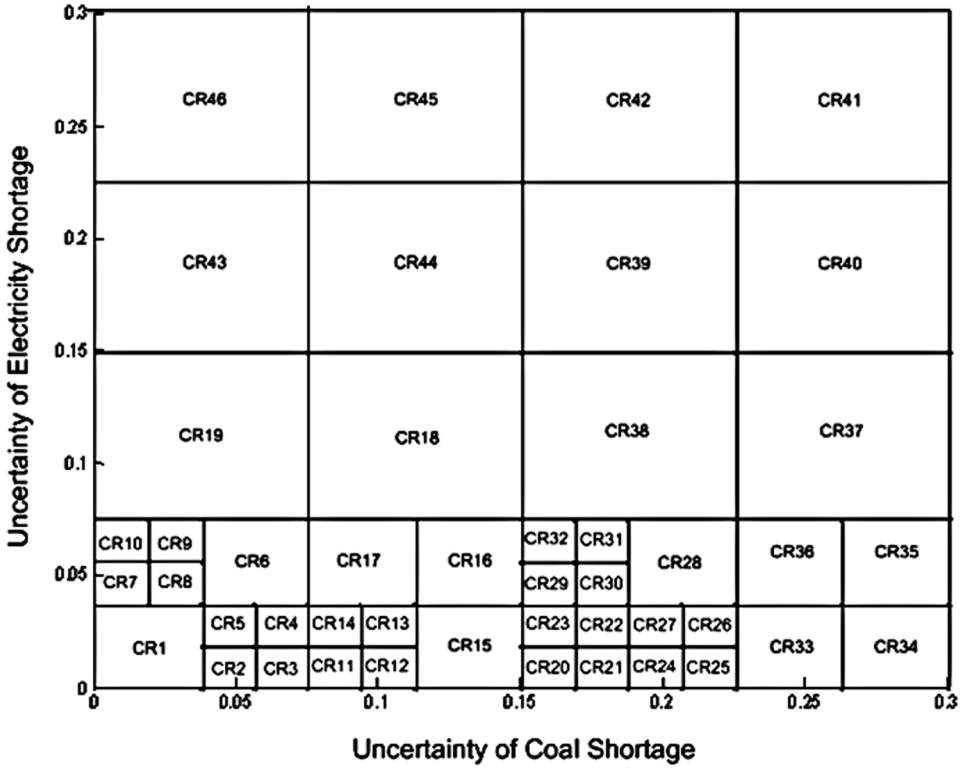
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is no time retention for electricity transmission between cities while the transportation time for source material is two hours between two different cities.

During the emergency situation, assume all types of energy suffer 10% loss in city A, meanwhile there is no energy loss damage to the other cities. Based on the developed energy dispatch model with GAMS(Cai, Zhao & Xu, 2012), the optimization result shows that the minimum dispatch time for this energy restoration of city A is 26 hours. Two parameters, the energy loss for coal and electricity in city A, are estimated before the energy dispatch optimization. They are actually typical uncertainties that should be investigated to disclose their impact to the final energy dispatch optimization results. Assume they can vary within the range from 0 (no energy loss) to 0.3 (30% energy loss). Then based on the proposed algorithm of uncertainty space partition, a two-dimensional uncertainty space has been constructed, where uncertainties θ_1 represents the energy loss fraction of coal ($0 \le \theta_1 \le 0.3$) and θ_2 represents the energy loss fraction of electricity ($0 \le \theta_1 \le 0.3$). Figures 1 and 2 show the partitioning result with the total of 46 critical regions (CR1~CR46). The standard criteria (SC) of derivative percentage is set as 1.5% to identify the approximation performance of function regression.

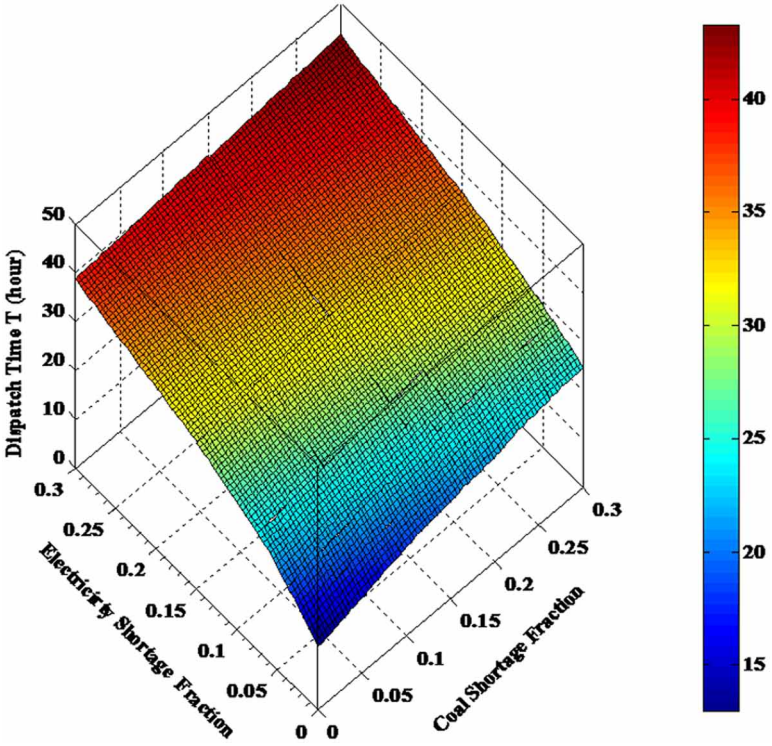
Note that the 3D profile in Figure 2 is not a smooth surface although it looks like. They characterize the relation between the optimal energy dispatch time and the studied two uncertain parameters. They provide decision makers a reference manual for the easy lookup of the possible impact from uncertainties and thus help conduct right decisions. For example, the 3D surface generally shows the less coal and electricity shortages will result in less energy recovery time. As its 2D projection on the uncertainty

Figure 1. Uncertainty space partitioning for the case study



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Figure 2. Minimum energy dispatch time with respect to uncertainties



space as shown in Figure 5, any emergency case specified by coal and electricity shortage for City A corresponds to a point (say point S) in the plane. The energy dispatch behaviors among the network are actually moving the point S to finally reach the left-bottom corner point. It should be known that any movement in a short time period can be decomposed into two directions: one is toward the iso-time direction that does not reduce energy recovery time at all; the other is gradient direction perpendicular to the iso-time direction, which represents the shortest energy recovery time and smart move direction. For illustration, the iso-time and gradient directions at a point S (with 20% electricity and 15% coal shortages respectively) are demonstrated in Figure 3. Based on such information, the dynamic impact of different energy dispatch strategies can be evaluated, which will help decision makings under uncertainties.

Environment Impact Assessment for Power Plant Emission (Cai, Wang, & Xu, 2013)

The studied case study involves a sunny spring day with the strong radiation of 20 K/km lapse rate and the surface wind speed of 1.8m/s at 10 meter height and the ambient temperature of 20 °C. Firstly, the potential risk analysis has been conducted to examine the current power plant emission, which assume all the plants initiate their capacity enhancement at the same time (08:00). Since the potential risk analysis has identified the potential air quality problem according to the original plant start-up plan, the optimal rescheduling for the multi-plant start-ups must be perform in the second stage. The objectives of the developed MOO model are set to minimize the overall air quality impacts to all AQCRs and total

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Figure 3. Application analysis based on uncertainty space partitioning

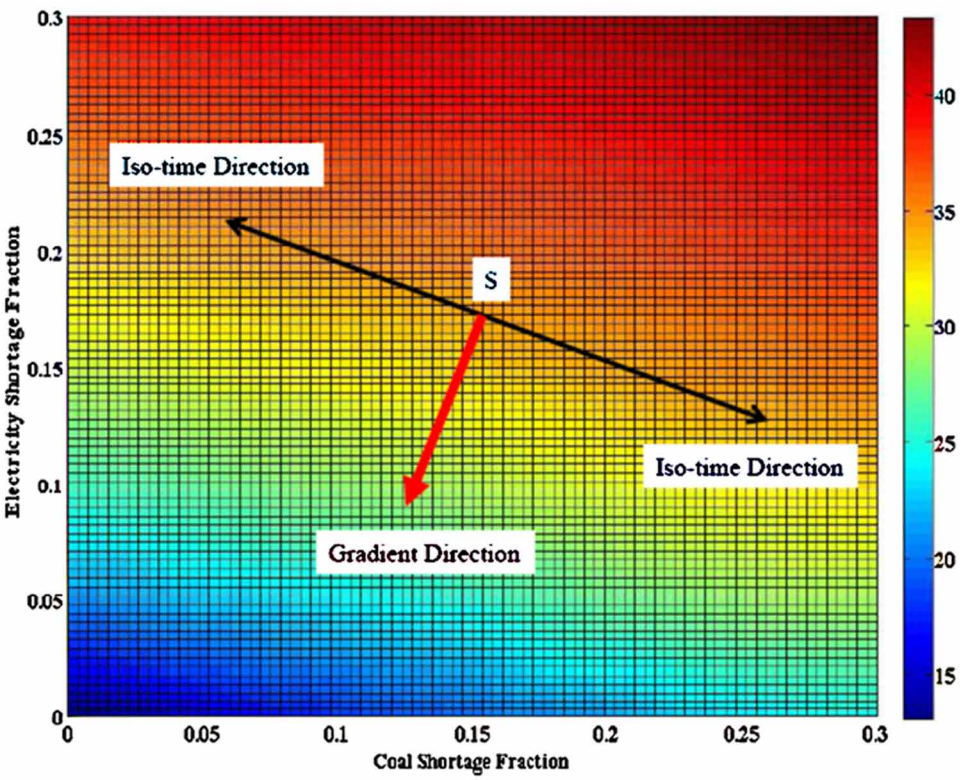
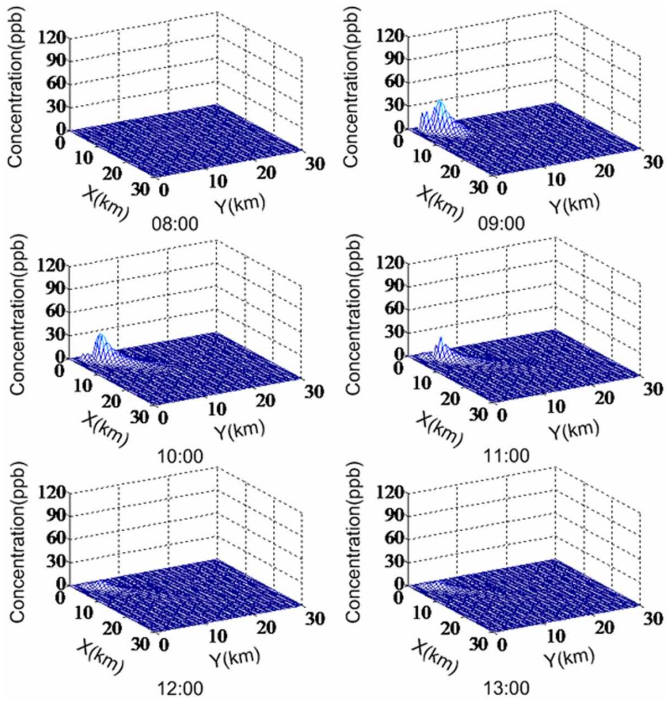
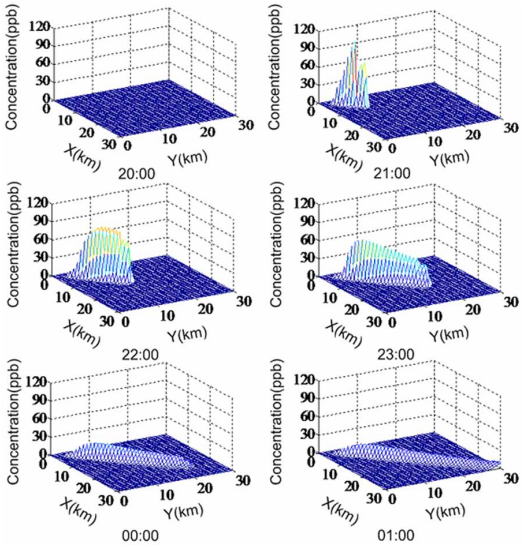


Figure 4.



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Figure 5.



start-up time mismatch for all the plants by manipulating the start-up beginning time of each plant. The MOO modeling is implemented in MATLAB with the help of Global Optimization Toolbox. The optimal solution is shown in Table 2.

CONCLUDING REMARKS

This chapter has provided the brief introduction of spatial and temporal predictive analysis techniques, especially for their application in energy network optimization. The application scope will cover the energy demand forecasting and prediction, energy network optimization to meet the demand requirement and environment impact for the emission from the current power plants during capacity enhancement. The design and optimization of energy network operation needs to predict the potential demand trend, integrate the consideration of the energy restoration during the emergency situation of regional shortage

Table 2. Summary of optimal solutions under different scenarios

Category	**Case 1**	**Case 2**	**Case 3**		
Scenarios	**No Air Quality Risk**	**Manipulating E1, E2, E3**	**Manipulating E1 Only**	**Manipulating E2 Only**	**Manipulating E3 Only**
E1 Mismatch Time (hr)	--	0	3	0	0
E2 Mismatch Time (hr)	--	1	0	2	0
E3 Mismatch Time (hr)	--	3	0	0	1
Total Mismatch Time (hr)	--	4	3	2	1
Maximal Concentration in AQCRs (ppb)	45	55	75	105	77

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and investigate the environment impact of current power plants in order to replace the fuel combustion method with renewable energy facility and. These will always involve large scale data and information systems. The application of spatial and temporal analysis for energy network operation will definitely helps to achieve these targets. It has shown a great potential to solve the problems that arise in the field of energy network operation. The technique significance and application demonstration have been presented to attract more engineers, scientists, researchers and the other related stake holders to dedicate to its development in the future.

DISCUSSION

This chapter provides valuable information for accidental investigations and root cause analysis for an emission event; meanwhile, it helps evaluate the regional energy network operation and air-quality impact as well. It lays out a solid foundation for multiple stake holders on diagnostic and prognostic decisions in face of an industrial air-pollution event, including government environmental agencies, regional chemical plants, and local communities.

FUTURE RESEARCH DIRECTIONS

It is necessary to further extend the current research to be integrated into the website service of environmental protection and energy management agency. Similar case studies and applications in using technologies and fundamental theory can be applied and demonstrated in the representative service domains with the combination of e-business services, mobile services, social networking services, cloud services, legal services, healthcare services, logistics services and educational services taking into account demands from government, organization, enterprise, community, individual, customer, and citizen.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence: Artificial intelligence (AI) is the human-like intelligence exhibited by machines or software.

Artificial Neural Networks: They are computational models inspired by animals' central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition.

Energy: In physics, energy is a property of objects, transferable among them via fundamental interactions, which can be converted in form but not created or destroyed.

Fuzzy Logic: It is a form of many-valued logic which deals with reasoning that is approximate rather than fixed and exact.

Optimization: In mathematics, computer science, or management science, mathematical optimization (alternatively, optimization or mathematical programming) is the selection of a best element (with regard to some criteria) from some set of available alternatives.

Renewable Energy: Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat.

Soft Computing: It is a term applied to a field within computer science which is characterized by the use of inexact solutions to computationally hard tasks such as the solution of NP-complete problems, for which there is no known algorithm that can compute an exact solution in polynomial time.

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Chapter 10
The Sustainable Development Approach in the Economy–Ecology Dilemma

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ABSTRACT

The managerial model of cooperation and dialogue-driven, international, and supranational efforts during the past half-century form one of the most important topics within the "sustainable development" concept. Rapidly growing human population, together with the unsustainable pattern of consumption of renewable natural resources for future generations, also leads to the transfer of resources. The concept of development in keeping with ecological concerns about the impact of the dynamic approach should be reformulated. Faced with such dilemmas, these debates illustrate the need for a rational approach. Without jeopardizing the needs of future generations, to meet the demands of today's resource usage, the authors envision a sustainable development approach that seeks to balance protection and use. This approach should be addressed in the context of an understanding.

INTRODUCTION

The world we live in entered into a recent flurry of ends which can be estimated even today. However, this haste is not likely to be fulfilled only by those living in the present time, but needs to reach into future time.

So what's all the fuss about; what is the reason for this concern? Actually it is not too difficult to answer this question; the answer is very clear: Unsustainability. This concept corresponds to the expression: END OF LIFE.

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It is mandatory to ensure continuity of natural resources, the living and non-living environment that constitutes the environmental components. So it is possible to separate these resources into two categories: living and nonliving resources (Keleş, Hamamcı & Çoban, 2012).

Live natural resources are biologically diverse and are composed of plants, animals and microorganisms. Humans are also a part of biodiversity and the life chain. Extinction of one of these species endangers other species which complement all the types generating the chain. If the Protection-usage balance cannot be established in a healthy way, the shortened chain may eliminate humans in the future. Commissioned by the United Nations Environment Program (UNEP), in 1995 the "Global Biodiversity Assessment" scientific report disclosed that about 1000 generations of species could rapidly become extinct (Türkman, 1998). Again, in 2010, declared the Year of Biodiversity by the United Nations, the International Union for Conservation of Nature (IUCN) reported that 44% face this danger, while 2% were also completely accounted for as extinct, of a total of 47,677 species on the IUCN's Red List (United Nations Environment Program [UNEP], 2010).

Essential and gradually decreasing living resources for food and agriculture are among the important advantages a country can have these days. The world's arable lands and water resources are rapidly becoming polluted and destroyed. Scientists agree that people will face a serious food and water problem in the near future. In the light of these developments, a country's biological diversity, particularly in terms of genetic resources, confers the status of a great power, because wild living resources are utilized to develop varieties with high production potential and resistance to environmental pressures (Convention on Biological Diversity [CBD], http://www.bcs.gov.tr/biodiversity/biodiversity.php).

Nonliving natural resources needed to sustain biological diversity are air, water, soil habitats and the subterranean base. The relative importance of these resources has an economic rather than ecological basis. As a result of unlimited economic growth, resource depletion has accelerated, creating the danger that the resources will fail to perform their functions due to global warming, soil erosion, and atmospheric pollution.

The exit point of the problems of living and non-living natural resources is related to conservation vs use, or "ecology" vs "economy", and reconciliation of these conflicting values.

The term "ecology" was first used by the German biologist Ernst Haeckel in 1866 (Keleş et al., 2012). He combined the Ancient Greek "Oikos", meaning "house, home, dwelling place, habitation" with the word "Logia", which means "speaking, discourse, treatise, doctrine, theory, science" (Okologie). In this respect, the word "ecology", derived from a discipline that identifies the subject areas of creatures' lives, encompasses the meaning "home science".

The etymological root of the word "economy" is similar to that of ecology. It (oikonomia) is derived from a combination of the Ancient Greek word for "home" (oikos) with the word for "law, management" (nomos). Economy might thus denote "thrifty household management", because in this context it incorporates the meanings "household management" and "being frugal, being thrifty".

However, the word "economy" has moved away from this meaning nowadays. Modern economics has lost its roots in the Greek word oikonomia (household management). It has instead absorbed chrematistics, or the maximization of short-run gain (Pearce, 1998, from Hayward, 1995).

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SUSTAINABILITY OF RESOURCES

The famous Greek philosopher Plato is remarkable for his unconscious insight into the use of natural resources. In his work "Kritias" he wrote that, as a result of cutting trees, fertile soil is lost to excessive erosion, so that water resources are depleted. The slogan of today's environmentalists, "Let's protect biological diversity", has its source in the "abundance, productivity, diversity" principle put forward by Plato. The ancient Roman Tacitus is one of the most important environmental thinkers. Today he can be regarded as the pioneer of green values and of natural areas, as well as the person who first came up with the idea of leaving natural areas as they are. Tacitus particularly opposed dam construction and the modification of river channels (Tont, 1997).

A pessimistic approach to this aspect of the world, of course, depends on many factors which might arise. Two of these factors are located at the heart of the problem.

The first factor is "non-sustainable" consumption (Keating, 1993). Largely because of this problem, continuity can only be assured by the balanced use of resources. The second factor is the tremendous increase of the human population worldwide. In particular, the rapid population growth in the least developed and developing countries raises the prospect of impoverishment and degradation. In this sense the unplanned consumption of resources by the population has increased.

Unsustainable consumption patterns in a world with a growing population continues to put increasing pressure on natural resources. Former United States Vice President Al Gore declared in the documentary film "An Inconvenient Truth" (Isaacs, 2009):

We are witnessing a collision between our civilization and the Earth. And there are three factors that are causing this collision, and the first is population. When my generation, the baby boom generation, was born after World War II, the (world) population had just crossed the two billion mark. Now, I'm in my 50's, and it's already gone to almost six and a half billion. And if I reach the demographic expectation for the baby boomers, it'll go over nine billion.So, if it takes 10.000 generations to reach two billion and then in one human lifetime, ours, it goes from two billion to nine billion, something profoundly different is going on right now. We're putting pressure on the Earth. Most of it's in the poorer nations of the world. This puts pressure on food demand. It puts pressure on water demand. It puts pressure on vulnerable natural resources, and this pressure is one of the reasons why we have seen all the devastation of the forest, not only tropical, but elsewhere.

United Nations population projections in 2012 confirm Al Gore's statement. According to calculations made in 2013, the world population of 7,162,119 will reach 9,550,945 in 2050, and 10,853,849 in the year 2100 (United Nations [UN], 2013a).

Physical and biological properties of natural resources around the world in countries with existing assets are not unlimited. Renewable natural resources face the danger of misuse as a result of disruptive activities. Rapidly growing human populations are placing ecological and social pressure on these natural resources, leading to concern about a livable environment, especially for future generations, and even about the end of available resources, let alone their sustainability.

At Stanford University, biologist Petr Vitousek and his team stated that 40% of the annual net primary production on the earth's land is used directly to meet people's requirements, or used and destroyed indirectly by human activities. According to a simple calculation based on this statement, for the human species to survive on earth only 60% will remain of the millions of species. However, the speed of population growth threatens to increase the current rate of net primary production to 80% in 2030. In addition, the increase in per capita consumption may shorten this period. The earth's people, increasingly usurping the

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dynamics of ongoing life, will further accelerate the collapse of natural systems. However, as indicated by Vitousek and his team, "it seems that the limits of growth today will be of interest to decision-makers who think it is so far away, unaware of this biological reality" (Brown, Flavin, & Postel, 1998).

Nowadays, the system of consumption of water, air and soil that we regard as "renewable" leads to the pollution of natural resources, the alternative being to reduce utilization. It should be noted that the resources of world are not compliant with this outlook; they are not enough.

All societies, especially in the developed countries, have a tendency to more and more consumption. In short, these societies have built their future scenarios on a world in which "they consume more than they produce", without being aware of the problems they may encounter as a result.

At this point, in the context of unsustainability, an imbalance emerges between the consumption of developing or less developed societies, and that of developed societies. First of all, continuity of supply represents a balance. Sustainability, ensuring a balance between the long-term integrated and systematic economic, environmental and cultural resources, is necessary and inevitable.

United States President Thomas Jefferson, on September 6, 1789, asked in a letter to the next president James Madison, "whether a generation, have the right to bind provisions of the next generation", and answered in the negative that the world belonged to the living not the dead and that therefore those currently living should not leave a debt to future generations (Boyd (ed.), 1950):

Would the present generation be obliged to apply the produce of the earth and of their labor to replace their dissipations? Not at all.

Former United States Vice President Al Gore, again, expressed the imbalance in consumption in the following way (Karaca, 1995): that every American child consumes and produces waste up to the equivalent of every 30 Indian children born.

The World Bank Development Indicators report for 2008 showed that, according to 2005 data, 20% of the richest countries in the world are consuming about 76.6% more than the rest of the world. However, constituting 20% of the world's population, the poor countries, despite being equally proportional in size to the rich countries, consumed just 1.5% (World Bank, 2008).

In the early 1990s, Mathis Wackernagel developed the methodology for the "Ecological Footprint" along with his doctoral advisor Professor William E: Rees at the University of British Colombia in Canada. This is a natural resource accounting tool that measures how much of nature we have, how much we use and who uses what (Amend et al. (eds), 2010).

It is a measure of how much area of biologically productive land and water an individual, a population or an activity requires to produce all the resources it consumes and to absorb the corresponding waste (such as carbon dioxide emissions from fossil fuel use), using prevailing technology and resource management practices. The Ecological Footprint is usually measured in global hectares (gha), and includes the area of built-up land (Wackernagel et al., 2012).

According to ecological footprint calculations in 2008, our planet's biocapacity was 12.0 billion gha, or 1.8 gha per person, while humanity's ecological footprint was 18.2 billion gha, or 2.7 gha per person. This indicates a biocapacity deficit of 0.9 gha per person. Biocapacity per capita continuously declines as population increases (World Wildlife Fund [WWF], 2012).

Every country of the world has a different ecological footprint. For example, if all humanity lived like an average Indonesian, only two-thirds of the planet's biocapacity would be used; if everyone lived like an average Argentinean, humanity would demand more than half an additional planet, and if everyone

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lived like an average American, a total of four Earths would be required to regenerate humanity's annual demand on nature (WWF, 2012).

Advanced societies not only consume their own natural resources quickly but also consume those natural resources of less-developed societies which are not used or operated due to lack of money.

Thus has emerged an imbalance of natural resources, on the one hand those developed by cultures grown better able to achieve their targets, and on the other hand those in cultures of developed societies that have reached a level of rapid rationalization leading to destruction.

While this disparity lasts, people living in poverty-ridden societies will find it difficult to wait for the protection of natural resources. However, one of the most important steps is to establish a balance between the positive and the moderate in seeking sustainability of natural resources and human resources.

Hence, all countries are obliged to create sustainable consumption patterns, the goal being pursued by a sincere effort under the leadership of developed countries. So, arising from unsustainable consumption of natural resources, we are required to review and limit the addiction that minimizes the world's resources and carrying capacity, in line with a more accurate understanding of consumption (Keating, 1993).

After a general statement about the elements of sustainability that should be seen as a threat, there is the question of what the concept of "sustainability" means and what its scope is.

PROTECTION AND USAGE BALANCE: SUSTAINABLE POLICY

The purpose of economic development since the 1950s, over 10-year periods, has been defined by a variety of changing catchwords. For example, in the 1950s it was "Industrial Development", and shortly afterwards, "Agricultural Development" (Agricultural Development); the 1970s brought in the concepts of "Poverty" and then "Basic Needs", when determining economic purposes; finally, "Sustainability" is added to the list in the middle of the 1980s (Bennett, 2002).

Along with the concept of sustainability as based in ecology, development-based approaches are also seen. Naturally, the question "Sustainability of what?" arises.

Scope of Sustainability

Sustainability embodies issues of environmental values as well as the question of the scope of democracy (International Council for Local Environmental Initiatives [ICLEI], 1997).

The environmental management principle and the democratic decision-making principle are the indispensable conditions of sustainability. The environmental management principle is applied within the time available and as long as each generation continues to achieve sustainability. However, sustainability cannot be realized independently of the principle of democratic decision-making. In an environment conducted independently of this principle it can only be managed to a certain level.

Likewise, when adopting the concepts of democracy and equality within the idea of sustainability, namely environmental values in the geographic and spatial sense, rejecting democracy and equality is unthinkable.

Sustainability, in the context of a rational use of resources, is also intended to address issues of intergenerational democracy and social equality. Over time, the understanding of democracy and equality presents a case extending well into future generations. In not separating future needs from those of today, sustainability represents a democratic element in terms of time. Likewise, when adopting the concept

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of democracy and equality within the idea of environmental sustainability in the geographic and spatial sense, it would be out of the question to reject democracy and equality.

Sustainability as a concept does not target a single point within the community. The aim of creating a sustainable life requires a joint effort by all institutions of the society. For example, an improvement to be made in consumption patterns cannot be separated from the population. Again, the selection of technology appropriate to the idea of sustainability cannot be independent of the social and cultural structure of the society. Hence, in forming a global community of interdependent parts, sustainability alone is unthinkable.

Sustainability is a broad concept in scope. The proposal entails provisions affecting many elements of society: population is kept under control by reducing poverty, alternative technology is introduced, consumption patterns are improved, hunger/famine issues affect biodiversity, the adequate apportionment of resources is established.

So the concept of sustainability involves not only the outlook of the ecological movement which aims to prevent environmental pollution, but also has much wider societal implications. However, the application of this insight is not possible solely within the concept of sustainability. The success of its implementation and realization of its purposes depends on management of the social and political struggle.

Transformation of Development Approach

The history of mankind's struggle with nature offers many examples. Some authors have asserted that societies must struggle with Nature in order to create civilization.

The famous historian Arnold Toynbee described the struggle of humanity with nature in his "Challenge and Response Theory", according to which, in the emergence and development of civilizations, the available geographical environment determines the status of the constant human "challenge". But it should be noted that the struggle against nature undoubtedly involves taking advantages of the resources given by nature. As early as 3000 BC, the oldest written epic, the Sumerian Gilgamesh Epic, relates how the King of Gilgamesh fought to kill the monster Huwawa, a protector of a forest containing cedar trees, which provide timber, an important raw material in meeting his country's development needs (George, 2003).

The human–nature struggle that went on through the historical process has been reshaped as further growth in the developed countries today, and the further development, as reflexes, of the developing countries.

The 18th century classical economist Adam Smith promoted economic growth on the assumption that natural resources are unlimited. Especially in the 19th century, marked by the Industrial Revolution, natural resources were under pressure, as they provided the input to intensive production.

The effect of imperialist values on the use and allocation of resources should not be underestimated. For example, in 1855, the Indian Chief Seattle, whose natural resources the white man wished to purchase, made a speech which is impossible not to heed. This letter may be considered among the "first civilian protests against imperialism bearing the ecological label" (Toprak, 2012).

Although the ideas of the Industrial Revolution and the Enlightenment are the main source of the increase in prominent ecological problems, they also played a major role in the increase in environmental and ecological sensitivity. Awareness of nature began with the problems of industrial society. In the United Kingdom the Alpine Club (founded 1857), the Open Spaces Society (1865) and the Royal

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Society for the Protection of Birds (1889), were among the organizations that displayed such sensitivity (Görmez, 2010).

In the second half of the 20th century, intense debate over intergenerational obligations became the subject of the period, though in the first half of this century, highlights from the work and comments of the economist Pigou on "Wealth and Welfare" (1912) are noteworthy. Indeed, Pigou was one of the earliest economists to robustly defend the interests of future generations, who are likely suffer harm due to the indulgence of present generations (Kula, 1998).

Especially in the period after the Second World War, states and governments revived moves to continue within the framework of the their intense development efforts up to 1960, so that, to ensure the legitimacy of these efforts, natural resources were neglected.

Problems related to the rational use of natural resources began to be noticed by 1960. However, this awareness had not yet spread throughout the world.

In 1962, the ideas of Rachel Carson's "Silent Spring" and Garrett Hardin's "The Tragedy of the Commons" were among the first examples of effective efforts towards sustainable development. Paradigm-breaking books and articles such as these galvanized individual countries and the international community into action (UNEP, http://www.unep.org/geo/GEO3/english/pdfs/chapter1.pdf).

Carson's work, discussing the impact of the use of the chemicals, especially DDT, and the nature of jamming, saw the beginning of the modern environmentalist movement, while Garrett Hardin's discussion of the pressure on natural resources created by population growth in public areas is considered an important contribution to environmental understanding in the 1970s.

The "Environmentalist years", as the 1970s were called, along with development of the "green management" approach, were building the tendency towards non-rational use of resources based on this awareness.

The concept of development has become one that needs to be reformulated, after evaluating the managerial approach within the framework of economic perceptions, along with the impact of the approach based on ecological concerns.

Looking Both Responsive to Development and Sensitive to the Environment

In the 70s, Western scientists and industrialists, observing the process of environmental problems arising and necessary measures not being taken, resulting in greater risks to vibrant life, began to offer responses having universal dimensions.

In 1971, MIT (Massachusetts Institute of Technology) professionals were commissioned by the Rome Club and in 1972, as a suggestion offered by developed countries to less developed countries in "The Limits to Growth" report, originated the "Zero Growth" model (Meadows, Meadows, Randers, Behrens, 1972).

The model's basic logic rested on the view that a stage of developed countries' economies and a certain level of welfare had to be reached before the environment was destroyed. Starting from that idea, developing countries could be prevented from making similar mistakes, so that at least in other parts of the world the environment would remain intact.

At that time the model seemed Utopian and exaggerated, containing elements contrary to equality in developing countries, and rightly evoked strong reactions. It was suggested that the Rome Club report was a "trap" for the development efforts of less developed or developing countries. Developed countries following such a model encouraged the establishment of polluting industries in less developed countries,

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thus indirectly threatening the latter while allowing their own capital in these countries to increase, but without the risk of contamination.

The reaction created by this concept, in a sense has led to the countries' search for a more realistic use of resources.

In 1972, the world experienced a development that would be recognized as a turning point in environmental policy: the Stockholm Conference on the Human Environment.

Recognizing the environment as a right for the first time, this conference took an important step towards sustainable development. Maurice Strong, secretary-general of the conference, who first used the maxim "environment does not exclude development" (Eco development), intended to adopt a development strategy from local sources, expressing the concept of equitable benefit (Keleş et al., 2012).

At the end of the conference, the Stockholm Declaration was issued, highlighting the relationship between the two principles for present and future generations, as the basis for recognition of sustainable development in the near future (UN, 1972):

- "Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations." (Principle 1)
- "The non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that benefits from such employment are shared by all mankind." (Principle 5)

In 1973, in Ernst Friedrich Schumacher's book "Small is Beautiful", underlining scarce resources in terms of production and consumption relations and the reorganization of necessity, criticized the capitalist perspective which defends growth and increases consumption (Schumacher, 1973).

In 1973, establishment of the United Nations Environment Program (UNEP) was among the first steps formulated in the corporate sense of environment–development relationships.

The most important of these concrete steps was the World Conservation Strategy (WCS) certificate, prepared and published in 1980 by UNEP, in partnership with the International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF).

The document was entitled "World Conservation Strategy – Living Resource Conservation for Sustainable Development". As can be seen, the "sustainable development" concept, first used in this strategy document with its current meaning, meant that the handling of its present meaning would take place in subsequent years.

WCS emphasizes the need for conservation and development to be dealt with so as to achieve a sustainable society. The document's definitions of development and conservation are as follows (International Union for Conservation of Nature [IUCN], UNEP, WWF, 1980):

Development is defined here as: the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life. For development to be sustainable it must take account of social and ecological factors, as well as economic ones; of the living and non-living resource base; and of the long term as well as the short term advantages and disadvantages of alternative actions.

Conservation is defined here as: the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance,

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sustainable utilization, restoration, and enhancement of the natural environment. Living resource conservation is specifically concerned with plants, animals and microorganisms, and with those non-living elements of the environment on which they depend. Living resources have two important properties the combination of which distinguishes them from non-living resources: they are renewable if conserved; and they are destructible if not.

The issue highlighted in this strategy document is the conservation of living resources. Accordingly, living resource conservation has three specific objectives:

- To maintain essential ecological processes and life-support systems (such as soil regeneration and protection, the recycling of nutrients, and the cleansing of waters), on which human survival and development depend;
- To preserve genetic diversity (the range of genetic material found in the world's organisms), on which depend the breeding programs necessary for the protection and improvement of cultivated plants and domesticated animals, as well as much scientific advance, technical innovation, and the security of the many industries that use living resources;
- To ensure the sustainable utilization of species and ecosystems (notably fish and other wildlife, forests and grazing lands), which support millions of rural communities as well as major industries.

"Sustainable utilization" is introduced to international literature in this document along with other concepts.

This first formulation of the sustainable development approach, foregrounding the more ecological approach and conservation of living resources, will consider reasons such as opposition to perceived improvement and the criticism that each activity will adversely affect the environment. The narrow perspective brought forward in WCS on the relationship between economy and ecology has created the need for reformulation of the concept of sustainable development. Development in a sustainable manner, without destroying natural resources and realizing the principles and decisions concerning the infrastructure, was outlined in the Brundtland Report of 1987 and has become effective.

1987 Brundtland Report (Our Common Future)

Unconscious and unplanned results of the use of natural resources, furthering the process of destruction, was an issue to be addressed once again, gaining importance in the international arena. By 1983 the United Nations created the UN World Environment and Development Commission (UN World Commission on Environment and Development); by 1987, it organized a meeting at the Kenyan capital Nairobi, where the principles for a sustainable future were applied and decisions were made. Here, the concept of sustainability, which today is used literally, was expressed by the Commission at the "Our Common Future" meeting, chaired by the UN Secretary General, former Norwegian Prime Minister Gro Harlem Brundtland. Hence the name "Brundtland report" entered the world agenda.

The most valid approach to the concept of sustainable development is found in the official definition of its scope provided by UNWCED (United Nations World Commission on Environment and Development) in 1987, in the Brundtland Report (Our Common Future):

According to the report, Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations World Commission on Environment and Development [UNWCED], 1987). Development, thus, includes not

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only rising aggregate consumption or output, but also environmental quality, social factors, and the distribution of income (Bretschger & Egli, 2001).

It contains within it two key concepts:

- The concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and
- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Critical objectives for environmental and developmental policies that follow from the concept of sustainable development include:

- Reviving growth;
- Changing the quality of growth;
- Meeting essential needs for jobs, food, energy, water, and sanitation;
- Ensuring a sustainable level of population;
- Conserving and enhancing the resource base:
- Reorienting technology and managing risk; and
- Merging environment and economics in decision making.

Sustainable development requires:

- A political system that secures effective citizen participation in decision making;
- An economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis;
- A social system that provides solutions to the tensions arising from disharmonious development;
- A production system that respects the obligation to preserve the ecological base for development;
- A technological system that can search continuously for new solutions;
- An international system that fosters sustainable patterns of trade and finance; and
- An administrative system that is flexible and has the capacity for self-correction.

This report counted as priority issues population, food, agriculture, energy, industry, health, human settlements, and environmental cooperation in international relations.

The concept of sustainability has been introduced to the world's agenda in a way that has not been top-down. This concept in the international sense of addressing, on the basis of "development carried out for every legitimate action and development for the sake of resources consumed in an unconsciously destructive process" was unquestioned in the 1960s, when a developmentalist ideology appeared, and the environmental movement, emerging as a response in the 1970s, had its effects. Here the Brundtland Report, in the 1980s, served the purpose of the 1960s developmentalist ideology, reconciling it with the environmental understanding of the 1970s.

The report does not offer policy recommendations, but instead focuses on current problems and preventative challenges. The report indicates the need for an integrated planning approach that no country's sustainable development can perform while abstracting itself from other countries. Thus the report

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reveals the necessity of change in international relations, mentioning the importance of the World Bank's leadership role in sustainable development.

The principles in the report were turned into a declaration by the UN General Assembly. Such a transformation in the form of recommendations is an important step in the creation of binding international environmental policy.

Despite the ideas it presented, the report has been subject to various criticisms (Erdoğan & Ejder, 1997). For example, some developed countries, especially in Germany, where the environmental groups were combined under the name "Alliance for Sustainable Development", presented their own reports. One such report, while praising the Brundtland Report, which drew attention to useful information and created an international debate about the environment, stated that the report would not bring fundamental change. The idea of showing environmental degradation as poverty and offering expansion as a remedy was rejected. The concept of Western-type growth and development from outside was a fallacy, since they should come from within the country. As an example, in answer to a question about the chances of India reaching Britain's living standards, Gandhi asserted: "this wealth of England was required to reach half of the world's resources. How many planets does a country like India want?"

The United Nations Conference on Environment and Development – Earth Summit

The Brundtland report provides a wealth of information on the concept of sustainable development, as well as paving the way to a global action plan for its implementation. However, the report has fallen far short of the expected "participation" that increasingly began to gain importance in the world (Emrealp, 2005).

Hence, the sustainable development approach adopted in 1987 must seek concrete implementation in terms of action-oriented policy, through arrangement of a global meeting to discuss need.

Indeed, in 1972, in Stockholm the world's first environmental conference was held, known as the "Human Environment Conference"; and on its 20th anniversary, the second largest world conference was held, on 3-14 June 1992 in Rio de Janeiro, the capital of Brazil.

For the development of environmentally compatible development policy, the summit aims at "a collective association", including representatives of the heads of state and governments as well as of non-governmental organizations (NGOs), considered as partners.

Meetings were carried out in two stages: the "Conference on Environment and Development (UNCED; 3 to 11 June 1992)" and "Earth Summit (12 to 14 June 1992)". Over 30,000 people from 172 countries participated in the well-attended conference, which brought together heads of state and government representatives at the global level for the first time to consider issues of environment and development.

As a result of UNCED, the Rio Declaration was published without a binding clause specifying the rights and obligations of countries in regard to environment–development issues.

The United Nations Conference on Environment and Development released, as one of the conference's five[1] documents, a declaration of principles containing 27 points.

The decisions taken and principles identified at the 1972 Stockholm Conference on Human Environment were reaffirmed; global environment and development systems would be studied for their protective agreements and the need to address these for the world as a whole was indicated. In addition, the creation of a new level was targeted, in order to establish a new and unbiased partnership of global cooperation between people and key sectors of society.

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We can specify 27 principles directly related to the "sustainable development" concept adopted in the Rio Declaration on Environment and Development (UN, 1992):

- **The Right to a Healthy Life:** Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.
- **Jurisdiction and Responsibility:** States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.
- **The Right to Development:** The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.
- **Integration of Environment and Development:** In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.
- **Poverty Eradication:** All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.
- **Special Priority to Developing Countries:** The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.
- **Global Partnership and Cooperation:** States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.
- **Patterns of Production–Consumption:** To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.
- **Exchange of Knowledge:** States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.
- **Participation of Women:** Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.
- **Importance of Youth:** The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.
- **Support to Local Communities:** Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

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- **Respect for International Law:** Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.
- **Good Faith and Spirit of Partnership:** States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

As seen earlier, many issues not addressed in a global dimension were discussed at Rio and agreed in principle. However, a full consensus could not be reached on all the policies raised, because of disagreements, particularly between developed countries and developing countries. No definitive consensus can be asserted on principles such as powers and responsibilities, the right to development, poverty alleviation, collaboration, and production-consumption-population.

The Rio Conference was a milestone of the world environmental movement, not only bringing the "sustainable development" concept into our lives, but also enhancing it, taking into account the participatory mechanisms and processes of the United Nations, and of all governments and other agencies and organizations. The Rio Conference reveals resources and dimensions in terms of environmental problems, and also includes a feature which enabled ideas and activities arising quite late in the history of mankind to be discussed on an international scale as comprehensive property. A basic common understanding of the principles adopted and expressed in the contracts signed at the conference is required; countries that have a common future cannot be unresponsive to environmental challenges, pollutants emitted into the global environment at different levels must be in amounts that do not endanger the environmental balance, and resources must renew themselves according to an ecologically sustainable conservation–use balance.

In order to take action on the topics discussed at Rio, an action plan has been prepared under the name of "Agenda 21".

The document presenting the Agenda of the 21st century, which features an action plan, is intended to form the basis for an understanding on sustainable development and environmental protection within the "global partnership". Agenda 21, which is one of the best-known documents of the United Nations, sets out the basic principles established in Rio about environmental protection and community development issues, based on their own residential properties.

The "global partnership" concept is introduced in the Agenda 21 Action Plan to meet basic requirements, improve living standards, better protect and manage ecosystems, and lay the building blocks for a more secure path to the future.

The Agenda 21 Action Plan consists of four main sections[2]:

- Social and Economic Dimensions;
- Conservation and Management of Resources for Development;
- Strengthening the Role of Major Groups;
- Means of Implementation.

At the Conference in Rio de Janeiro, world leaders signed three international treaties – the United Nations Framework Convention on Climate Change (UNFCCC) (followed by the Kyoto Protocol in 1997), the Convention on Biological Diversity (CBD), and the Convention to Combat Desertification (UNCCD) – which pursue one common goal: sustainable human development. All three Conventions

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are of equal status in terms of their relevance to the preservation of our natural life-support systems, poverty reduction, and achieving greater global justice (Amend et al. (eds), 2010).

The United Nations Conference on Environment and Development in 1992 recognized the important role that the indicators could play in helping countries make informed decisions concerning sustainable development. As a matter of fact, Chapter 40 of Agenda 21 has called on countries, as well as international, governmental and non-governmental organizations, to develop indicators of sustainable development that can provide a solid basis for decision-making at all levels. Agenda 21 also has called for the harmonization of efforts to develop such indicators (UN, 2007).

Founded in 1992, the Commission on Sustainable Development (CSD) has since 1995 initiated the international sustainable development indicators, of which the main and sub-themes are as follows (UN, 2007):

- **Poverty:** Income Poverty, Income Inequality, Sanitation, Drinking Water, Access to Energy, Living Conditions.
- **Governance:** Corruption, Crime.
- **Health:** Mortality, Life Expectancy at Birth, Health Care Delivery, Immunization against Infectious Childhood Diseases, Nutritional Status, Health Status and Risks.
- **Education:** Education Level, Literacy.
- **Demographics:** Population, Tourism.
- **Natural Hazards:** Vulnerability to Natural Hazards, Disaster Preparedness and Response.
- **Atmosphere:** Climate Change, Ozone Layer Depletion, Air Quality.
- **Land:** Land Use and Status, Desertification, Agriculture, Forests.
- **Oceans, Seas, and Coasts:** Coastal Zone Fisheries, Marine Environment.
- **Freshwater:** Water Quantity, Water Quality.
- **Biodiversity:** Ecosystem, Species.
- **Economic Development:** Macroeconomic Performance, Sustainable Public Finance, Employment, Information and Communication Technologies, Research and Development, Tourism.
- **Global Economic Partnership:** Trade, External Financing.
- **Consumption and Production Patterns:** Material Consumption, Energy Use, Waste Generation and Management, Transportation.

These indicators are intended to give guidance to countries on how to create national sustainable development indicators.

Despite all these efforts, Agenda 21 failed to reach an agreement on all the issues up for discussion. These issues can be summarized as orientation of technology from rich countries to poor countries, transfer of financial resources, the protection of water resources, chemicals and hazardous waste management, data and information flow (Keleş & Hamamcı, 1993). It is not surprising that sharp differences of opinion on "sustainable development" have emerged between the developed countries who have used enhanced levels of access to natural resources rashly and caused a very large portion of current environmental problems, and those who are oppressed under the weight of the rapid urbanization process and whose natural resources are being depleted by development (Emrealp, 2005).

Similar efforts were made after 1992, with similar topics carried over to the following years.

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Millennium Development Goals

The United Nations Millennium Development Goals were considered in September 2000 at the UN Millennium Summit in New York City by 192 members of the United Nations, who scheduled eight goals to be met by 2015:

The Millennium Development Goals for 2015 (UNEP):

1. Eradicate extreme hunger and poverty
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

In 2015 the eighth goal was to be achieved, as the United Nations 2013 Millennium Development Goals Assessment Report discussed poverty reduction, wider access to clean water, improvement of living conditions in poor urban neighborhoods, and achievement of gender equality in primary schools, and stated that millions of people had realized improvement; as of 2015 it has become possible to achieve far more within the Millennium Development Goals (UN, 2013b).

However, one of the most important factors affecting the achievement of targets is the reduction of aid to developing countries. The report declares that the poorest countries received the biggest blow from this reduction. In 2012, net aid disbursements from developed to developing countries totaled $126 billion. This represents a 4 per cent drop in real terms compared to 2011, which was 2 per cent below 2010 levels. The decline affected least developed countries the most (UN, 2013b).

Rio+10, Rio+20

In 1992 was the Rio Environment and Development Summit; in 1997, the fifth annual assessment meeting was held in New York City, the Rio +5 Conference, following 10-year aims to be evaluated; and Rio +10, known as the World Sustainable Development Summit, 26 August to 4 September 2002, in Johannesburg was arranged.

The summits were followed by more than 104 heads of government and state as well as 20.000 participants, among them representatives of civil society organizations.

According to the Plan of Implementation of the World Summit on Sustainable Development, poverty eradication, changing consumption and production patterns, and protecting and managing the natural resource base for economic and social development are overarching objectives of and essential requirements for sustainable development (UN, 2002).

To achieve the objectives of Sustainable Development a new World summit was added, known as the Rio+20 Conference on Sustainable Development, aimed at a 20-year review of the 1992 Rio Summit. Held in Rio de Janeiro, “Sustainable development and the green economy” were established as the most important items on the agenda of the conference. In particular it was to lead to countries making

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the transition to a green economy, while realistic and implementable solutions for public and private sectors were also put forward.

The outcome of the Rio +20 Earth Summit, the "Future We Want" document, discussed limitations and failures, despite the activities of the last 20 years, in meeting the objectives of sustainable development. According to the document, poverty is still the world's biggest problem. Poverty eradication, highlighting the aspects of sustainable consumption and production, and conservation and management of natural resources in economic and social areas of development, are confirmed once again as objectives of basic and comprehensive sustainable development. As of 2015, it was necessary to accelerate the achievement of development goals, including the Millennium Development Goals, by making repeated efforts to show commitment (UN, 2012).

Key to Ecology-Economy Dilemma: Sustainable Development

The idea of economic growth had the dominant role in the development process of the country until the 1970s, when the idea of Sustainable Development was first put forward.

Backward countries never had to handle economic development in relation to the environment. However, the concepts of environment and development are not independent of or opposed to each other.

Development sustainability and acceptability are connected to adoption of the idea that the environment is the source of economic development and has limits. In this spirit, the sustainability of economic development makes the maintenance of environmental health also necessary. Each of these two cases can seem, at first glance, to have a property which endangers the existence of the other.

Within the framework of the international efforts mentioned above, today's three basic elements of sustainable development, economy, environment and society, have experienced a major transformation in their relationship.

Sustainable development within this vision requires:

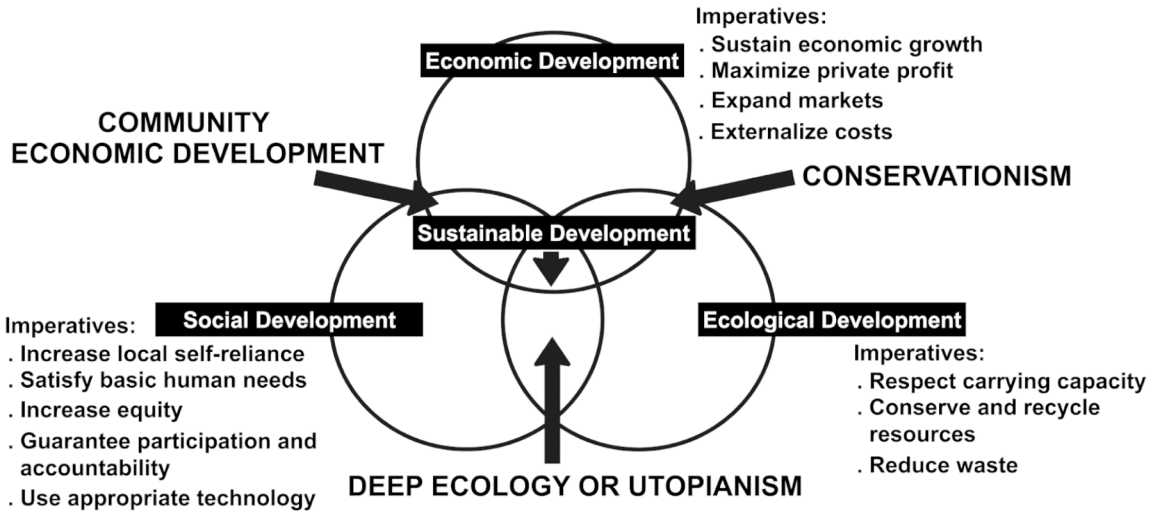
Economic competition within the world market, ensuring that basic needs such as education, people's housing, health, and clean drinking water are met in an appropriate manner, raising the level of welfare; Socially equitable policies, inclusive of disadvantaged groups and boosting the quality of life, From an environmental perspective, environmental pollution prevention and protection of the natural systems that support life in mutually supportive and complementary ways. A balanced planning, implementation and management process, between generations and inter generations. (Republic of Turkey, Ministry of Development, 2012)

1992 and later events showed that development begins first at the local level. It would not be possible to think of economy as separate from environment, environment from community, and community from the economy. The elements of economy, community and environment complement each other and each one has its own specific requirements (see Figure 1[3]).

Economic development also includes stable economic growth. It is necessary in the search for new markets that production capacity will inevitably need to grow. Community development requires an egalitarian social structure. Participation in decision-making should be improved. The presence of a social structure which is self-sufficient, able to meet basic needs and improve the quality of life is required. Ecological development demands resource utilization, reproduction of sources and less development, through technologies that respect the carrying capacity of nature. In fact, some aspects of community

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Figure 1. The sustainable development challenge



development will take place in a more effective in a way with the establishment of a healthy balance between economy and ecology.

So are these three requirements of the development process in conflict within each other? The answer to this question is yes, by the shortest path. Economic production resource needs will put pressure on the idea of conservation of natural resources. The basic needs of society as well as individuals within the framework of luxury consumption habits can support economic development at the expense of ecological development. Economically prosperous sectors of society will increase inequality in income distribution in relation to impoverished segments of society. These contradictions, as can be seen within a single society, can also be clearly observed between countries.

In this regard, sustainable development is a process of bringing these three development processes into balance with each other. The implementation of a sustainable development strategy therefore involves negotiation among the primary interest groups (stakeholders) involved in these three development processes (ICLEI, 1996).

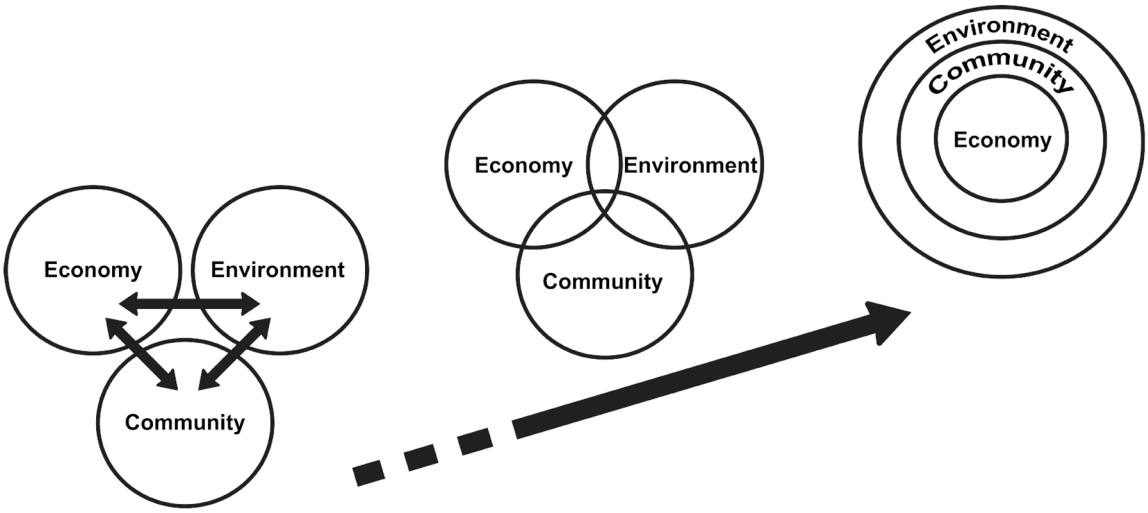
The current perception of the three dimensions of sustainable development is shown in Figure 2[4]. There is little belief in sustainable development as a mechanism for adaptation of these three dimensions, in an environment that has not produced effective solutions despite efforts taking place over the last 40 years. The presence of conflicting or crosscutting aspects render these three elements insufficient for the creation of a healthy harmony.

In a new perception, environment is evaluated in society and from the economy-wide perspective. Namely, the environmental conditions will acquire sustainability features or will weaken according to the community's economic preferences within their own lives. Developed at Rio +20, the "green economy" concept aims at catalyzing a reformulation of the environment rather than seeing environmental and economic thought as two separate, intersecting or conflicting, elements.

Sustainability means improving the quality of life concept in accordance with the carrying capacity of the area. The concept of sustainability is designed to provide sustainable development.

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Figure 2. Evolution of sustainable development thought



In fact, sustainability is meant to include the environmental sustainability of natural resources as components. The concept of sustainability, resource use, not only takes into account the needs of the present generation but also those of future generations.

Environment, earlier perceived narrowly as short-term solutions to contamination problems and their elimination, today has begun to present itself in terms of natural, economic, social and cultural values as a whole. The most important factor determining this outlook is the destruction of the resources used to carry out social and economic development by rapid and irreversible methods.

Sustainable development as a concept popular in recent years is not, however, actually a new concept. In one respect, it upholds one of the basic elements of classical growth theory. It is possible to trace the original roots of this concept to Ricardo and Malthus. Both asserted that there were "natural limits" to economic growth. Ricardo argued that land resources are limited, while Malthus argued that in the relation between increasing population and resources, there were limits to the growth of the "natural", and that, once these limits were reached, producing goods would not be possible (Aruoba, 1992). The basis of this idea is that progression of population growth is geometric, while the increase in natural resources is subject to an arithmetic progression. So while population multiplies greatly over 25 years, natural resources increase only slightly (Keleş et al., 2012).

The question to discuss in seeking an approach to resource allocation, in view of the "Environment-Production" problem, is whether to allow the use of sources of growth to continue at a rapid pace, if they are also to be used in the future.

The question to be asked at this point is: how long will this development continue?

Long-term and steady development, if adopted as a goal to be achieved at the expense of short-term goals embodying a wasteful attitude to consumption of natural resources, will bring us to the point of blockage. In the future, if it is not possible to replace exhaustible resources with other sources, sustainable development will be out of the question.

In this context, two different perceptions of sustainability have been suggested: Weak and Strong Sustainability (Pearce, 1999).

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These two concepts are shaped by the substitution relationship between natural resources and man-made capital. According to the weak sustainability concept, there is an unlimited opportunity for substitution between natural resources and man-made capital. Natural resources are not endangered, therefore do not require protection. Growth continues with only partial restrictions. Strong sustainability adopts a reverse approach. Replacement of natural resources as a policy is inadequate, since these resources' ability to renew themselves is limited. Therefore, prevention is required.

In some sources a third definition of sustainability is added: Environmental Sustainability (Tietenberg, 2003). By this definition, it is not only the total value of natural resources that is important; protection of the individual is connected. For example, if a lot of fish are caught on a regular basis, more than the total number of fish caught are taken into account in protecting them.

In this context, if physical or human capital can be substituted by natural resources, the total natural resource base will not decrease (Ertürk, 2011). Indeed, sustainable development depends on the sustainability of renewable natural resources. In this regard the production of renewable energy needs to be more involved in the process.

Accordingly, the ideas brought forward by the concept of sustainable development can be summarized as economic development that does not consume natural capital, does not take away the possibility for future generations to meet their own needs, protects the balance between the economy and the ecosystem, and is ecologically sustainable (Berkes & Kışlalıoğlu, 1990).

Environment, in terms of natural resources, is the foundation of the economy needed to sustain the lives of people living in the surrounding area, and thus coexists with it. With the close connections between the environment and economic stability, ensuring the sustainability of human life is of vital importance.

However, economic growth always brings the risk of environmental damage, as it puts increased pressure on environmental resources. But policy makers guided by the concept of sustainable development will necessarily work to ensure that growing economies remain firmly attached to their ecological roots and that these roots are protected and nurtured so that they may support growth over the long term (UN, 1987). Friendly compliance will be provided between environment and economy through sustainable development policy.

A balance between environmental sustainability and the economy can be established only when communities, with fewer resources, can take "a precautionary approach" to prevent environmental problems before they occur, rejecting the principle of "the development concept despite everything" and to that extent reducing the uneven development and prosperity gap between countries.

Against the concept of sustainable development, some other approaches have emerged. One of the most important is "rather than sustainable development, sustainable living" (Karaca, 1998). On this understanding, sustainable development means depletion and pollution. Depletion and pollution risks all life, should these goals be pursued. Because development means production, consumption means contamination. It is necessary to seek the concept of a life that will guarantee of the survival of all living things in the future.

Another topic of discussion is whether the sensitivity that governments show in the international conventions is adequately reflected in their internal legal order.

In relation to this issue, some examples are found in provisions of the 1982 Constitution of the Republic of Turkey[5].

In the 1982 Constitution of the Republic of Turkey, "Social and Economic Rights and Duties" are listed under the headings of Article 56 and 65, as follows:

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A. Health services and protection of the environment ARTICLE 56. Everyone has the right to live in a healthy and balanced environment. It is the duty of the State and citizens to improve the natural environment, to protect environmental health and to prevent environmental pollution. ….

XIII. The Extent of Social and Economic Rights (Before 2001) ARTICLE 65. The State shall fulfill its duties as laid down in the Constitution in the social and economic fields within the limits of its financial resources, taking into consideration the maintenance of economic stability.

XIII. The extent of social and economic duties of the State (After 2001) ARTICLE 65 (As amended on October 3, 2001; Act No. 4709): The State shall fulfill its duties as laid down in the Constitution in the social and economic fields within the capacity of its financial resources, taking into consideration the priorities appropriate with the aims of these duties.

As seen in Article 56, protecting the environment is located among the social obligations of the government and citizens.

Hence, as of today, according to Article 65 entitled "The extent of social and economic duties of the State", before the 2001 amendments, the state was looking out for economic stability in the social and economic performance of its duties. So that is one of the social obligations of environmental protection activities, should they adversely affect the economic stability of the state in carrying out its task. This application strengthened the state's discretion.

By the change made in 2001, "the maintenance of economic stability" was removed, and "the priorities appropriate with the aims of these duties" were added. In this case the government now will not only oversee economic stability to protect the environment, but the observance of environmental protection is expressed as a priority issue by the administration; if accepted, the government will fulfill this duty, but in fact, it is still at the discretion of the administration. However, the government's duty to protect the environment will not get caught on obstacles to economic stability alone.

As can be seen in the work of national legislation, taking into account the international approach to intellectual transformation, more is needed.

CONCLUSION AND REMARKS

The concepts of economy and ecology are not irreconcilable opposites. Greater competition between countries and the search for growth creates this dilemma. The only concern is for countries to exhibit a friendly attitude when discussing sustainable policies.

At the point of implementation of the principle of sustainable development, although it is not a full consensus even after a period of over 40 years, it is going ahead. The starting point of discussion is the developed countries which do not respect the balance of claims between protection and use. Those countries which destroyed the ecology are also trying to partner with less developed countries on the invoice.

With declarations and contracts signed after prolonged discussion by several governments, it remains to be seen to what extent sustainable life will be achieved. However, in reflecting on the application of these universal efforts, it appears that delays and conflicts of interest under the influence of forces might allow possible violations to occur.

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Today all mankind are connected to each other more than ever because of the problems faced in relation to a common destiny. So far, all the national and international entities have combined to serve the common destiny and to find solutions to the problems on a national and international basis. For this reason, international organizations and governments have to be more responsible and responsive to the opinions and expectations of the people of the whole world.

There isn't a single mould for sustainability, because economic systems and ecological conditions vary greatly between countries. Therefore, each nation must determine for itself its own concrete policy requirements. But regardless of these differences, environmentally sensitive, sustainable development is seen as a global objective.

No country cannot develop apart from the others. Hence, in the quest for sustainable development, a new orientation to international relations is required. Long-term and environmentally sensitive sustainable development ensures that necessary changes of great magnitude are also inevitable, with trade, capital and technology flowing more equitably and more in sync with the environment.

As a result, environment and development depend on how each one is clear on the relationship between ecology and economy. In this respect, protection and use preferences should be implemented in a harmonious balance. In fact, the relationship between ecology and economy, as elements indicating a contradiction, reflect how developed and developing countries embody non-harmonized preferences. When these two approaches reject each other, communities are interconnected willy-nilly. Instead of criticizing so as to trivialize the sustainable development approach, finding the solution to practical problems by joint action on economic, social and ecological issues, and eliminating inequalities, are the most important responsibilities of today's society.

International responsibilities to guarantee a sustainable future will vary according to the development level of countries and sectors. What's important is to manage sustainability in a common format, for a common future of all nations. Because humanitarian needs have common characteristics, a multilateral system is required. This system must accept that the world is one.

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KEY TERMS AND DEFINITIONS

Brundtland Report: This report established the "sustainable development" term.

Eco Development: This means that "environment does not exclude development".

Ecological Footprint: It refers to a measurable concept of the impact of production and consumption activities on the natural environment.

Resource Management: It refers to management of resources by considering the protection and usage balance.

Rio Conference: This was the second largest earth summit, held in 1992 in Rio de Janeiro, the capital of Brazil. It is known as the United Nations Conference on Environment and Development Earth Summit.

Stockholm Conference: This was the first largest global conference on environment under the leadership of the United Nations, held in 1972.

Sustainable Development: The development approach which envisages the use of today's resources by considering the needs of future generations.

Zero Growth: It is the Roma Club's utopian approach which aimed to limit growth and development, at the beginning of the 1970s.

ENDNOTES

1 The other four documents are Agenda 21, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity.

2 Social and Economic Dimensions: International cooperation to accelerate sustainable development in developing countries, and related aims of Combating poverty, Changing consumption patterns, Demographic dynamics and sustainability, Protecting and promoting human health conditions, Promoting sustainable human settlement development, Integrating environment and development in decision-making; also: Conservation and Management of Resources for Development: Protection of the atmosphere, Integrated approach to the planning and management of land resources,

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Combatting deforestation, Managing fragile ecosystems: combatting desertification and drought, plus sustainable mountain development, Promoting sustainable agriculture and rural development, Conservation of biological diversity, Environmentally sound management of biotechnology, Protection of the oceans and all kinds of seas, including enclosed and semi-enclosed seas and coastal areas and the protection, rational use and development of their living resources, Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management and use of water resources, Environmentally sound management of toxic chemicals, including prevention of illegal international traffic in toxic and dangerous products, Environmentally sound management of hazardous wastes, Environmentally sound management of solid wastes and sewage-related issues, Safe and environmentally sound management of radioactive wastes; also: Strengthening the Role of Major Groups: Global action for women towards sustainable and equitable development, Children and youth in sustainable development, Recognizing and strengthening the role of indigenous people and their communities, Strengthening the role of non-governmental organizations: partners for sustainable development, Local authorities' initiatives in support of the Agenda, Strengthening the role of workers and their trade unions, Strengthening the role of business and industry, Scientific and technological community, Strengthening the role of farmers; also: Means of Implementation: Financial resources and mechanisms, Transfer of environmentally sound technology, cooperation and capacity-building, Science for sustainable development, Promoting education, public awareness and training, National mechanisms and international cooperation for capacity-building in developing countries, International institutional arrangements, International legal instruments and mechanisms, Information for decision-making.

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Chapter 11
Green Growth in Mexico, Brazil, and Chile:
Policy Strategies and Future Prospects

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ABSTRACT

This research focuses on identifying the main policy strategies that could potentially contribute to the advance of three Latin American economies, namely Brazil, Chile and Mexico towards a green growth model that is social and inclusive, given the actual patterns of development of those economies. With this aim, we first identify and describe past and current policies in each country in terms of economic, social and environmental indicators. A detailed analysis follows for Brazil, Chile and Mexico, in which we propose a series of green growth indicators and choose a definition and classification of green growth sectors. We estimate an empirical model to explain the determinants of greenhouse gas emissions and deforestation in Latin American countries. We broadly identify the sectors that contribute to its increase and describe the main green policies applied in each country. In turn we identify the sectors with higher potential for the future. Finally, we present policy recommendations and reflections for the future.

1. INTRODUCTION

There is a vast interest for countries in achieving green growth not only as it is related to lower energy intensities but also as it is related to a higher quality of life. This interest has also led to a growing proliferation of studies and scientific research, whose main objective has been to identify the factors that contribute to green growth and the policies that should be implemented in different countries to enter the path of green growth. The main objective of this research is to analyze from a socio-economic and environmental perspective recent developments in three Latin American countries, namely Brazil, Chile and Mexico, concerning green growth and social inclusion. Past and current environmental as well as

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social policies are compared between the countries and are related to a selection of indicators. We analyze in particular developments of greenhouse gas emissions, deforestation and social indicators.

According to The United Nations Environment Program (UNEP), a green economy should aim at improving human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Green growth in income and employment should in turn be driven by investments that reduce carbon emissions and pollution, improve resources and energy efficiency and avoid the loss of biodiversity (UNEP 2013). The main greenhouse gas is carbon dioxide (CO_2) and therefore CO_2 will be used as the main global environmental-degradation indicator. Other greenhouse gases considered are CH_4 and N_2O. In order to account for biodiversity losses, we rely on the measure of forest area in each country.

This research has four complementary objectives. First, a detailed description of the most relevant economic and socio-economic indicators in the three countries under study is presented in order to identify the main environmental challenges. As economic indicators we present the sectoral distribution of GDP (agriculture, services, manufactures) as well as GDP and trade growth figures. The socio-economic indicators considered are GDP per capita, population, life expectancy and education (World Bank 2013; World Economic Forum 2013; FAOSTAT 2013), poverty and social inequality (poverty rate, Gini coefficient, gender inequality), as well as the different dimensions of the Human Development Index and the Human Opportunity Index, both developed by the World Bank and the Global Gender Gap Index, published by the World Economic Forum since 2006. We further study what are the main industries/sub-sectors in each country in terms of production and employment and identify how much each sector contributes to pollution in terms of greenhouse gas emissions in order to describe and analyze the impacts these sectors have on green growth. Second, we analyze a number of green growth indicators classified according to international criteria for Brazil, Chile and Mexico and select four of them, namely CO_2, CH_4 and N_2O and deforestation to analyze how sectoral changes have contributed to the development of the four green growth indicators. Third, a detailed description of the institutional structure and the measures and strategies related to environmental policy and its impact on poverty, social and gender inequality is outlined. Based on the results obtained, the most successful economic activities in terms of green growth and inclusion are identified for each country, and are studied in comparative terms using an economic model. Finally, the study provides policy recommendations concerning social, economic and sectoral issues to draw specific action lines for each country to improve the results in terms of social inclusion and green growth.

The methodology is based on secondary data collection, graphical and descriptive analysis of the data and specification and estimation of an economic model to draw policy implication based on the results. A comparative analysis of country data in terms of polluting effects of the most important sectors and industries in each country is presented. We also analyze the data collected for LA countries by specifying and estimating an economic model, which explains the determinants of three greenhouse gases and deforestation. The model, which is used to identify the contribution of each economic sector to green growth, is derived from the identity IPAT identity:

$$Impact = Population * Affluence * Technology\,.$$

This identity states that the level of pollution, impact (I), depends on three factors: population (P), gross domestic product (A) and the state of technology (T) in a country. Marin and Mazzanti (2009)

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apply this model at the aggregated level; this paper proposes to apply the model to sectoral-level data of CO_2, CH_4 and N_2O emissions, gases that significantly contribute to the greenhouse effect. Grunewald and Martínez-Zarzoso (in press) have applied the IPAT model to estimate the effect of country participation in the Kyoto Protocol on carbon emissions.

The paper is structured as follows. Section 1 presents a brief review of the economic, social and environmental patterns in the three selected countries. Section 2 outlines the methodology. First, several green growth indicators are presented and compared between the three countries and second, four green growth indicators are chosen to analyze how sectoral changes affected green growth in Latin America. Section 3 presents the main results of the model estimation and of the comparative study. Section 4 describes the main green policies implemented in each country in the last decade to improve environmental quality and to encourage clean development, their limitations and their expected outcomes. Finally, section 5 outlines policy recommendations regarding the subsectors with a greater growth potential.

2. CURRENT ECONOMIC POLICIES

In this section we first present current and historic economic and social indicators. We describe the main economic sectors and their economic and social weight in order to identify the key environmental issues that are relevant for each sector and country.

2.1 Model of Economic Development and Growth Patterns

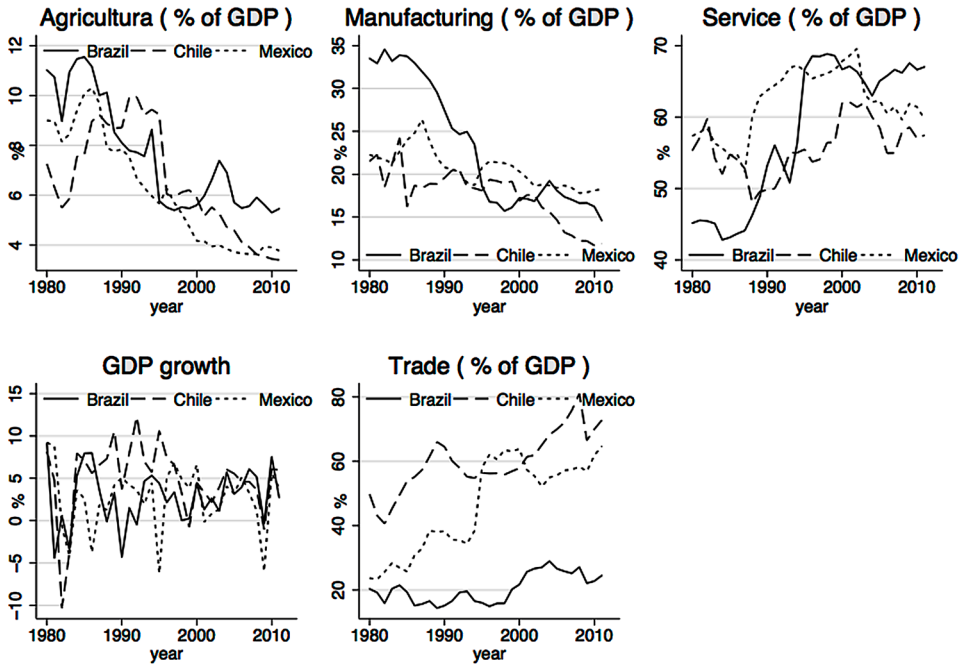
After a period in which import substitution and trade limitation had been the main foreign policies in most Latin American countries, these policies were replaced in the 1980s by trade liberalization and export promotion strategies. Brazil, Chile and Mexico tried to increase economic competitiveness by supporting the creation and intensification of specific clusters of economic activity. Brazil and Mexico focused on the manufacturing sector, and in particular on the automobile industry, whereas Chile focused on the refining and extraction of natural resources, such as copper. The free trade strategies in the three countries were further strengthened with the creation of Mercosur and with Mexico entering the NAFTA free trade agreement in 1995. Meanwhile, out of the three countries Chile has been the most active signing free trade agreements outside the American continent. At the same time, a number of economic reforms have aimed at creating the legal basis to attract foreign direct investment (Peres, 2011).

Figure 1 has been steadily increasing, fact which can be attributed to the above-mentioned policies. The strong rise in Mexican trade has been mainly based on exports of manufacturing goods. The expansion of Brazil's agricultural sector, especially in soy and bio ethanol, explains the more modest decline in the share of value added of the agricultural sector in comparison with the other countries. Also the share of value added in manufacturing goods has been declining for all three countries especially for Brazil. In Mexico it declined just slightly over the period analyzed.

Turning to the specific policies in each of the three countries, Brazil's policy reforms between 2003 and 2008 focused on the development of international well-established industries such as high tech and pharmaceutics, in which the country however did not have a comparative advantage. At the same time, one of its core industries, namely the car industry, was protected with a 30 percent import tax on cars imports with more than 65 percent foreign content (Ban, 2013). Currently, Brazil is promoting the biofuel sector as part of its low carbon development plan. The Brazilian National Plan on Climate Change aims

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Figure 1. Sectoral development and trade
Source: World Bank (2013).



at providing low carbon growth in line with social development and poverty reduction. In particular, the applied policies try to identify the most vulnerable groups and provide climate change adaption, education and development assistance (Fujita et al., 2013).

The golden age of growth in Chile, from 1978 to 1997, was mostly achieved through export led growth driven by the mining sector. Since 1990 Chile started to apply and enforce the implementation of environmental policies focusing on a few key sectors, namely mining, energy, agriculture, transport and tourism. The mining sector contributed up to 18 percent of total GDP and around 50 percent of total exports between 2004 and 2008. It is the most capital as well as water and energy intensive sector. Since 1970 Chile has been determined to treat wastewater from the mining industry before discharging it surface waters. Chile is leading in water management and introduced tradable water rights already in 1981. Nevertheless, the total revenues from environmental taxes are still low compared to other OECD countries (OECD, 2011).

Mexico turned to a marked driven industrial policy after the crisis in 1982. State preferences for specific industries, as well as subsidies and other distortions, were reduced or eliminated. As a result, Mexico started to diversify its economy and moved from exporting mainly primary products to also focusing on export of manufacturing goods. Since the mid-1980s, the steady increase in trade and foreign direct investment has also generated technological spillovers, especially in the maquiladora industry located on the US border. Car manufactures and electronics are among the main industrial sectors, the latter sector in particular was growing very fast in the 2000s. However, Gallagher & Shafaeddin (2010) find that these technological spillovers are minor and that US firms producing in the Maquiladoras achieve their technological developments mainly outside of Mexico. They further point out that foreign direct investment partially crowded out local investments in research and development. Although the first Na-

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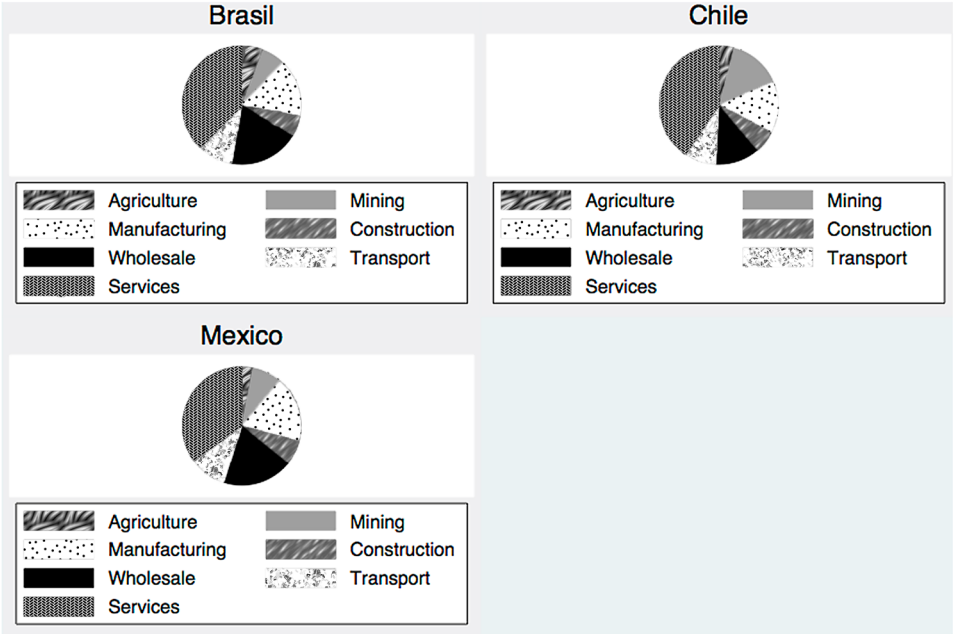
tional Climate Change Strategy was only launched in 2007, Mexico was the first of the three countries to implement policies that promoted the use of renewable energies. It started in 1975 with the Public Electricity Service Law, which main aim was to provide electricity more efficiently and to incorporate the electricity from renewable energies.

2.2 Human Development Indicators

A green economy should contribute to reducing poverty and social inequality. Hence, to achieve sustainable growth human and social progress should also be achieved. Figure 2 shows how the above-mentioned economic policies have influenced socio-economic development. We use four indicators, namely GDP per capita in international dollars, secondary school enrolment rates, life expectancy at birth and population. The first three indicators are commonly known as the basis of the Human Development Indicator (HDI) computed by the United Nations, which define development as progress in the three dimensions of the index: income, education and health.

Regarding Figure 2, Chile clearly shows the highest GDP per capita figures with a strong rise since the early 1990s. Mexico and Brazil show instead a moderate growth in GDP per capita. Concerning education, Brazil reached full secondary school enrolment already in 2000; meanwhile Mexico and Chile still show values below full enrolment in 2012.[1] Life expectancy, which is closely correlated with GDP per capita, is the highest in Chile with almost 80 years in 2010 followed by Mexico (77) and Brazil (74). Therewith, we conclude that the progress in human development in the three countries has not only been driven by higher GDP per capita rates, but also by improved educational as well as health standards. Population has been growing steadily in Brazil as well as in Mexico, and at a lower path in

Figure 2. Socioeconomic development indicators
Source: World Bank (2013).

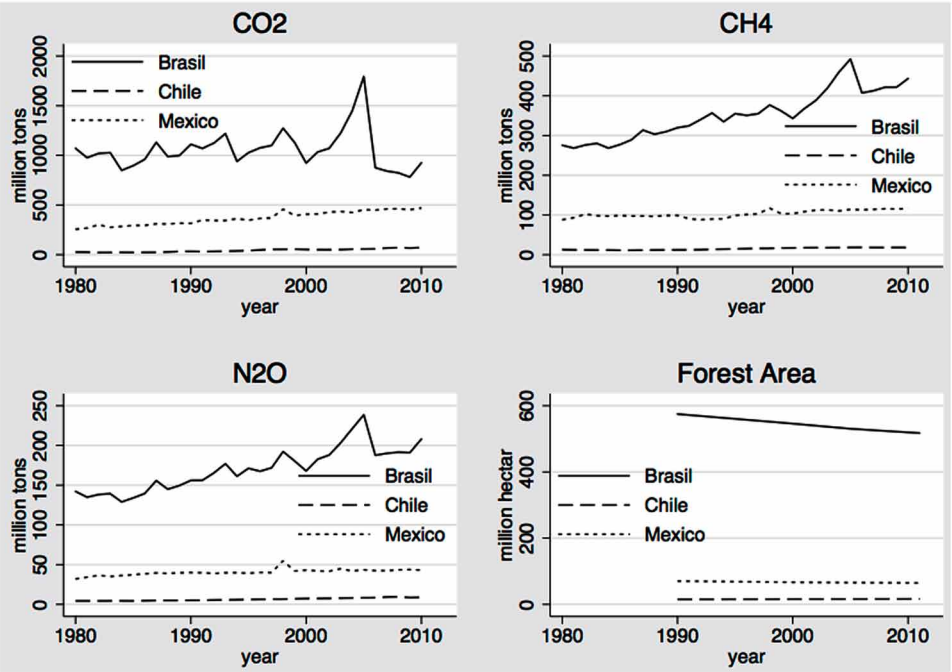


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Chile. The HDI as a composite index ranges between 0 and 1, with higher values indicating higher levels of development. During the period from 980 to 2012, Brazil improved its HDI by 21 percentage points (from 0.52 to 0.73), Chile's HDI gained instead18 percentage points (from 0.64 to 0.82) and Mexico 17 percentage points (from 0.6 to 0.77). Chile and Mexico's scores are in the range attributed to high human development countries, meanwhile Brazil is still considered to have medium human development.[2]

The second important aspect of social development is related to equity and poverty reduction. The upper part of Figure 3 shows the evolution over time of income inequality and poverty rates in the three countries. The Gini index is used as a measure of inequality in levels of income among individuals within a country. A value of 100 indicates total inequality (one individual earns all the income) and a value of 1 indicates total equality (every individual earns the same). As shown in Figure 3, the Gini index of Brazil is the highest among the three countries, with a value of 54 in 2010. Mexico, on the other hand, with an income inequality of 47 is much closer to the OECD average, which is 46. Those differences reflect historic distributions of assets among the population and are a consequence of past policies, which failed to give equal opportunities to the population. Figure 3 also shows that the levels of income inequality have been declining over time in the three countries and that the number of people living with less than 2 international dollars a day also declined drastically since the mid-nineties. This indicates that the social policies from the last two decades also seem to have had an effect on income inequality and poverty levels. Therefore, we can conclude that some of the GDP per capita growth as indicated in Figure 2 has reached poor households. Other important indicators of socioeconomic development are the access to water and electricity. Figure 3 shows that the access to water has increased substantially since 1990 with Chile reaching almost 100 percent access and Mexico 94 percent. Access to drinking water in the household goes usually in line with access to sanitation and shows large health and environmental

Figure 3. Poverty and capability measures
Source: World Bank (2013).



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benefits. The data on electrification of households is scarce and indicates that almost all households in Brazil and Chile have access to electricity. However, the related literature indicates that remote areas in the three countries still do not have access to electricity.

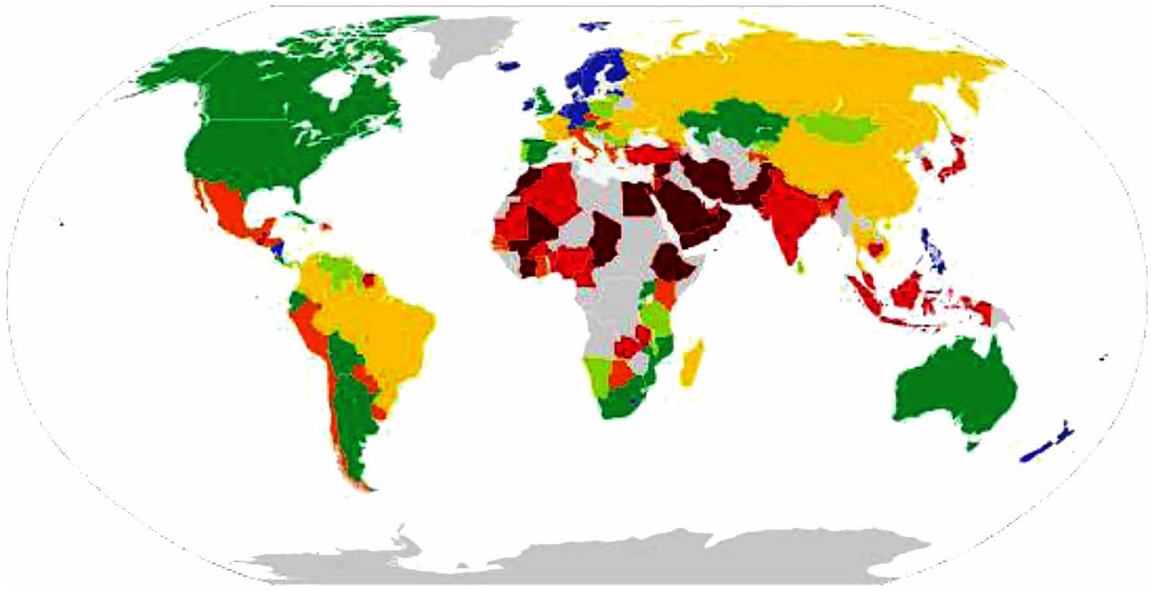
In terms of the Human Opportunity Index (HOI, World Bank), which measures how personals circumstances impact children's probability of accessing the necessary services to success in life, Chile (95 percent) and Mexico (90 percent) have the highest overall HOI in Latin America, being first and third in the LA ranking, whereas Brazil lies behind (78 percent). In all three countries there have been moderate improvements over the last decade. Finally, the Global Gender Gap Index (Figure 4), which measures the percentage of the inequality between women and men that has been closed in access to resources and opportunities, indicates that the three countries have made some progress in closing this gap in the last seven years, with Brazil been slightly better positioned (0.69 in 2012, place 62 in the ranking of 135 countries) than Mexico (0.67) and Chile (0.66).

Summarizing, in terms of human development the situation of the three countries is as follows. Whereas Chile is the country with the best performance, Mexico has also performed well and both countries are classified as highly human-developed countries. On the other hand, Brazil, which has also improved in several aspects, especially in decreasing poverty and inequality rates and in closing the gender gap, is still classified as medium human-developed country in terms of its HDI rating.

2.3 Main Economic Sectors and Environmental Concerns

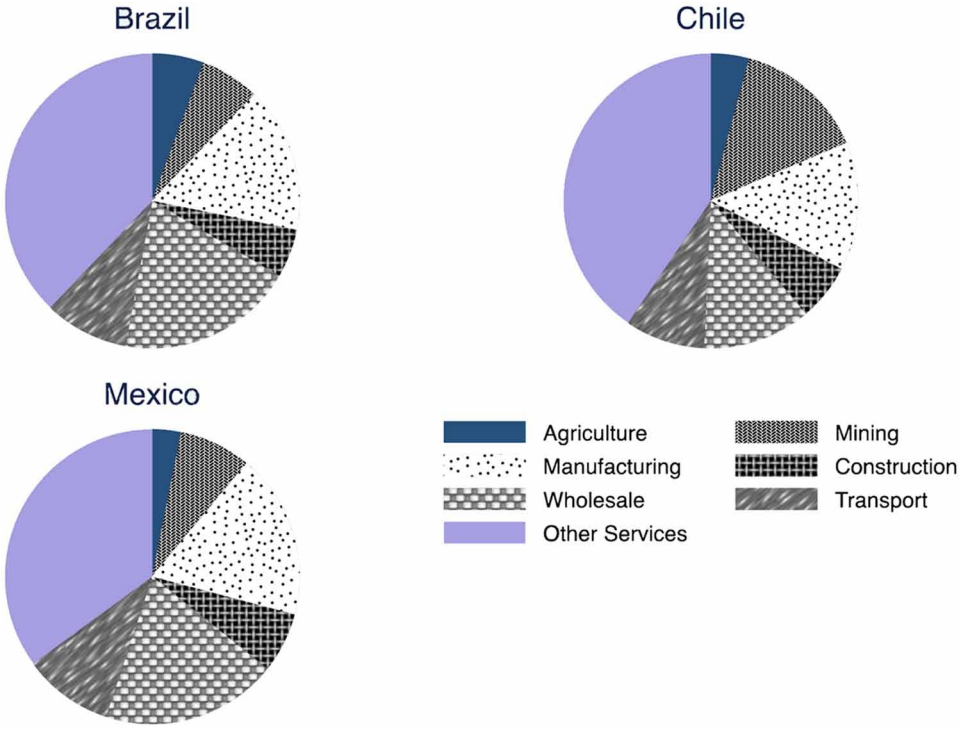
Generally during the development process a country passes through a stage in which the agricultural sector is prevailing, followed by industrialization with a growing manufacturing sector and reaching later on a post-industrialization stage with a strong service sector. We present a more disaggregated look into the composition of the sectoral value added for each country in Figure 5. More specifically, the mining

Figure 4. Global gender gap
Source: World Economic Forum (2013).
Note: The highest possible score is 1 (equality) and the lowest possible score is 0 (inequality).



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Figure 5. Sectoral value added to GDP in 2011
Source: UNSTAT (2013).



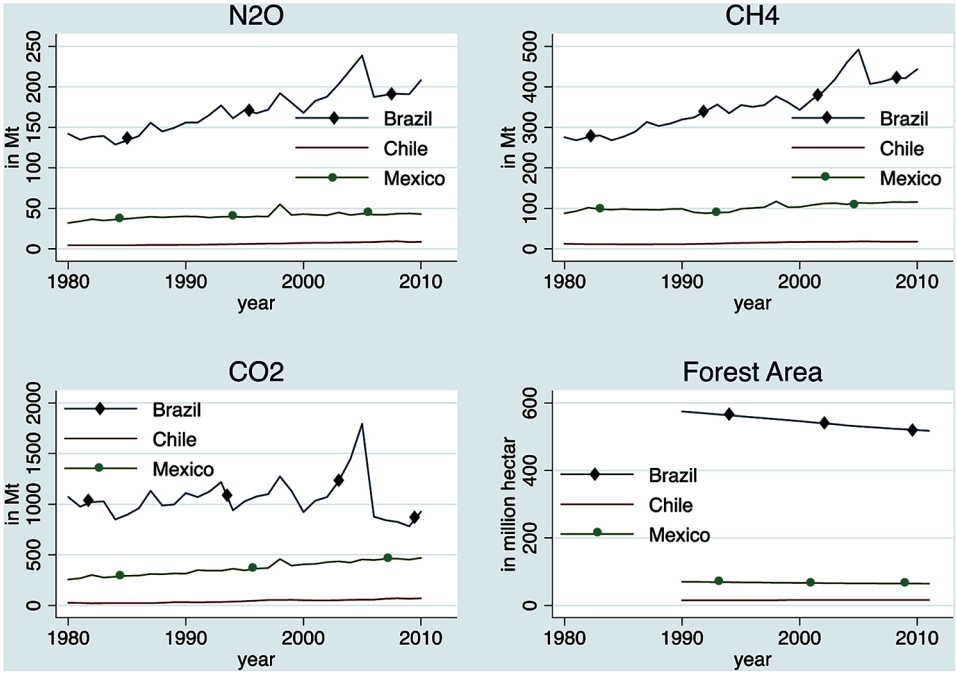
sector is shown separately and the service sector is decomposed into wholesale, construction, transport and other services. The wholesale sector includes retail trade, restaurants and hotels. The main difference between the three countries is the larger share of the mining sector and smaller share of the wholesale and manufacturing sectors in Chile in comparison to Brazil and Mexico.

The socio-economic importance of each specific sector could be measured with the number of people employed. In Brazil the largest sector is "other services[3]", which accounted for around 30.3 million formal jobs (33 percent) in 2007, followed by the wholesale sector, which accounted for almost 20 million employees (22 percent), agriculture with 16.6 million jobs (18 percent) and manufacturing with 13.1 million jobs (14 percent). Mining, which creates about 10 percent of value added, occupies 379000 (0.4 percent) employees. Also in Chile, the largest employer is "other services" with almost 2.5 million employees (37 percent of total employment) in 2008 followed by wholesale with 1.3 million employees (20 percent), manufacturing with 865000 employees (12 percent) and agriculture with 790000 employees (12 percent). Only 1.5 percent of the employees work in the mining sector. Finally, in Mexico the picture is slightly different, with the wholesale sector accounting for 12.8 million employees (30 percent), followed by other services with 12 million jobs (27 percent), manufacturing with 7.2 million jobs (17 percent) and agriculture with 7.6 million jobs (13 percent).

Figure 6 shows the development of three major greenhouse gases and forest area in the three countries. Brazil the biggest economy of the three countries has the highest emissions from N_2O, CH_4 and CO_2. The data on CO_2 emissions is the most volatile in comparison with other greenhouse gases, mainly

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Figure 6. Sectoral composition of the three economies
Source: (EDGAR 2013; FOASTAT 2013).



because CO_2 emissions are highly correlated with GDP. CH_4 and N_2O are mainly omitted by agricultural activities such as the use of fertilizers.

Figure 6 shows that over time greenhouse gas emissions have been steadily rising over time, fact that should raise environmental concerns. Also an alarming signal comes from the forest area measure for Brazil and Mexico, where loses in forest area of 10 and 8 percent, respectively are shown in the last two decades, whereas in Chile an increase in 7 percent has been observed.

3. METHODOLOGY

The methodology section is structured as follows. First, section 2.1 presents a more detailed selection of green growth indicators that will be used to identify the sectors with greater potential for green growth by country. Second, section 2.2 presents the model specification for the regression analysis including all Latin American countries, whose results will be presented in section 3.

3.1 Green Growth Indicators: Measurement and Analysis

Until very recently green growth publications have mainly dealt with specific issues related to climate change and with assessing the efficiency of environmental policy instruments. Currently, the related discussion goes beyond the above-mentioned aspects and covers taxation, eco-innovations, public infrastructure, and access to clean water as well as resource efficiency. Therefore, new analytical tools

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are needed to integrate the use of natural resources into productivity measurement and growth models in order to develop new methods to assess environmental impacts. This evolution is also reflected in the "green models" followed by Brazil, Chile and Mexico in recent years.

3.1.1 Selection of Indicators

In this section we present a number of indicators to measure progress in green growth in each country and analyze their evolution over time. We partly follow the framework proposed by the Green Growth Knowledge Platform (GGKP) in 2013. GGKP is a global network created with the main aim of identifying and addressing the major knowledge gaps concerning green growth in theory and practice. It was launched in Mexico in 2012 by the OECD, United Nations Environment Program (UNEP), the World Bank and the Global Green Growth Institute (GGGI). Its Green Growth Knowledge Platform Scoping Paper (GGKPSP 2013) proposes a common approach on green growth indicators based on the knowledge already accumulated by the GGKP members since 2009, when the UNEP took a leading role in the promotion of "green growth" with its Policy Brief "Global New Deal".

The main characteristics that green growth indicators have to fulfill according to the GGKP are: to be dynamic and flexible; to cover the main areas of concern at the country level but also at a global level; and to allow for the evolution or addition of new indicators. Furthermore, indicators should be selected based on transparent criteria and should be available from reliable sources. The set of categories covered can be classified into 5 categories, namely: *natural asset base*; *environmental life quality*; *environmental and resource productivity indicators*; *economic opportunities* and policies; and *social (well-being) indicators*. We compare a number of indicators from each category across the selected countries. Some of them will be selected for our IPAT analysis in the next section. The selection criteria are availability and relevance.

First, as indicators of the *natural asset base* we present forest resources, land resources and water resources, as well as the percentage of threatened species, as a measure of diversity. Table 1 shows the average values of a list of available indicators. Brazil has the highest percentage of forest area (61 per-

Table 1. Natural assets, environmental life quality, and biodiversity: 1990-2011

Indicator	Average			Change		
	Brazil	Chile	Mexico	Brazil	Chile	Mexico
GG_C12: Renewable freshwater, thousand m3 per capita	-	62.8	4.1	-	-24%	-26%
GG_C13: Total freshwater abstraction, thousand m3 per capita	0.3	2.0	0.6	-	-	-
GG_C41: Arable and cropland, % total land area	8.1	3.0	14.1	38%	-42%	7%
GG_C42: Pasture, % total land area	22.8	18.0	39.8	6%	9%	-3%
GG_C43: Forest, % total land area	64.6	21.2	34.6	-10%	7%	-8%
GG_C44: Other land, % total land area	4.5	57.8	11.6	81%	-2%	31%
GG_C51: % Threatened species – Mammals	-	25.1	35.0	-	-	-
GG_C52: % Threatened species – Birds	-	10.9	21.9	-	-	-

Source: OECD Statistics (2013).

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cent in 2011, equivalent to 5.17 million km^2) with a decline of 10 percent over the period 1990 to 2011, followed by Mexico (646 thousand km^2), which also experienced a decline of the forest area of about 8 percent. Whereas, Chile's forest area (around 20 percent, 163 thousand km^2), has increased over the period (7 percent). In Mexico pasture and cropland represent more than 50 percent of the total land, with other land showing the highest percentage in Chile (58 percent). In Brazil pasture, cropland and arable land represent around 30 percent of all available land.

Concerning *environmental life quality*, Chile is relatively rich in fresh water resources in comparison to Mexico; whereas this indicator is not available for Brazil. Regarding biodiversity, the percentage of threatened species is considerably higher in Mexico than in Chile, and unfortunately, the data from the OECD is only available for a single year and is missing for Brazil. In addition, according to World Bank data, the number of threatened fish (mammals) species is 83 (81) in Brazil, 20 (20) in Chile and 152 (100) in Mexico. The World Bank also provides data on the benefits index for biodiversity (from 0= no biodiversity potential to 100=maximum). Brazil's rating is 100, with the maximum potential, followed by Mexico with a value of 69 and Chile with 15. Out of the first two categories we will use forest area as an indicator for the economic model estimated in the next sub-section.

Table 2 shows environmental and resource productivity and intensity indicators (category 2). We mainly focus on emissions productivity/intensity, energy and non-energy material productivity as well as the supply of renewable energy. The first indicator, production-based CO_2 emissions show a decrease in Brazil, but an increase in Chile (25 percent) and Mexico (5 percent). Concerning intensity indicators, emissions intensity has almost doubled in Brazil and Chile and increased by 17 percent in Mexico. At the same time, energy intensity has increased in the three countries. Regarding productivity, production based indicators measure the total amount of CO_2 emitted during production processes relative to GDP,

Table 2. Environmental and resource productivity: 1990-2010

Indicator	Brazil		Chile		Mexico	
	Aver.	Change	Aver.	Change	Aver.	Change
GG_B11: Production-based CO2 emissions, index 1990=100	91.37	-8.17	118.12	25.63	102.55	4.94
GG_B12: Production-based CO2 productivity, US$ per kg of CO2	5.05	-8.14	3.32	26.52	3.30	4.97
GG_B13: Production-based CO2 intensity, tonnes per capita	1.68	51.13	3.23	72.88	3.47	17.78
GG_B14: Demand-based CO2 productivity, real net national income per unit of CO2	2.37	-2.41	2.69	-	2.72	1.87
GG_B21: Energy productivity, US$ per ktoe	7.51	-3.26	7.11	28.59	7.58	13.49
GG_B22: Energy intensity, toe per capita	1.12	42.71	1.50	70.75	1.52	8.90
GG_B26: Renewable energy supply, % TPES	43.09	-6.14	25.99	-21.01	11.29	-19.85
GG_B27: Renewable electricity, % total electricity generation	90.00	-10.35	53.81	-24.98	20.30	-28.72
GG_B32: Non-energy material consumption - DMC, 1990=100	117.23	39.23	205.69	212.94	116.03	37.06
GG_B33: Non-energy material productivity, US$ per kg	0.62	5.08	0.39	-26.67	1.32	10.57

Source: OECD Statistics (2013).

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demand-based indicators measure instead the CO_2 embedded in final domestic demand (CO_2 footprint) and therefore also consider the effect of international trade. Production-based CO_2 productivity shows a slight decrease in Brazil and a slight increase in Chile and Mexico. In contrast, demand-based CO_2 productivity has remained stable and at similar levels in the three countries. Material productivity is the highest in Mexico and the lowest in Chile and it has sharply increased over time in Brazil and moderately in Mexico but decreased in Chile. In contrast, energy productivity has slightly decreased in Brazil and increased in Chile and Mexico, but stays at similar levels in the three countries. In terms of renewable energy supply, it represents more than 40 percent of total energy supply in Brazil, but only around 22 and 10 percent respectively in Chile and Mexico. Renewable electricity represents more than 80 percent of total electricity generation in Brazil in contrast to 40 and 18 percent in Chile and Mexico. Hence, in the latter two countries there is potential to increase these percentages to higher levels.

From this category, production based CO_2 emissions, will be used in the empirical analysis, since it is available for all LA countries and over time.

As *economic opportunities* and *policy responses*, a number of proxies for innovation and environmental policies are shown in Table 3. Brazil is the leader in terms of green patents, showing an impressive increase in 2005 and 2010. Unfortunately, this indicator is not available for Chile and Mexico, for which only the percentage of green patents as a share of total patents is shown. Patents in renewable energy represent around 2 percent of total number of patents in Brazil and 1.75 in Mexico, but less than 1 percent in Chile, a country which has been more active with innovations in the water pollution sector since 2010. It is worth noting that expenditure on R&D was only 1.1 percent in Brazil in 2010 (compared with only 0.37 in Chile in 2008 and 0.40 in Mexico in 2010), significantly below the OECD average. As regards environmental policies, total environmental taxes as a percentage of GDP shows the highest value in Brazil (more than 3 percent) and the lowest in Mexico, with Chile collecting around 1 percent of its GDP in environmental taxes. The values in Brazil are the closest to the OECD average of 3 percent. In comparison to labor taxes, environmental taxes account for a similar percentage of GDP in Chile. In Mexico labor taxes represent only 0.25 percent of GDP and are higher than environmental taxes (which show negative values in 2006-2008 and 2010-2011). This negative revenue is due to the structure of the existent fuel tax, which is levied inversely to oil prices and therefore turns into expenditures above

Table 3. Innovation and environmental policy indicators: 1990-2010

Indicator	Brazil	Chile	Mexico
GG_E13: Public spending in environmentally related RD, % total public spending	-	-	1.366
GG_E17: Green Patents, Index 1990=100	720.5	-	-
GG_E19: Patents - Electric and hybrid vehicles, % total PCT patents	0.072	0	0.106
GG_E110: Patents - Energy efficiency in buildings and lightning, % total PCT patents	0.114	0	0.116
GG_E111: Patents - Renewable energy, % total PCT patents	0.998	0.196	0.65
GG_E112: Patents - Air pollution, % total PCT patents	0.962	0.244	0.522
GG_E113: Patents - Water pollution, % total PCT patents	0.874	0.782	1.374
GG_E114: Patents - Waste management, % total PCT patents	1.904	0.516	1.254
GG_E41: Total environmentally related taxes, % GDP	2.264	1.038	-
GG_E42: Labour taxes, % GDP	-	1.362	-

Source: OECD Statistics (2013).

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a certain level. We will not be able to use indicators in this section in the economic model because they are only available for a limited number of years and their incidence (e.g. patents) is still very low.

Finally, we present a number of *socio-economic or well-being indicators* that depart from the use of GDP per capita as the only indicator and move towards measures related to sustainability and the quality of growth. The better life index is part of the Better Life Initiative (LBI). This index has been constructed following the approach proposed by Stiglitz et al. (2009), which distinguishes between current wellbeing and its sustainability over time and includes environmental related aspects. It is planed that future work will also include inequality indicators. The ranking of OECD countries indicates that Chile and Mexico have very low scores (0.37), and are only better placed than Turkey (0.23). Although Brazil is not included in the overall score, it is ranked according to a single indicator.

Table 4 presents the values of the different categories used to compute the index for the three countries under study, as well as the average score for OECD countries. A total of 11 categories are listed, which refer to different aspects related to the quality of life. In recent years the quality of life of its citizens has improved in Brazil, which reflected by the value of the "life satisfaction" indicator. Indeed, Brazilian life satisfaction is slightly above the average OECD value and the value for Chile is slightly below, with Mexico showing a higher value. However, in terms of net adjusted disposable income Brazil is far below the OECD average and also Chile's and Mexico's values are half than the OECD average. In terms of housing facilities, the percentage of dwellings without basic facilities (access to an indoor flushing toilet) is very high in Chile and Brazil. Mexico's value is still twice as high as the OECD average, hence there is potential for improvement. Concerning jobs, 68 percent of the population in Brazil have a paid job (80 percent for men compared to 56 percent for women), whereas in Mexico's and Chile's the employment rate is lower and below the OECD average. Long-term unemployment rates are lower in the three countries than the OECD average and personal earnings are close to the bottom of the earning distribution in OECD countries, especially in Mexico. The quality of the support network measures the percentage of people that believe to know someone they could rely on in time of need. A weak social network is reported for Mexico, whereas Brazil shows the highest percentage close also to the OECD average.

In terms of education attainment, which measures the percentage of adults with a high-school degree, Mexico and Brazil present very low numbers, whereas Chile is close to the OECD average, hence room is left to improve education in the first two countries. Indeed, in Mexico around 60 percent of the population aged 25 to 64 have not completed upper secondary education.

The quality of local living environment is measured with two indicators. First, using PM_{10} concentrations as a proxy for local air pollution, which are highly above 20 micrograms per cubic meter (annual guideline limit set by the World Health Organization) in Chile and Mexico, with Brazil showing a lower level (19). Second, the indicator "access to clean water", which is basic for human well-being, measures the percentage of people that are satisfied with water quality in each country, with Brazil showing the lowest percentage and Chile and Mexico also with values below OECD average.

Civil engagement is the highest in Mexico when measured by the consultation on rule-making indicator, which is based on a composite index that comprises information on the openness and transparency of a consultation process. However, Chile shows the lowest score in the sample of countries and also Brazil shows a low score. In contrast, in terms of voter turnout Mexico shows a value of 63 percent, well below the values observed for Chile (88) and Brazil (78), both above the OECD average (72).

Also health indicators are considered to construct the better life index. Among them are life expectancy and self-reported health, the later indicating that about 59 percent of adults in Chile say their health is good or very good. Values closer to the OECD average are reported in Mexico and Brazil.

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Table 4. Socio-economic indicators: better life index indicators

Measure	Indicator	Country			
		Chile	Mexico	Brazil	OECD
Housing	Dwellings without basic facilities	9.4	4.2	6.7	2.2[a]
	Housing expenditure	18	18	21[a]	21[a]
	Rooms per person	1.3	1	1.4[a]	1.6[a]
Income (USD)	Household net adjusted disposable income	11039	12732	10225[a]	23047[a]
	Household net financial wealth	16972	9946	5861[a]	40516[a]
Jobs	Employment rate	61	60	68	66
	Job security (% of temporary contracts)	10.5 [a]	21.4	14	10.5
	Long-term unemployment rate	2.94 [a]	0.11	3.02[a]	3.14
	Personal earnings (USD)	15820	9885	10905[a]	34466
Education	Educational attainment (% with High-school)	71	36	41	74
	Student skills	439	420	401	497
	Years in education	16.2	14.9	16.3	16.5
Environment	Air pollution (PM10 concentrations)	53	33	19	21
	Water quality (% of people satisfied)	77	78	75	84
Civic engagement	Consultation on rule-making (index)	2	9	4	7.3
	Voter turnout (%)	88	63	78	72
Community	Quality of support network	82	76	88	90

Note: * denotes estimated values. Source: OECD Statistics (2013).

Table 5. Socio-economic indicators: better life index indicators continued

Measure	Indicator	Country			
		Chile	Mexico	Brazil	OECD
Health	Life expectancy	78.3	74.2	73.5	79.8
	Self-reported health	59	66	69[a]	69
Life Satisfaction	Life satisfaction	6.5	7.3	6.7	6.6
Safety	Assault rate (% of people assaulted, last 12 months from Gallup World Poll)	8.3	13.1	7.9	4
	Homicide rate (murders per 100,000 inhabitants)	3.7	23.7	21	2.2
Work-Life Balance	Employees working very long hours (% of employees working more than 50 hours per week)	16.32	28.63	12.5	8.76
	Time devoted to leisure and personal care (hours per day)	13.66[a]	12.66 [a]	14.84 [a]	14.87 [a]

Note: * denotes estimated values. Source: OECD Statistics (2013).

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Safety is a great matter of concern in Mexico with extremely high rates of assault (more than 3 times the OECD average) and homicide (more than 10 times the OECD average), the later being also very high in Brazil. Finally, regarding work-life balance indicators, nearly 29 percent of the employees work very long hours in Mexico, in contrast to only 16 and 12 in Chile and Brazil respectively, and only 8 on average in OECD countries. In terms of time devoted on other activities, the three countries are closer to the OECD average. Although we are fully aware of the importance of well-being indicators that depart from the use of GDP per capita, we are constrained to use GDP per capita in our empirical analysis as a proxy for wellbeing due to insufficient data across countries and over time in the abovementioned "new proposed" socio-economic indicators.

3.2 Determinants of Environmental Indicators in LA Countries

Before looking at each country separately we use data on 19 Latin American countries between 1980 and 2012 to estimate the abovementioned IPAT model that explains the determinants of a number of environmental indicators (see Table 12 in the appendix for a list of countries). The data on GDP, and sectoral composition of the countries is taken from the World Development Indicators (World Bank 2013). Greenhouse gas emissions CO_2, NO_2, and CH_4 and forest area from the Edgar Database and FAO (FAOSTAT, 2013; EDGAR, 2013). Value added for each sector (Agriculture, Forestation and Land Use; Construction; Energy; Industry and Transport sector) comes from UNSTAT (United Nations Statistics Division, 2013). Summary statistics of the data are shown in Table 13 in the appendix.

3.2.1 Model Specification and Estimation Technique

We estimate a model based on the IPAT equation and apply a regression analysis to determine the relative importance of the drivers of environmental impacts. Greenhouse gases namely CO_2, N_2O, CH_4 are taken as indicators of environmental pollution and forest area is taken as an indicator of sustainability. The choice of the three greenhouse gases was made in the light of global warming and the preparation of the NAMAs. Since the share of renewable energy is still considerably low, the three countries could be considered as fossil fuel based economies. The goal in the next years is to reduce emission intensity in order to mitigate climate change and in order move towards a more efficient economy by promoting green growth.

The regression model builds on the IPAT equation by York et al. (2003), which attributes an environmental impact to its major sources of origin, namely changes in the size of the population, changes in affluence, which is referred to as GDP or as value added of the specific sector, and changes in the technology. Originally, the model was formulated as an identity and later it was reformulated in stochastic terms (STIRPAT) to be able to test hypothesis. The main model specified in natural logs is given by:

$$\ln EnvInd_{ikt} = \alpha_i + \lambda_t + \beta_1 \ln POP_{it} + \beta_2 \ln VA_{ijt} + \beta_3 \ln EE_{it} + \beta_4 \ln X_{it} + \varepsilon_{ikt} \quad (1)$$

where $lnEnvInd_{it}$ is the natural logarithm of a given environmental indicator k. Here k denotes CO_2, CH_4, N_2O emissions in kilo tons or forest area in hectares of country *i* in year *t*. α_i and λ_t are country and year-specific effects that control for unobservable country heterogeneity and common time-varying effects that could affect emissions. The population variable POP_{it} is measured by the number of inhabitants. VA_{ijt}

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represent the value added of sector j, where j=1,…4 (AFOLU=Agriculture, Forestation and Land Use; Construction; Industry and Transport sector) measured in constant 2005 US$ respectively. EE denotes energy efficiency measured as GDP per unit of energy use (GDP ppp constant 2005 per kg). X denotes other control variables, namely the level of urbanization and level of openness ((exports+imports)/ GDP), which could influence in particular CH_4, N_2O and deforestation. Finally, ε_{ikt} is the error term that is assumed to be independent and identically distributed.

4. MAIN RESULTS

Table 5 presents the results from the regression analysis. In column 1 the dependent variable is total CO_2 emissions in the classic IPAT approach. While changes in population do not affect CO_2 emissions from fossil fuels in LA countries, changes in the affluence variable and in energy efficiency do significantly influence a the impact variable. More specifically, a rise of GDP by 10 percent contributes on average to an increase of CO_2 emissions by 11 percent. The average effect of a rise in energy efficiency of 10 percent is related to a decrease in emissions by 3.9 percent, which is only below the increase of CO_2 caused by increasing GDP. In column (2) the results for CH_4 are presented, showing that increasing population is associated to lower levels of CH_4 emissions and that changes in GDP are not associated to changes emissions. Whereas increases in energy efficiency are related to lower emissions, given that an increase of 10 percent in energy efficiency reduces emissions by 2.4 percent, emissions of CH_4 increase with urbanization and decrease with openness. When the model is estimated for N_2O, the results in column

Table 5. Aggregate results for environmental indicators

Variables	(1) Ln CO_2	(2) Ln CH_4	(3) Ln N_2O	(4) Ln FOREST
Ln POP	-0.544	-1.148***	0.356	0.260**
	[0.492]	[0.337]	[0.241]	[0.118]
Ln GDP	1.101***	0.135	0.280***	0.00964
	[0.187]	[0.129]	[0.102]	[0.00628]
Ln EE	-0.387***	-0.241**	-0.0274	-0.00537
	[0.146]	[0.0992]	[0.0866]	[0.00335]
Ln Urban		0.799**	-0.619**	-0.538***
		[0.379]	[0.270]	[0.109]
Ln Open		-0.0842*	-0.0227	-0.00476**
		[0.0476]	[0.0462]	[0.00208]
Constant	-7.757**	24.84***	3.156	6.873***
	[3.085]	[2.164]	[2.493]	[0.0320]
R-squared	0.586	0.483	0.388	0.422
Observations	566	566	566	378
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets).

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(3) indicate that whereas affluence is contributing less than proportionally to higher N_2O emissions, higher urbanization decreases these types of emissions. Finally, concerning deforestation, the model indicates that the level of forest area decreases with urbanization and with openness and is positively associated to population increases.

In a next step we estimate similar equations for sectoral emissions and sectoral value added. Table 6 shows the results for CO_2 emissions coming from each sector of economic activity. Results in Table 6 indicate that an increase in value added in the Agriculture, Forestation and Land Use sector reduces emissions of CO_2, whereas population and energy efficiency are not significantly affecting CO_2 emissions. As regards the construction sector, an increase of 10 percent in its value added increases emissions of this pollutant by 3.4 percent, whereas for industry and transport sectors the corresponding increase is 8.3 and 4.2 percent respectively. Increases in energy efficiency only appear to reduce emissions from the industry sector more than proportionally.

Table 7 shows the sectoral results for CH_4, which indicate that energy efficiency mainly reduces emissions of this gas in the construction and industry sectors, whereas population increases only foster emissions in the transport sector and indeed, more than proportionally. As before, an increase in value added of the industry sector is associated to higher emissions, although the elasticity is lower than for CO_2.

Finally, Table 8 shows the sectoral results for N_2O emissions, for which increases in value added in the industry and transport sectors are associated with higher N_2O emissions on the industry and transport sectors, but not in construction and agriculture and population increases are also associated to higher emissions, but only in the transport sector.

To summarize, on the one hand we find that population growth mainly contributes to the increase in greenhouse gases in the transport sector, whereas a rise in sectoral value added contributes to increasing emissions of N_2O and CO_2 not only from the transport sector from but also from the industrial sector. On the other hand, increases in energy efficiency are associated with reductions of CO_2 and CH_4 in the industry sector.

Table 6. Determinants of sectoral emissions (CO_2)

	Ln CO_2 by Sector			
Variables	**(1) AFOLU**	**(2) Construction**	**(3) Industry**	**(4) Transport**
Ln POP	2.110	0.224	-0.0883	1.372***
	(1.572)	(0.774)	(0.586)	(0.447)
Ln VA	-0.501**	0.339**	0.833***	0.425***
	(0.237)	(0.154)	(0.113)	(0.0850)
Ln EE	0.129	-0.262	-1.037***	-0.0774
	(0.389)	(0.305)	(0.277)	(0.174)
Constant	-15.00	-3.625	-7.324	-22.27***
	(23.58)	(12.40)	(9.751)	(7.298)
Observations	585	585	585	585
R-squared	0.115	0.590	0.755	0.885
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets).

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Table 7. Determinants of sectoral emissions (CH_4)

Ln CH_4 by Sector				
Variables	**(1) AFOLU**	**(2) Construction**	**(3) Industry**	**(4) Transport**
Ln POP	0.175	0.0520	-0.0661	2.044***
	(0.539)	(0.863)	(0.365)	(0.654)
Ln VA	0.119	0.0286	0.278**	0.259
	(0.111)	(0.129)	(0.107)	(0.180)
Ln EE	0.216	-0.542*	-0.441***	0.197
	(0.190)	(0.307)	(0.152)	(0.307)
Constant	5.619	5.871	3.333	-30.96**
	(8.868)	(14.31)	(5.613)	(10.81)
Observations	585	585	585	585
R-squared	0.114	0.081	0.913	0.617
Number of countries	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets). Other control variables, urban, open where not statistically significant in any regressions and are therefore not included in the model explaining sectoral emissions.

Table 8. Determinants of sectoral emissions (N_2O)

Ln N_2O by Sector				
Variables	**(1) AFOLU**	**(2) Construction**	**(3) Industry**	**(4) Transport**
lnPOP	-0.218	0.210	-0.0345	1.935***
	(0.475)	(0.733)	(0.358)	(0.350)
lnVA	0.148	0.0699	0.506**	0.461***
	(0.117)	(0.119)	(0.190)	(0.115)
lnEE	-0.0956	-0.485	-0.0731	0.269
	(0.118)	(0.288)	(0.152)	(0.212)
Constant	12.17	1.706	-5.291	-27.44***
	(7.571)	(12.15)	(3.693)	(5.884)
Observations	585	585	585	585
R-squared	0.285	0.087	0.469	0.792
Number of cid	19	19	19	19

Note: ***, **, * denote respectively significance at the 1, 5 and 10 percent level, based on robust standard errors (in brackets). Other control variables, urban, open where not statistically significant in any regressions and are therefore not included in the model explaining sectoral emissions.

The analysis shows that policies regarding energy efficiency can have different effects depending on the sector and on the pollutant they are targeting. The industrial sector can contribute most to GHG reductions when policies target energy efficiency. Nevertheless, strengthening value added from the

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agricultural sector relative to the other sectors does also contribute to lower CO_2 emissions. The analysis further shows that it is not straightforward to quantify the green growth potential of a specific policy measure as the ones listed in the following chapter. The effects can be manifold. Policies enforcing the use of renewable energy such as biofuel can have a positive impact on a countries overall CO_2 emissions due to the use of alternative fuels rather than fossil fuels. Still, the production of biofuels goes in line with other pollutants and an intensified use of fertilizers, which again are the source of GHGs. In the analysis at hand energy efficiency policies show the highest potential for green growth in terms of reducing different GHGs. Nevertheless, policies have to be evaluated in case by case studies taking into account the specific prerequisites of the countries.

After examining the effect of different activities on the four indicators, we outline in the next section the current policies in each country. Later we discuss their strengths and weaknesses before pointing to options to improve those policies.

5. DIAGNOSIS OF THE GREEN GROWTH SECTORS BY COUNTRY

In this Section we first present national-level green policies that have been pursued in each country under study in the recent past and also make an attempt to relate the results obtained in the previous section to evaluate the effectiveness of these policies.

5.1 Brazil

5.1.1 Identification of Green Policies

The corner stone of Brazil's green policies is its 2008 National Climate Change Plan, which aims to promote sustainable development through mitigation and adaption, the reduction of vulnerability and impact, research and development as well as human capital development. summarizes the main green policies in Brazil since 1996. One of the main mitigation options is a high use of renewable energy in the energy production and the use of bio diesel in the transportation sector. Brazil has implemented several market-based mechanisms, starting with electric power auctions for biomass in 2008 and for wind in 2009. Brazil was one of the first countries to demand the addition of biodiesel in vehicle fuel.

Currently, Brazil has a total primary energy consumption of 10,055.1 PJ, of which renewable energy amount to 4,606.7 PJ. Due to large hydro power plants such as Iguaçu, Brazil has a very high share of renewable energies (45.8 percent). The country has a target of 16 percent of electricity generation from renewables by 2020, without taking large hydro power plants into account. Furthermore, Brazil aims to extend its wind energy capacity to 11.5 GW, its biomass-fired energy capacity to 9.2 GW and its small hydro capacity to 6.4 GW by 2020 (IRENA, 2013).

A large share of Brazil's greenhouse gas emissions originates from its agricultural sector and from deforestation. The Agriculture and Livestock Plan from 2010 aims at reducing CO_2 emissions from agriculture by 4.9 to 6.1 percent by 2020. Our analysis from section 3 shows that CO_2 emissions from Brazil's agricultural sector are actually declining with rising value added from this respective sector. All the other sectors in the analysis show a positive relationship between value added and the respective emissions. According to the results of our model, higher share in value added from the agricultural sector is associated to lower CO_2 emissions. This result shall not indicate that to de-industrialize is desired. It

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should rather indicate that, when countries are industrializing more, they should take advantage of the leapfrogging options they might have with modern technology. This result only holds for CO_2 emissions. For CH_4 emissions, which are mainly originated from the agricultural sector we do not find a significant relation between value added in agriculture and these emissions, the same is true for N_2O. To validate this result, the next figure shows the evolution of CO_2 emissions from the agricultural sector in Brazil.

Table 9. Green policies in Brazil

Title	Year	Policy Type	Policy Target
Agriculture and Livestock Plan	2010	Policy Support, Strategic planning,	Reduce CO_2 for agriculture by 4.9 to 6.1% by 2020
2010-2019 Plan for Energy Expansion	2010	Economic Instruments, Direct investment, Infrastructure investments, Policy Support, Strategic planning	Multiple RE Sources
Electric power auctions - Wind	2009	Regulatory Instruments	Wind, Onshore
Climate Change Policy	2009	Green House Gas Reduction Policy	Green House Gas reduction of 36.1 to 38.9 of projected emissions by 2020
Mandatory Biodiesel Requirement	2008	Regulatory Instruments, Other mandatory requirements, Regulatory Instruments	Bioenergy, Biofuels for transport
Brazil National Climate Change Plan	2008	Policy Support, Strategic planning	Wind, Solar Thermal, Solar, Solar photovoltaic, Multiple RE Sources, Hydropower, Bioenergy, Bioenergy, Biofuels for transport
Electric power auctions - Biomass	2008	Regulatory Instruments	Bioenergy, Biomass for power
India-Brazil-South Africa Declaration on Clean Energy	2007	Public Voluntary Schemes	Multiple RE Sources
Luz para Todos (Light for All) electrification program	2003	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Loans, Policy Support	Multiple RE Sources, Power, Multiple RE Sources
Program of Incentives for Alternative Electricity Sources - PROINFA	2002	Economic Instruments, Market-based instruments, Green certificates, Fiscal/financial incentives, Loans, Economic Instruments, Fiscal/financial incentives, Grants and subsidies, Regulatory Instruments, Other mandatory requirements, Regulatory Instruments, Obligation schemes	Wind, Bioenergy, Biomass for power, Hydropower
Integrating Environmental Strategies	2000	Policy Support, Research, Development and Deployment (RD&D)	
National Rural Electrification Program	1999	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Loans	Multiple RE Sources, Power, Multiple RE Sources, CHP
Interministerial Commission on Climate Change (CIMGC)	1999	Information and Education, Advice/Aid in Implementation, Policy Support, Institutional creation, Policy Support, Strategic planning, Research, Development and Deployment (RD&D)	Multiple RE Sources, All
National Program for Energy Development of States and Municipalities - PRODEEM	1996	Policy Support, Economic Instruments, Fiscal/financial incentives, Grants and subsidies	Solar, Solar photovoltaic

Source: IRENA (2013) and (Fujita et al. 2013).

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The graph clearly shows a reduction in emissions around 2010, which could be associated to the Agricultural and Live Stock Plan of 2010.

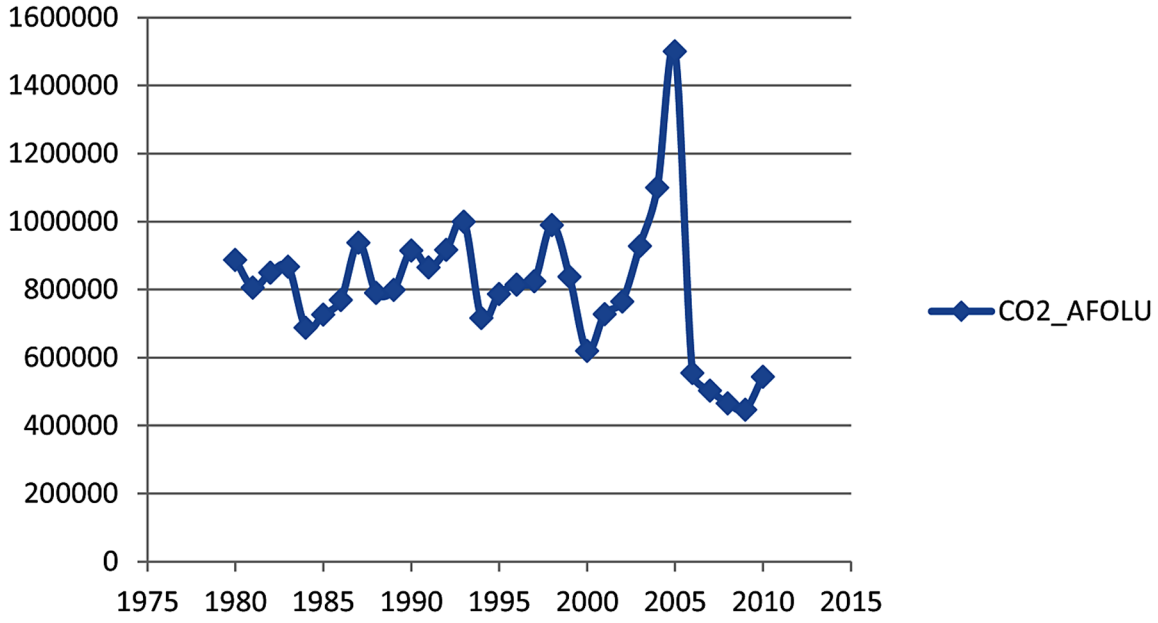
The strength of Brazil's green growth policies such as the National Climate Change Plan is that it aims to harness green growth with economic growth and poverty reduction simultaneously. Promoting the use of renewable energy in remote un-electrified regions does contribute human capital development. The size and the distribution of the population make it reasonable to apply a more decentralized energy grid (Fujita et al. 2013).

5.1.2 Strengths and Weaknesses of the Policies

Brazil is a resource abundant country and can afford a large biofuel industry. Nevertheless, if the production of biofuel leads to further deforestation in the country then it does not contribute to the mitigation of greenhouse gases and does not help to prevent dangerous climate change. The use of cultivated land for biofuel production is also under critique as it may lead to higher prices for other agricultural goods such as wheat or corn. Gibbs et al. (2008) and Field et al. (2008) find that the use of biofuels can contribute to the reduction of greenhouse gases, but this reduction is rather small. This makes the use of biofuels controversial as on the one hand there shall be no new croplands cultivated, and on the other hand the cropland available for food production becomes smaller and food prices may rise. For the poverty reduction the provision of energy access is a basic requirement, but the current rise in energy demand cannot yet be met with renewable energy sources.

Concerning the policies aimed at control climate change and at reducing emissions from the agricultural sector, it is not straightforward to evaluate their effects, because those coincided with the economic crisis and started to be implemented in very recent years. However, it is clear that CO_2 intensity figures

Figure 7. Evolution over time of CO_2 emissions from the agricultural sector in Brazil



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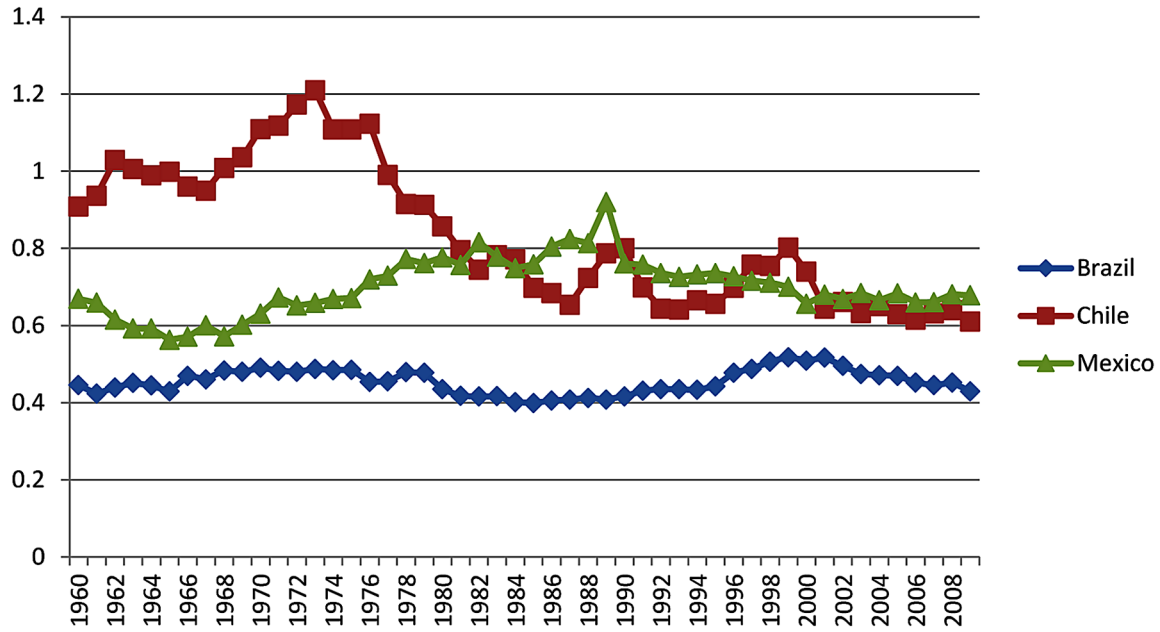
show a decreasing trend in Brazil, as shown in Figure 8, after 2002, when a number of initiatives to support alternative energy sources stated been suported.

5.1.3 Policy Recommendations

Brazil has a great potential in relation to its resource abundance. It can literally increase the production of all sorts of renewable energies and it has its own resources from fossil fuels. The current phase of strong economic growth has come along with higher inflation and rising prices as well as rising inequality. The goal of Brazil's green growth strategies have to focus on reducing inequality and increasing the access to resources such education and health care meanwhile further increasing the quality of those public goods.

According to the recent economic developments, the sectors targeted should be the transport sector with a great potential to improve energy-efficiency and the renewable-energy sector. Switching to more fuel-efficient vehicles in public transport is an option. Given that this option is costly and public transport is in most cities undersupplied, new vehicle would not replace old ones but should be added to the fleet. The implementation of forest protection management practices also should play an important role in preserving deforestation, which according to our analysis in Section 3 is affected by population growth, by urbanization and openness.

Figure 8. CO_2 emissions intensities in three countries
Note: Calculated as CO_2 emissions/GPD.



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5.2 Chile

5.2.1 Identification of Green Policies

Chile has a long history of market based policy instruments regarding green growth. Table 10 gives an overview of the relevant policies, which already have been implemented. It is among the first country that launched a system of nationwide water rights (in 1981) to use this scarce resource more efficiently.

Table 10. Green policies in Chile

Title	Year	Policy Type	Policy Target
National Strategy for the Energy Sector	2012	Policy Support, Strategic planning	Multiple RE Sources
Support for Non-Conventional Renewable Energy Development Program	2012	Economic Instruments, Direct investment, Infrastructure investments, Economic Instruments, Direct investment, RD&D funding	Bioenergy, Geothermal, Hydropower, Multiple RE Sources, Ocean, Solar, Solar Thermal, Wind
Creation of the Ministry of Environment	2010	Legal Act	Environmental Protection, Efficient Resource Use
Regulatory Framework for Solar Water Thermal (Law 20,365)	2009	Regulatory Instruments, Codes and standards, Economic Instruments, Fiscal/financial incentives	Solar Thermal, Solar heat
Program for Rural and Social Energy (PERYS)	2009	Policy Support, Economic Instruments, Regulatory Instruments	Solar, Solar Thermal, Multiple RE Sources, Bioenergy, Wind
National Policy on Chemical Safety	2008	Regulatory Instruments, Regulatory Instruments, Obligation schemes	Reduce Risks from Handling of Chemicals
Non-conventional renewable energy law (Law 20.257)	2008	Regulatory Instruments, Regulatory Instruments, Obligation schemes	Bioenergy, Biomass for power, Geothermal, Multiple RE Sources, Ocean, Solar, Solar Thermal, Wind
National Strategy of Integrated River Basin Management	2007	Policy Support, Strategic planning	Improve Public Sector Coordination
Invest Chile Project	2005	Economic Instruments, Direct investment, RD&D funding	Wind, Bioenergy, Biomass for power, Geothermal, Power, Hydropower, Multiple RE Sources, Power
Specific Policies on Endangered Species, Areas and Wetlands	2005	Regulatory Instruments	Multiple Species and Areas
Access for Small and Non-Conventional Power Producers: Short Law I and II	2004		Multiple RE Sources, Power, Multiple RE Sources
National Biodiversity Strategy	2003	Policy Support, Strategic planning	Multiple Natural Resources
Rural Electrification with Renewable Energy Program	2001	Economic Instruments, Direct investment, Infrastructure investments	Wind, Onshore, Hydropower, Solar, Solar photovoltaic
Law 19,657 on Geothermal Energy Concessions	2000	Regulatory Instruments, Codes and standards	Geothermal, Power
Transferable Quotas for Several Fish Species	1992	Regulatory Instruments, Quota	Fish Resources
Tradable Particulate Mater Emission Permit in Santiago de Chile	1992	Regulatory Instruments, Quota	Air Pollution
Nationwide Trading of Water Rights	1981	Regulatory Instruments, Quota	Water

Source: IRENA (2013) and OECD (2011).

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The National Strategy of River Basin Management from 2007 aims at improving the public-sector coordination on water rights. In 1992 the country launched a system of tradable emission permits for particulate matter in Santiago de Chile to solve the severe health problems caused by local air pollution. In the same year transferable fishing quotas were established to protect the country's natural resources. Later on, Chile provided governmental support for aquaculture fish industry, which turned the country into a global player in fish exports. Further policies to protect biodiversity, the country richest resources, were launched in 2003 with the National Biodiversity Strategy and the follow up specific policies on the protection of endangered species as well as areas and wetlands from 2005 (OECD 2011). Chile is in a favorable position compared to the other two countries due to its currently high share of renewable energy. CO2 intensity considerably decreased in the 1970s and in the 1980s (see Figure 8) and has been maintained since then below Mexico's levels. Since Chile is a rather resource abundant country, which had managed its resources well in the recent past, the topic of energy efficiency is not any longer high on the agenda. Still investing in energy efficiency provides a double dividend since it goes in line with technological improvements, which make the countries industries more competitive.

The currently strongest green growth potential is located in Chile's energy sector and the use of renewable energy. Currently, Chile has a total primary energy supply of 1,205.1 PJ of which are renewable 302.9 PJ. This amounts 25.1 percent energy use from renewables, which is mostly addressed to hydropower, one of the country's natural advantages. The country set a target of 8 percent of electricity generation from renewables excluding large hydropower plants by 2020. The policies to pave the way for this target go back to 2000 when Chile promoted the use geothermal power plants. The nature of renewable energy plants such as geothermal or photovoltaic allows the decentralized energy supply of remote urban regions such in the Rural Electrification Program in 2001. Several policies to promote the investment into renewable energies especially in the rural area, such as the Rural Electrification with Renewable Energy Program in 2001 and the Program for Rural and Social Energy (PERYS), have had been following since 2001 and amount into the National Strategy for the Energy Sector from 2012 (IRENA, 2013).

5.2.2 Strengths and Weaknesses of the Policies

The strength of Chile's green growth policies is in the renewable energy sector, currently dominated by hydropower. However, Chile placed instead ambitious targets on the use of energy from photo voltaic, geothermal and wind. Especially, the electrification of rural areas has been a key target in this renewable energy plan. If the target of a higher use of renewable energies in remote areas is reached, then there would be not only a higher use of renewable energies, but also a higher quality of life in remote areas, which are mostly populated by indigenous people. Considering that the first policies in this field were passed in 2001 the progress has been rather slow compared to countries, which implemented those policies later. Nevertheless, the ministry of environment was just recently established in 2010. Therefore, future coordination and implementation of policies might be faster (OECD 2011).

Within the international effort to prevent dangerous climate change, Chile proposed currently 16 National Appropriate Mitigation Actions (NAMAs) in order to mitigate greenhouse emissions. Six of those actions are in the field of energy supply. Within this field, greenhouse gas emissions are mostly reduced through the implementation of renewable energy projects. There are two mitigation actions in the area of waste management such as the flaring of methane gas. Another four mitigation actions are

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in the transport sectors and are based on efficiency improvements and the electrification of transport (NAMA Database 2013).

The report on Chile going green by the OECD (2011) identifies Chile's fresh water management as still being inefficient. The issuance of water rights has been too generous, which leads farmers, energy generators and speculators to stock up on water rights, which have not yet been used. There is only a limited amount of trade in water rights as too many have been issued. The National Strategy on River Basin Management could potentially help to coordinate the public sector in this area. Apart from the agricultural sector the mining sector is one of main water consumers. Mining is crucial part Chile's economy and the environmental regulations dealing with the negative side effects from this industry are not yet established. There is a National Policy on Chemical Safety, which aims to regulate poisonous hazards to human health and the environment from the industries, which apply chemicals. Still the mining sector has not been targeted.

5.2.3 Policy Recommendations

Green growth policies need to be further integrated in sectoral policies. The use of renewable energy in specific sectors such as transport should be promoted and the protection of biodiversity and water rights play a major role for two crucial industries in Chile namely, the mining sector and the aquaculture. Public policies are not coordinated well enough to protect the environment from the negative side effects from those industries.

Revenues from the strongest sector in the Chilean economy, the mining sector, could be transferred to increase human, environmental and social capital. The National Climate Action Plan from 2008 focuses solely on greenhouse gas mitigation in the energy sector other sectors have been given less attention in order estimate the countries' mitigation potential (OECD 2011). As our findings in chapter 3 show, there is potential to reduce CO_2 emissions in the industrial sector through improved energy efficiency. Nevertheless, activities with high potential to reduce other GHGs such as CH_4 are waste management activities (also in the mining sector), and or recycling.

5.3 Mexico

5.3.1 Identification of Green Policies

Mexico was the first of the three countries to implement policies promoting the use of renewable energies. Table 11 describes the main environmental policies launched in Mexico since 1975. In this year the Public Electricity Service Law was implemented to provide electricity more efficiently and incorporate the electricity from renewable energy. Twenty six years later, the grid interconnection contract for renewable energy was passed, which improved the integration of renewable energy into the energy grid. From 2008 onwards, several policies have been applied in order provide financial resources for investments into renewable energy projects. Nevertheless, the share of renewable energy in the Mexican energy supply is only 9.5 percent. This is considerably low given the natural potential that the country has to generate electricity from renewable sources. The target is to reach a share of renewable energy of 25 percent by 2012 and 34 percent by 2024.

Mexico, like Chile, faces high levels of air pollution in its urban areas (see Table 4, air pollution indicator, according to which PM_{10} concentrations are well above the average OECD level). In 1990, the

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Table 11. Green policies in Mexico

Title	Year	Policy Type	Policy Target
Large-scale renewable energy development project (PERGE)	2013	Economic Instruments, Direct investment	Multiple RE Sources, Wind
National renewable energy inventory	2013	Information and Education, Information provision	Multiple RE Sources,
General Law of Climate Change	2012	Policy Support, Institutional creation	Multiple RE Sources, Power
National Energy Strategy 2012-2026	2012	Policy Support, Strategic planning	Multiple RE Sources, Power
National Ecological Land Use Plan	2012	Policy Support, Strategic planning	Sustainable use of Natural Resources
Special Program on Climate Change	2009	Policy Support, Strategic planning	Measures and Objectives for Mitigation and Adaption
Fund for the Energy Transition and Sustainable Electricity Use	2009	Economic Instruments, Direct investment, Research, Development and Deployment (RD&D), Research program	Multiple RE Sources
Special Program for the Use of Renewable Energy 2008-2012	2009	Regulatory Instruments, Codes and standards, Information and Education, Information provision, Advice/Aid in Implementation, Economic Instruments, Fiscal/financial incentives, Tax relief, Grants and subsidies, Loans, Policy Support, Strategic planning, Direct investment, Infrastructure investments	Multiple RE Sources
Methodology to value the externalities associated with the Electricity Generation in Mexico	2009	Policy Support, Strategic planning	Multiple RE Sources, Power
Law for the Development of Renewable Energy and Energy Transition Financing (LAFAERTE)	2008	Regulatory Instruments, Economic Instruments, Fiscal/financial incentives, Policy Support, Strategic planning, Institutional creation	Wind, Geothermal, Solar, Hydropower
Integrated Energy Services Project (2007-2014)	2008	Economic Instruments, Direct investment, Infrastructure investments, Fiscal/financial incentives, Grants and subsidies, Policy Support	Solar, Solar, Solar photovoltaic
Energy Sustainability Fund	2008	Research, Development and Deployment (RD&D), Research program	Multiple RE Sources
National Climate Change Strategy	2007	Policy Support, Strategic planning	Medium and Long Term Goals for Mitigation
National Development Plan	2007	Policy Support, Strategic planning	Framework of Sustainable Development
National Environmental Policy for the Sustainable Development of Mexico's Coastlines and Oceans	2007	Policy Support, Strategic planning	Sustainable use of Natural Resources
Strategy of Environmental Education for Sustainability	2006	Policy Support, Strategic planning	Adding Sustainability in the curriculum at school, green schools program
Accelerated Depreciation for Environmental Investment	2005	Economic Instruments, Fiscal/financial incentives, Tax relief	Multiple RE Sources, Power
Project of Ecological Norm for Wind Farms	2005	Policy Support	Multiple RE Sources
Wheeling Service Agreement for electricity from renewable energy sources	2004	Regulatory Instruments	Multiple RE Sources, Power
Federal umbrella program that promotes sustainable forestry	2004	Policy Support, Strategic planning	Sustainable use of Natural Resources, Support of Indigenous People
National Program of Payments for Ecosystem Services	2003	Regulatory Instruments	
Methodology to establish service charges for transmission of renewable electricity	2003	Regulatory Instruments	Multiple RE Sources, Power
Grid interconnection contract for renewable energy	2001	Regulatory Instruments	Wind, Hydropower, Multiple RE Sources, Power, Solar
National Biodiversity Strategy	2000	Regulatory Instruments	
Policies against Air Pollution - Pro Aire	1990	Regulatory Instruments	Local Pollutants
Public Electricity Service Law	1975	Regulatory Instruments, Other mandatory requirements	Multiple RE Sources, Power

Source: IRENA (2013) and (OECD 2013).

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Table 12. List of countries

Argentina	Honduras
Bolivia	Mexico
Brazil	Nicaragua
Chile	Panama
Colombia	Paraguay
Costa Rica	Peru
Dominican Republic	Trinidad and Tobago
Ecuador	Uruguay
El Salvador	Venezuela, RB
Guatemala	

Source: World Bank (2013).

first Pro Aire project, among many which followed, was launched in order to find a way to reduce traffic and therewith pollution. There are a number of policies which aim to encourage sustainable resource use, such as the National Ecological Land Use Plan from 2012, the Federal umbrella program that promotes sustainable forestry from 2004, National Program of Payments for Ecosystem Services from 2003 and the National Biodiversity Strategy from 2000. Those policies are regulatory instruments to improve the efficiency of the resource use and protect environmental areas (OECD 2013).

5.3.2 Strengths and Weaknesses of the Policies

The National Development Plan is at the core of Mexico's environmental policies. It aims to cover sustainable development in the area of water and waste management, climate change mitigation and adaption, the preservation of biodiversity and the efficient use of natural resources and last but not least the creation of human capital and awareness for the environment. The sub-targets in each of those categories are not clearly defined and an evaluation of the success of the single policies is missing so far (OECD 2013).

One of the most pressing issues is the energy subsidies, which Mexico applies to fossil fuels. The subsidized fossil fuels do encourage people to buy and use cars. Therefore, the subsidies in the energy sector do not only undermine the efforts from policies such as the Pro Aire clean air project but also make it harder for alternative energy sources such as renewable to enter the market.

Mexico does engage in the mitigation of dangerous climate change. The National Climate Strategy from 2007 targets a greenhouse gas reduction of 50 percent by 2050 with 2000 as the base year. The General Law on Climate Change from 2012 allows producers of renewable energy sources to access the grid and feed in renewable energy. The targets are very ambitious and are not jet broken down into specific sectors. There is the idea of launching an emission trading system but it has not been implemented yet. Therefore, it seems unclear if the targets will be met especially since there is no monitoring of the progress made (OECD 2013).

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5.3.3 Policy Recommendations

The greenhouse gas reduction targets from the General Law on Climate Change have to be substantiated and defined among sectors. An intra-industry emission trading system could lead to substantial greenhouse gas reductions at lowest cost. Removing the energy subsidies would not only encourage efficient resource use but also make the use of renewable energy sources more attractive. Decentralized energy systems from renewable should also be applied in remote areas. Vehicle fuel efficiency standards and an efficient low carbon public transportation could further curb greenhouse gas emissions (OECD 2013). Therefore, based on the above analysis of green growth indicators and policies, Mexico should focus on the renewable-energy sector and the transport sector. In line with our results from Section 3 CO_2 emissions from the transport sector are highly sensitive to increasing demand due to rising population and income. Therefore the transport sector should be as energy efficient as possible to reduce CO_2 emissions. Again our results indicate the need of an efficient resource use. The Mexican policies aim on an efficient resource use. The success of these policies is hard to be evaluated without a baseline from the time before the implementation of the relevant policies.

6. REFLECTIONS

This study presents a comparative analysis of the green growth strategies and achievements in three Latin American countries, namely Brazil, Chile and Mexico. These three countries have made important progress in some of the areas under study, in particular in setting the necessary institutional and regulatory framework to protect the environment and to preserve its natural resources. As regards the implementation of green policies, all three countries have launched regulatory instruments and policy instruments and have given economic support to renewable energy sources. Brazil has also established greenhouse gas reduction plans, whereas Chile and Mexico have launched regulatory instruments to control local air pollution. However, many important challenges remain.

Also an important progress has been made in some social aspects as reducing poverty and increasing education and opportunities for women, but more effort is needed. More specifically, poverty and inequality levels are still very high, despite the important progress made in the past decade. In particular, income indicators (household net disposable income and financial wealth) are well below the OECD average, inequality levels are very high in Brazil. Secondly, air pollution levels in big cities are still very high and life expectancy is below average OECD levels. Thirdly, resources dedicated to R&D, especially in green good sectors, are still at very low levels in comparison to OECD standards and more public effort has to be made in this area. Finally, there is room to improve the regulatory framework and to delimit competences between central, regional and local authorities. It is worth to emphasize the need to address distributional issues. Hence, green policies should be identified favoring the poor and middle class, instead of only benefiting the upper social class and elites. Also the burden of the most vulnerable and disadvantaged communities that could be most affected by climate change should be alleviated with appropriate mitigation policies and direct payments to the poor and disadvantaged.

Our empirical analysis has shown that there is the potential to reduce greenhouse gas emissions especially CO_2 through improvements in energy efficiency in Latin America. Those improvements in energy efficiency can also be achieved through the use of renewable resources. CO_2 emissions from the agricultural sector are not sensitive to an increase in value added from the respective sector. Greenhouse

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gas emissions from the industrial sector (manufacturing and mining) are especially sensitive to a rise in value added from the respective sector. Nevertheless, an increase in value added rises emissions less than proportionally.

Since each country has also its particularities, some specific activities have a higher potential to be developed successfully in each country. First, Brazil started to implement green policies only in 1996, whereas Chile started already in 1981 and Mexico in 1975. Brazil is the richest in terms of resource abundance and has therefore the greatest potential in bioenergy, biomass and forest conservation. Although most of the regulations launched since the late 1990s have been supporting investments in renewable energies, the share of Geothermal together with solar and wind energy production is still below 1 percent, hence there is room for improvement, otherwise, the share of biofuel and waste has steadily increase since the 1970s, as well as the share of hydropower. However, oil still represents 40 percent of total primary energy supply and hence there is room for increasing the share of renewables. As regards electricity generation, Brazil has a very clean energy matrix, however emissions from agriculture, steel and transportation are expected to growth with its development process. Hence, to launch low carbon options for these sectors is recommended.

Concerning other regulation initiatives, it has only been in the late 2000s that the Climate Change Policy and the Agriculture and Livestock Plan aimed at reducing greenhouse gas emissions have been launched and as a consequence, it is still too early to evaluate its effects. It is also worth noting that deforestation has been observed in the last 2 decades, with a decrease of 10 percent of forest land, hence more efforts have to be done to conserve the forest and to protect the Amazonia region. The country has already moved in this direction and deforestation has been already reduced in recent years.

In terms of social policies, Brazil should continue dedicating resources to reduce inequality and to support education of poor children. Initiative aimed at training and employing low income workers in reforestation and renewable energy firms are recommended.

Secondly, Chile started already in the early 1980s to set green policies related to water management, air pollution and resources conservation, as well as supporting investments in renewable energy. As we mentioned in previous sections, Chile's production structure is biased towards the mining sector, which is more pollutant intensive than other industrial activities. Hence, according to our analysis Chile's activities with high growth potential are waste management activities in the mining sector (copper in particular), and aquaculture. Aquaculture is a very important activity in Chile, in particular salmon and trout aquaculture, with salmon volumes just behind Norway in its contribution to the world production. However, the appearance of an infectious disease in 2007 led to a crisis and an important drop in production that is now recovering. To control the disease new density regulations will be put in place in 2014 that involve density limits in each neighborhood based in its sanitary risk. This could also have a positive impact on prices, benefiting therefore the producers.

It is also worth mentioning that the forest area in Chile increased by 7 percent in the last two decades, in part as an outcome from the reforestation policies that have been in place. For instance, Chile and Uruguay are the only two South American countries where woodland has increased; it has indeed doubled in Chile in the last three decades. Since almost 90 percent of new forest is situated on grounds with erosion, reforestation generates not only environmental benefits, but also economic and social gains, including employment creation. Chile could also benefit from improving the levels of secondary school enrolment, which according to our analysis lay below the desirable levels.

Finally, among Mexico's main GG initiatives are the Special Climate Change Program launched in 2009 aimed at cutting gas emissions by 50 percent by 2050 and the National Development Plan 2007-

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2012 aimed at strengthening and consolidating adaptation capacities among the most vulnerable. Both initiatives are ambitious and have already accomplished some achievements, with an increasing share of renewable energies in electricity production. However, the country still presents the highest share of total primary energy supply coming from oil (54 percent) and hence subsidies supporting fuel consumption should be phased out and replaced by cash-transfer programs to help poor consumers to overcome its energy needs.

According to our analysis car manufactures and electronics are among the main industrial sectors in the country, the latter sector in particular was growing very fast in the 2000s. Since the growth in value added in both sectors will contribute to increasing emissions according to our model in Section 3, the country should make an effort in diversifying more its economic activities, focusing in tourism and other services as well as continue to support free trade initiatives and to profit from technological spillovers by investing more in R&D in order to increase the quality of its products, also by making them "cleaner". The privileged location of Mexico, sharing border with a huge market, the US, should be also taken as an advantage to exploit its comparative advantage in producing part and components of final goods.

Mexico has therefore a high potential to improving the efficiency of the transport sector with the subsequent reduction in emissions and also to increase the share of renewable energy supply and electricity generation from renewable sources. In addition, the country should greatly benefit from implementing social programs to improve security in big cities and to reduce assault and homicide rates, which are among the highest in the world and clearly have a negative impact on wellbeing.

Summarizing, this study indicates that the three countries under study have made a remarkable progress by setting the necessary institutions and regulations to pave the road towards GG. However, it is still early to evaluate whether the initiatives have been fully implemented and whether the progress has been translated to an increase in wellbeing that is respectful with the environment. Surely, some tensions and complementarities between the model of economic growth and the proposed environmental and socio-economic policies will have to be solved in the near future and, in specific ways in each economy.

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KEY TERMS AND DEFINITIONS

HDI: Human Development Indicators.
HOI: Human Opportunity Index.
IPAT: Impact by Population: Affluence and Technology.
IRENA: International Renewable Energy Agency.
GGKP: Green Growth Knowledge Platform.
GGKPSP: Green Growth Knowledge Platform Scoping Paper.
NAFTA: North American Free Trade Agreement.
NAMA: National Appropriate Mitigation Actions.
OECD: Organization for Economic Cooperation and Development.
UNEP: United Nations Environment Program.

ENDNOTES

1 The gross enrolment rates can be above 100% since they account for students of all ages. If there is late enrolment or repeaters the number of students can exceed the number of children in that age group in the population.
2 The data on the human development index is from the United Nations Development Program (UNDP 2013).
3 Other services main categories are: Financing, insurance, real state, education, information and communication and business services.

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APPENDIX

Table 13. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2	589	1.16E+05	2.44E+05	1.90E+03	1.79E+06
CH_4	589	4.15E+04	8.03E+04	2.17E+03	4.92E+05
N_2O	589	1.82E+04	3.83E+04	1.83E+02	2.39E+05
Forest Area	418	5.02E+04	1.19E+05	2.26E+02	5.75E+05
Pop	608	2.40E+07	3.91E+07	1.08E+06	1.97E+08
GDP	603	1.97E+11	3.62E+11	1.01E+10	2.02E+12
EE	587	7.39E+00	2.35E+00	1.46E+00	1.51E+01
N_2O_Transport	589	4.60E+02	8.33E+02	2.30E+01	3.98E+03
N_2O_Industry	589	9.13E+02	2.13E+03	2.34E+01	1.25E+04
N_2O_Energy	589	1.80E+02	3.58E+02	1.98E+00	2.44E+03
N_2O_Buildings	589	1.23E+02	1.62E+02	3.32E+00	1.07E+03
N_2O_AFOLU	589	1.66E+04	3.52E+04	7.62E+01	2.25E+05
CH_4_Transport	589	7.49E+01	1.24E+02	2.06E+00	5.33E+02
CH_4_Industry	589	5.32E+03	1.11E+04	2.84E+02	6.41E+04
CH_4_Energy	589	6.00E+03	9.49E+03	5.85E+00	3.88E+04
CH_4_Buildings	589	5.34E+02	7.28E+02	1.15E+01	5.05E+03
CH_4_AFOLU	589	2.96E+04	6.22E+04	6.64E+01	3.95E+05
CO_2_Transport	589	1.82E+04	3.19E+04	6.10E+02	1.66E+05
CO_2_Industry	589	1.42E+04	2.45E+04	1.61E+02	1.24E+05
CO_2_Energy	589	1.71E+04	3.21E+04	1.21E-05	1.87E+05
CO_2_Buildings	589	4.26E+03	6.90E+03	5.00E+01	2.62E+04
CO_2_AFOLU	589	6.20E+04	1.85E+05	3.20E+00	1.48E+06
VA Agriculture	608	5.53E+09	8.98E+09	6.45E+07	5.40E+10
VA Construction	608	6.63E+09	1.25E+10	7.09E+07	6.48E+10
VA Services	608	3.57E+10	7.11E+10	9.08E+08	3.59E+11
VA Industry	608	2.84E+10	5.13E+10	5.43E+08	2.46E+11
VA Transport	608	8.11E+09	1.67E+10	1.41E+08	9.33E+10

Source: World Bank (2013).

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Chapter 12
Harnessing Knowledge for Sustainable Development: Challenges and Opportunities for Arab Countries

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ABSTRACT

Arab countries face two major challenges resulting from increasing competition from the rest of the world and persistent reliance on mineral resources for their growth. At the same time, sustainable development is increasingly becoming a major concern for world development. In this respect, and from a sustainability point of view, knowledge economy opens up new and more accessible opportunities through the 'substitution' of physical resources by immaterial resources. This situation raises two fundamental questions: the first one relates to the opportunity of ensuring sustainable development while the knowledge base remains rather weak and policies often short-sighted. The second one is how an integrated approach based on knowledge can strengthen existing knowledge bases and create new ones to further sustainable development. Looking at a sample of advanced countries and Arab countries, this chapter argues that sustainability of growth rests fundamentally on the capability of properly harnessing knowledge.

INTRODUCTION

Sustainable development is becoming increasingly a major concern for world development since the Rio Summit in 1992 and one of the major challenges on the international agenda in the face of bad indicators of most resource-use and worsening environmental impact. The 1987 Brundtland Report, of the World Commission on Environment and Development, (WCED 1987) defined sustainable development as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The new regulatory principle, "pollution prevention pays," aims at promoting competitive and environmentally sustainable industrial production. While many of the work and resolutions are centred on costs and pricing both in terms of understanding and as a policy instruments, it is

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only in the last few years that science and technological capabilities issues are recognised as deserving to be given top priorities. It is gradually recognized that sustainability relies more and more on innovation capabilities and on harnessing the necessary knowledge.

In Less Developed Economies (LDCs), the situation is more challenging: while GDP growth of 6% to 8% per year is needed in the next three or four decades to meet all their needs, they have to comply with sustainability requirements while developing the necessary knowledge assets and capabilities, they often lack. The transition to a global, networked knowledge economy will be one of the most important social and economic challenges of the next decades. Knowledge is known, to be sometimes difficult to access and its price is distorted by world market, under intellectual property rights and other restrictive practices which do not benefit LDCs. This is the case of Arab countries where the level of innovation performances remains weak and where major investments made in education, training and research have yielded only limited results. This situation raises two fundamental questions. The first one relates to the opportunity of insuring sustainability of growth while competitive pressures drive these countries to maximum use of natural resources, over-crowding of cities, and the acquisition of packaged, ready to use technology, produced elsewhere. The second one relates to the relatively weak knowledge base and the difficult integration of knowledge economy approach in most economic policy agendas (Djeflat 2006b). We will argue, in this chapter, that sustainability of growth rests fundamentally on the ability to properly harness knowledge. In other words, "sustainable knowledge" remains paramount to sustainable development. This raises important theoretical and conceptual issues on the linkages between sustainability of development and knowledge. From an empirical point of view, we will try to analyse the difficulties met in the process of putting knowledge to work for sustainability while stressing some of the new opportunities. In this endeavour, we will look, in a first section, at the relationship between knowledge systems, knowledge economy and sustainability from a conceptual and theoretical point of view. The second section will raise the issue in relation to Arab countries with the objective of highlighting the effects of low knowledge base on sustainability. A third section will examine from an empirical point of view this relationship and its measurement, using data from both advanced and Arab countries.

1. SUSTAINABLE KNOWLEDGE FOR SUSTAINABLE DEVELOPMENT: CONCEPTS AND ISSUES

There is an increasing belief that science, technology and knowledge play an important role in sustainable development (Dayan, 2005). Consequently knowledge systems and knowledge economy seem to open up new and varied avenues to be explored in the direction of sustainability. How can knowledge enhance sustainable development? This is the main issue we will address in this section.

1.1. Knowledge Systems and Sustainable Development

In an organised economy, according to the loops of re-using resources and the quality of information, development and efficiency are not dependent anymore on salaries and large scale of production. The critical resources become practical knowledge, local entrepreneurial dynamism, and trust, cooperation over the fence among organisations, human intelligence and know-how. This leads to an "economy of human intelligence" (Dayan, 2005). Knowledge can make substantial and essential contributions to

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sustainability across a wide range of places and problems (International Council for Science, 2002). Unless that contribution can be dramatically increased, however, it seems unlikely that the transition to sustainability will be either fast or far enough to prevent significant degradation of human life and the earth system (National Research Council, 1999). To achieve that level of contribution, several conditions need to be fulfilled. They relate to the specific nature of knowledge, to successful combination of material and knowledge assets, and to the type of knowledge system.

Firstly, regarding the specific nature of knowledge, it obeys public goods rational and evolutionary principles on one hand and market rules in a neo-classical framework, on the other as seen earlier (Djeflat 2006b). Integrating knowledge and sustainability requires often a mix of the two in a pragmatic way. It is clear from Table 1 that sustainability is easily reached when knowledge is public, non competitive, codified and source of high externalities. It can thus be more easily circulated and shared amongst various actors. Its potential for sustainability is reduced if it is privately owned, subject to market rules and fierce competition, highly protected, tacit, and specialized and under the constant threat of obsolescence.

Secondly, as a result of ever increasing proportion of knowledge in the production of goods and services, more and more emphasis is put on knowledge assets as source of wealth creation. However, these kinds of assets may not be easily grasped when it comes to sustainability. Several studies reveal that sustainability can be more easily achieved when material assets are efficiently combined with knowledge assets. Industrial ecology, for example has already explored avenues for combining efficiently material and knowledge assets. Knowledge management is one of the key elements in this process (Dayan, 2005).

Thirdly, it became more and more evident that sustainability depends on developing integrated knowledge systems, a lesson already learned in the agriculture, defence, and health sectors (Cash et al. 2003). Knowledge system approach appears to give knowledge more effectiveness in harnessing S&T with the goals of sustainable development. A Knowledge system is viewed as consisting of a network of linked actors, stakeholders, organizations, and objects that perform a number of knowledge-related functions (including research, innovation, development, demonstration, deployment, and adoption) that link knowledge and know-how with action. Included are also incentives, financial resources, institutions, and human capital that give such a system capacity to do its work. Bearing in mind that usable knowledge is ultimately "contextualized," i.e., adapted to specific circumstances or places, several issues can be raised: they relate to the generalization of the effective knowledge system to various places, sectors

Table 1. The various spheres and actors involved in environment protection and sustainable development innovation systems

Research Sphere	Industry Sphere	Government Sphere	Donors Sphere	Social Acceptance	International Organizations
-University-university -University industry -University research centres -University-industry-research centres	-Industry-industry -Industry market -Industry-university -Industry-Government	-Compliance R&D support -Prevention of resources-diversion -Innovation diffusion within national boundaries -Innovation Diffusion abroad -Training of regulators	-Donors-government In LDCs -Donors-NGOs -Donors civil society	-Civil society -NGOs -Press and Media	-Setting International regulations -Diffusion of standards and best practices -Incentive system

Sources: drawn form A. Warhurst

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and problems including governing knowledge systems (Matson 2007), to the kind of knowledge which needs to be mobilised (formal, clinical or tacit knowledge), to the mix of knowledge to be used and to pricing. Recent contributions have developed a critical review of controversial economic theories of pricing natural capital and knowledge capital that affect prices (Nguyen, 2006). Finally they relate to the balance between intangible capital and material resources. The importance of the intangible resources in sustainability is increasing. While production and growth are material-centred, sustainability appears to rest more on intangible assets used to exploit material resources. A development strategy that focuses only on production capital and neglects intellectual capital is therefore not sustainable. However, society lacks a critical understanding of what kind of programs, institutional arrangements, and, more generally, knowledge systems can most effectively help in harnessing S&T for sustainability (Cash et al., 2003). Knowledge economy approach appears to give a more accessible and easily understandable relationship between sustainability and integrated approach to knowledge.

1.2. Knowledge Economy and Sustainability

Knowledge system paradigm is usually put in the framework of knowledge economy. It could be defined as "the economy in which knowledge is the key resource and in which the generation and exploitation of knowledge have come to play a predominant part in the creation of wealth" (Department of Trade & Industry, 1998). The knowledge economy framework (Dahlman, 2003) uses a systemic approach of four pillars (innovation, education, ICTs and institutional framework) which shows how knowledge is created, circulated, valorised and governed for the purpose of economic development and growth (Aubert & Reiffers, 2003). In an earlier work (Djeflat, 2006a) we addressed several issues relating to the relationships between knowledge economy and innovation systems. This section will look at the new opportunities for sustainability that knowledge economy offers. The knowledge economy paradigm suggests that physical resources can be almost infinitely stretched through the 'substitution' of physical resources by information, knowledge and immaterial resources, giving thus new prospects for sustainability. Examining closely each one of the components, gives deeper insight into this relationship.

Firstly, ICTs have brought tremendous potential for sustainability and environmental protection and several contributions have listed the countless possibilities which they bring: (learning, database collection and storage, diffusion of vital information, data generating systems, monitoring and control of environments etc.). Recent studies illustrate ICT's potential for sustainability (Mansell and When 2005). In Indonesia, for example, a programme initiated by the Forestry Ministry to aid in sustainable forestry management involved identifying and coding of trees, optimizing forest maintenance and training in the use of laptop computers using specialised software (Talero & Gaudette, 1995). Other techniques include computer-aided, scientifically applied, modelling techniques, networking and information exchange. Several international organisations and institutions have built all their environment and sustainable development programmes on ICTs. For example, UNDP built a Sustainable Development Networking Project. This is a specialised on-line system for scientific, technical, bibliographic, and institutional sources. The network currently consists of 173 national, government-designated focal points that are collaborating with the UNDP. Other important issues include the inter-generational transfer of masses of information and know-how in the era of the Internet as mentioned in Ermine (2008) and also in Vachon (2008).

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Secondly, innovation is a key element in sustainability. In the drive to highlight the fundamentals of sustainability, many scholars have concentrated on cost and benefit, the two key elements in decision-making for environmental protection (Tilton, 1992; Warhurst, 1998). This approach in terms of cost/benefits however fails to integrate the technology factor. From an empirical point of view, studies conducted in the mining sector have shown that environmental degradation is greatest in operations working with obsolete technology. Firms that pollute the most are mismanaging the environment precisely because of their inability to innovate and the most efficient firms are generally better environmentally managed, because they are innovators (Warhurst, 1998). Examples from the literature show that innovation can reduce pollution, and that firms that adopt this strategy build competitive advantages as well as environmental benefits. In the mining sector, environmental performance of an enterprise is more closely related to its innovative capacity than to the regulatory regime under which it operates (Lagos, 1992; Acero, 1993). Companies adapt to environmental regulatory pressures by innovating, improving, and commercializing their environmental technology and environmental-management practices, at home and abroad. New and more stringent noise pollution regulations in the seventies saw the emergence of a host of new products and services for noise control in Great Britain and some Scandinavian countries, including from the polluters themselves (Djeflat, 1975). On more global terms, technical innovation, for instance in terms of developing substitutes to naturally scarce raw products, may help to overcome the fact that natural capital cannot always be reproduced. (Johnson & Lundvall, 2000). However, pollution control and environment protection are only one of the objectives of sustainable development. Sustainability is also about reducing poverty, education, health and welfare, and rural development. Finally, innovation requires that innovative capabilities are transferred to future generations on top of the fact that some results of fundamental research may be stored to meet future needs.

Thirdly, education and training need to be singled out when raising the issue of sustainable development not only because of their importance in the production of appropriate knowledge, but also in its diffusion and renewal. As stated in the world summit for sustainable development, young adults tend to emerge from the educational system without a deep sense of ecological matters and without knowing what to do with the knowledge they have. They are unequipped to make decisions that are environmentally enlightened when they take their place in the work force (International Environment Forum, 2002). The new education paradigm should therefore foster different values and attitudes such as cooperation instead of competition. Such an educational approach would be participatory, interactive, integrative, value-driven, and knowledge-based i.e. that it encourages creativity, innovative attitude and the constant drive to renew its stock of knowledge. Knowledge is under the permanent threat of being obsolete and requires learning permanently through the academia and interactive lifelong learning.

Finally, one of the key questions is how institutions can play an adequate role and give the necessary atmosphere to mobilise knowledge for sustainable growth and development. This issue raises another question relating to the private sector involvement, both as user and as a source of relevant knowledge for sustainability (Hardi, 2000). It involves also all the other issues addressed usually by public economics of free-riding, prisoner's dilemma, aligning incentives, and the distribution of authority applied to knowledge (Olson, 1971). Policy aims generally at integrating sustainable development as a guiding principle in all government actions in order to ensure that economic and social development keep within ecological limits, particularly in the area of S&T policy, where there is a lack of incentives to set strong priorities for promoting sustainable development.

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2. KNOWLEDGE AND SUSTAINABILITY IN ARAB CONTEXT

The issue of knowledge and sustainability in Arab countries, in particular, raises several questions, as a result of a weak knowledge base, incomplete innovation system and often weak sensitivity to sustainable development gains. As remarked elsewhere, these issues may seem as luxury in a continent were poverty, hunger, illnesses, disease and conflicts prevail (Johnson & Lundvall, 2000). However, one cannot help relate the issues of Arab development to that of sustainability based on knowledge, where current endogenous capabilities are weakened by limited access to advanced technology and its difficult transfer. Yet when examining the linkages between knowledge and sustainability, it becomes clear that new opportunities exist for Arab development. We will examine, in this section, what these difficulties are and what new opportunities exist.

Knowledge systems and sustainability raise specific issues from a developing country perspective, in our view. The relatively weak knowledge base and the difficult integration of knowledge economy in most economic policy agendas are more than obvious. In an earlier work we have highlighted some of the impediments (Djeflat, 2006 b). While the impact on the local industry can be quite substantial in terms of employment creation, outsourcing to local industry with the aim of upgrading their facilities and know-how, and perhaps in some cases, triggering a real innovation dynamics, examples and success stories to substantiate that, are still relatively limited and particularly when it comes to Arab countries, with the exception of South Africa.

It is recognized in recent contributions, that building more effective knowledge systems for sustainability takes time and patience (Cash et al., 2003). Strategies to promote such systems require a sufficiently long-term perspective that takes into account the generally slow impact of ideas on practices, the need to learn from field experience, and the time scale involved in enhancing human and institutional capital necessary for doing all these things. A decade or more thus seems the minimal period over which efforts are deployed to harness S&T for sustainability (International Council for Science, 2002; Lubchenco, 1998; Unesco, 2000). In many Arab countries, pressure for development, coupled often with the need to face global competition, leave very little scope and room for manoeuvre for decision-makers to start off this long-maturing process. ICTs, while making remarkable progress in recent years, are very much in the realm of digital divide and again more demand and less supply oriented. Education and training as a means of knowledge diffusion and competence building face major obstacles. As seen earlier, knowledge which is vital to sustainability sees its price distorted in the face of high intellectual property barriers. Institutions are mismanaged and governance appears to be a common concern for the majority.

While stressing all these difficulties in harnessing knowledge systems, there are several opportunities which the adoption of the knowledge economy approach opens up for Arab countries in terms of sustainable development. ICTs give new opportunities for taping into global knowledge for Arab countries and improving their relatively weak local knowledge base. They also give them the opportunity to extend their knowledge system to include their Diasporas as shown by success stories in India, China and South Korea. They finally give the opportunity for local firms and research institutions to integrate knowledge networks and update their often obsolete tools and methodologies. New opportunities offered by e-learning can help reinforce the often weak education and training system. Paradoxically, while the much publicized digital divide is a real issue for Arab countries and indeed raises the threat of

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these countries being left behind, the "knowledge divide" is rarely put forward as another possible risk enhancing what we could call the "sustainability divide" which is gradually taking place. Improving the knowledge base of Arab countries will, therefore, lead to higher potential for sustainability as we have hypothesized and we will try to substantiate in the next section.

3. MEASURING THE LINK BETWEEN KNOWLEDGE AND SUSTAINABILITY

From an empirical point of view, knowledge systems appear to be closely related to sustainability. Two indicators have been selected to show this relationship: the knowledge index and the sustainability index.

3.1. The Knowledge Index

As explained earlier, the knowledge economy builds on indicators and variables: the two main parameters are the knowledge economy index (KEI) and the knowledge index (KI). The knowledge index, which appears more appropriate and for which data are available for a sufficient number of countries, measures the ability to generate, adopt and diffuse knowledge. It constitutes an indication of overall potential of knowledge development in a given country and is defined by the World Bank Institute as "the average of the normalized performance scores of a country or region on the key variables in three indicators: education and human resources, innovation system and information and communication technologies" (Dahlman, 2003). The three indicators include several variables related to knowledge generation and knowledge diffusion as shown in Table 2. The fourth indicator which relates specifically to the KEI reflects the institutional dimension and has moved gradually in recent years to reflect more and more the business climate. This is the reason we have not taken it into account here.

The normalization procedure brings all the indicators to the same standard of measurement through the process known as normalization through the next formula:

Table 2. The knowledge economy, index and variables

Indicators	Variables
Knowledge Index	
Education and human resources	-adult literacy rate -secondary enrolment -tertiary enrolment
Innovation system	-Royalty and license fees payments and receipts -Patents applications granted by the US Patent and Trademark Office (USPTO) -Scientific and technical journal articles
Information and Communication Technology	-telephone per 1000 people -computers per 1000 people -Internet Users per 10 000 people
Knowledge Economy Index (Add)	
Institutional framework and governance	

Source: World Bank Institute 2011

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$$N(u) = 10*(1-Nh/Nc)$$

where N(u) represents the normalized score of an index, Nh represents the number of countries with high rank and Nc the total number of countries in the sample with available data.

3.2. The Environmental Sustainable Index and Environmental Performance Index

The two main indexes used are the Environmental Sustainable Index (ESI) and the Environmental Performance Index (EPI). The ESI provides a gauge of a country's long-term environment trajectory. Constructed around the concept of sustainability, it tracks the environment past, present and future. In contrast, the EPI addresses the need for a gauge of policy performance in reducing environmental stresses on human health and promoting ecosystem vitality and sound natural resources management (Yale Centre for Environmental Law & Policy and Centre for International Earth Science Information Network, 2005). The ESI score represents an equally weighted average of the 21 indicator scores (Table 3). Each indicator builds on between 2 and 12 data sets for a total of 76 underlying variables. The 21 indicators are grouped into 5 components: environmental systems, reducing environmental stress, reducing environmental vulnerability, social and institutional capacity and global stewardship.

Of all the components, the "social and institutional capacity" appears to be more related to our problematic. The four components relate to knowledge dimension either directly or indirectly: the first indicator "Environmental governance" includes knowledge creation in environmental science, technology and policy variable, stressing thus the need for knowledge in sustainability. The "science and technology" indicator includes also direct measurement of knowledge: namely innovation index, digital access index, female primary education completion rate, gross tertiary enrolment rate, number of researchers per million inhabitants and world economic forum survey on private sector environmental innovation. On top of these direct knowledge variables, many of the others can be considered as indirect measures of knowledge e.g. government effectiveness or number of ISO 14001 certified companies per billion dollars GDP (PPP).

The EPI builds on two broad environmental protection objectives: (1) reducing environmental stresses on human health, and (2) promoting ecosystem vitality and sound natural resource management. Envi-

Table 3. The environmental sustainability index (ESI)

Indicators	Indicators
-Air Quality -Biodiversity -Land -Water Quality -Reducing Air Pollution -Reducing Ecosystem Stress -Reducing Population Pressure -Reducing Waste & Consumption Pressures -Reducing Water Stress -Natural Resources Management -Environmental Health -Basic Human Sustainability	-Reducing Environment-related Natural Disaster Vulnerability - Social and institutional capacity -Environmental Governance -Eco-efficiency -Private Sector Responsiveness -Science and Technology -Participation in International Collaborative Efforts -Greenhouse Gas Emissions -Reducing Transboundary Environmental Pressures

Source: The "2005 Environmental Sustainability Index" report

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ronmental health and ecosystem vitality are gauged using 25 indicators tracked in six policy categories: environmental health, air pollution (effects on ecosystems), water (effects on ecosystems), productive natural resources, biodiversity and habitat, and climate change. The EPI utilizes a proximity-to-target methodology focused on a core set of environmental outcomes linked to policy goals. The 2008 EPI includes 149 countries based on data availability (Yale Centre for Environmental Law & Policy & Policy Centre for International Earth Science Information Network, 2008). The EPI has since 2005 replaced the ESI for a variety of reasons explained by the authors (Yale Centre, 2006).

The empirical analysis was conducted on two samples of countries: the first fifteen countries in the world in terms of ESI which are then compared to the seventeen Arab countries for which complete sets of data for ESI, EPI and KI are available. The non availability of published data made it difficult to include all Arab countries. Both least square and correlation coefficient methods are used to have complementary and more robust results.

3.2.1. Environmental Sustainability Index and Knowledge Index

The latest data found for ESI are from 2005 while KI data are from 2008. A first glance, Table 4 shows that nine out of the first fifteen countries in ESI are from advanced countries in terms of environmental sustainability. Nonetheless six countries are from the developing world, half of them from Latino-America.

This is an indication that sustainability may not be directly related to the level of development, which is also the conclusion that the World Sustainability Report found. The relatively high score can be related to certain indicators found in the ESI matrix. These include air quality, biodiversity, land and greenhouse

Table 4. Environmental sustainability index and knowledge index in the first fifteen countries in the world in terms of ESI (option a)

Rank	**Country**	**ESI 2005**	*KI 2008*
1	Finland	76.1	9.34
2	Norway	73.4	9.30
3	Uruguay	71.8	6.28
4	Sweden	71.7	9.69
5	Iceland	70.8	8.90
6	Canada	64.4	9.05
7	Switzerland	63.7	9.00
8	Guyana	62.0	4.50
9	Argentina	62.7	6.39
10	Austria	62.7	8.77
11	Brazil	62.2	5.90
12	Australia	61.0	9.23
13	New Zealand	60.9	9.00
14	Latvia	60.4	7.47
15	Peru	60.4	4.66

Source: World Bank Institute 2008 & Report "Pilot 2006 Environmental Performance Index"

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gas emissions. This argument needs to be put in relative terms though. In terms of knowledge, the first countries in the world have also relatively high to medium knowledge index (above 5) with the exception of two countries: Guyana and Peru.

When looking at the first fifteen countries in the world in terms of KI, half of them score less than 60 in terms of ESI (2005). Only four can be considered to have high scores: Iceland, Sweden, Finland and Norway (Table 5).

Data in Table 6 indicate that Arab countries which score relatively low in knowledge index are also ranked in low positions in the ESI. Here also, some remarks can be made. Some countries which are

Table 5. Environmental Sustainable index and knowledge index (option b)

	ESI 2005	KI 2008
Denmark	58.2	9.56
Sweden	71.7	9.69
Finland	75.1	9.34
Netherlands	53.7	9.34
Norway	73.4	9.30
Canada	64.4	9.05
Switzerland	63.7	9.00
United States	52.9	9.09
Australia	52.9	9.23
Germany	56.9	9.01
United Kingdom	50.2	8.81
Iceland	87.6	8.90
Austria	62.7	8.77
Ireland	59.2	8.79

Source: World Bank Institute 2008 & "Pilot 2006 Environmental Performance Index" Report

Table 6. Environmental sustainability index and knowledge index in Arab countries

	ESI 2005	KI 2008
Tunisia	51.8	4.50
Oman	47.9	3.02
Jordan	47.8	5.23
Algeria	46.0	3.42
United Arab Em.	44.6	5.69
Morroco	44.8	3.26
Egypt	44.0	4.07
Syria	43.8	3.07
Mauritania	42.6	1.01
Lebanon	40.5	5.55
Saudi Arabia	37.8	4.93
Yemen	37.3	1.26
Kuwait	36.6	5.45

Source: World Bank Institute 2008 & "Pilot 2006 Environmental Performance Index". (*) The KEI is used in this case as a good proxy of the KI because of the missing figures for this latter. (**) The EPI score is used as good proxy of ESI because of the missing data.

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least developed countries in the region seem to have relatively higher ESI than wealthier countries: this is the case of Yemen which scores higher than Kuwait for example.

On the other hand, Arab countries which score higher on the KI are not the best in terms of ESI with the exception of Tunisia. This is partly due to the fact that these countries have some industrial base and infrastructure which are contributing to the degradation of the environment: oil, steel and petrochemicals in Algeria and phosphates in Morocco.

A simple regression analysis shows that advanced countries tend to concentrate in the top of the first half of the linear trend, while Arab countries are in the bottom. The strength of the relationship is shown by the relatively high score of the correlation coefficient which is $R^2 = 0.75209$ (option a) and $R^2 = 0.8620$ (option b). However, when taking Arab countries separately, the coefficients are much lower. This is an indication that other factors that matter are at play such as governance and financial capital.

3.2.2. Environmental Performance Index and Knowledge Index

The environmental performance index scores of 2008 make it more appropriate to cross with the 2008 KI index. Table 7 shows that the first fifteen countries in the world on the knowledge grid score reasonably high on the EPI 2008 grid.

They all score higher than 80 with the exception of the Netherlands and Australia. Arab countries which score relatively low in Knowledge Index are also ranked in low positions in the EPI (Table 8). These latter seem to have higher EPI scores: Algeria's score for example is nearly equal to that of the Netherlands even though its KI is fifty per cent less. This is partly due to the fact that these countries have made a significant progress in environment protection in recent years, particularly from the insti-

Table 7. Environmental performance index and knowledge index 2008 in most advanced countries

	EPI 2008	**KI 2008**
Denmark	84.0	9.56
Sweden	93.1	9.69
Finland	91.4	9.34
Netherlands	78.7	9.34
Norway	93.1	9.30
Canada	86.6	9.05
Switzerland	95.5	9.00
United States	81.0	9.09
Australia	79.8	9.23
Germany	86.3	9.01
United Kingdom	86.3	8.81
Iceland	87.6	8.90
Austria	88.9	8.77
Ireland	82.7	8.79

Source: World Bank Institute 2008 & Report "2008 Environmental Performance Index"

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Table 8. Environmental performance index and knowledge index in Arab countries

	EPI 2008	KI 2008
Tunisia	71.8	4.50
Oman	70.3	3.02
Jordan	76.5	5.23
Algeria	77.0	3.42
United Arab Em.	64.0	5.69
Morroco	72.1	3.26
Egypt	76.3	4.07
Syria	68.2	3.07
Mauritania	44.2	1.01
Lebanon	70.3	5.55
Saudi Arabia	72.8	4.93
Yemen	49.7	1.26
Kuwait	64.5	5.45

Source: World Bank Institute 2008 & "2008 Environmental Performance Index" Report

tutional point of view, but slower progress in knowledge, namely as a result of poor innovative activities (Djeflat, 2006).

This is clearly also shown through a simple regression analysis. Advanced countries tend to concentrate in the top right of the first half of the line, while Arab countries are in the bottom left part. The least square line indicates a relatively strong relationship which is reflected through the relatively high coefficient correlation $R^2 = 0.9296$ and $R^2 = 0.8402$ for Arab Countries taken separately. This is an indication that in the case of Arab countries, knowledge counts a great deal for sustainability. Further research is needed to shed more light on these issues.

4. DISCUSSION

Knowledge systems are thus closely correlated with sustainability both in developed and in developing countries. And indeed, the weak position of Arab countries in the sustainability grid is partly the result of their difficult access to knowledge with all its components. One of the key elements of this difficulty is the issue of technology transfer; the second one is the innovation issue which is closely related.

Firstly, technology transfer has always been an issue of concern for Arab countries who have remained for decades, permanently dependent on their technology suppliers (Djeflat, 1988). Under competitive pressure and market rules, technology suppliers have no incentive to transfer technology to recipients. However, in the area of environmental protection, there are grounds, according to several scholars (Warhurst, 1998), for a "new type of technology transfer" to take place in environmental management. It includes the knowledge, expertise, and experience required to manage technical change, the development of human resources to improve overall production and energy efficiency and environmental management of plants and facilities. It emphasizes training and skills acquisition, the novelty being the emphasis put

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on training and skill acquisition in environmental R&D. Technology transfer and technology partnership through joint ventures or strategic alliances are ways to build up these technological and managerial capabilities (Warhurst, 1998; Djeflat, 1996). However, evidence from the field tends to suggest that this process has some limitations. Examples from the mining sector show that international firms transfer significant amounts of managerial and engineering expertise through joint ventures and other collaborative arrangements but limited to the specific project. Yet, these contributions can be considerably increased without adversely affecting the supplier's strategic control of its proprietary technology (Bell, 1990; Warhurst, 1991a, b; Auty & Warhurst, 1993). Donors and international organisation can sometimes help suppliers to transfer their technology: they usually cover the costs of such operations. One of the programmes of Agenda 21, for example, encourages self-regulation, environmental R&D, worldwide corporate standards, and partnership schemes to improve access to clean technology worldwide. However, for this transfer to be effective, a substantial increase in the technological capabilities of recipient countries is required (Barnett, 1993). This new concept mostly examined in a Latino American context does not seem however to be easily generalized to Arab countries where the mining sector is relatively important as a foreign currency earner and where it is almost fully dominated by technology suppliers.

Secondly, innovation is to be put against "most pressing needs" issue. Pressing needs include of course hunger, poverty, protecting the earth life support system and biodiversity. Two questions can be raised: the first one is what drives Arab countries to innovate for sustainability, if ever? The second questions is what S&T capabilities could they mobilise? There are several motives for Arab countries to innovate for sustainability: firstly, because upstream, some of them suffer from resources limitation which requires using them in a very parsimonious way not to have to undergo heavy environmental costs they could not bear and to guarantee to future generation access to a certain amount of these resources. Secondly, they need to innovate because of the many problems they are suffering from and which conventional techniques and approaches have proved difficult to resolve. Innovation has to be in all fields and not simply in the technical field: in the social, the political, and the organisational fields. While all this drive to innovate exists, there are several impediments and we have highlighted some of these looking, specifically at Middle East and North Arab (MENA) countries in previous contributions (Djeflat, 2000). The most important impediments include the cost to the environment which does not seem to be strong enough to have a significant impact and which is usually externalised at firm level and does not constitute a strong motive to undertake innovative activities in this sense. This situation is found in the mining sector in Latin America (Warhurst, 1998) and can easily be found in the oil sector (Algeria, Libya) and in the phosphate industry (Morocco) (El Khabli, 2001). The second one is the force of regulations which normally should be a driving motive and which, in an Arab context faces several obstacles due to governance problems and widespread corruption in the judicial system in particular. The third motive relates to social pressure which is relatively weak, the communities and villages most affected by pollution, environmental hazards and non sustainable behaviour have very little voice at the political level to express concern and put pressure on polluters to undertake technical or organisational innovation. Examples from the oil sector in Algeria show that major oil companies started changing their attitude and being more concerned with pollution control and environment protection only when, their key technical personnel started exercising pressure when they felt personally at risk. Pressure could not come from villages and populations living in the affected areas as a result of flared gas and severe air pollution. The fourth one is pressure from international organisations. This factor seems, in the current situation the most plausible factor which can have a significant impact on Government and firms to change their technologies and organisation to more responsible behaviour. However, the limited financial

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means of certain debt ridden Arab states make it difficult to divert precious resources to innovation, while other urgent needs are not satisfied. Moreover, it may have a counter-productive effect, and lead to a drawback in sustainability as a result of less investment for poverty reduction, health protection and education promotion. International public funding could play an important role in this respect. Credit conditionality could help enterprises change their technological and environmental behaviour (Warhurst, 1998). The fifth one is related to the support coming from donor organisations, which has had some significant impact in recent years. This was the case in the agricultural sector where some progress has been made using local competences in R&D to find local solutions to problems such as crop disease, water treatment or water-saving irrigation techniques. However, these success stories are far too limited, not sufficiently publicised and far too concentrated in agriculture and less in the industrial sector.

CONCLUSION

We have highlighted above some of the fundamental issues and obstacles in the face of using knowledge for sustainability. Both the conceptual and the empirical analyses have shown that knowledge systems and sustainability are closely inter-linked and relatively highly correlated. This buttresses our hypothesis that knowledge and technology transfer remain paramount to sustainable development in developing countries as a whole and Arab countries in particular. However knowledge systems and sustainability are on different time scales and face different kinds of imperatives. While the building of knowledge is a long-time scale, some of the sustainability issues are on a much shorter time scale. For this latter type of issues, there are prospects and opportunities which could be seized. We will list them briefly here. The first opportunity is the new drive in the industrial fields for more ethical conduct, equitable trade and common destiny which is rapidly expanding in advanced countries. The social responsibility of enterprises appears a common concern for industrial firms throughout the world. New investment projects increasingly incorporate economic and environmental efficiencies into the production process, not just through new plants or equipment but also through improved management and organizational practices. They encourage both a dialogue between stakeholders in S&T and the elaboration of an appropriate regulatory and policy environment to nurture private investment in R&D. The second opportunity is the prospects offered by indigenous knowledge: What is missing is the capability based approach, as well as more generally a focus on learning capabilities as a whole. Many different kinds of learning are going on in society, i.e. in rural areas, villages, firms and organizations in the public sector as well as the private sector. Yet, only a part of this takes place in the formal education system or in the research system. What needs to be understood is how and to which extent individuals, communities, firms and organizations are geared to learning and innovation, either by themselves or in interaction with others (Johnson & Lundvall, 2000). The recognition of local and indigenous knowledge systems creates opportunities for establishing sustainable development and natural resource management processes that are rooted in social equity and relevance, local ownership and value systems, sound institutional partnerships and the valuation of both cultural and biological diversity. Another reason is that the need and opportunity to build on local and traditional knowledge may be relatively bigger in the South than in the North. The existence, character and usefulness of this knowledge may not be well known to national and international firms and policy makers. It is therefore vital to underline the importance of tacit knowledge and to draw attention to the need not to lose large parts of mostly not codified and undocumented local

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competencies. All these avenues are promising for Arab sustainable development through sustainable knowledge. They need to be further investigated.

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KEY TERMS AND DEFINITIONS

Degradation of Human Life: The negative effects of a degraded environment on human life. This deterioration is expressed under the direct and indirect costs of living that include the impacts on housing, food and infrastructure of different forms of environmental degradation (water, air, and soil pollution besides congestion). These costs culminate when health of individuals and groups is affected. Health costs are important measures of human life degradation.

Environmentally Sustainable Industrial Production: An industrial production that includes the indirect costs and the benefits related to the industrial process. Under this approach, industrial enterprises engage in social programs that account for the interests of businesses but also of society.

Less Developed Economies (LDCs): While most of the chapters in the present book use the concept of developing and developed economies, the present chapter uses the terminology of less developed economies or countries. As such, this is consistent with both approaches based on GDP and HDI and the relation to World Bank and UNDP rankings of countries. In this chapter, LDC refers to those countries with low economic and social performances.

New Opportunities: Knowledge economy has the merit of providing technologies and instruments needed in identifying and valuing new opportunities offered to businesses, to communities, and to society.

Public Goods Rational: The general framework that defines public goods and where non-exclusion and non-rivalry are the most important features by opposition to private goods.

Sustainable Development: An inclusive concept, as it accounts for economic, social and environmental dimensions of development. In addition, all natural resources in different locations and territories are included. But sustainability in development is mainly dynamic as it considers the improvement of

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the well-being of the populations throughout years and generations. In this sense, a development process is sustainable if it includes all the factors cited above.

Threat of Obsolescence: Knowledge is also known to have the property of quick obsolescence mainly under the on-going speeds of production and exchange of knowledge. Globalization of world economies is increasingly placing countries and regions in different benchmarks that help observe the state of knowledge in each country and region.

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Chapter 13
Integration of Demand-Side Management Programs and Supply-Side Alternatives for Decentralized Energy Planning:
An Analysis of Energy Import and Export Effects

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ABSTRACT

Optimally selection of an appropriate mix of renewable sources for supplying electricity of remote areas has been always an important challenge for policy makers. Also, in recent years, the great advantages of Demand Side Management (DSM) programs such as postponing investments in construction of new plants and/or desirably modification of electricity consumption pattern has turned great attention of energy planners to these programs. Moreover, the issue of global warming has caused the need for reduction of human use of fossil fuels and switching to employing green energy sources. To address the mentioned concerns, in this paper, an integrated mathematical formulation for selecting the best mix of renewable energy technologies is proposed. In this study, DSM considered as a competitive option against supply-side alternatives for making energy planning decisions. Additionally, by considering real data from a case in Iran, the effects of considering energy import and export has been taken into account. To validate the model, for smaller-scaled test problems the model has been solved by Lingo 8.0 software while for solving larger instances of problems (real scale of case study) a novel genetic algorithm (GA) is devised. The numerical results indicate that DSM policies have made use of their maximum capacity and resulted in significant improvements, especially in terms of reducing consumption and suitably changing the load shape.

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INTRODUCTION

Environmental concerns like global warming and climate change along with other factors such as recent financial crisis, the ever-increasing electricity demand, obligations to reduce greenhouse gas (GHG) emissions and current tendencies to achieve sustainable development, has led world leaders to expedite the process of replacing fossil fuels with renewable energies (RE) (Kyoto protocol - unfccc.int/kyoto_protocol/items/2830.php). Likewise, utilizing demand side management (DSM) strategies has ever more attracted the attention of policy makers. The higher the utilization of DSM policies is, the lower the need for investments in new power plants will be (Ardakani & Ardehali, 2014). As a result, not only GHG emissions will be remarkably reduced but also funds previously designated for constructing power generation plants will find the opportunity to be invested in more profitable settings.

There are a variety of RE technologies each of which has its own advantages and disadvantages. Thus, making a conscious decision on choosing an appropriate mix of different types of RE plants and determining their locations and capacities has always been a challenging task. Furthermore, there are different end-use sectors and accordingly different DSM programs suitable for each sector. Moreover, to reach the optimal energy planning decision, demand side resources must be compared to supply side alternatives (Kreith & Goswami, 2007). The above mentioned concerns show the need for an integrated modeling of the system such that helps policy makers come to the best decision.

Optimal designing wind park, solar plants, DSM programs and other RE systems have been extensively studied in the literature. However, none of which considers these different supply-side and demand-side alternatives all together. Because of this, we are going to integrate these options as a comprehensive model by considering effects of environmental parameters, possibility of importing and exporting of electricity, different RE options and DSM techniques and finally determining the best mix of energy technologies.

Among many approaches used for planning of energy in the literature, the most frequent ones include Linear Programming (LP) models (Ramakumar et al. 1986; Devadas, 2001), Delphi study (Iniyan & Jagadeesan, 1997), Optimal Renewable Energy Mathematical model (OREM) (Iniyan et al. 1998; Iniyanet.al, 2000) and etc. Hiremath (Hiremath e al. 2007) provided a great literature review on the new approaches and models toward decentralized energy planning (DEP). (Senjyu et al. 2007) and (Lagorse et al. 2009) used genetic algorithm for solving a DEP model. Herran and Nakata (Herran & Nakata, 2008) employed a goal programming (GP) approach to obtain satisfactory pareto optimal solutions to a DEP problem. Hiremath et al. (Hiremath et al. 2009) and Kanase-Patil et al. (Kanase-Patil et al. 2010) developed new models for decentralized energy planning in rural areas while they used GP method to solve their multi-Objective optimization model as well. Hessami and Bowly (Hessami & Bowly, 2011) studied the economic benefits of utilizing large-scale and different energy storage systems. The objectives sought to be optimized in the above mentioned studies are of either minimization or maximization type. The former type includes objectives such as total cost, utilization of petroleum products, etc. while the objectives of the latter type are system performance, utilization of available local resources and so forth.

As discussed earlier, global warming and climate change have caused GHG emissions to be regarded as an important problem in the last decade (Leung & Yang, 2012). For this reason, recent studies have tried different approaches such as changing the type of fuel Consumed (Sims et al. 2003), utilizing different renewable energy sources (Panwar et al. 2011; Hessami et al. 2011), new energy planning methods (Tsioliaridou et al. 2011) by applying mixed integer programming, goal programming (Cristóbal, 2012) and multi-objective evolutionary algorithms (Hashim et al. 2005; Agustín et al. 2006; Katsigiannis et al. 2010) for reducing the amount of these pollutants.

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In a latest research, Narula et al. (Narula et al. 2012) carried out critical reviews on the potential of renewable energies and their economic feasibility analysis in the future (see also Moriarty & Honnery, 2012; Yang et al. 2012; Katsaprakakis, 2012). Also, a number of researches have been conducted about new types of RE sources (Evans et al. 2009; Trapani et al. 2013).

Nowadays, as a result of increasing cost of energy in hours of consumption peak, the role of smart appliances in balancing of electricity cost (Gottwalt et al. 2011) and applying TIMES model for minimizing the costs (Pina et al. 2012); Doostizadeh & Ghasemi. 2012; Monteiro et al. 2013) have been investigated.

As a result of the ongoing growth of energy-intensive industries and the present remarkable increase in the demand of energy users, the need for establishing new power generation plants and/or changing the consumer behavior have been really amplified. Rodriguez et al. (Rodriguez et al. 2010) and Moura and de Almeida (Moura & de Almeida, 2010) conducted great reviews on the latest methods of distributed energy resources planning and analyzed the scope within which DSM policies can be applied. Finn et al. (Finn et al. 2013) and Gudi et al. (Gudi et al. 2012) showed the application of DSM and pricing policies and shifting the peak of demand to other hours that causes to defer the additional investments in new power plants.

Among the existing huge literature focused on RES, a little portion has been dedicated to surveying the role of imports and exports in creating a non-blackout grid. Kost et al. (Kost et al. 2011) and Dassisti and Carnimeo (Dassisti & Carnimeo, 2012) have studied the role of imports and exports of electric energy in RES and Supersberger and Führer (Supersberger & Führer, 2011) have analyzed the advantages and disadvantages of renewable energies by considering import and export dynamics in North African countries.

In a recent study, Kazemi and Rabbani (Kazemi & Rabbani, 2013) proposed an integrated DEP model wherein DSM policies were aptly regarded as a competitive solution against the supply-side alternatives for electrifying a rural area. Based on their obtained results, DSM policies were contributing to electrifying the supposed area at their maximum capacity. Additionally, they considered environmental measures in their study to make the plan more sustainable. However, a significant shortcoming of their work is that since the hypothetical village in their study was completely secluded, the benefits and detriments of being a part of a mini grid and having interactions with other supply/demand areas were totally disregarded. This paper in addition to covering the strengths of the work (Kazemi & Rabbani, 2013), has made the analysis of import and export effects achievable.

Based on the literature review provided above it is clear that none of the mentioned studies has considered DSM policies together with the possibility of import and export in making decision-planning policies. Moreover, a variety of foremost issues such as ever-rising energy demand, lack of sufficient energy infrastructures and dependence on energy imports for supply purposes or on energy exports for its profitability has further highlighted the need to fill the gap by proposing an integrated model in which both DSM policies and the possibility of import and export in a mini grid are taken into account. Thus, in this paper, a mixed integer nonlinear programming formulation capable of addressing the mentioned concerns is presented. Briefly speaking, the article attempts to answer the following questions:

- When is the appropriate time to import energy instead of self-generating it?
- Does combining DSM policies with the possibility of importing (exporting) a part of demanded energy from (to) other generating (consuming) locations make a big difference in terms of financial measures?
- Why mathematical programming has been selected for modeling such a complex system?

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- What approach should be chosen for solving real sized large scale instances of the problem?
- And finally, regarding the modeling of the problem under the given assumptions, what would be the best mix of renewable energy technologies in which an investment should be made?

The remainder of the paper is organized as follows. In the next section the proposed mathematical formulation is presented. Subsequently, in section 3 a novel genetic algorithm for solving the proposed model for large-scaled problems is devised and fully explained in detail. Afterward, in section 4 a case study has been introduced and solved by the optimization problem and the obtained results are discussed. Finally, in section 5 conclusion remarks are drawn.

PROPOSED MODEL

After providing a general review on the related area, in this section our proposed model that is aimed to provide answers to the above questions is presented.

Assumptions

The model presented in this study has been built on the base of the following assumptions:

- Region sets or nodes are connected by a mini grid.
- Blackout is not permitted.
- Savings resulted from implementing DSM policies reveals itself as a change in the consumption pattern.
- Imports and exports are considered in the form of an internal grid.
- Since this model is not intended for a particular region, to show the applicability of the model, we will solve it in the next section with the data that are mainly related to the global averages and have been derived from the latest scholarly papers in the literature.

Given the assumptions provided above, the optimization model can be formulated as follows:

Mathematical Formulation

Notations

Sets:
I: Set of manufacturer of energy sources
J: Set of end- uses
K: Hour of day and night that energy consumed in that hour $K \in \{1,2,3,\ldots,24\}$
L: Set of regions
Parameters:

c_{ijk} **:** Electricity generation cost of resource *i* for *j* th end- use in *k* th hour $\left(\mathrm{US\$}/\mathrm{kWh}\right)$

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$CDSM_{jkl}$ **:** Electricity saving cost using the implemented DSM program by *j* th end- use in k th hour and in *l* th region $\left(\text{US\$}/\text{kWh}\right)$

D_{jkl} **:** Average energy demand for *j* th end- use in *k* th hour and in *l* th region (*kWh*)

$Factor\,Parameter_{ikl}$ **:** Determining factor of maximum capacity of electricity can be produced by *i* th resource in *k* th hour and in *l* th region (in fact Factor $Factor\,Parameter_{ikl}$ is a binary parameter that can only take the values 0 or 1)

Su_i **:** Base capacity of energy produced by *i* th resource

$Alpha\,\boldsymbol{Ex}$ **:** A coefficient denoting an excess income from exports

Alpha Imp : A coefficient denoting a tariff imposed on imports

S_i **:** The cost of initial investment *i* th resource (Purchasing resource) ($Rial$)

P **:** A parameter representing the minimum compulsory budget that must be allocated to implementing DSM programs

Q **:** A parameter representing an upper bound on the budget that must be allocated to implementing DSM programs

$FDSM_{ijk}$ **:** The amount of improvement resulting from the implementation of DSM_{ijk} policy

$BigM$: A big number

Variables:

X_{ijkl} **:** The amount of produced energy by *i* th resource for *j* th end- use in *k* th hour and in *l* th region (*kWh*)

Y_{ijkl} **:** A free real variable showing the amount of electricity imports (if negative) or export (if positive) from *i* th resource to *j* end-use in *k* th hour and from *l* th region (city) *(kWh)*

Z_{ijkl} **:** A binary variable indicating whether *l* th city is an exporting city or an importing one

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Df_{il} **:** Integer matrices used for selecting the optimal number of *i* th resource

$SDSM_{jkl}$ **:** The determining matrix showing whether or not implementing DSM programs by *j* th end- use in *k* th hour and in *l* th region and is a binary variable

An Integrated Renewable Energy System (IRES) model has been proposed to generate electricity for using in agricultural, community, domestic and small-scale rural industrial regions. This model which is formulated as a nonlinear mixed integer programming approach is given below:

Minimize Total Cost =

$$\sum_i \sum_j \sum_k c_{ijk} \times \left(\sum_l X_{ijkl} - Y_{ijkl}.Z_{ijkl} \left(1 + Alpha\,\boldsymbol{Ex}\right) + Y_{ijkl}.\left(1 - Z_{ijkl}\right)\left(1 + Alpha\,\boldsymbol{Imp}\right) \right) + \sum_i S_i \left(\sum_l Df_{il}\right) + \sum_j \sum_k \sum_l SDSM_{jkl}.CDSM_{jkl}$$

Subject to:

$$\sum_j \left(-Y_{ijkl} + X_{ijkl}\right) \le Su_i.Df_{il}.Factor\,Parameter_{ikl} \;\forall i \in I, k \in K, l \in L \tag{1}$$

$$\sum_i \left(-Y_{ijkl} + X_{ijkl}\right) = D_{jkl}.\left(FDSM_{jkl}.SDSM_{jkl} + (1 - SDSM_{jkl})\right) \;\forall j \in J, k \in K, l \in L \tag{2}$$

$$\sum_i \sum_j \sum_l X_{ijkl} \ge \sum_j \sum_l D_{jkl}.\left(FDSM_{jkl}.SDSM_{jkl} + (1 - SDSM_{jkl})\right) \;\forall k \in K \tag{3}$$

$$\sum_j \sum_k \sum_l SDSM_{jkl}.CDSM_{jkl} \ge P \tag{4}$$

$$\sum_j \sum_k \sum_l SDSM_{jkl}.CDSM_{jkl} \le Q \tag{5}$$

$$\sum_i \sum_j \sum_l Y_{ijkl} = 0 \;\forall k \in K \tag{6}$$

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$$\sum_i \sum_j \sum_l Y_{ijkl} \leq BigM * Z_{ijkl} \ \forall i \in I, j \in J, k \in K, l \in L \tag{7}$$

$$\sum_i \sum_j \sum_l Y_{ijkl} \geq -BigM * (1 - Z_{ijkl}) \ \forall i \in I, j \in J, k \in K, l \in L \tag{8}$$

Df_{il} : $integer \ \forall i \in I, l \in L$

Y_{ijkl} : $Free \ \forall i \in I, j \in J, k \in K, l \in L$

$$SDSM_{jkl} = \begin{cases} 1 & If\ the\ DSM\ policy\ be\ used \\ 0 & otherwise \end{cases} \quad \forall j \in J, k \in K, l \in L$$

$$Z_{ijkl} = \begin{cases} 1 & If\ \ Y>0 \\ 0 & If\ \ Y<0 \end{cases} \quad \forall i \in I, j \in J, k \in K, l \in L$$

The first term of the objective function calculates the cost consisting of both generated electricity costs and costs of importing or exporting electricity. The second term of the objective function calculates the total cost of investment for purchasing the renewable energy technologies. Furthermore, total costs of implementing DSM programs are computed by the third term.

Constraint (1) implies that total amount of electricity generation must not exceed the maximum power production capacity. The demand balance constraint is enforced by constraint (2). Based on constraint (3), the hourly total production of electricity must not be less than the hourly demand of total network because blackout is not permitted.

Constraint (4) represents that a minimum mandatory proportion of demand must be met through DSM programs. In other words, it ensures the implementation of DSM programs through obligatory policies. Constraint (5), on the other hand, sets an upper bound for the maximum DSM achievement target. Constraint (6) enforces the import/export balance constraint. Finally, using constraints (7) and (8) prevent Y_{ijkl} gets infinitive value.

SOLUTION METHODOLOGY

Although the model proposed in the above section has been solved by commercial Lingo software for small-scaled test problems, for large-scaled instances of problems a novel genetic algorithm (GA) is devised. Bagley (Bagley, 1967) introduced the words ‘‘Genetic algorithms” (GAs) and published the first applications of GA. Then, GA was developed in the 1970s as an optimization toolbox, that was applied by Holland (Holland, 1975).

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Generally, GA parameters and components are: chromosome, population size, fitness function, selection operator, crossover operator, mutation operator, crossover percentage, mutation percentage and mutation probability.

In this section the GA procedure is comprehensively explained and its steps one after another are well delineated.

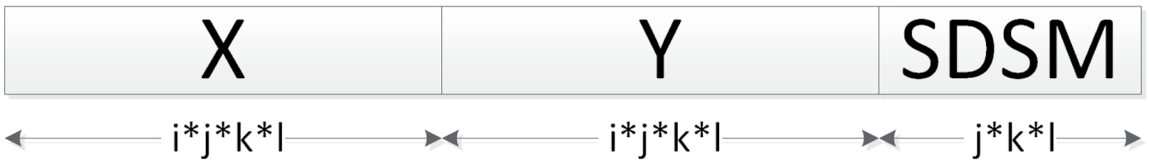
Definition of Chromosomes

Chromosome is a demonstration of an acceptable answer of the problem and must have special conditions of being unique; therefore, the chromosome is defined for this problem includes three components X, Y and the SDSM as shown in figure 1. To have a better understanding of described procedure in sections 3.1, 3.2 and 3.3, it is highly recommended to refer to figure 2.

In the first SDSM (that is a binary parameter) is generated randomly that has $j \times k \times l$ length. Then parameters X and Y are generated as follows with considering the initial data values and generated SDSM values:

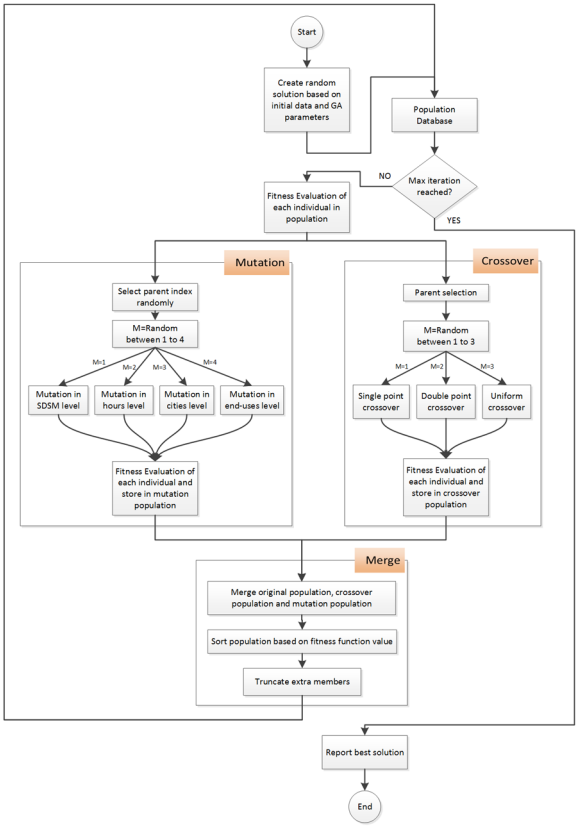
1. According to the values of D, FDSM and SDSM available, right side of the second constraint is generated.
2. By calculating $\sum_{j}\sum_{l} D_{jkl} \cdot \left(FDSM_{jkl}.SDSM_{jkl} + \left(1 - SDSM_{jkl}\right)\right)$, the value of $D_k^{'}$ is obtained. Now, the right side of the third constraint is calculated.
3. By combining the constraints (3) and (7), we conclude that if the constraint (3) is satisfied, constraint (4) will be established in the form of equity; According to the expressed points $D_k^{'}$ will equal to $XK = \sum_{i}\sum_{j}\sum_{l} X_{ijkl} = D_k^{'}$.
4. By generation of Nl random numbers for each K, so that the $\sum_{l} Nl_l = 1$, the $XKL = \sum_{i}\sum_{j} X_{ijkl}$ can be obtained.
5. By generation of Nj random numbers for each K and L, so that the $\sum_{j} Nj_j = 1$, the $XJKL = \sum_{i} X_{ijkl}$ can be obtained. Now, due to the constraints (2) and that $\sum_{i} X_{ijkl}$ is known,
6. $YJKL = \sum_{i} Y_{ijkl}$ can be obtained.
7. By generation of Ni random numbers for each K and L and J, so that the $\sum_{i} Ni_i = 1$, X_{ijkl} can be obtained.

Figure 1. Demonstration of chromosome



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Figure 2. Proposed GA procedures



8. We do 3.1.6 Step to calculate Y_{ijkl} this time.
9. Parameters X, Y and SDSM are arranged in the order in which X placed at the beginning of the chromosome, Y placed at the middle of the chromosome and SDSM placed at the end of the chromosome.

As is clear, the length of chromosome in this mode is equal to $(1+2i)jkl$, that the length of X would equal to ijkl, the length of Y would equal to ijkl and the length of SDSM would equal to jkl.

According to above sequence, the important feature of mentioned chromosome is that all the obtained values for X_{ijkl} and Y_{ijkl} satisfying the constraints (1), (2) and (3), but since that the values of SDSM may be not satisfy constraints (4) and (4) from the beginning, we have defined penalties in the fitness function up to during the implementation of evolutionary process, feasible SDSMs be generated.

Crossover

Crossover is an operator that combine two chromosomes (parents) in order to create new chromosomes (offspring). Because of specific mode of chromosome's definition, except on two-parent SDSMs any changing in structure of crossover is not possible, because it will lead to the generation a chromosome that would not be satisfy constraints (1), (2) and (3) simultaneously. According to the mentioned reason,

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the crossover is implemented by using the following three methods on the pair of parent SDSMs. First, a random number between [1, 2, and 3] is selected and placed in m.

1. If m=1, Single point crossover is used.

A random number between $\left[1 : j \times k \times l\right]$ is selected and placed in α. The first child will be created of the genes 1 to α of first parent's SDSM and genes α+1 to $j \times k \times l$ of second parent's SDSM. The second child will be created in contrary of creation procedure of the first child.

2. If m=2, Double point crossover is used.

Two random numbers between $\left[1 : j \times k \times l\right]$ is selected and placed in α and β, so that α<β. The first child will be created of the genes 1 to α of first parent's SDSM and genes α+1 to β of second parent's SDSM and genes β+1 to $j \times k \times l$ of second child's SDSM. The second child will be created in contrary of creation procedure of the first child.

3. If m=3, Uniform crossover is used.

A random vector of binary numbers with size $j \times k \times l$ are generated that called α. In the first child, wherever the element β of the vector α be equal to 0, β^{th} gene of first parent's SDSM and wherever the element β of the vector α be equal to 1, β^{th} gene of second parent's SDSM will be placed as the βth gene first child. The second child will be created in contrary of creation procedure of the first child.

Mutation

Crossover is an operator that randomly change one chromosome in order to create new chromosome.

Mutations in four stages are applied randomly; First, a random number between [1,2,3,4] is selected and placed in m.

1. If m=1, the mutation is applied in SDSM. $nMu = ceil(mu \times (j \times k \times l))$ samples are taken from the numbers $\left[1 : j \times k \times l\right]$ without replacement and the values of them if it be 1 will be changed to 0 and if it be 0 will be changed to 1.
2. If m=2, $nMu = ceil(mu \times k)$ samples are taken from the numbers $\left[1 : k\right]$ without replacement and then we repeat the steps 3.1.4 to 3.1.8 only for sample members.
3. If m=3, $nMu = ceil(mu \times l)$ samples are taken from the numbers $\left[1 : l\right]$ without replacement and then we repeat the steps 3.1.5 to 3.1.8 only for sample members.
4. If m=4, $nMu = ceil(mu \times j)$ samples are taken from the numbers $\left[1 : j\right]$ without replacement and then we repeat the steps 3.1.6 to 3.1.8 only for sample members.

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Fitness Function

Fitness function includes all three objective functions that the values of them are added together and be put in the objective function value (OFV). Also the penalty values relate to the SDSM infeasibility as Constraint penalty added to the above value and ultimately the value of the fitness function is reported.

Selection Method

Selection method is used for selecting parents for crossover or mutation operator. In this paper, two methods roulette wheel selection (RWS) and tournament selection (TS) are used for process of selection (For more information about selection methods refer to Holland, 1975). To compare the differences of performance between these two mechanisms, after setting the parameters of genetic algorithms by applying of Response Surface Methodology (RSM) (for more information about methods of designing experiment and necessary conditions for ANOVA see 11th chapter of Montgomery, 2008) for both mechanisms, 30 tests for each mechanism are conducted to it be possible the using of assumption normality of the data. Then, by using of the obtained results, we conducted an analysis of variance (ANOVA) to differences or no differences between the two approaches be examined.

The RSM results show that the best choice for both methods is obtained with the following parameters presented in Table 1.

According to Table 2 that shows the results of the ANOVA, It can be concluded that there is no reason to reject the null hypothesis, so there is no significant difference between the results obtained by the two methods, but according to the lower mean and variance, TS method is selected.

F-test for analysis of equality of variances and then the t-test for equality of means show similar results.

Table 1. RSM results

	Crossover Percentage	Mutation Percentage	Mutation Probability
Range	0.6-0.9	0.3-0.5	0.1-0.3
RWS	0.8805	0.5	0.1
TS	0.888	0.5	0.1

Table 2. ANOVA results

Groups	Count	Sum	Average	Variance		
RWS	30	2.58998E+16	8.63328E+14	3.92636E+25		
TS	30	2.58332E+16	8.61108E+14	2.27248E+25		
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7.39374E+25	1	7.39374E+25	2.3855	0.1279	4.0069
Within Groups	1.79766E+27	58	3.09942E+25			
Total	1.8716E+27	59				

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CASE STUDY AND EXPERIMENTAL RESULTS

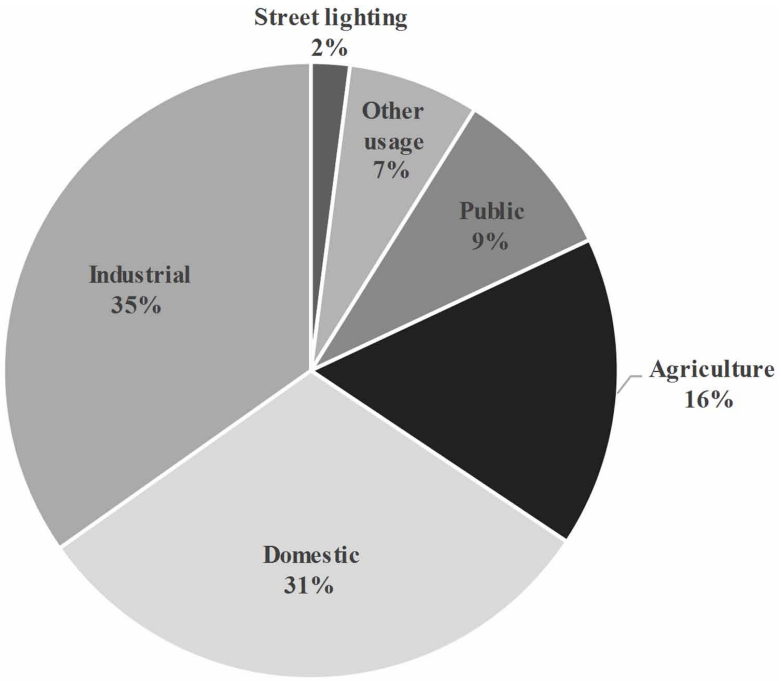
Data Collection

As previously mentioned, the aim of this study is the use of renewable sources to meet the development needs electricity of a country. According to long-term plans of Ministry of Energy (MOE) (www.moe.org.ir) and annual reports, which are published for top executives in the electricity industry, Iran seeks to reduce dependence on fossil fuels to generate electricity in the years ahead. In this regard and given the information collected about the amount of demand, price, amount of consumption of end-users and other related data, which is obtained from Iran grid management company (www.igmc.ir) or is derived from the literature review, capabilities of the model are shown to provide the overload due to annual demand growth by different generated resources for different users at different hour of day and night and in different cities.

Demand

First, the available data about the electricity consumption were extracted from the (www.igmc.ir), which is available based on hour for the years 2006 to 2011. According to the report published by reports for managers 2012, the amount of consumption of different end-uses has been shown in Figure 3. Other sectors of electricity consumption except for domestic, industrial and agriculture sectors (such as street lighting and etc.) have been considered as public sector. Furthermore, according to the forecasting of electricity demand in Iran up to the year 2017, the average growth rate is 8.5%. By multiplying previ-

Figure 3. Amount consumption of different end-uses (reports for managers 2012, www.igmc.ir)



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ous percentages and obtained growth rate in the average of the data collected, the amount of Electricity consumption per end-use will be achieved separately. Based on the above, according to the average consumption of the four provinces of Isfahan, Tehran, Khorasan and Fars respectively, the average consumption per province in each hour will be obtained. Because of all data are separated from one source, so consumption load shape for all end-uses is same. In order to solve this problem and obtain a fit load for each end-use, according to the literature review and items such as office hours (8 am to 2 pm) and peak information about the end-uses, set of coefficients generated. By applying these coefficients, the final electricity demand will be achieved.

Price of Electricity

Because of reduction the state budget, a policy in Iran has implemented to eliminate energy subsidies in the recent years. To obtain more realistic estimates, the average electricity price in 2012 is used. Considering that the cost of generated electricity by different sources and consumed electricity for different end-uses are different, specific coefficients for each source and each end-use was used to be considered these differences between prices in solving model.

FDSM's Coefficients

According to the implementation DSM plans, that their main goals are modify the consumer behavior, and accordingly, changing in the load shape and savings in electricity consumption, data related to FDSM are generated by considering to create a specify basic savings for each end-use and changing the load shape according to different hours.

The Values of Factor Parameters

This parameter states the level of access to producer sources in specified times; for example, that electricity generation source is dependent on the solar energy, not available in the hours that there is no sunlight. This information is obtained based on the average amount of solar radiation. In different regions of Iran, the average annual wind speed and diagrams of energy production proportional to wind speed for wind turbines, potential and the number of rivers within each province for generation of hydroelectric power and Finally, access to resources for electricity generation from Biomass (NASA Surface meteorology and Solar Energy, 2004; www.windflow.co.uk; geography-dept.talif.sch.ir).

Computational Results

The problem's data are arranged in the following order:

- The cities are arranged respectively as Isfahan, Tehran, Khorasan and Fars.
- The power sources (Plants) are arranged as wind turbine, solar panel (PV), Hydro and Biomass, respectively.

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Remark. The objective function value is based on Rials (IRR currency) and can be converted to dollars by using the exchange rate 1\$ = 25000Rials.

In order to prove the possibility of solving the original problem, one test problem was produced according to the original data and it has been solved by Lingo software (version 8).

The results obtained from solving the sample with dimensions of $1\times2\times2\times3$ is given in table 3. This solution is a global solution to the problem and it can be used for calculating the primary error of genetic algorithm.

As it is clear from the results in Tables 3 and 4, the application of DSM policies can reduce the costs (cost showed by OFV in tables). Therefore, the implementation of DSM policies can reduce overall costs significantly in the long term. In addition to the above, the application of DSM policies will also reduce the number of energy sources. This issue appears more important when the energy sources are pollutants.

Table 3. Lingo results with considering SDSM policies (Test Problem)

OFV=1.209426E+14						**City**			
				1		**2**		**3**	
				Hour					
				1	**2**				
X	Plant 1	End-use	1	0	0	687661.9	1991521	0	0
			2	0	0	1881827	681469.5	0	0
Y	Plant 1	End-use	1	-191920.2	-238603.9	0	1136588	-316793.3	-393851.9
			2	-241055.6	-190191.9	1147668	0	-397898.7	-313940.6
SDSM		End-use	1	0	1	0	1	0	1
			2	0	1	1	1	0	1
Df	Plant 1			0		4455		0	

Table 4. Lingo results without considering SDSM policies (Test Problem)

OFV=1.370659E+14						**City**			
				1		**2**		**3**	
				Hour					
				1	**2**				
X	Plant 1	End-use	1	0	0	687661.9	2243831	0	1920
			2	0	0	2009465	801728.8	1920	0
Y	Plant 1	End-use	1	-191920.2	-265115.5	0	1293906	-316793.3	-435693.2
			2	-241055.6	-223755.2	1145748	0	-395978.7	-369341.9
SDSM		End-use	1	0	0	0	0	0	0
			2	0	0	0	0	0	0
Df	Plant 1			0		5076		4	

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By considering the above example data, the best answer genetic algorithm after 10 iterations and with Max Iteration = 10000 is shown in Table 5. In this case, error of the solution obtained by the algorithm is equal to 20.65757%.

The results in Tables 3 and 5 indicate that SDSM has played an important role in problem of electricity supply network and in most cases it has been implemented. In other words, the constraint of maximum budget SDSM is an important limitation of problem, because different tests proved that the model moves towards the more implementation of policies SDSM that this issue leads to reduction in cost of system. In addition, results in Tables 3, 4 and 5 show that the initial cost of purchasing energy sources have the largest share in the objective function. So we can further reduce the objective function value than other states with the help of any way that we can reduce the demand, such as DSM policies.

Considering that the solving of main problem by using of exact algorithms is not possible, so the main problem with dimensions of $4 \times 4 \times 24 \times 4$ is solved by using of Genetic Algorithm. After problem solving, the results show that nearly 50% of SDSM variables have the value 1. In other words, this issue indicates that the DSM policies are often implemented.

The results in Table 5 shows Hydro and PV have the greatest share in the supply of electricity among the renewable energy sources respectively in the future of Iran that this matter was predictable according to geography and climate situation of Iran.

Table 5. GA results with considering SDSM policies (Test Problem)

OFV=1.459263964E+14						**City**			
				1		**2**		**3**	
				Hour					
				1	**2**				
X	Plant 1	End-use	1	726126.6	1539.4	13931	12.4	1823743	3425.5
			2	4643	2362445.9	56.2	73388.6	989.5	232178.7
Y	Plant 1	End-use	1	534206.4	-237064.5	-673730.9	-854920.2	1506949.7	-390426.4
			2	-236412.6	2172254	-734103.3	-608080.9	-396909.2	-81762
SDSM		End-use	1	0	1	0	1	0	1
			2	0	1	1	1	0	1
Df	Plant 1			1604		2561		1489	

Table 6. Df values for original problem with large scale data (solved by GA)

		City				**sum**
		1	**2**	**3**	**4**	
Plant	1	1205	1340	887	891	4323
	2	2808	9541	4997	5560	22906
	3	3849	9022	8747	5114	26732
	4	2181	5807	3296	3863	15147
sum		10043	25710	17927	15428	69108

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CONCLUSION AND FUTURE RESEARCH

The aim of this paper was to create an integrated model for decentralized electricity planning, so that criteria of DSM and the possibility of import and export are taken into account. The presented model in this paper has the potential usage capability for development of the national grid and/or entirely pre-planning of grid networks where the penetration of renewable energy technologies is dominated. Another feature of the proposed model is its ability to use the same resources with different capacities, that this feature causes flexibility in use of various resources with different capacities.

The obtained results of Table 3 and Table 4 indicate that implementing DSM programs can play a substantial role in reducing costs of planning electrical grids. Also, it can be pointed out that considering the case study data, because of the desirable rainfall in northern Iran and many rivers flowing in this country together with considering the fact that most days in central Iran are sunny during the year, the PV and Hydro should be used more widely as renewable energy technologies (RETs) for electricity supply and development of networks in the future. Therefore, making huge investments in PV and Hydro technologies and supporting DSM policies are very crucial for the country to reduce total costs of electricity generations and contribute to achieving sustainable development targets. In this paper, several step-by-step modifications is done to reduce the algorithm error rate from 50% to 20%.

Several issues can be considered as future studies. Utilizing of Prediction consumer demands methods for hourly demands (such as time series, neural networks and regression) and comparing the results of these methods with common methods is one of the best of these future studies. Another issue that can be considered as future studies is considering the amount of pollutants produced by renewable resources. In this case, the objective function also includes the reducing emissions and the problem will change to multi-objective problem. Moreover, utilizing of graph and network models and combining of these models with simulations methods can reduce the algorithm error rate significantly.

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Chapter 14
Policy Provisions and Teachers' Needs on Climate Change Education for Sustainable Development in Mongolia

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ABSTRACT

There is scientific consensus that Mongolia is already facing the negative consequences of climate change. Raising public awareness and increasing education initiatives is one of the most important ways to adapt and mitigate climate change. The present research team reviewed the policies and provisions in support developing climate change education for sustainable development. To strengthen public awareness of climate change and sustainable development, teachers at all level must play an important role. The team analyzed the level of teachers' knowledge of climate change education for sustainable development and determined the needs for teacher training. Education policy recommendations and the possibilities for teacher training were defined.

INTRODUCTION

Education is critical for promoting sustainable development and improving the capacity of the people to address environmental and developmental issues (UNCED, Agenda 21. The United Nations Action from Rio., 1992). From the time sustainable development was first endorsed at the UN General Assembly

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in 1987, the parallel concept of education to support sustainable development has also been explored. From 1987 to 1992, the concept of sustainable development matured as committees discussed, negotiated, and wrote the 40 chapters of Agenda 21. Initial thoughts concerning Education for Sustainable development were captured in chapter 36 of Agenda 21, "Promoting Education, Public Awareness, and Training" (McKeown, Education for Sustainable Development Toolkit, 2002). Obviously, education is an essential tool for achieving sustainability. People around the world recognize that current economic development trends are not sustainable and that public awareness, education and training are essential to move society toward sustainability (Charles Hopkins and Rosalyn McKeown, 2002).

Mongolia, like most of the countries, agreed on the UNFCCC declaring the commitment to develop and implement an Education for Sustainable development, in 1992. The following result is the first national policy document on sustainable development, "MAP 21: Mongolian Action Plan for the 21st Century", which was developed and approved in 1998. One of the main goals, "Concentration on nurturing the educational and scientific sectors to allow them to be better able to meet the diverse intellectual requirements of Mongolians as they strive to implement sustainable development" (MAP, 1998), is the initial and official statement of education for sustainable development in Mongolia.

Climate change impacts the natural environments and the livelihood of the people in Mongolia, obviously. The study of climate change, began in 1979 in Mongolia, after the second World Meteorological Conference. "Climate change" was the first symposium, organized by the Institute of Meteorology and Hydrology in June, 1980 (Dagvadorj.D, Natsagdorj.L, Dorjpurev.J, Namkhainyam.B, 2009). Sustainable development, however, has been discussed in Mongolia since 1992 while the issue of education for sustainable development was initially discussed in policy documents since 1997. As a result, the "State Ecological Policy" was developed and approved by the State Great Khural (Parliament) in 1997. But ecological policy and ecological education issues are strongly based on biological science perspectives in Mongolia, and climate change education for addressing sustainable development issues is still not declared at the official policy level.

Issue is that Mongolia is very sensitive to climate change due to its geographic location, sensitive ecosystems and socioeconomic condition (Dagvadorj.D, Natsagdorj.L, Dorjpurev.J, Namkhainyam.B, 2009). While there is emerging awareness of the current and potential impacts of climate/environmental change on education provision and learning, it is also clear that education: formal and non-formal, from primary through to tertiary and adult education-has an important role to play in addressing this change (Colin Bangay, Nicole Blum, 2010) around the world. Moreover, climate change education for sustainable development is a new term in Mongolia. According to its obligations and commitments under the UNFCCC, the Mongolian Government initiated and implemented the National Action Program in Climate Change which was approved by the Government in 2000. The Millennium Development Goals (MDGs)-based Comprehensive National Development (MDGbCPND) Strategy of Mongolia was approved by the Parliament of Mongolia on 12 February 2008 (MNET, 2011). Pilot area 5 of the MDGbCPND strategy states, "To create an environment for sustainable development in the way of building capacity to adapt to climate change, and limiting and protecting loss of ecological equivalence" and this statement is the basic rationale for the development of the National Action Program on Climate Change (MNET, 2011). Because of the statement, "Within this framework, activities in expanding public participation and awareness about eliminating negative consequences, ways to overcome, and adapt to climate change and desertification will be implemented" (Pilot area 5 of the strategy) (MDGbCPND,

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2008), MDGbCPND Strategy is the first policy statement that addressed climate change education in Mongolia, in terms of education.

Due to the existing socio-economic situation, the National Action Program in Climate Change was redeveloped and approved in 2011. The most detailed statement about "climate change education" was appeared on the "National Action Program on Climate Change". The fifth objective of the program was "to conduct public awareness campaigns and support citizen and community participation in actions against climate change". To achieve the objective, the following actions will be taken in 2012-2021:

- Include courses about climate change and the green economy in all levels of school programs;
- Develop educational curriculums and define new profession indexes and classifications related to climate change and environmental sectors.

As mentioned in Bangay and Blum, we do not see education's response to climate change as simply the provision of new curriculum inputs; rather, the challenges of climate change require all concerned to look to fundamentals and examine the degree to which existing educational provisions are adapted for radically different futures (Colin Bangay, Nicole Blum, 2010), especially in Mongolia.

In the other hand, to enhance the development of young professionals in the field of climate change adaptation, the topic could be included in higher education, especially in formal education programs. Higher education should be done through lectures and course work, field studies, internships, and establishing the education-research link by exposing students to field realities. In this regard, guiding principles could include an inclusive curriculum, focus on basic theory, field orientation, multidisciplinary courses, and practical skill enhancement (IPCC, 2014).

In secondary education, there are often existing tensions between a centralized curriculum and the need to promote locally based and locally appropriate issues. Areas of knowledge will require cooperation between local, national and international actors (Colin Bangay, Nicole Blum, 2010). Thus, we would like to know the coverage level of climate change education for sustainable development in national educational standards, curricula and textbooks. Beyond the policy, are we ready to play a key role in addressing climate change? It is obvious that poor environmental literacy and limited knowledge of climate change are manifestations of a more profound problem with the low quality of science education (R. Abbasi, 2006).

The "National Action Program on Climate Change" (2011) was approved by the State Great Khural is the initial and most important achievement to develop climate change education in Mongolia. The main expected outcome of the program is "Expanded and increased number of citizens, cooperatives and organizations who are engaged in actions to respond to climate change and implement relevant projects and programs" by 2021. To succeed, climate change education for sustainable development "must have an authoritative impetus from national or regional governments that will drive policy development" (McKeown, 2002). Our previous research results showed that public understanding of climate change is limited and unclear. Thus, we need teachers to play important role in accomplishing the goal. As Sherrie Forest argued, "the public's limited understanding of climate change is partly the result of critical challenges that have slowed development and delivery of effective climate change education (Sherrie Forest, Michael A. Feder, 2011). The question is whether teachers are prepared to engage in public awareness efforts on climate change?

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Making progress towards a more sustainable society requires a population that is aware of the goals of sustainability and has the knowledge and the skills to contribute towards those goals (UNESD, 2005, p.29). Although documents have been developed that define the term "climate literacy," further elaboration of its meaning is needed, particularly around expectations for actions or activities to combat climate change ("stewardship") (Sherrie Forest, Michael A. Feder, 2011).

Recent concerns over climate change have increased interest in mitigation and adaptation. Adaptation seems most relevant to vulnerable communities in Asia; they contribute minimally to emissions and therefore play a minimal role in climate change mitigation. Their entire future, however, is jeopardized by imminent climate change impacts, and thus they are dependent on appropriate climate change adaptation (CCA) interventions. CCA and DRR are also closely linked and have a number of other related thematic areas of concern that require attention (AUEDM, 2011).

Effective communication of climate change science is important not only to ensure that individuals understand the impacts of climate change but also to encourage action for climate change mitigation and adaptation (Boon, 2014). If pre-service and in-service teachers learn to weave ESD issues into the curriculum and to use pedagogical techniques associated with quality ESD, then the next generation will be capable of shaping a more sustainable world (UNESCO, 2005). Understanding the knowledge, beliefs and attitudes towards climate change that exist among members of the general public is important in designing appropriate teacher training for educators. Equally important is examining teachers' knowledge, beliefs and attitudes towards climate change (Boon, 2014).

"Climate change education (McKeown, Education for Sustainable Development Toolkit, 2002) for sustainable development" is quite a new concept in Mongolia, and the country has been at its starting point of integrating the related concepts into its education system. At this moment, the integration level has been limited. Thus, our team proposed to determine the level of current integration of climate change education for sustainable development into the Mongolian educational teaching and learning process by conducting a National Study in the areas of policy development and teacher knowledge to define future possibilities. To achieve the main goal, the following objectives were defined:

- To analyze current policies, plans, and programs in terms of CCE/DRR/ESD;
- To assess teacher knowledge of CCE and DRR and to identify their training needs.

RESEARCH METHODOLOGY AND DATA

The research study consists of two main analyses:

- **Review of Policy:** Educational, environmental and development related national policy documents, laws, national programs, guidelines and orders;
- **Review of Teachers' Knowledge of Climate Change:** In order to define the needs of the training on Climate change education for sustainable development.

The following methods were used in the research study:

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- Policy analysis matrix (PAM) comprised of two sections:
    - The first section reviewed total 37 documents, such as educational laws, programs, plans and policy documents related to climate change education (CCE), disaster risk reduction (DRR) and education for sustainable development (ESD) in Mongolia. This includes 6 laws, 19 national programs passed by the parliament, plans, and policy documents, and 5 programs adopted by the orders of the Minister for education and science;
    - The second section covered 12 laws related to environmental management, climate change and disaster risk reduction and 16 national programs and other policy documents.

Quantitative/qualitative analysis:

- To define the level of teacher knowledge and understanding of CCE/DRR/ESD, a 25-questions survey was developed;
- In addition to the standard questionnaire, the qualitative assessments were made via unstructured interviewed of research participants.

RESULTS

Policy Analysis Matrix

The team reviewed all of the above documents to locate any provisions, content and issues related to CCE/DRR/ESD. We did not look only for the exact words "Climate change education" and "Education for sustainable development". Instead, we counted and evaluated terms with similar meaning:

1. **Educational Policy:** In the six educational laws, there have been numerous provisions related to sustainable development, but no provisions directly related to CCE and DRR were found. The only provision that seemed to be related to DRR had to do with what actions need to be taken when disasters happen and who can be covered by these actions. The provisions are 8.3, 15.3, and 9.3 in the laws of Higher Education, Primary and Secondary Education, and Pre-school Education, respectively. Compared to the laws, quite a few provisions were found relevant to the areas of CCE/DRR/ESD in some of the national programs passed by the cabinet;
2. **Environmental and Development Related Polic**y: Review of these documents reveals that the first policy documents on climate change and disaster management were produced in 1992. However, certain policies including public awareness activities, transferring knowledge and offering education on these subjects, have existed in policy documents since 1997. Table 1 shows a list of documents where CCE/DRR/ESD have been reflected.

Table 1 shows that there have been 19 provisions related to CCE/DRR/ESD included in 11 policy documents out of 16 reviewed. Eight of them are related to ESD, 5 of them specifically to CCE and 6 of them specifically to DRR.

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Table 1. Reflection of CCE/DRR/ESD in climate change and environmental policy documents

№	Policy documents[1]	Validation	Related provisions of		
			ESD	CCE	DRR
1	State Ecological Policy	Parliament resolution #106 in 1997, (1997-12-26)	+	-	-
2	State Food and Agricultural Policy	Parliament resolution #29 in 2003, (2003-06-18)	+	-	-
3	Millennium Development Goals based Comprehensive Policy for National Development of Mongolia	Parliament resolution #12 in 2008 (2008-01-31)	+	+	-
4	National Program on Water Resources	Parliament resolution #24 in 2010	+	+	+
5	National Program on Coping with Desertification	Parliament Resolution #90 in 2010 (2010-04-14)	+	+	+
6	National Program on Climate Change	Parliament resolution #02 in 2011	+	+	+
7	National Program on Building Capacity in Protection from Disasters	Parliament resolution #22 in 2011	-	-	+
8	State Disaster Management Policy	Parliament resolution #22 in 2011	-	-	+
9	Law on Preventing Disasters	Passed by the Parliament on June 20, 2003 and updated in 2005, 2007, 2011, and 2012	-	-	+
10	Mongolian Sustainable Development Program: Progress, Difficulties and Perspectives	Joined report by the GoM and UN, 2012	+	+	-
11	Law on Genetically Modified Organisms	Parliament June 28, 2007	+	-	-
	Total Provisions		8	5	6

+ reflected
- Not reflected

The Millennium Development Goals based Comprehensive Policy for National Development of Mongolia (MDGbCPND) of Mongolia, as a main policy document, contains a limited number of provisions on DRR, even though there have been some provisions on CC/SD. The National Program on Water Resources, the National Program on Coping with Desertification, and the National Program on Climate Change that were produced based on the MDGbCPND, however, have contained comprehensive provisions in all three areas (Table 2).

In disaster related policy documents, provisions have focused on delivering indigenous approaches, improving knowledge of the public, using remote sensing to identify risk and disasters, introducing forecasting approaches and technologies, developing ways to deliver forecasted information to users immediately, and improving forecasting systems. The focus, however, did not include public awareness activities for preventing disasters and improving consciousness of the public on disaster risk and its consequences.

Eventhough CCE/DRR/ESD related terms and issues have been presented in many of the documents, progresses and processes to increase a public knowledge and awareness and introduce the related concepts into the educational system have been slow.

In addition, it was found that CCE/DRR/ESD provisions have been reflected in a limited way in legal documents related to environmental conservation and proper use and protection of natural resources. Furthermore, CCE issues have been reflected in only the National Program on Climate Change, and DRR has been considered in the National Program on Prevention of Disasters.

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Table 2. Interrelations of provisions on CCE/DRR/ESD in different policy documents

Provisions in the Millennium Development Goals based Comprehensive Policy for National Development of Mongolia		
4.4. Strategic Objective 2: Updating training standards and curricula of all levels of education in accordance with student needs and social requirements: - Contents of all levels of education must contain possibilities for students to select courses, and be updated with focuses on respecting national values, being proud of history and culture, being respectful to others culture, valuing high-tech knowledge, and building creative thinking - Introducing training standards and curricula that comply with international education standards	Priority #5: To create an environment for sustainable development in the way of building capacity to adapt to climate change, and limiting and protecting loss of ecological equivalence. Within this framework, activities in expanding public participation and awareness about eliminating negative consequences, ways to overcome, and adapt to climate change and desertification will be implemented.	
Provisions in National Programs that originated from the above policy document		
National Program on Water Resources	National Program on Coping with Desertification	National Program on Climate Change
3.6.3. To update curricula of pre-schools, primary and secondary schools, and higher education institutions for introducing effective ecological education. 3.6.4. To improve contents, quality and curricula of professional water training, to determine of water profession job titles, to develop and implement master's program for integrated water resources management at higher institutions, and to intensify trainings to prepare technicians and professionals in water fields.	9.4.1. Objective 1; to intensify trainings for youth to deliver knowledge on understanding factors that influence desertification and deteriorating ecology, and their negative consequences within the framework of delivering education for sustainable development at all levels of schools. 9.4.1.1. To integrate concepts of "UN Decade of Education for Sustainable Development" Program by UNESCO into secondary school curricula	The 5th objective refers to supporting active participation of the public in raising public awareness on climate change and necessary actions to be taken against the CCE. At all levels in 2011-2012: - To prepare and deliver brochures and handouts on climate change adaptation and mitigation - To integrate into curricula of all levels of schools the concepts/ideas of CCE, sustainable development, and green economy development - To carry out regular trainings and advocacy activities on rescuing in disasters, properly using information on natural risky phenomenon and disasters

Analysis of Teacher Education

A questionnaire has been developed to measure the knowledge, and identify continuing training needs of teachers, on ESD/CCE/DRR. This questionnaire was applied to approximately 150 teachers in urban and rural areas, and 94 percent of respondents were women and 6 percent were men. The dominance of female teachers in our sample matches the overall ratio of male and female teachers in the country. Over 80% of secondary school teachers in Mongolia are female.

The questionnaire consisted of two parts: (i) respondent's age, years of employment, level of their training, and (ii) questions to determine teachers' needs. For example:

- What do you know about adaptation to climate change?
- What source (where) do you rely upon for information about climate change?
- What kind of training would you choose to improve your knowledge of climate change?
- How much are the following CCE/DRR concepts related to your teaching?
- What are the ways to teach CCE/DRR through your field of teaching?

Rural teachers were a target for focus group discussions. 46% of the respondents answered that the questions in the questionnaire related to their course and 39% think that these issues are deeply involved

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while only 5% answered as related and necessary to be taught at schools. The followings are example questions of focus group discussions:

- Is there any faucet in your school toilet that leaks?
- Have you seen any empty classrooms with the lights left on?
- Do teachers use both sides of the paper when printing or making photocopies?
- Do you have garbage bins at your school for sorting garbage?
- What are the main issues that you are facing at the local level? Are there ways to resolve them?
- How much do parents participate in renovating classrooms and gardening school areas?
- What aspects of indigenous knowledge has been forgotten in your area?
- Have you attended any training on CCE/DRR?

Answers of the respondents are shown in Table 3.

Although most of the respondents agree that concepts relate to their courses, teachers have different thoughts on each of the questions depending on their professional background. For example, primary school, Mongolian and foreign language teachers think that teaching about cultural differences and the misunderstandings associated with it and maintenance of traditional culture is deeply related, while natural and social science teachers answer that issues being faced by people, climate change, social and human ecological issues and changes in the relationship between people and nature would be the deeply related ones. There have been some teachers who think that it is not necessary to teach about CCE/DRR/ESD. This picture indicates the need for comprehensive training to improve teacher knowledge.

Most teachers answered that it was important to integrate these topics in their curricula and teach to students (Table 4).

Table 3. Relationship of CCE/DRR/ESD into teaching

Main Concepts of ESD/CCE/DRR	Not Related	Related	Deeply Related
Change in relationships of humans and nature, positive and negative consequences of social development	8	58	24
Main concepts of social and human ecology: CCE/DRR	5	61	26
Issues being faced by people	4	42	46
Over consumption and resource scarcity	10	58	23
Cultural difference and misunderstanding	9	60	23
Keeping traditional culture and habits	5	46	39

Table 4. Thoughts of teachers in integrating ESD/CCE/DRR into their courses

ESD Concepts	Not Important	Do Not Know	Important
Skills to understand personal and social values	11	10	71
Ethics	1	10	81
Needs of working and living together	1	8	84
Safety of living environment	4	8	80
Healthy living (right diet, fitness & wellness, nutrition etc.)	2	9	81

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Answers to the questions to assess teachers' knowledge show that most of the teachers do not have a clear understanding of ESD/CCE/DRR. Perhaps the questions were unclear, which led to this results. Table 5 describes the answers of teachers.

There have been many trainings organized for teachers. As a result of these trainings, teachers should have already been advanced into a level where they can teach CCE/DRR/ESD in secondary schools. In-service teachers were asked to evaluate the quality of general/not specific trainings they attended and findings are presented in Figure 1.

67 percent of teachers think that in-service trainings are timely and important in terms of content, building new knowledge, and importance. 53 percent of the respondents answered that training methodologies have been suitable. To the questions of selection and development of methodologies, similar percentages of teachers answered positively. However, respondents gave negative answers to the quality of organizational material of trainings and the sufficiency of teaching aids.

In terms of duration and timing of the in-service trainings, respondents think that trainings should last one to five days (75%) during students' holiday times (82%).

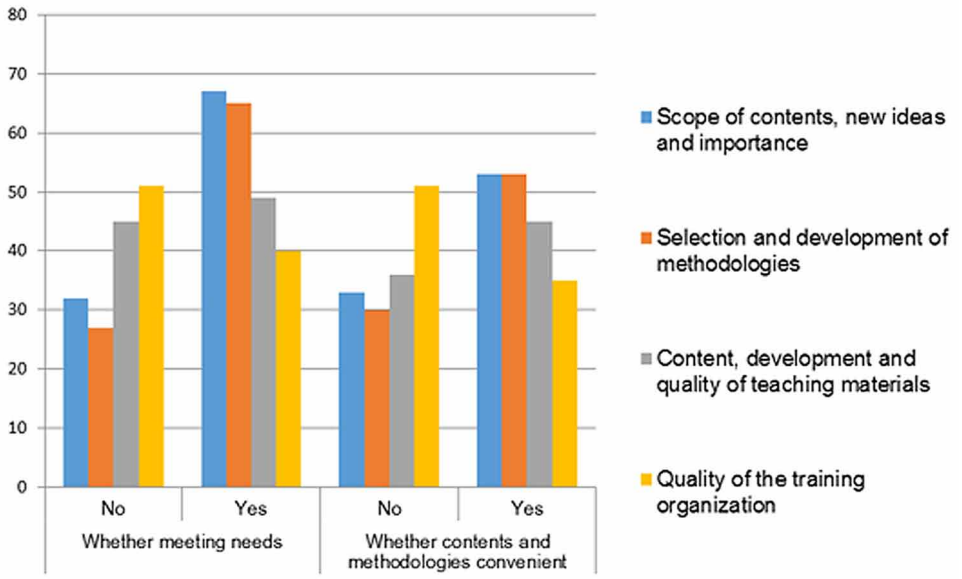
The study team has also investigated the impressions of in-service teachers regarding results of the trainings. The findings are presented in Table 6.

Table 5. Teacher knowledge of CCE/DRR/ESD (percent)

	Connecting Concepts of CCE/DRR into Education Activities	**Reflecting Main Characteristics of CCE/DRR/ ESD in Order to Introduce CCE/DRR/ESD in their Teaching**	**Assessing Student Development and Changes in Behavior**
Education standard	52.0	25.0	23.0
Level of textbook use	32.0	44.0	25.0
To have a set of curricula for an entire course	41.0	34.0	25.0
To have curricula for an entire chapter	45.0	32.0	2.04
To have curricula for a unit	44.0	32.0	25.0
Periodic plans	44.0	28.0	28.0
Teaching aids	32.0	33.0	36.0
Teaching subjects	36.0	41.0	32.0
Improving curricula for all grades	42.0	37.0	21.0
Analysis of subjects	35.0	26.0	38.0
Developing students	22.0	24.0	54.0
Training environment	35.0	34.0	31.0
Skill and knowledge improvement training	28.0	48.0	24.0
Developing extra curricula	40.0	30.0	30.0
Teacher ethics	49.0	38.0	14.0
Developing oneself	34.0	35.0	22.0
Participating in extra curricular activities	50.0	29.0	21.0

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Figure 1. Quality of trainings for in-service teachers, by percentage



The findings of this questionnaire show that trainings give achieve average results, with 62% and 67% for each of the questions. Only 12% and 16% think that the trainings have good results, with similar numbers that the results are bad. This indicates that training contents, methodologies, and quality should be improved to meet needs of teachers.

The study team also asked questions related to the problems hindering their attendance in in-service trainings. Findings are presented in Table 7.

Table 6. Results of in-service trainings

Results of Trainings	Unsatisfied	Average	Good
Whether the trainings touch issues that teachers face every day and activities they conduct every day.	12	62	16
Whether the trainings give needed guidance to make effective changes to their curriculum	12	67	12

Table 7. Problems hindering the attendance in in-service trainings (percent)

Questions	No	Yes	Very Much
School supports teachers to attend in-service trainings	38.0	49.0	13.0
Do you pay tuition fees from your own pocket	9.0	57.0	34.0
Systems to distribute announcements of trainings	29.0	52.0	19.0
Possibility to know training quality in advance	35.0	48.0	16.0
Possibility to select trainings based on own need	3.0	58.0	12.0
Provisions of methodologies to improve own skills and knowledge at workplace	28.0	53.0	19.0
Possibility and condition to improve own skills and knowledge at workplace	33.0	57.0	11.0

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In most cases, teachers do not experience problems in attending in-service trainings, but around 30 percent of teachers feel some kind of difficulty. Although 30% is less than half of the votes this indicates that there is some level of problems with the operations of in-service training compared to what we would expect with no problem. Teachers do not face any problem of paying training fees to attend in-service training fees. In all cases, this is generated by the state budget, except for a few cases.

CONCLUSION AND RECOMMENDATIONS

This study shows that there has been limited coverage of climate change education and disaster risk reduction in legal and policy documents. This indicates that more work is required to develop ways to include issues of climate change and disaster risk in the educational system.

Teacher knowledge and skills have been limited in teaching CCE/DRR/ESD. Depending on background, every teacher explains the concept of climate change education for sustainable development differently. There is a need to give the same level of CCE/DRR/ESD education to all teachers.

Activities to improve public understanding of CCE/DRR policies, and clear expected outcomes should be added to national programs including the "National Program on Water Resources", the "National Program on Coping with Desertification", and the "National Program on Climate Change".

Every environmental law should have certain provisions related to climate change and disaster management in accordance with their purposes. For example, water laws should contain provisions on supporting: (i) local initiatives on conserving water sources, (ii) re-introducing traditional and indigenous knowledge on water conservation, and (iii) research on best practices of water conservation, and introducing new methods for conservation best suited to Mongolia, etc.

In related laws and policy documents, an organizational structure of raising public understanding and advocacy should be clearly incorporated.

Legal documents should clearly say what should be done under the current capacity building programs for climate change education for sustainable development. In current documents, capacity building programs have been mentioned, but there is no clear guidance on how will it be carried out.

It has been difficult to list names of specific trainings needed for teachers since study results show that teachers lack general understanding of CCE/DRR/ESD. Therefore, the team suggests the following:

- Systematic trainings for teachers on CCE/DRR/ESD are needed to ensure that all teachers have the same level of knowledge and skills in teaching the subjects. To do this, trainers at the CCESD and training materials and manuals should be prepared well to transfer the knowledge to in-service teachers;
- Teachers should learn methodologies to transfer their knowledge to students, connecting the CCE/DRR/ESD with the subjects they teach. Teachers agree that they should transfer CCE/DRR/ESD knowledge to their students, but they remain unsure how to transfer the knowledge. In other words, they lack methodologies in teaching;
- Teachers need up to date teaching aids to help them efficiently transfer their knowledge to students;
- Teachers need to learn not only new knowledge and new ways of teaching, but also the methods on assessing students' knowledge and skills.

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Chapter 15
Smart Energy and Cost Optimization for Hybrid Micro-Grids:
PV/ Wind/ Battery/ Diesel Generator Control

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ABSTRACT

This chapter is concerned with the energy management of a hybrid micro-grid composed of photovoltaic/ wind/ battery bank and diesel generator, which is used to supply domestic loads. Hence, a control strategy is proposed to manage the power flow between the power sources and the loads, which ensures the maximization of the renewable sources use, and therefore the minimization of the battery bank and diesel generator use. The control strategy allows the installation operating cost to be minimized and the safe operating for the battery bank to be guaranteed. The strategy is tested using measured data of some climatic parameters of the target area, showing its efficiency in fulfilling the fixed objectives.

INTRODUCTION

Electrical energy is a vital input for the social and economic developments, for which the demand has significantly increased (Lund et al., 2015; Santamouris et al., 2015). However, due to the instability in the fossil fuel prices and the increase in the greenhouse gas emissions, renewable energy sources are best

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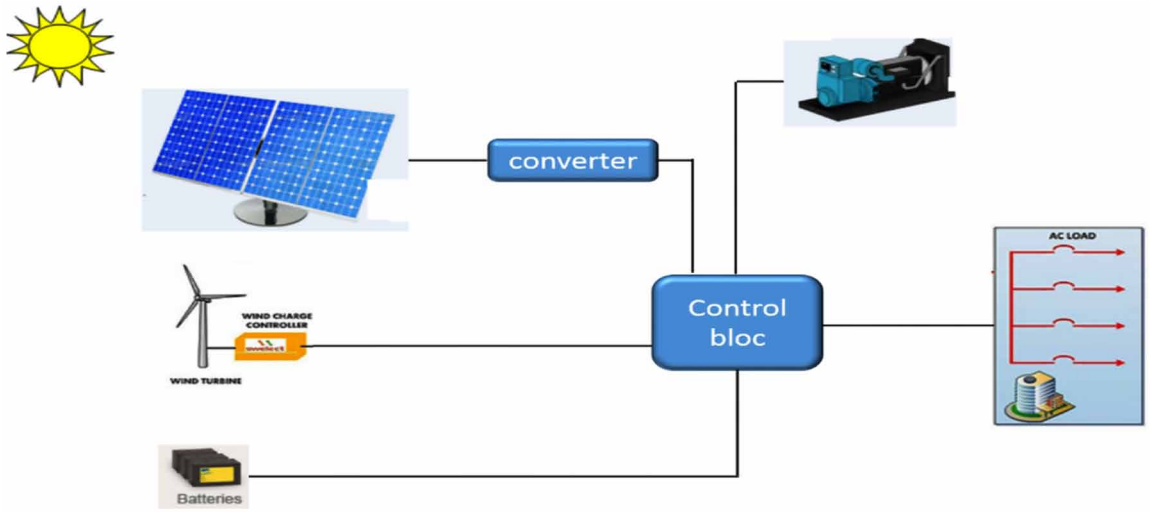
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placed to solve these issues (Jacobson et al., 2015; Mathiesen et al., 2015). Since renewable energies depend on the climatic parameters, characterized by their intermittence, it is necessary then to optimize and to use smart strategies (Østergaard et al., 2016; Narimani et al., 2015), which can be applied in micro-grids, including smart grids (Mathiesen et al., 2015; Pouresmaeil et al., 2015). Fortunately, the continuous advances in computer hardware and software are allowing researchers to deal with smart grids systems. This is performed by applying optimization and energy management strategies to the renewable and sustainable energy field, in such a way to ensure the optimum use of the generated energy, to provide the energy needed to the loads, and to guarantee a safe and secure operation for the whole smart grids system (Oró et al., 2015; Sonnenschein et al., 2015). Establishing an energy management strategy for smart grids systems is essential, since it allows the system autonomy and the continuity in the power supply to be ensured, thanks to the use of operational planning network through two-way power flow and communication (Farhadi et al., 2015; Zhao et al., 2015). Moreover, these strategies allow looking out the system security, by detecting defaults when occur, predicting energy generation and consumption from the one hand, and fulfill the energy demands whenever and wherever are needed from the other one (Aman et al., 2015; Sabo et al., 2016).

Hence, in this research chapter, a strategy for the optimum energy control of a hybrid system composed of photovoltaic (PV) panels, a wind turbine, a lead- acid batteries bank, a diesel generator which supply a variable domestic load, is proposed and discussed in depth (Figure 1). The proposed Energy Management strategy (EMS) is based on several considerations related with the electricity generation, maintenance, components replacements and fuel price costs. Therefore, a cost function is introduced and minimized in order to optimize the involvement degrees of each power source, by comparing, at each sample time, the power sources combinations costs while supplying the domestic loads. The electricity generation cost includes the components operation, maintenance, fuel and replacement costs of the system parts studied during 20 years. The proposed strategy aims to guarantee the system operation continuity; in such a way the load is always supplied. Secondly, it ensures the system safe operation, since it respects constraints that allow extending the components lifetime. Furthermore, the EMS aims to minimize the use of the

Figure 1. Scheme of the proposed photovoltaic system connected to a single-phase grid utility



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diesel generator to emergency and strictly required cases and maximize the use of the renewable energy for the domestic load power supply. Nevertheless, these components can be used in case of defaults in some components, or in case of non-availability of the renewable energies. Therefore, the battery bank and/ or the diesel generator takes part in generating the power needed to supply the domestic loads. Consequently, the proposed energy strategy allows guaranteeing the smart grid security operation and to supply an energy flow with the network settings including a protection system.

The proposed EMS is tested using measured data of climatic parameters of the target area (Medjez El Beb: Northern Tunisia, latitude: 36.39°, longitude: 9.6°), showing the efficiency of the proposed optimization method in minimizing the electricity generation cost, from the one hand, ensuring a safe operation for the system components, and providing the loads with the needed energy, from the other one.

Background

Hybrid renewable energy systems are becoming popular, especially for remote area, thanks to advances in renewable energy technologies. However, renewable energies, especially PV and wind energy are characterized by their intermittence, since they extremely depend on the climatic parameters, namely the solar radiation G, the ambient temperature T_a and the wind speed *V*. Therefore, the discontinuity in the power generation often involves reliability problems associated with their operation for micro-grid systems. This issue is more complicated, if several systems are interconnected between each other, as in the case of smart grids, for which this chapter concentrates. Thus, to face this issue, many research works focused in enhancing the renewable sources efficiency, such as establishing techniques for accurately predicting the powers generated, and reliably integrate them with other conventional sources, namely storing energy devices (Choubin et al., 2016; Mohanty et al., 2016). Other works, concentrated in extracting the maximum of power generated by these sources and enhancing the hybrid system components efficiency, by studying the design techniques, as it has been studied by Rezk et al., 2015 and Yahyaoui et al., 2016a.

Additionally, multi-objective algorithms have been proposed, in order to optimize the mix of the renewable system. In fact, these research works focused in maximizing their contributions to the peak load, while minimizing the combined intermittence, at a minimum cost, and minimizing the total greenhouse gas emissions of the system during its lifetime (Feng et al., 2016). For instance, some researchers applied the Particle Swarm Optimization (PSO) approach, to solve this issue (Chen et al., 2014). Indeed, they concluded that its performance is better than the conventional optimization techniques (Chen et al., 2014). Other researchers use the Genetic Algorithm (GA) to solve the economic environmental dispatching of a hybrid power system, including the wind and solar thermal energies throughout the useful life of the installation and the pollutant emissions (Carlucci et al., 2015). GA has also been mixed with the simplex, to optimize a hybrid system coupled to PV, a battery and a fuel cell for stand-alone street lighting systems, considering the monthly average solar irradiation and the wind speed data (Hamdy et al., 2016). The results obtained when designing a photovoltaic–wind–diesel system demonstrate the practical utility of the design method used.

Moreover, some other research works concentrate on optimization techniques which are based on the artificial intelligence tools, including the Artificial Neural Network (ANN) (Bhandari et al., 2015) and Fuzzy logic (Yahyaoui et al., 2014; Suganthi et al., 2015; Balaman et al., 2016). These techniques gave good results, since they hold the uncertain renewable energy supplies, load demands and the non-linear

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characteristics of some components that constitute the system. Further, some authors have dealt with determining the optimal combination of renewable energy technologies. Indeed, the renewable energy resources safe operation has been taken into account, in addition to the technology characterization, and economic parameters, namely the installation, maintenance and replacement costs. Moreover, some authors studied the optimum composition of hybrid systems, considering socio-demographic factors algorithm (Tito, S et al., 2016).

MAIN FOCUS OF THE CHAPTER

This research chapter focuses on the energy optimization of a typical hybrid plant used in smart grids systems. Indeed, the system is composed of PV panels, a wind turbine, a lead- acid battery bank, and a diesel generator, which are used to supply a variable domestic load. Hence, the present work proposes and details in depth an Energy Management Strategy (EMS), to optimize the powers generated by the power sources, maximize the renewable sources use and to minimize the use of the battery bank and the diesel generator. Moreover, the EMS aims to guarantee a safe operation of the system components and the continuity in the loads power supply. These objectives are performed by the minimization of a cost function, in which the power generation cost, the battery depth of discharge (dod) and the energetic balance are considered. This strategy is important for smart grids system security, since it can be used to supervise smart grids systems from both the energetic and the economic points of view.

Issues, Controversies, Problems

The energy management in hybrid systems faces two issues: first, the optimization strategy should take into account all the system components nonlinearities, from the one hand, and the loads power demand, from the other one. This includes the system components operation under uneven climatic parameters changes (namely the solar radiation, the wind speed, etc.). Additionally, the EMS is a multi-objective function, which includes energetic and economic objectives and criteria, in addition to taking into account a safe operation of the system elements. Since the proposed plant is the heart of smart grids systems, therefore, several issues and criteria interconnected are included in this proposed EMS (energetic and economic). Sure, to solve it, a powerful and reliable tool should be used. In this research chapter, the Genetic Algorithm (GA) is chosen, to perform the proposed strategy. The solution is tested for a typical hybrid plant, which can be then generalized for more sophisticated systems, namely the smart grids systems.

Numbered Lists

The following numbered lists are proposed, in such a way to describe in a coherent and comprehensive manner the topic proposed in this research chapter. Indeed, the chapter begins by describing the models of the system components. Then, the EMS adopted for the cost optimization of the hybrid plant is detailed. After that, the simulation results of the components models used and then the energy management algorithm are presented and explained in depth. Finally, the chapter ends by conclusions, in which the authors mention the impact of the proposed strategy for smart grids security systems. The numbered list is explained now:

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1. System Components Modelling
    a. Photovoltaic panels
    b. Incremental conductance for MPPT
    c. Battery bank
    d. Wind turbine
    e. Diesel generator
2. Energy Management Strategy (EMS)
    a. Investment cost
    b. Production cost
    c. Use cost
3. Application to a Case Study
    a. Results of the system components models
    b. Energy management strategy and interpretation
4. Conclusions
5. Acknowledgements
6. References

SOLUTIONS AND RECOMMENDATIONS

System Components Modelling

Photovoltaic Panels

The earth surface receives approximatively 1.79 10^8 kWh of solar energy, which is equivalent to a continuous power of 1.729 10^{17} W. however, 23% of this energy is reflected directly back into space, 29% is absorbed in the atmosphere and converted to heat radiated within the infrared spectrum. The remaining 48% of the energy is used to supply the hydrological cycles and photosynthesis (Yahyaoui, 2016c). Taking into account the alternations of day and night and cloudy periods, the peak power is estimated to be 1kW (Yahyaoui, c, 2016). The solar energy is converted to electricity using PV arrays. In the literature, several models have been studied to model the PV panels. Indeed, some models consider the two diodes model (Chin, et al., 2016). Other models characterize the PV panels by yield (Fernández et al., 2015; Steiner et al., 2015). In this research chapter, the photovoltaic panel is modelled using the one-diode non-linear model (Hasan et al., 2016). This model depends on the solar radiation *G (t)*, the ambient temperature $T_a(t)$ at the panel surface, and the panel parameters namely the number of photovoltaic cells connected in series, the short- circuit current and the open- circuit voltage at the reference temperature. The model evaluates the photovoltaic current $I_c(t)$ and power $P_{pv}(t)$. The adopted model is described by (1)-(6) (Hasan et al., 2016).

$$I_c = I_{ph}(t) - I_r(t)\left(\exp\left(\frac{V_c(t) + R_s I_c(t)}{V_{t_T_a}} \right) - 1 \right) - \frac{V_c(t) + R_s I_c(t)}{R_p} \quad (1)$$

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$$I_{ph}(t) = \frac{G(t)}{G_{ref}} I_{sc}(t) \tag{2}$$

$$I_{sc}(t) = I_{sc_T_{ref}} \left(1 + a\left(T_a(t) - T_{ref}\right)\right) \tag{3}$$

$$I_r(t) = I_{r_T_{ref}} \left(\frac{T_a(t)}{T_{ref}}\right)^{\frac{3}{n}} \exp\left(\frac{-qV_g}{nK_B}\left(\frac{1}{T_a(t)} - \frac{1}{T_{ref}}\right)\right) \tag{4}$$

$$I_{r_T_{ref}} = \frac{I_{sc_T_{ref}}}{\exp\left(\frac{qV_{c_T_{ref}}}{nK_B T_{ref}}\right) - 1} \tag{5}$$

where: $T_a(t)$: the ambient temperature at the panel surface (K),

$G(t)$: the solar radiance at the panel surface (W/m^2),
$I_c(t)$: the estimated photovoltaic cell current (A),
$I_{ph}(t)$: the generated photo-current at G (A),
$I_r(t)$: the reverse saturation current at T_a (A),
$V_c(t)$: the open circuit voltage of the photovoltaic cell (V),
R_s: the serial resistance of the photovoltaic module (Ω),
V_{t_Ta}: the thermal potential at the ambient temperature (V),
R_p: the parallel resistance of the photovoltaic module (Ω),
G_{ref}: the solar radiation at reference conditions (W/m^2),
$I_{sc}(t)$: the short circuit current for T_a (A),
$I_{sc_T_{ref}}$:the short circuit current per cell at the reference temperature T_{ref} (A),
a: the temperature coefficient for the short circuit current (K^{-1}),
$I_{r_T_{ref}}$: the reverse saturation current for T_{ref} (A),
n: the quality factor,
q: the electron charge (C),
V_g: the Gap energy (e.V),
K_B: the Boltzmann coefficient (J/K),
$V_{c_T_{ref}}$: the open circuit voltage per cell at T_{ref} (V).

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Hence, the photovoltaic power P_{pv} generated by the panel is then described by (Yahyaoui et al., 2014; Hasan et al., 2016; Yahyaoui et al., 2016b):

$$P_{pv}(t) = n_s n_p V_c(t)\left(I_{ph}(t) - I_r(t)\left(\exp\left(\frac{V_c(t) + R_s I_c(t)}{V_{t_T_a}} \right) - 1 \right) - \frac{V_c(t) + R_s I_c(t)}{R_p} \right) \quad (6)$$

where:

n_s : the number of serial photovoltaic cells,
n_p : the number of parallel photovoltaic modules.

Incremental Conductance for MPPT

Climatic parameters, namely the solar radiance and the ambient temperature, are intermittent; in such a way that they change continually during the day, which therefore affect the PV power generated by the PV arrays. Consequently, it is necessary to use techniques that track the maximum power point, called Maximum Power Point Tracking (MPPT) methods (Yahyaoui et al., 2016a). In this sense, several methods for MPPT have been studied in depth namely, the Perturb and Observe (Muthuramalingam et al., 2014), the Look up Table (Ozdemir et al., 2014), Fuzzy logic (Boukenoui, et al., 2016) and the incremental conductance methods for MPPT (Bizon, 2016). In fact, they all differ in complexity and tracking accuracy, but they require sensing the PV current and voltage, using the off-the–shelf hardware. Thanks to its good efficiency and reliability, in this research chapter, the incremental conductance algorithm for MPPT is used to track the MPP generated by the photovoltaic panels, and to generate the control signal for the boost converter (Bizon, 2016; Yahyaoui et al., 2016a) (Figure 2). In fact, this method consists in using the current ripple in the chopper output I_{pv}, to maximize the panel power P_{pv}, using the relation between the current and voltage continuously identified online (Bizon, 2016, Yahyaoui et al., 2016a). Indeed, the algorithm tests the actual conductance $-\frac{I_{pv}}{V_{pv}}$ and the incremental conductance $\frac{dI_{pv}}{dV_{pv}}$ as follows (Bizon, 2016; Yahyaoui et al., 2016a):

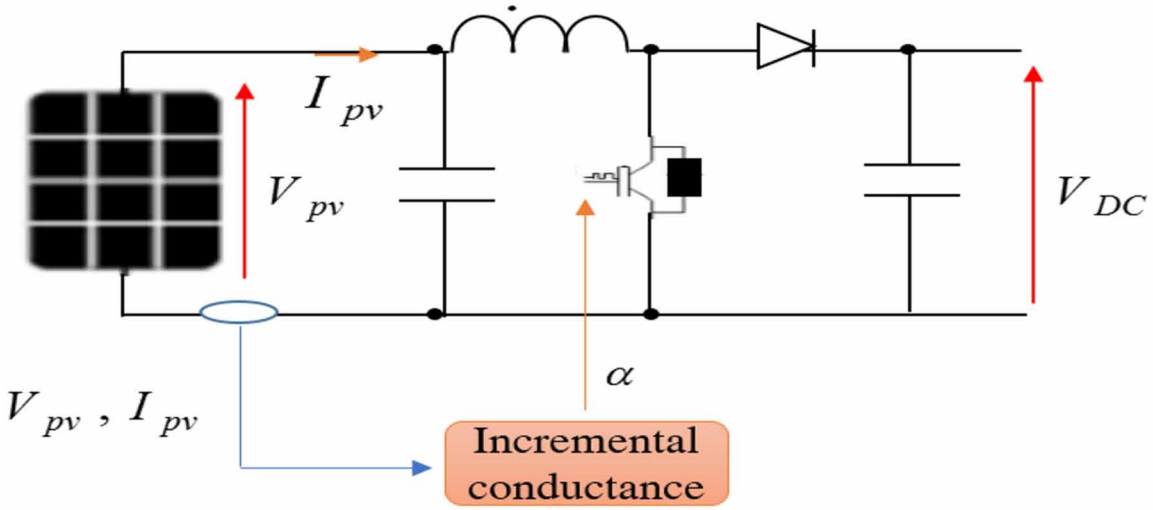
If $\frac{dI_{pv}}{dV_{pv}} \succ -\frac{I_{pv}}{V_{pv}}$, then the operating point is on the left of the MPP, so (7)

α is varied to increase V_{pv}.

If $\frac{dI_{pv}}{dV_{pv}} \prec -\frac{I_{pv}}{V_{pv}}$, then the operating point is on the right of the MPP, so (8)

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Figure 2. Scheme of the control principle of the DC- DC converter for MPPT



α is varied to decrease V_{pv}.

If $\frac{dI_{pv}}{dV_{pv}} \approx -\frac{I_{pv}}{V_{pv}}$, then the operating point is in the MPP, (9)

So, the value of α is maintained.

where dI_{pv} and dV_{pv} are the PV current and voltage variations, respectively.

Thus, the duty cycle α, used to generate the PWM signal for the DC- DC converter control, is calculated using (10) (Bizon, 2016; Yahyaoui et al., 2016a):

$$\frac{V_{DC}}{V_{pv}} = \frac{1}{1-\alpha} \tag{10}$$

Battery Bank

It is well known that renewable energy sources generate electrical energy intermittently. Therefore, the use of an energy storage device, in which the excess of the photovoltaic energy generated is stored, is necessary. This stored energy can be extracted when the power generated by the renewable energy sources is not sufficient to supply the load with power. Generally, batteries are used to save energy (Burgos et al., 2015; Yahyaoui et al., 2016). Lead-acid batteries are among the most common energy saving devices. A battery type is composed of positive and negative electrodes separated by an electrolyte. It is used to convert the chemical energy to electric energy thanks to oxidoreduction reactions (Burgos et al., 2015; Yahyaoui, 2016c). Some researchers developed models for the battery character-

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istics, to describe the battery State Of Charge (SOC) or its depth of discharge (dod). In this sense, linear modeling methods, namely the Coulometric, the open-circuit voltage method, and the non-linear dynamic modeling method have been developed (Burgos et al., 2015; Yahyaoui, 2016c). In this research chapter, a non-linear model for the lead- acid battery is used to model the battery bank behavior (Yahyaoui et al., 2016b). In addition to its simplicity, both the battery current and voltage are used to describe preciously the battery bank's behavior during charging and discharging. Its performance is evaluated by the depth of discharge dod. To evaluate it, the stored charge in the battery C_R is first determined by (Yahyaoui et al., 2014):

$$C_{R(k)} = C_{R(k-1)} + \frac{\partial k}{3600} I_{bat_{(k)}}{}^{k_p} \tag{11}$$

where ∂k is the time between instant k-1 and k and k_p is the Peukert coefficient.

Hence, the depth of discharge dod is given by (Yahyaoui et al., 2016b):

$$dod_{(k)} = 1 - \frac{C_{R_{(k)}}}{C_p} \tag{12}$$

where C_p is the Peukert capacity, considered constant (A.h).

Wind Turbine

Wind is a physical phenomenon in the nature. As it knows; it is the result of the differential pressure between warm and cool areas in the atmosphere that produces the constantly movements of the air masses (Krishnamoorthy et al., 2014; Lanzafame et al., 2014; Yahyaoui, 2016c). The electricity generated from wind is created by a turbine that converts a portion of the kinetic energy from the wind into a mechanical energy, which is available on a generator shaft (Lanzafame et al., 2014; Yahyaoui, 2016c). This mechanical energy runs the wind turbine and thus, allows electric energy to be generated (Yahyaoui, 2016c). World wind energy resources are substantial, and in many areas, such as the USA and Northern Europe, could in theory supply all of the electricity demands. However, the intermittent character of the wind resources and the necessity of long distances for energy transmission are considered the main disadvantages of the wind energy (Krishnamoorthy et al., 2014; Yahyaoui, 2016c). The wind turbine creates a wind energy deficit between the wind leaving the turbine (known as wake) and the wind arriving in front of the turbine. Hence, a reduction of power output is produced at downwind turbines (Krishnamoorthy et al., 2014; Lanzafame et al., 2014). In this research chapter, the wind turbine power P_W is modelled by a non- linear expression, which essentially depends on the wind speed v and the blades' pitch angle β, as it is described now (Krishnamoorthy et al., 2014; Lanzafame et al., 2014):

$$P_W = \frac{1}{2} \rho A C_p(\lambda_1) v^3 \tag{13}$$

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where ρ is the air density (kg. m^{-3}), A is the surface of the
Turbine blades (m^2) and C_p is the power coefficient (Lanzafame et al., 2014):

$$C_p\left(\lambda_1\right)=0.5176\left(\frac{116}{\lambda_i}-0.4\beta-5\right)e^{\frac{-21}{\lambda_i}}+0.0068\lambda_1 \tag{14}$$

$$\frac{1}{\lambda_i}=\frac{1}{\lambda_1+0.08\beta}-\frac{0.035}{\beta^3+1} \tag{15}$$

and:

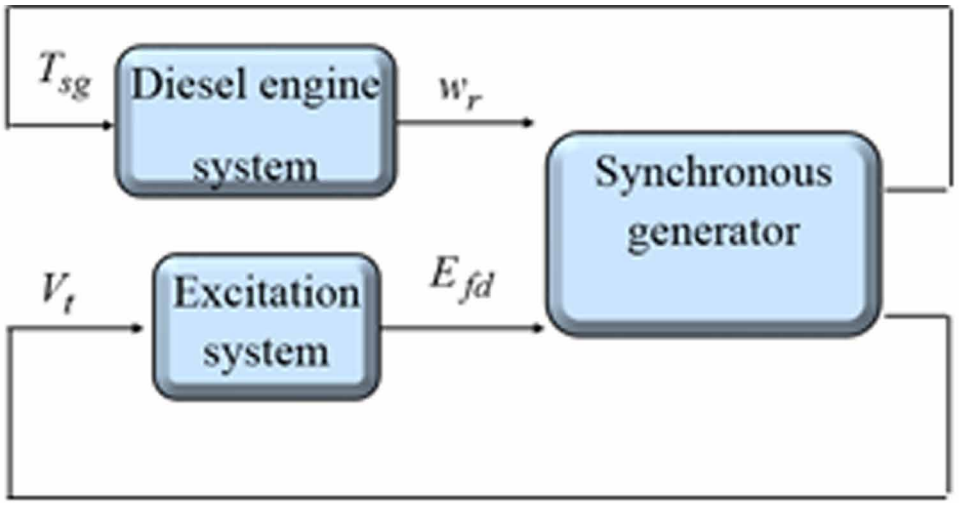
$$\lambda_1=\frac{\Omega R}{v} \tag{16}$$

where: R is the helix radius (m) and Ω is the angular mechanic speed (rad. s^{-1}).

Diesel Generator

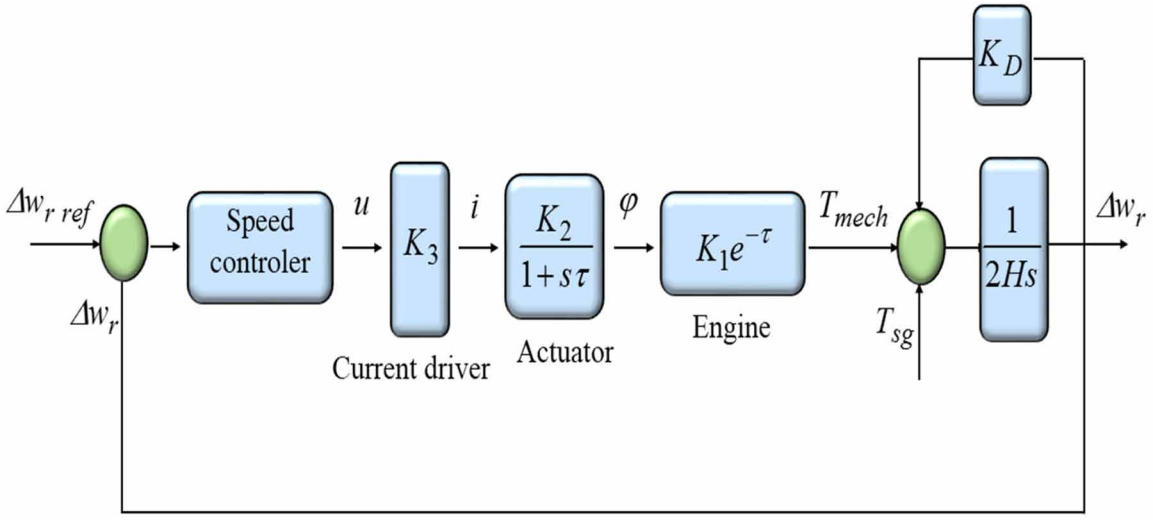
Typical diesel generator is composed of three main components, which are the diesel engine, the synchronous generator and the excitation system (Figure 3) (Salazar et al., 2015; Yahyaoui et al., 2016d). In fact, the first component (the diesel engine) is composed of the current driver, the actuator, the engine and the flywheel, as it is described in Figure 4 (Salazar et al., 2015; Yahyaoui et al., 2016d). Indeed, the current driver, which is presented by a constant K_3, converts the fuel flow into a mechanical torque.

Figure 3. Block diagram of the diesel generator



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Figure 4. Block diagram of the diesel engine



Moreover, the speed of the engine is controlled by the actuator, which relates the fuel intake. Therefore, the fuel rack position depends on the input current, which determines the fuel amount φ, injected into the combustion chamber (Graciano et al., 2015, Yahyaoui et al., 2016d). The third element of the diesel engine consists of the combustion system, which is designed by the Engine block in Figure 4 (Graciano et al., 2015; Salazar et al., 2015). Consequently, the movement of the piston during the power strokes produces the crankshaft drive and the mechanical torque T_{mech}, which is generated by the injection of the fuel ignited by the compressed hot air in the combustion chamber. Finally, the flywheel comprises the engine inertia dynamics, the damping factor (K_D) and the loaded alternator.

The rotor angular velocity w_r and the mechanical torque T_{mech} relation is given by (Salazar et al., 2015):

$$2H\frac{d\Delta w_r}{dt} = T_{mech} - T_{sg} - K_D \Delta w_r \tag{17}$$

$$\frac{d\delta}{dt} = w_0 \Delta w_r \tag{18}$$

$$\Delta w_r = w_r - 1 \tag{19}$$

where the time *t* is in seconds (s), the rotor angle δ is in radian, the rated generator speed w_0 is in rad/s, Δw_r is the speed deviation (pu), w_r is the rotor angular velocity (pu), T_{sg} is the generator torque (pu) and *H* is the inertia constant.

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Using the Park transformation, the synchronous generator is modeled as follows (Salazar et al., 2015):

$$V_d = E^{''}_d - R^{'}_s I_d + X^{''}_q I_q \tag{20}$$

$$V_q = E^{''}_q - R^{'}_s I_q - X^{''}_d I_d \tag{21}$$

where $R^{'}_s$ is the armature resistance, I_q and I_d are the currents flowing in the stator windings, the $X^{''}_{d,q}$ are the so-called subs transient d and q-axis reactance and $E^{''}_{d,q}$ are given by:

$$E^{''}_d = \frac{\left(X_q - X^{''}_q\right)}{1+\tau^{''}_{q0} s} I_q \tag{22}$$

$$E^{''}_q = \frac{1}{1+\tau^{''}_{d0} s} E^{'}_q - \frac{\left(X^{'}_d - X^{''}_d\right)}{1+\tau^{''}_{d0} s} I_d \tag{23}$$

where:

$X_{d,q}$ and $X^{'}_{d,q}$: the synchronous and transient reactances,
$\tau^{''}_{d,q0}$: the open circuit sub transient time constants,

and $E^{'}_q$ is given by:

$$E^{'}_q = \frac{1}{\left(\frac{X_d - X^{''}_d}{X^{'}_d - X^{''}_d}\right) + \tau^{'}_{d0} s} E_{fd} + \frac{\left(\frac{X_d - X^{'}_d}{X^{'}_d - X^{''}_d}\right)}{\left(\frac{X_d - X^{''}_d}{X^{'}_d - X^{''}_d}\right) + \tau^{'}_{d0} s} E^{''}_q \tag{24}$$

where: E_{fd} is the exciter field voltage and $\tau^{'}_{d0}$ is the open circuit transient time constant.

The excitation block supplies and automatically adjusts the field current of the synchronous generator, by applying control and protective functions required to the satisfactory performance of the system (Salazar et al., 2015; Yahyaoui, 2016c).

Energy Management Strategy

Since the hybrid system is composed of several non –linear components that supply a variable domestic load, then it is necessary to use an Energy Management Strategy (EMS) that controls the energy flow

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between the power sources and the load. Thus, in this research chapter, the aim of the EMS is to optimize the operational costs of the hybrid installation, guarantee the loads' power supply and ensure a safe operation for the lead- acid battery bank, using the powers P_{pv}, P_w, P_{bat} and P_G, generated by the photovoltaic panels, the wind turbine, the battery bank and the diesel engine, respectively, the power consumed by the variable domestic loads P_L, from the one hand, and the installation operation cost, from the other one, as it is described in Figure 5.

In fact, the EMS consists in evaluating, at each sample time, the optimum power sources combination that minimizes the cost of the power production, as it is explained in Figure 6. Indeed, since the system is composed of five components, then it can be modeled by fives power sources, as it is described by equation (25):

Figure 5. Synoptic scheme of the proposed approach

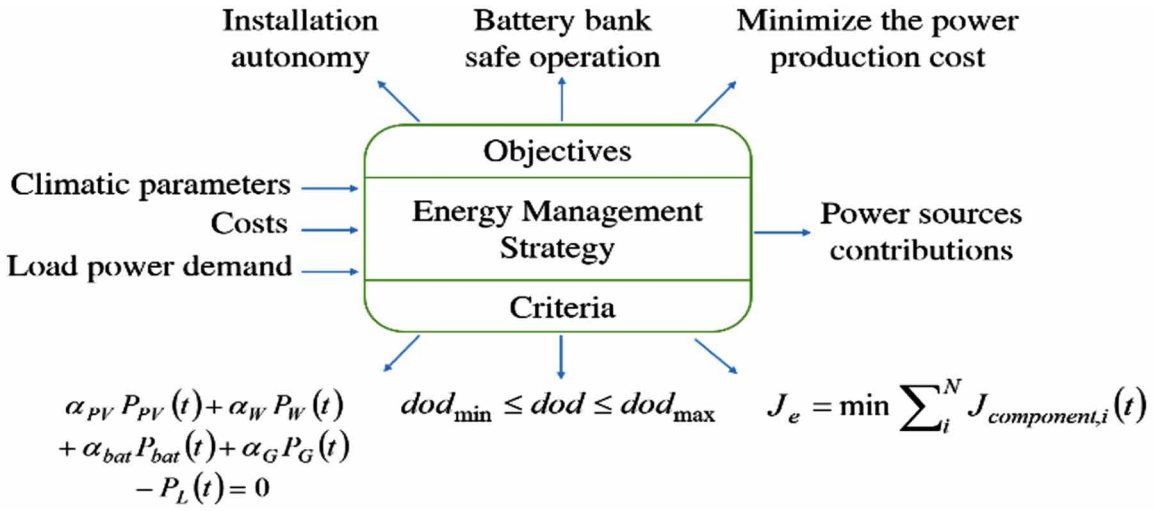
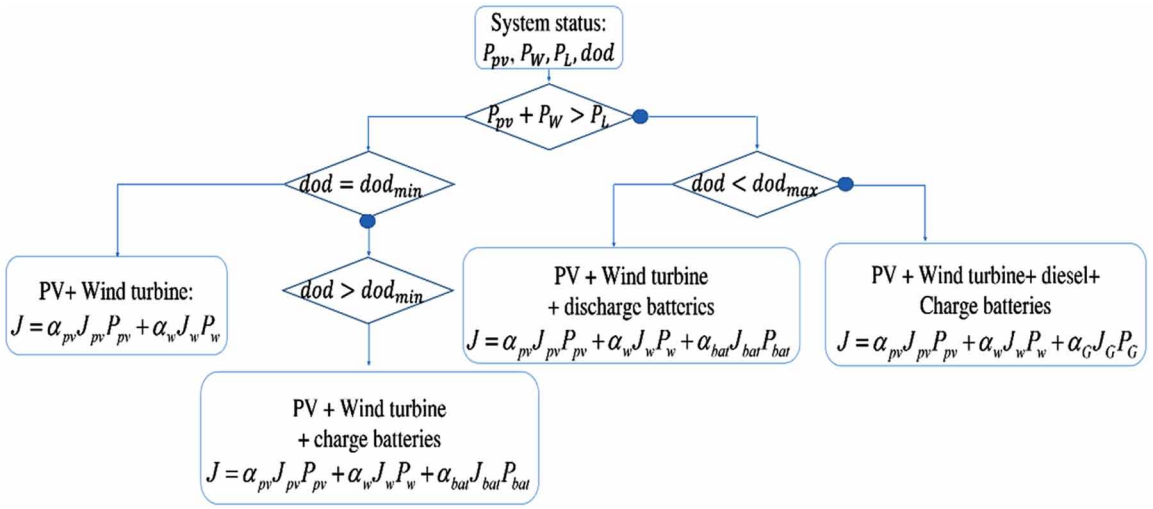


Figure 6. Energy management strategy principle



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$$V(t)=\begin{bmatrix} v_1(t) \\ v_2(t) \\ v_3(t) \\ v_4(t) \\ v_5(t) \end{bmatrix}=\begin{bmatrix} P_{PV}(t) \\ P_W(t) \\ P_{bat}(t) \\ P_G(t) \\ P_L(t) \end{bmatrix} \tag{25}$$

Thus, for each sample time, the state vector $\alpha(t)$ describes the contribution of each power source for supplying the domestic load with power, as it is given by equation (26):

$$\alpha(t)=\begin{bmatrix} \alpha_{PV}(t) \\ \alpha_W(t) \\ \alpha_{bat}(t) \\ \alpha_G(t) \end{bmatrix} \tag{26}$$

Hence, during the optimization, the power sources provide to the loads the needed power, which must fulfill the following condition (equation (27)), which ensure the continuity of the power supply of the domestic load:

$$\alpha_{PV}P_{PV}(t)+\alpha_W P_W(t)+\alpha_{bat}P_{bat}(t)+\alpha_G P_G(t)-P_L(t)=0 \tag{27}$$

where:

α_{PV}, α_W, α_{bat}, and α_G are the power contribution of the PV panel, the wind turbine, the battery bank and the diesel generator, respectively, to supply the load.

Therefore, for an installation composed of *N* components, the objective function to be minimized is defined as the absolute minimum of the total micro grid cost, as it is described by equation (28). The minimization of this function allows then providing the load by the needed power, while maintaining a safe operation of the system elements. In the present research chapter, this cost function is minimized using the Genetic Algorithm tool (GA), since it as good performance and easy in application (Sakellaridis et al., 2015).

$$J_e=\min\sum_i^N J_{component,i}(t) \tag{28}$$

The EMS objective evaluates and minimizes the objective function $J(t)$ for 20 years of the system operation. Thus, it must include the investment, the production and the use costs, $J_I(t)$, $J_P(t)$ and $J_U(t)$, respectively, during this period. It is described by equation (29) (Sakellaridis et al., 2015):

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$$J_{component}(t) = J_I(t) + J_P(t) + J_U(t) \tag{29}$$

These costs are detailed now in depth.

Investment Cost

The investment cost $J_I(t)$ describes the cost of the maximum power $P_{PV}, P_W, P_{conv}, P_{bat}$ provided by its system's components. This cost includes the buying and implementation costs, J_{Ic} and J_{Ie}, respectively:

$$J_I(t) = J_{Ic} + \frac{1}{8760} J_{Ie} t \tag{30}$$

where J_{Ie} is evaluated during N_a amortization years (20 years in this research work), characterized by its maximum energetic capacity, $P_{\max}$, which is described by equation (31) (Sakellaridis et al., 2015):

$$J_{Ie}(t) = \frac{1}{(1+\xi)^{N_a} - 1} \left[J(P_{\max}) - J_{Ic} \right] \xi (1+\xi)^{N_a} \tag{31}$$

where ξ is the annual interest rate.

Production Cost

The production cost $X_P(t)$ depends on the power generated by a power source $X_P(t)$ of the hybrid system elements and its maximum $X_{P\max}$ at instant *t*. It is given by the equation (32) as follows:

$$J_P(t) = \sum_0^t \alpha_P \left[X_{P_{\max}}, sign\left(X_P(\tau)\right), t \right] X_P(\tau) \Delta\tau \tag{32}$$

where α_P is the per unit element energetic cost (€ kWh).

a. Use cost

The use cost $J_u(t)$ includes the annual up keeping and maintenance costs, $J_u(t)$ and $J_M(t)$, respectively. Indeed, the maintenance cost describes the usury and the maximum installation production $P_{\max}$, and it is given by equation (33) (Sakellaridis et al., 2015):

$$J_U(t) = \frac{\beta_a(P_{\max})}{8760} t + \sum_0^t \gamma_a \left| X_E(\tau) \right| \Delta\tau \tag{33}$$

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where:

β_a : the annual mean cost up keeping coefficient,
γ_a : the mean usury cost.

Consequently, the total cost $J_{PV}(t)$ that corresponds to the photovoltaic panel is expressed by (Sakellaridis et al., 2015):

$$J_{PV}(t) = J_{I_{PV}}\left(P_{P_{PV}}, t, N_a, \delta_a\right) + \frac{\beta_{PV} P_{P_{pv}}}{8760} t \tag{34}$$

The total cost $J_W(t)$ for the wind turbine is given by equation (35) as follows:

$$J_W(t) = J_{I_W}\left(P_{P_W}, t, N_a, \delta_a\right) + \frac{\beta_W P_{P_W}}{8760} t + \sum_0^t \gamma_W\left(P_{P_W}\right) P_W(\tau)\Delta\tau \tag{35}$$

While the total cost $J_{bat}(t)$ that corresponds to the battery bank is expressed by equation (36):

$$J_{bat}(t) = J_{I_{bat}}\left(P_{P_{bat}}, t, N_a, \delta_a\right) + \frac{\beta_{bat} P_{P_{bat}}}{8760} t + \sum_0^t \gamma_{bat}\left|P_{P_{bat}}(\tau)\right|\Delta\tau \tag{36}$$

The cost related to the inverter is given by equation (37):

$$J_{conv}(t) = J_{I_{conv}}\left(P_{P_{conv}}, t, N_a, \xi\right) \tag{37}$$

Therefore, the total cost function J includes the operation, maintenance, fuel and replacement costs, and it is given by equation (38), as follows (Sakellaridis et al., 2015; Yahyaoui et al., 2016d):

$$\begin{aligned} J(t) = {} & J_{I_{PV}}\left(P_{P_{PV}}, t, N_a, \delta_a\right) + J_{I_W}\left(P_{P_W}, t, N_a, \delta_a\right) + J_{I_{bat}}\left(P_{P_{bat}}, t, N_a, \delta_a\right) + J_{I_{conv}}\left(P_{P_{conv}}, t, N_a, \delta_a\right) \\ & + \frac{t}{8760}\left[\beta_W P_{P_W} + \beta_{PV} P_{P_{PV}} + \beta_{P_{bat}} P_{P_{bat}}\right] + \sum_0^t \gamma_W P_{P_W} P_W(\tau)\Delta\tau + \sum_0^t \gamma_{bat}\left|P_{bat}(\tau)\right|\Delta\tau \end{aligned} \tag{38}$$

The EMS used to minimize the cost C_{glob} of the hybrid plant composed of the PV panels, the wind turbine, the battery bank and the diesel generator, perform the optimization over a fixed duration T_f, taking into account the following constraints expressed by equation (39) (Figure 6):

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$$\begin{cases} P_L(t) & = \alpha_{PV} P_{PV}(t) + \alpha_W P_W(t) + \alpha_{bat} P_{bat}(t) + \alpha_G P_G(t) \\ dod_{\min} \le dod(t) \le dod_{\max} \end{cases} \quad (39)$$
$$\forall t \in \left[0, T_f\right]$$

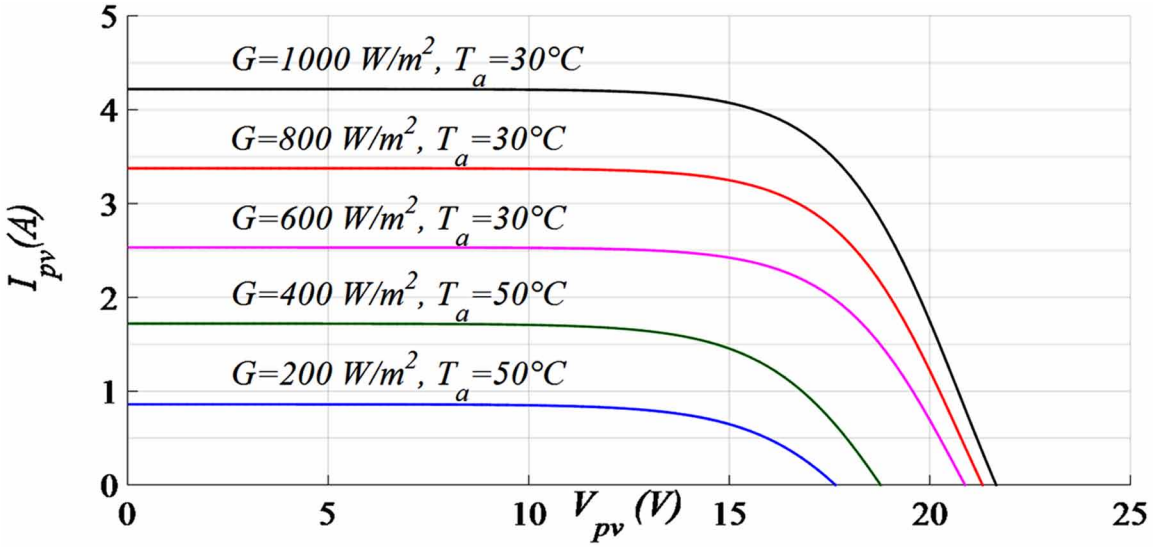
In fact, the management strategy consists in maximizing the use of the renewable energy sources (the PV panels and the wind turbine) (Figure 6). If excess of renewable energy is generated, then the excess is saved in the battery bank in case it is discharged. When the renewable energy generated is not sufficient to supply the load, thus if the battery is charged, then it participates in supplying the domestic loads with power, otherwise, the diesel generator is switched on and it complete the missing power. This is described by Figure 6.

Application to a Case Study

Results of the System Components Models

The models of the system components are first tested using measured data of the solar radiation *G*, the ambient temperature T_a and the wind speed *V*, that correspond to a sunny day of the target site (Northern Tunisia, latitude: 36.39°, longitude: 9.6°). The simulation results of the photovoltaic panels, the wind turbine and the diesel engine models are given in Figure 7 to Figure 11 respectively. Figure 7 shows that the variation of the solar radiation *G* affects significantly the PV current generated. Similarly, the wind turbine power increases when the wind speed increases, as it is shown it Figure 8 and 9.

Figure 7. Photovoltaic module generation variation following the solar radiation and the ambient temperature changes



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Figure 8. Wind power coefficient variation following the pitch angle

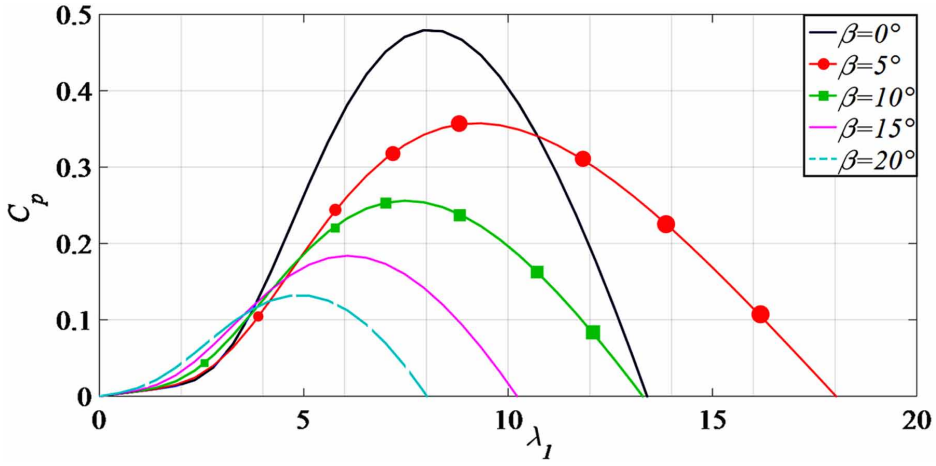


Figure 9. Wind power variation following the wind speed

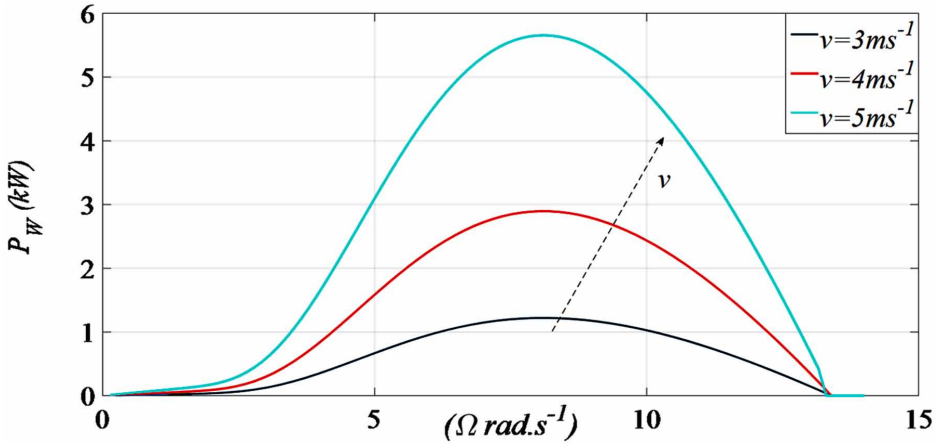
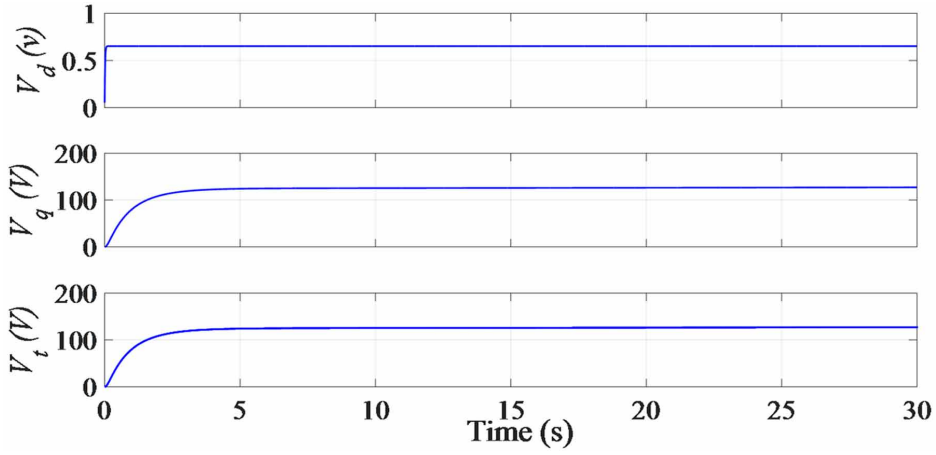
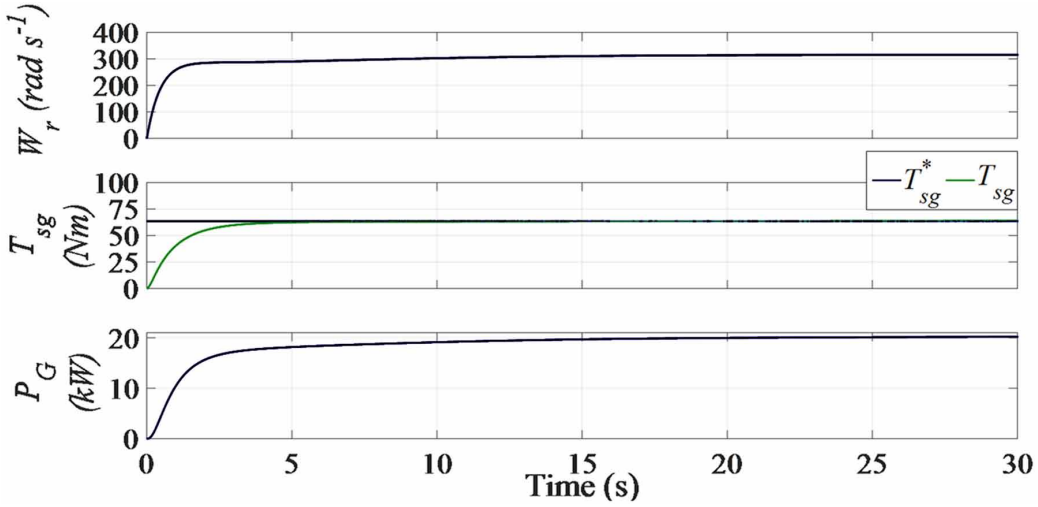


Figure 10. Stator terminal voltage of the diesel engine



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Figure 11. Power, torque and rotor angular velocity of the diesel engine

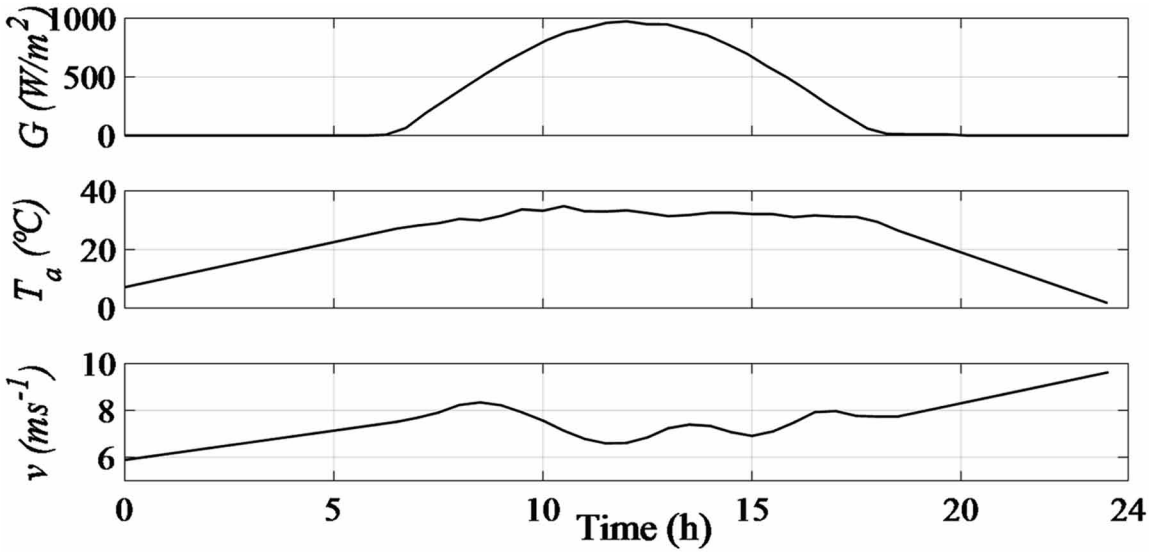


Energy Management Strategy and Interpretation

The algorithm is tested by simulation using the climatic parameters data, which are the solar radiation *G*, the ambient temperature T_a and the wind speed *V* of the target area (Northern Tunisia, latitude: 36.39°, longitude: 9.6°). The powers P_{pv} and P_W generated respectively by the PV panels and the wind turbine, that corresponds to the climatic parameters are presented in Figure 12 and Figure 13.

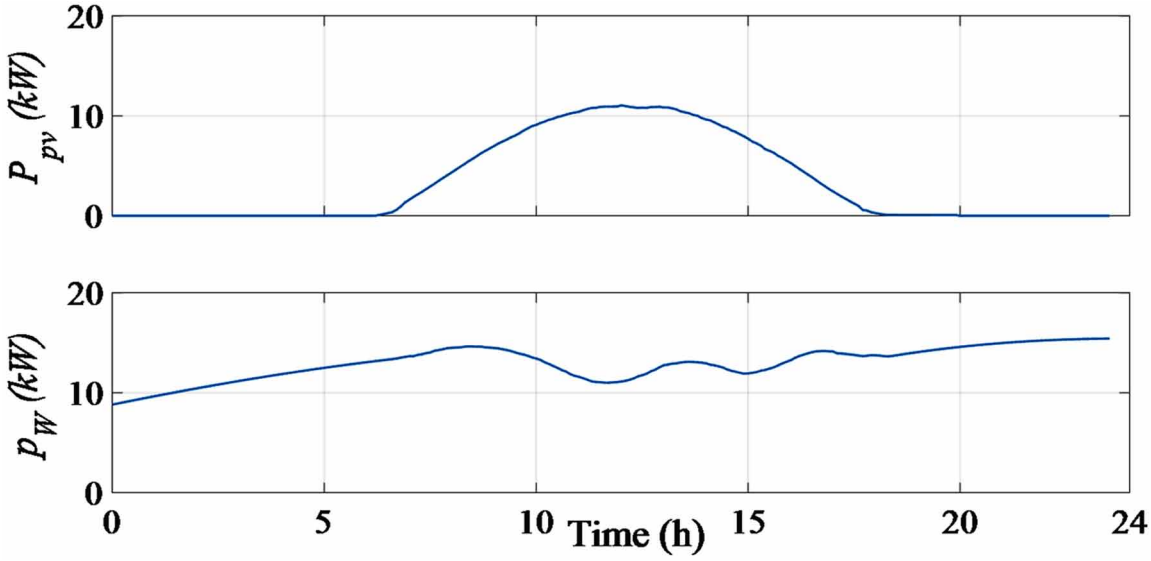
The EMS is tested by simulation using Matlab- Simulink. The obtained results show that the algorithm always ensures the load power supply, a safe operation of the battery bank and the minimization of the

Figure 12. Climatic parameters of a sunny day



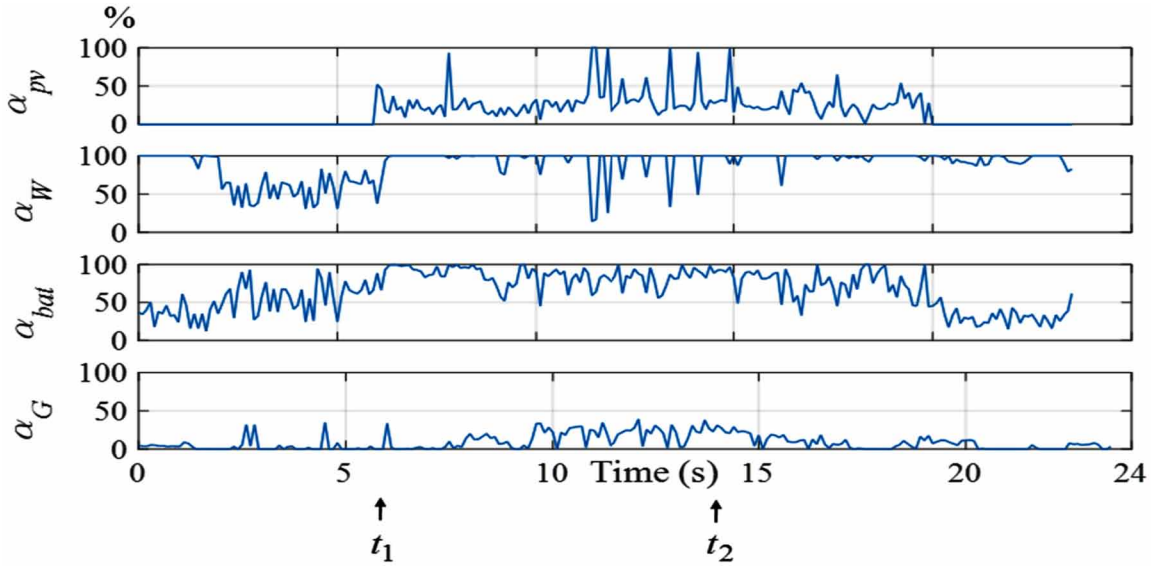
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Figure 13. Generated powers from renewable sources



genset use. In fact, Figure 14 shows that during the night, the wind turbine and the battery bank supply the load with power, since the wind turbine generates insufficient power to the domestic load power supply and the battery bank is charged. This is presented by the EMS response at t_1. Then, when the PV panels start generating the PV power, the renewable power source and the battery bank, together supply the load with the needed electrical power. Figure 14 also shows that, when this generated power is insufficient for the domestic load power supply, therefore the diesel generator is switched on and all the components participate to supply the load, as it is shown at the EMS response at t_1.

Figure 14. Power sources contributions to the load power supply



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In addition, it is clear that the battery depth of discharge (dod) is always maintained between the maximum and minimum limits (0.02 and 0.8). Thus, this allows the battery bank to be protected against charges excess and deep discharges, and the excess of the renewable energy generated to be stored and then used to supply the domestic loads when it is needed.

Consequently, using an appropriate EMS applied to the GA, it has been demonstrated the efficiency and the reliability of the EMS proposed in maintaining the domestic loads supplied continually, with taking into account of criteria related to the system components safe operation. Moreover, the EMS al-

Figure 15. EMS objectives fulfillment: batteries safe operation and loads power supply

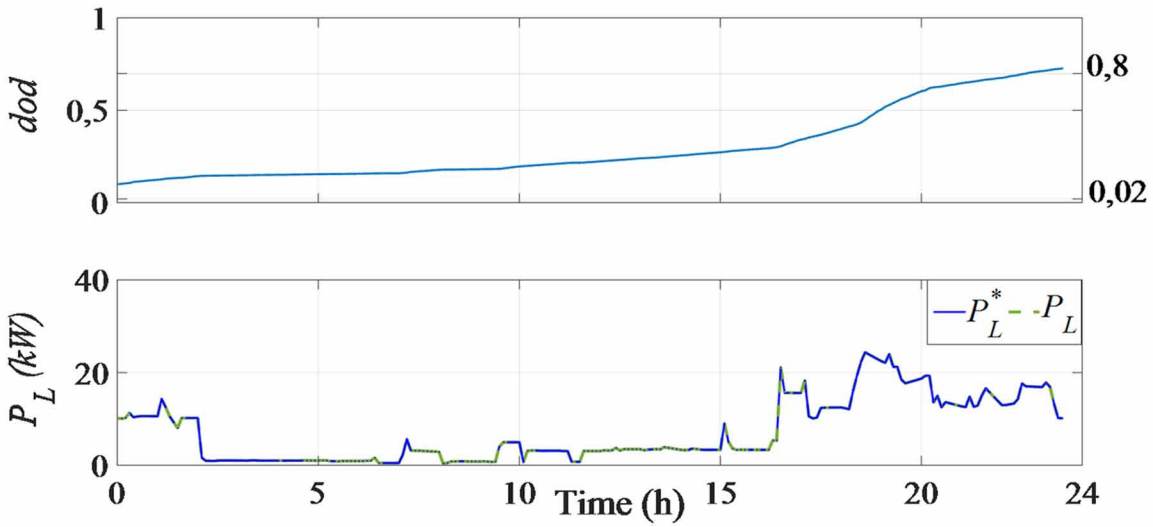
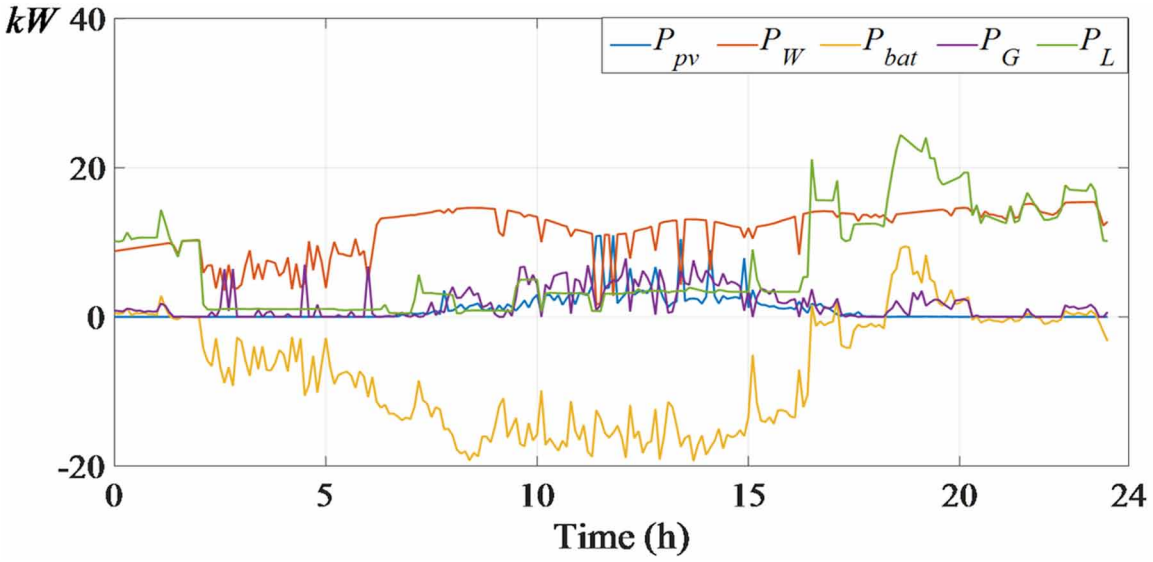


Figure 16. Contribution of each power source for the loads power supply



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Table 1. Explanation of the used symbols and their definitions

Symbol	Definition	Symbol	Definition
a	Temperature coefficient for the short circuit current (K^{-1})	R_p	Parallel resistance of the photovoltaic module (Ω)
A	Wind turbine blades (m^2)	R_s	Serial resistance of the photovoltaic module (Ω)
C_p	Peukert capacity (A.h)	R'_s	Armature resistance (Ω)
C_R	Stored charge in the battery bank (A. h)	S_1, S_2	Inverter control signals
E_{fd}	Exciter field voltage (V)	T_{sg}	Diesel generator torque (pu)
$\frac{dI_{pv}}{dV_{pv}}$	Incremental conductance (1/Ω)	V_{dq}	Direct and quadratic voltage, respectively (V)
G	Solar radiation (W/m^2)	$V_c(t)$	Open circuit voltage of the photovoltaic cell (V),
G_{ref}	Solar radiation at reference conditions (W/m^2)	V_{t_Ta}	Thermal potential at the ambient temperature (V)
H	inertia constant	V_g	Gap energy (e.V)
I_{bat}	Battery current (A)	V_r	Modulation wave amplitude (V)
$I_c(t)$	Estimated photovoltaic cell current (A)	$V_{c_T_{ref}}$	Open circuit voltage per cell at T_{ref} (V)
I_{dq}	Direct and quadratic currents, respectively (A)	α	Chopper duty cycle
		V_c	Carrier wave amplitude (V)
$I_{ph}(t)$	generated photo-current at G (A)	VOC	Voltage Oriented Control
$I_r(t)$	Reverse saturation current at T_a (A)	$X_{d,q}, X'_{d,q}$	Synchronous and transient reactances
$I_{sc}(t)$	Short circuit current for T_a (A)	ζ	Damping ratio
$I_{sc_T_{ref}}$	Short circuit current per cell at the reference temperature T_{ref} (A)	w_n	Natural frequency (Hz)
$I_{r_T_{ref}}$	Reverse saturation current for T_{ref} (A)	w_r	Rotor angular velocity (pu)

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Table 1. Continued

Symbol	Definition	Symbol	Definition
$-\frac{I_{pv}}{V_{pv}}$	Actual conductance (1/Ω)	β	Pitch angle (°)
K_B	Boltzmann coefficient (J/K)	ρ	Air density (kg. m^{-3}),
MPPT	Maximum Power Point Tracking	Ω	Angular mechanic speed (rad. s^{-1})
n_p	Number of parallel photovoltaic modules	φ	Fuel amount (m^3)
P	Active power (W)	δ	Rotor angle (radian)
P_W	Wind power (W)	Δw_r	Speed deviation (pu)
P_{pv}	Photovoltaic power (W)	τ'_{d0}	Open circuit transient time constant
Q	Reactive power (VAR)	$\tau''_{d,q0}$	Open circuit sub transient time constants
Q	Electron charge (C)	$\alpha_{PV}, \alpha_W, \alpha_{bat}, \alpha_G$	Sources contribution in the load supply
R	Helix radius (m)		

lows maximizing the use of the renewable energies and minimizing the use of the battery bank and the diesel generator. Consequently, this affects the system cost operation studied for twenty years.

FUTURE RESEARCH DIRECTIONS

Following the developed work in this chapter, it has been proved the efficiency and the reliability of the EMS in fulfilling the energetic and economic objectives planned for the hybrid installation destined to supply a variable domestic load. This approach can be applied for other applications, including grid connected systems (hybrid or renewable). Moreover, this work can be also performed using other optimization methods and tools, namely the Artificial Neural Network, the Fuzzy logic, etc. Consequently, in the future, the present work can be extended and applied to several applications, since it is simple, easy to develop and practical.

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CONCLUSION

An Energy Management Strategy that consists in minimizing a cost function of a hybrid system is proposed and tested. The system supplies a variable domestic load via the contribution of the micro-grid elements, which is composed of photovoltaic panels, a wind turbine, a battery bank and a genset. The EMS allows providing the domestic load with the power in demand and ensures a safe operation for the battery bank. The EMS minimizes a cost function that takes into account of the operation, maintenance and production costs during twenty years of operation. The EMS efficiency is tested by simulation and gives good results. The reliability of the studied EMS is important and encouraging, since it can be applied in real–time to more sophisticated systems that are constituted of various interconnected micro-grids, as it is the case of smart grids systems. Moreover, this strategy showed its efficiency, since it has been tested using measured data. Thus, it is powerful and reliable, especially in cases of non-availability of sufficient renewable energy to supply the loads with the needed power. Consequently, this approach contributes to the security of micro-grids and hence, for the smart grids too.

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Chapter 16
Developing Sustainable Processes Through Knowledge Management

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ABSTRACT

Sustainable development of a process depends on a harmonious association of three sustainable pillars: Economy, Society, and Environment. Yet, in case of DMAIC (Define-Measure-Analyze-Improve-Control) process, the combination is challenged by inefficient management of knowledge resource in the process. The potential economy resource is not preserved and renewed, and therefore influents on sustainability of the process. In this article, the authors present and discuss sustainable aspects of a knowledge management model for DMAIC in which knowledge resource is accumulated and reused efficiently. In particular, the key concepts of sustainable development are reviewed, a process of knowledge management based on Ontology Engineering is presented, and sustainable criterial and measures for the proposed model are applied. The authors find that preserving and renewing knowledge is an indispensable process of sustainable development of DMAIC process.

INTRODUCTION

Sustainable Aspects in Product Development

In 1987, the term of "Sustainable Development" is used to refer a long-term development, and stated in a Brundtland report titled "Our Common Future" that: "Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). This conception is useful for organizations and society in order to aim at a sustainable development. Sustainable development is represented as a deep transformation about how

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to utilize natural resources, choose investment criterions, propose advanced technologies applied, and change administrative mechanism that accord with current and future needs (Harris, 2000).

However, notion of Sustainable development is very neutral (Hallstedt S., 2008). It needs to be concretized into principles or measures for business and society. It is recognized that three essential factors impacting on sustainable development are Economy, Environment, and Society (Harris, 2000) (Aparna & Keren, 2007). Basing on the factors, several sustainable measures and criteria have been presented in literature. Ritzen Rofia proposes five proactive measures for integrating environmental aspects into product development. (Ritzen, 2000). Ansari *el at* have mentioned seven sustainable measures for knowledge management (Ansari, Holland, & Fathi, 2010). Harris have pointed out principles for sustainable development in the three essential aspects or pillars.

In particular, goods and services need to be continuously developed without damaging agricultural or industrial production. A resource base need to be retained stably by preventing over-exploitation of renewable resource system and eliminating non-renewable resource. Biodiversity, stability of atmospheric, and other ecosystem function must be maintained. Social equity, adequate provision of social services, gender equity, and political accountability and participation must be assured. More importantly, a harmonious combination of sustainable aspects of development would guide products towards a greener, clearer and more equitable growth (Bleischwitz, Giljum, Kuhndt, & Schmidt-Bleek, 2009), (Roblek, Meško, Bach, & Bertoncelj, 2014) (Wu & Hans-Dietrich, 2013). However, the combination (or a balance) is one of primary challenges for product designers.

To be honest, a product such as a physical artefact, software, service, process, or combination of these (Hallstedt S., 2008) has positive and negative impacts on environment and society during its life-cycle through the activities such as energy or material consumption for production and delivery, emission to land, water or air, resource exploitation, and use and elimination of products (Ritzen, 2000). Yet, in order to gain economic benefits, the conventional approach of product designers is only to meet preference of customers based on functions, efficiency, and aesthetic elements of products. Supplementing new elements such as environmental requirements may complicate designing processes and increase producing and management costs. Hence, the designers become embarrassed with considering the sustainable aspect of environment (such as resource usage) in the process of designing their products (Nambiar, 2010).

Besides, not all types of resource are exploited and managed effectively. Knowledge is one of typical examples. Although knowledge is a type of resource that plays a vital role in creating organizational value and competitive advantage (Wu & Hans-Dietrich, 2013), it is difficult to verify a process or identify or methods that assure the capture and reuse of that knowledge (Hallstedt, Anthony, & Pia, 2013). With quality improvement processes such as DMAIC, the problem can affect negatively its sustainable development.

Environmental Sustainability of DMAIC Process

In Six Sigma system, DMAIC (Define-Measure-Analysis-Improve-Control) (Park, 2003) is a problem-solving process. Its ultimate aim is to produce 99.9996% defect-free products, in order to improve business profits, and business excellence (Yang, 2005), (Pande, Neuman, & Cavanagh, 2000). DMAIC deployment creates a favourable environment for managers, working teams, suppliers and customers to communicate, discuss, and propose ideas and insights with each other (Wu & Chinho, 2009). Consequence, new knowledge can be created in discussions such as gate review sections (Stevens, 2006) (Kifor & Baral, 2013) and improvement solutions (Zou & Lee, 2010).

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In order to reach comprehensive development of individuals and economy (Sztangret, 2016) and environmentally sustainable development (Ritzen, 2000), the potential economy resource need to be renewed and reused. However, the knowledge resource is often easy to be lost or difficult to access (Stevens, 2006). While implicit knowledge is often resident in minds or brain of individuals that is difficult to be queried again after DMAIC execution, explicit knowledge is documented into text-based document and reports that may be permanently secreted in filing cabinets. Therefore, the potential resource of economy which is considered as the key for sustainable competitive advantage (Roblek, Meško, Bach, & Bertoncelj, 2014) meets challenges. It is not reused and renewed efficiently. In order words, sustainability of DMAIC process should be improved.

One of the intelligent choices for sustainable development of products is to apply technology systems into monitoring continuously resource usage of products (Nambiar, 2010), (Nagel, M.H., & Tomiyama, 2004). A technology platform enables to efficiently capture, store, search and retrieve knowledge for successful sustainability implementation (Hallstedt, Anthony, & Pia, 2013). Thereby, a product can be minimized its negative impacts on the aspect of environment during its life-cycle.

In this article, we focus our intention on applying concepts of sustainable development to enhance sustainability of DMAIC process, and Ontology Engineering in the realization of resource management of the process. In the next section of this article, a review of related works are presented. Afterwards, a conceptual model for enhancing sustainability of DMAIC process through knowledge management is discussed in the third section. The fourth section explains the sustainable aspects of the proposed model. The final section is to conclude the article.

LITERATURE REVIEW

Several recent research show that knowledge management plays an important role in sustainable development of a process.

According to Sophie I. Hallstedt and the colleague, two of eight key elements affecting sustainability aspects of a product innovation process relate to knowledge i.e. knowledge utilization as well as knowledge share and reuse (Hallstedt, Anthony, & Pia, 2013). More importantly, knowledge sharing and reuse supports decision-making activities in future product development projects, enhances the sustainability aspects of products, and reduces the design cost basing on experience available. Furthermore, the authors point also out that systematic solutions such as knowledge-based processes, tools, or methods that would enable the capture and reuse of the knowledge are challenges for companies in order to enhance sustainability aspects of the product innovation processes.

In another research, the authors in (Wu & Hans-Dietrich, 2013) note that investing knowledge management facilitates sustainable development implementation. It supports to fill knowledge gaps and resolve current frustrations stemming from inadequate and inappropriate policy development and implementation. It also provides recommendations and best practices that guide innovation towards sustainability. Therefore, the authors present a process of KM for gaining sustainability performance in their framework involving three main stages: Knowledge acquisition, knowledge sharing, and knowledge utilization (Figure 1).

Kalakul and co-authors propose a framework to design a sustainable chemical and/or biochemical process (Kalakul, Malakul, Siemanond, & Gani, 2014). The authors develop four supporting tools integrated with a Life Cycle software in the framework (Figure 2). One of the most notable points in

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Figure 1. Process of KM for Wu's framework. Adapted from (Wu & Hans-Dietrich, 2013)

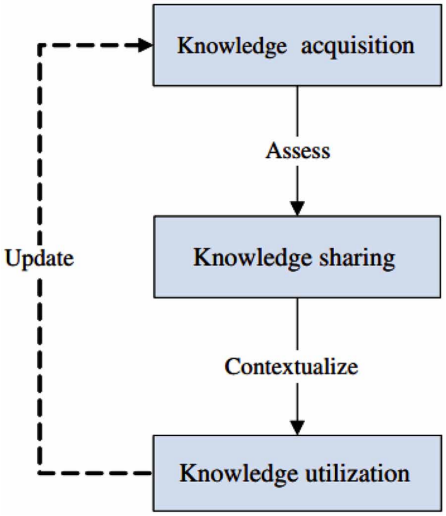
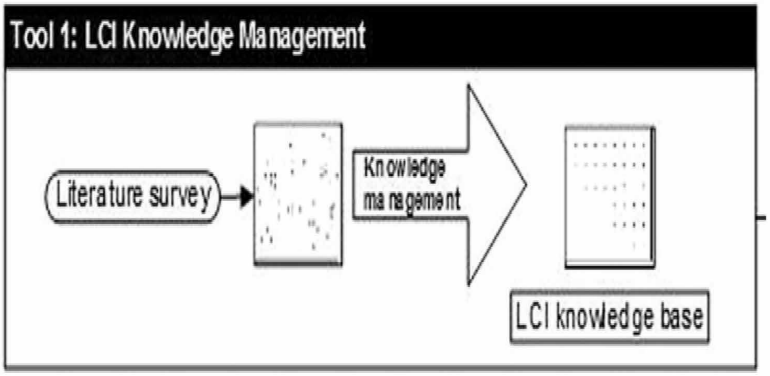


Figure 2. KM tool supporting designing a sustainable chemical and/or biochemical process. Adapted from (Kalakul, Malakul, Seimanond, & Gani, 2014)



the framework is that knowledge of the process is managed by a specific tool used to organize data and support maintenance. Moreover, knowledge is represented by an Ontology and stored in a knowledge base. Therefore, it enables future expansion of KM tool.

In the model of Sztangret, knowledge management plays a vital role in implementing concepts of sustainable development in a company (Sztangret, 2016). It influents on a comprehensive development of individuals, and success of a company. The model of sustainable development is designed on the basis of multi-subject, multifunctional, and multi-tool, and implemented on the basis of three pillars: (1) company strategy based on awareness, knowledge and learning, (2) environment of knowledge application, share and creation, and (3) tools for knowledge management and distribution. The ultimate goal of the author is to reduce the use of, reuse, and recycle natural resource and energy.

In other research, although the authors do not present sustainable aspects regarding to their products i.e. processes or models, the problem of knowledge management attracts their attention in research. In

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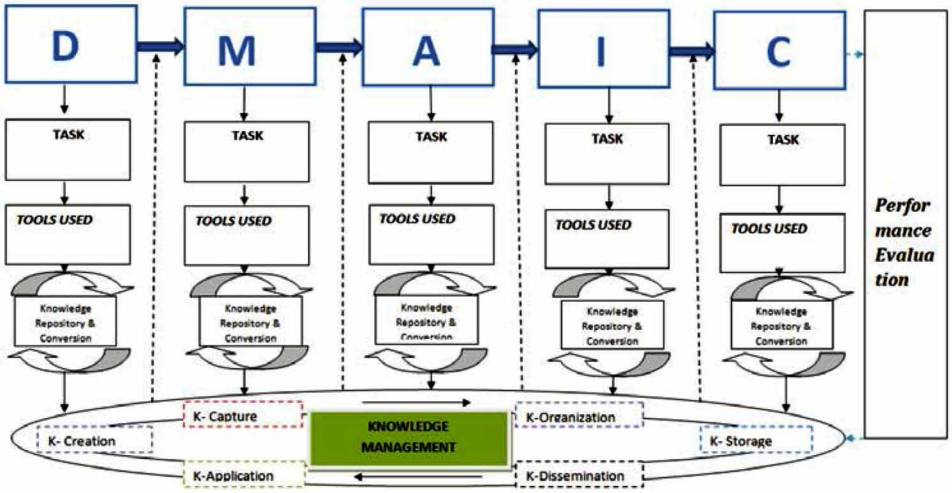
(William, 2009), William R. King has of six steps for a process of knowledge management consisting of Create/Acquisition, Refinement, Memory, Transfer/Sharing, Utilization/ Organizational Performance in order to support organizational processes in innovation, learning and decision making. Ricky Yeung (Ricky, 2004) introduces Integrated Knowledge Representation model for DMAIC execution on the basis of two components: 5W1H framework and Total Enterprise Knowledge Integrated Platform. The components are used to represent contents and manage knowledge in a KM process involving evolution, gathering, organization and storage, learning, nomination, and discussion.

Kifor & Baral (Kifor & Baral, 2013) introduce a conceptual model for KM in DMAIC process in order to improve product quality and organizational performance. The process of KM is integrated with each DMAIC phases on the basis of six steps: knowledge creation, capture, organization, storage, dissemination, and application. Moreover, tasks, tools, activities, knowledge managing IT platform and project performance evaluation tools are used to support knowledge works in their Six Sigma projects (Figure 3).

The aforementioned research depicting the same point of view is that knowledge plays a pivotal role in development of products, and affects their sustainability. However, most of them do not present how knowledge is structured, stored and reused effectively yet. In other words, a solution that facilitates knowledge storage, renew and reuse is not mentioned yet thought there are many approaches for the problem.

In IT techniques, three typical approaches for organizing and representing knowledge are to base on Documents, Ontology, and Artificial Intelligence (Ribino, Oliveri, Lo Re, & Gaglio, 2009). These approaches aim at making a converting from tacit knowledge to explicit knowledge, and sharing the expertise and information resource of an organization. In case of the Ontology-based approach, both of tacit and explicit knowledge are represented and hierarchically structured. In the case, knowledge is described and defined as a set of concepts and their relationships. This approach is suitable to share DMAIC knowledge because Ontology supports a specification of conceptualizations, and helps programs and humans to share knowledge (Gruber T. R, 1993). It also can be used to "share and reuse among different applications" (Benjamins, Fensel, & Gomez Perez, 1998).

Figure 3. DMAIC-KM model. Adapted from (Kifor & Baral, 2013)



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In the next section, the authors of this article present a conceptual model of KM in order to enhance sustainability of DMAIC process. The authors' approach is based on Ontology Engineering used to structure and represent DMAIC knowledge.

THE PROPOSED OKMD MODEL

Overview

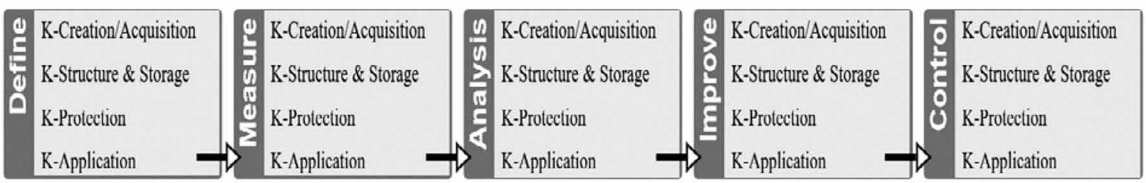
In the process of carrying out DMAIC activities, the quality profession and statisticians often apply several tools and techniques for the purpose of improving an existing product, process or service (Thomas, 2003). Each of tools and techniques (Table 1) helps the profession and statisticians to create reports in which new ideas or knowledge are proposed and applied. However, the DMAIC reports are often produced in text-based document format, some of them are in unstructured formats that may be permanently secreted in filing cabinets. Moreover, innovations or breakthrough solutions proposed by domain experts or individuals are often hidden in the reports and difficult to access (Stevens, 2006). Hence, a solution supporting accumulate, sharing, exchange of knowledge is necessary.

The proposed OKMD (Ontology-based Knowledge Management process for DMAIC) model (Figure 4) is an integrated conceptual model that combines activities of DMAIC process, knowledge management and ontology engineering. The ultimate goal of OKMD model is to construct a knowledge base to accumulate and share knowledge created by DMAIC improvement process. Knowledge available should be represented by existing Ontologies. Thereby, knowledge resource of DMAIC improvement process will be preserved and reused sustainably.

Table 1. Tools and Techniques used during DMAIC execution

Project phase	Brief Description	Tools and techniques
Define	Define the goals of the improvement activity	Project Charter, Stakeholder Analysis, SIPOC, …
Measure	Measure valid and reliable metrics in the existing system	Preliminary Data Analysis, Initial Sample Results / DPMO…
Analyze	Analyze the system to identify ways to eliminate the gap.	Five Why Root Cause Analysis, Failure Modes and Effects Analysis…
Improve	Improve the system	Solutions Ratings Analysis, Benchmarking Report, Corrective Action Plan…
Control	Control the new system	SPC, FMEA, Best Practices Log…

Figure 4. KM process in OKMD model



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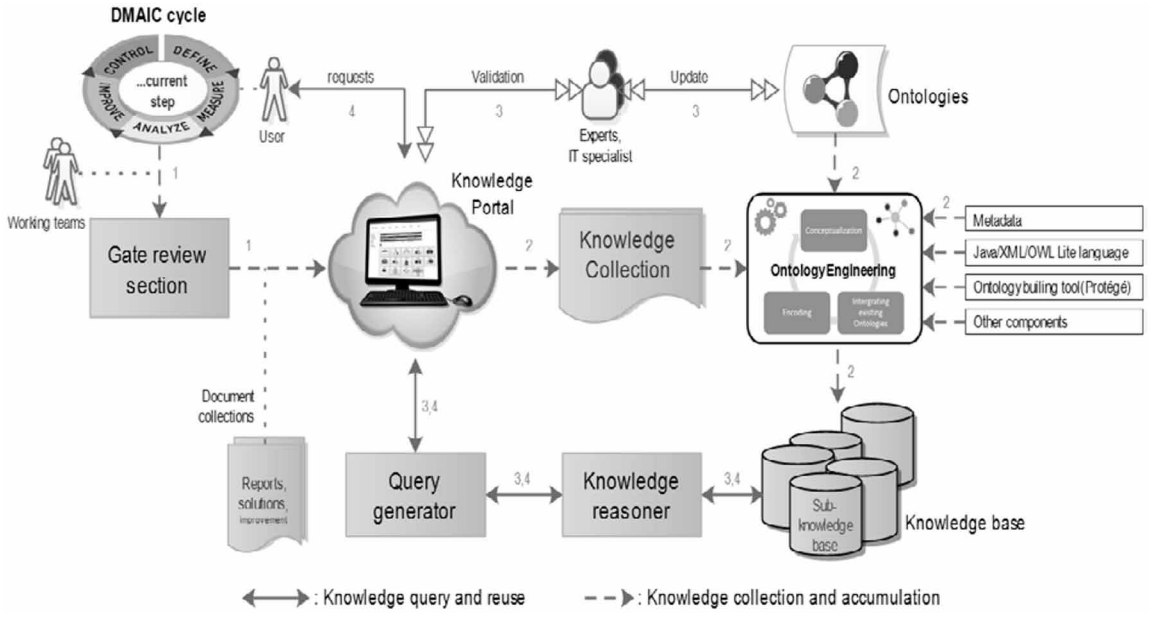
Activities of DMAIC process are planned and deployed step by step according to the recommended Six Sigma guideline (Kifor & Baral, 2013), Gate Review sessions are arranged by the project participants recommended in (ISO13053-1, 2011) and tools and techniques proposed in (ISO13053-2, 2011). These activities provide opportunities to generate new knowledge that is then accumulated and reused in the during DMAIC process execution. The activities of knowledge management (Figure 5) involving Knowledge Creation/Acquisition, Knowledge Structure & Storage, Knowledge Protection, and Knowledge Application (Gold, Albert, & Arvind, 2001) are executed continuously within each of five DMAIC steps consisting of Define, Measure, Analysis, Improve, and Control. DMAIC knowledge is structured and stored by using Ontology engineering into sub-knowledge bases.

Ontologies are built by using supported tools in IT area such as Ontology editing tools, programming languages, and natural language processing techniques. Moreover, activities of knowledge accumulation and reuse are fulfilled by knowledge workers (Mikael, Ioana, & Sachin, 2003) through Knowledge Portal where various information sources such as reports, plans, and text-based documents are collected. It provides activities of knowledge management with the functionalities: Content presentation, user account, chat room, forums, news module, and online quiz, questionnaire with multiple choices, file uploader, file downloader, search/query generator, and Knowledge Reasoner/inference engine.

Accumulating and Reusing DMAIC Knowledge

In OKMD model, a knowledge management process typically consists of four stages videlicet K-Creation/Acquisition, K-Structure & Storage, K-Protection, and K-Application. Figure 5 depicts the typical activities executed by working teams who participate a Six Sigma project, experts, specialists of Information technology, and web users.

Figure 5. Integration of KM and DMAIC process



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The activities of K-Creation/Acquisition stage (arrow path 1 in Figure 4) is to obtain new knowledge (Gold, Albert, & Arvind, 2001). The stage should be started at the Gate review section of every DMAIC step where members of project team such as Black Belt, Green Belt, domain experts discuss and review problem-solving solutions or improvement plans basing on reports and documents created. The support of Knowledge Portal allows them to submit or upload their reports, documents, writings, and relevant files to Knowledge Portal. Data collected at the Gate review section is used to extract potentially valuable knowledge (King, 2009) for reusing in the next stages. Domain experts can be interviewed in case tacit knowledge need to be supplemented.

K-Structure & Storage stage (arrow path 2) aims at structuring and cumulating new knowledge into sub-knowledge bases on the basis of Ontology Engineering. As Figure 4 shown that data collected on Knowledge Portal is extracted to explicit knowledge under the support of Ontologies available, Ontology building tools (such as Protégé), natural language processing techniques, and programing languages. Concepts of new knowledge as well as their relationship are defined and updated by the support of IT specialists into each of DMAIC stages correspondently.

K-Protection stage (arrow path 3) plays an important role in protecting crucial knowledge before it would be distributed to the next stages. This stage is proposed in order to prevent illegal or inappropriate behaviors of web users who are querying knowledge available on Knowledge Portal. It provides security mechanism for web users and supporting tools for maintaining and validating knowledge. The knowledge access and activities of web users are monitored and controlled through their accounts. Experts are required to validate knowledge available, and their opinions are helpful to contribute to making created valuable knowledge and eliminating outmoded knowledge. Ontologies are updated by expert's opinion and IT specialists.

K-Application stage (arrow path 4) is necessary to share and reuse created knowledge. Activities found in Figure 4 consist of querying knowledge, and applying valuable knowledge. Knowledge found can support improvement activities of the next steps of DMAIC. A knowledge request of a web user is sent to the query generator where a command of knowledge query is generated. Intelligent results of the query are then responded by Knowledge Reasoner after appropriate knowledge is reasoned from a knowledge base.

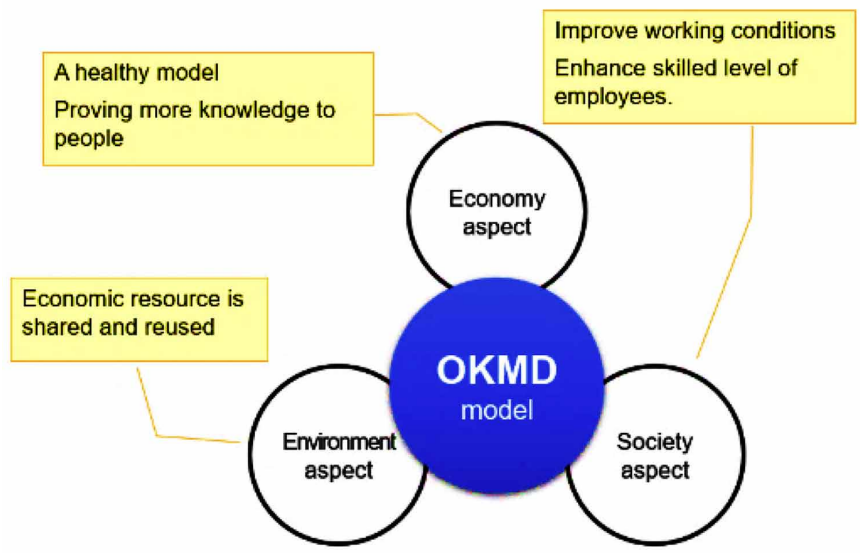
SUSTAINABILITY OF OKMD MODEL

In various fields, there are different points of view to make sustainability. Hence, there is no unique standardized criteria and almost no practical experience for sustainability of a process (Ansari, Holland, & Fathi, 2010) (Azapagic, Allan, & Aaron, 2006). In this article, sustainability of the conceptual OKMD model is achieved by effectively managing and exploiting knowledge resource. Sustainable aspects of the proposed model are discussed through criteria presented by (Harris, 2000), (Brundtland, 1987) and seven sustainable measures presented by the authors in (Mahesh, Henrietta, Laszlo, & Jozsef, 2008) (Ansari, Holland, & Fathi, 2010) (see Figure 6).

The essential goals of sustainability are economic growth, environmental conservation, and social equity (Aparna & Keren, 2007). For economically sustainable aspect, OKMD is a healthy business model. DMAIC focuses on a continuous improvement cycle that benefits organizations in several years (Kwak & Anbarib, 2006). Increasingly, OKMD improves economic sustainability of DMAIC process when more knowledge is provided to people.

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Figure 6. Sustainability of OKMD



Valuable knowledge is queried online for the purpose of applying into improvement activities. Knowledge accumulation benefits the share and renewal and maximizes use of this renewable resource for the purpose of enhancing environmental sustainability (Adams & Scott, 2013). This would "*create greater willingness to share global resources equitably*" (Brundtland, 1987).

The social sustainability of OKMD can be attained when it creates easier knowledge access and opportunities to enhance skills of employees. The Knowledge Portal would support an organization to improve working conditions, help employees to communicate and create relationships with customers and providers. Therefore, the relationships provide them with insights regarding sustainability aspect of the model (Hallstedt, Anthony, & Pia, 2013).

Moreover, sustainability of OKMD model can be evaluated on the base of seven sustainable measures in which DMAIC knowledge is preserved and developed through its KM process:

- Converting economic goals to knowledge goals
- Discharging obsolete knowledge
- Protecting and preserving of sensitive knowledge
- Identification and retention of human knowledge hosts
- Optimizing "Use of knowledge" infrastructure
- Externalization of tacit knowledge
- Offering incentives for knowledge sharing

In knowledge economy, products are often produced by improving and innovating previous ones. Contribution of valuable knowledge is necessary for the improving processes. OKMD model creates opportunities to target the valuable knowledge in order to preserve and renew it. Yet, during knowledge accumulation, outmoded knowledge is not useful and conducive to improvement activities. It does not provide breakthrough insights but cause problems in term of processing data and making decision.

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Besides, valuable or sensitive knowledge is just strategic assets of an organization that can create the competitive advantage in business (Roblek, Meško, Bach, & Bertoncelj, 2014). Hence, the outmoded knowledge should be eliminated and sensitive knowledge must be protected through implementation of the K-Protection phase. Another sustainable measure to discuss is knowledge sources. DMAIC knowledge can be found in various kinds of document. This causes troubles to knowledge identification and storage. Fortunately, Knowledge Portal and Ontology Engineering are helpful to optimize exploiting knowledge and overcome the problem. They are used to collect, structure, maintain, and share DMAIC knowledge. Nonetheless, not all kinds of knowledge can be collected easily, particularly tacit knowledge. Using Ontologies and other techniques, KM process of OKMD model creates a conversation from tacit knowledge to explicit knowledge. Therefore, valuable experience and knowledge of experts will be accumulated and shared equitably. Far more than that, it encourages employees and managers participation in the knowledge sharing, and impulse the development of knowledge (Ritzen, 2000).

CONCLUSION AND FUTURE WORKS

In this research, the necessity for integrating concepts of sustainable development with a quality improvement model has been pointed out. A harmonious combination of three economic, social, environment aspects is essential to archive sustainable development of a quality improvement model. In case of the proposed conceptual model, crucial knowledge is created to improve business processes and enhance quality of products. Hence, accumulation and reuse of the knowledge, a potential economic resource (Roblek, Meško, Bach, & Bertoncelj, 2014), is necessary. Effective managing and exploiting this resource of knowledge contribute innovation of products towards sustainable development of the DMAIC process. Finally, sustainable measures for knowledge management have been analyzed theoretically. For future work, the conceptual model can be validated by using data collected from a Six Sigma project in practice and applied into IT operations management.

ACKNOWLEDGMENT

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Chapter 17
Making Sustainable Energy Communities a Reality:
The "MPC+" Decision Support Framework

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ABSTRACT

The aim of this chapter is to present a decision support framework for local energy planning, entitled "MPC+ (Map - Plan - Choose - Check)". The proposed framework incorporates the development of the baseline emissions inventory, the identification and modelling of renewable energy and rational use of energy actions, as well as the creation of alternative Scenarios of Actions at the city level. The evaluation of alternative Scenarios is based on a multi-criteria ordinal regression approach. In addition, an extreme ranking analysis method is used, in order to examine robustness problems, estimating the best and worst possible ranking position of each Scenario. The MPC+ framework contributes to the selection of the most promising Scenario of renewable energy and rational use of energy actions, supporting the local - regional authorities in creating Sustainable Energy Communities (SEC). Finally, the "Methodological Approach for Monitoring SEC Targets" is introduced.

INTRODUCTION

This chapter presents a decision support framework for local energy planning. The overall philosophy of the proposed framework aims to support the local and regional authorities in the development, implementation and monitoring of the Sustainable Energy and Climate Action Plan, especially within the framework of the Covenant of Mayors' initiative. More specifically, the proposed framework "MPC+ (Map - Plan - Choose - Check)" integrates the following four components:

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- **"Map":** This component is the starting point of the Action Plan's development process. It involves the mapping of the current status within the region, emphasizing on the development of energy and baseline emission inventory. The results at this stage are the basis for the formulation of a comprehensive Action Plan and the monitoring and control of targets set.
- **"Plan":** This component focuses on the design of alternative Scenarios of Actions, namely a set of appropriate measures and actions for implementation at local - regional level. The design of scenarios is achieved through the modeling of measures and actions, the assessment of future trends in CO_2 emissions at local - regional level and the participation of local stakeholders.
- **"Choose":** This component aims to support decision makers in the process of identifying the most promising Scenario of Actions for the region. It includes the evaluation of the alternative Scenarios of Actions using multi-criteria analysis and robustness analysis.
- **"Check":** This component is related to the monitoring of the targets set in each activity sector of the municipality. In this way, the monitoring and assessment of the progress towards sustainable development in economic, social and environmental context is achieved.

Apart from the introduction, the paper is structured along six sections. Section 2 provides a description of the overall technical framework of the proposed "MPC^{+}" approach. Sections 3-6 are devoted to the presentation of the four components of the proposed approach, namely "Map", "Plan", "Choose" and "Check" components. Finally, the last section just summarizes the key issues that have arisen in this paper.

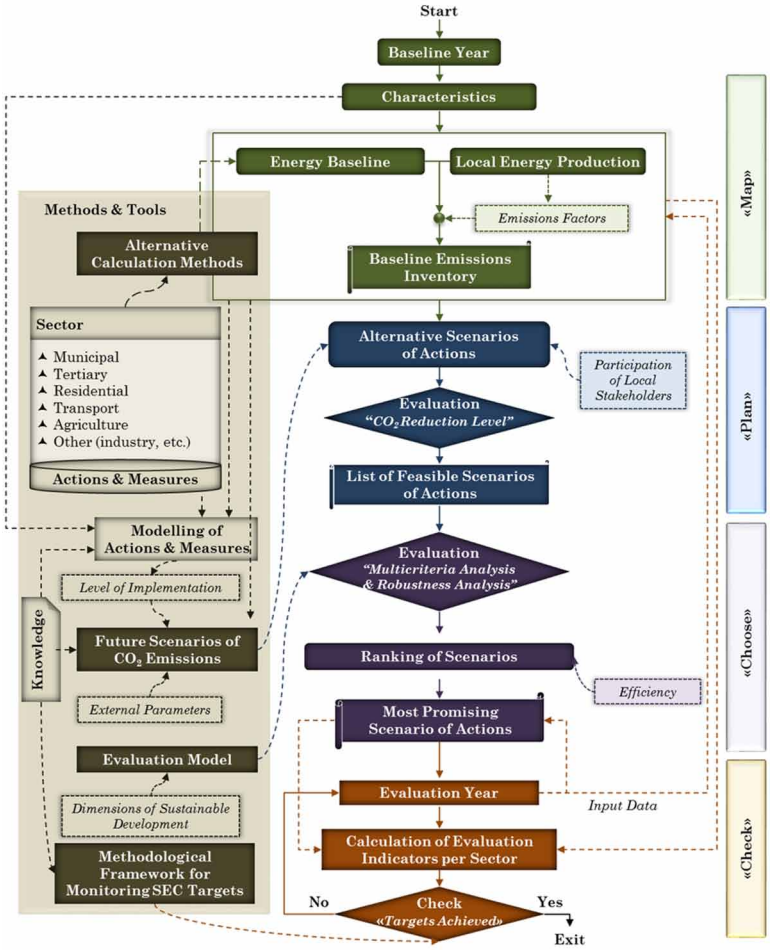
Technical Framework

The proposed framework includes individual components, which are described in Figure 1:

- **"Map" Component:**
  - **Baseline Year:** Selection of the year for which the energy and emission baseline inventory will be developed.
  - **Characteristics:** Some basic information and statistics are required for the municipality (e.g. population, number of dwellings, land uses, etc.). These data are used both in the development of energy and emission baseline, as well as in the design of alternative Scenarios of Actions.
  - **Energy Balance:** Calculation of energy balance at the local-regional level with the use of alternative methods.
  - **Local Energy Production:** Data on the local electricity production and local heating / cooling systems. These data are used for the calculation of regional CO_2 emission factors.
  - **Baseline Emissions Inventory:** The last stage includes the development of the baseline emission inventory, taking into consideration the energy balance and emission factors per energy use (national and local).
- **"Plan" Component:**
  - **Actions' Modelling:** First of all, a number of renewable energy and rational use of energy actions have been identified for the following sectors, as proposed by the Covenant of Mayors' guidelines (CoM, 2017):

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Figure 1. Algorithm of the proposed decision making framework



- Agricultural/fishery/forestry sector;
- Municipal buildings, equipment/facilities (public, tertiary and residential);
- Transport (municipal fleet, public transport, private and commercial transport);
- Local electricity production (hydroelectric power, wind power, photovoltaic, combined heat and power, etc.);
- Local district heating/cooling (combined heat and power, district heating plant, etc.).

These actions take an "editable" form using data provided by decision-maker (community's profile, baseline energy and CO_2 emission inventory), as well as indicators from the international literature and reports.

- **Scenarios' Development:** An initial design of alternative scenarios takes place according to the range of the actions' application in each sector. The appropriate modifications are made on these scenarios through a participatory approach (using questionnaires, public consultation meeting, etc.).

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- **Evaluation (Level of CO_2 Emissions Reduction):** All the alternative scenarios are evaluated concerning the reduction of CO_2 emissions, based on the threshold set by the local authorities (e.g. 20% by 2020 or 40% by 2030).
- **List Feasible Scenarios of Actions:** Creation of the list of feasible Scenarios, which will be evaluated subsequently in order to identify the most promising scenario to be implemented by the region.
    - **"Choose" Component:**
- **Evaluation (Multicriteria Decision Support and Robustness Analysis):** The alternative scenarios are evaluated through the construction of a coherent family of criteria and an evaluation model. An Additive Value Function is used for the assessment of the alternatives scenarios. Linear programming techniques used in conjunction with qualitative regression analysis (Multicriteria Ordinal Regression Approach). The extreme ranking analysis method is used, in order to take into account the model's robustness, estimating the best and worst possible ranking position of each scenario.
- **Ranking of Alternative Scenarios of Actions:** Based on the above approach, the final ranking of alternative Scenarios of Actions is derived, reflecting the maximum and minimum position of each Scenario. In this respect, the most promising Scenario of Actions can be identified taking also into consideration the relevant efficiency.
    - **"Check" Component:**
- **Evaluation Year:** For the elected evaluation year, the relevant data for the baseline emission inventory and the progress on actions and measures implementation are introduced.
- **Calculation of Monitoring Indicators in Each Activity Sector:** Based on the data input, the calculation of the monitoring indicators in each activity sector take place.
- **Check (Targets Achieved):** Calculation of the composite index "SEC_{Index}" in each activity sector, in order to evaluate the overall progress and facilitate the identification of deviations and corrective measures needed.

"MAP" COMPONENT

Baseline Year

According to the Covenant's guidelines, the recommended baseline year is 1990, but if the local authority does not have data to compile a CO_2 inventory for 1990, then it should choose the closest subsequent year for which the most comprehensive and reliable data can be collected.

Characteristics

The end-user provides data regarding general characteristics of the municipality, as follows:

- **General Information:** Population; area; climate zone; employment.
- **Agricultural Sector:** Cultivate land; number of tractors; irrigation methods.
- **Municipal Sector:** Number of municipal buildings; type and total area; number and type of pumps, drillings, water tanks, biological treatment

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- **Residential Sector:** Number of buildings and area; buildings with or without central heating; detached houses or block of apartments.
- **Tertiary Sector:** Number buildings, types and area
- **Municipal Lighting:** Number and type of lights
- **Transport:** Number of municipal cars, buses and other vehicles; number of private passenger vehicles, motorcycles, trucks, etc.
- **Locally Energy Production:** Solar radiation; wind speed; river area and flow.

Energy Baseline: Alternative Calculation Methods

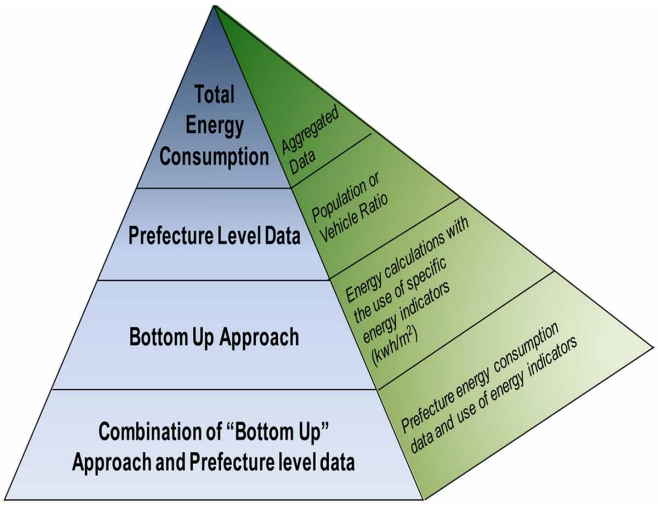
A common technical approach has been adopted, as well as the necessary algorithms for the calculations of the energy and CO_2 emissions baseline have been developed. It should be noted that specific emphasis has been given in the sectors of agriculture, forestry and fishery, taking into consideration that these sectors constitute an important part of the baseline emission inventory of the city. The main aim is to facilitate the calculation of energy consumption per sector (especially for tertiary sector, residential buildings, private and commercial transport, agriculture, etc.), providing alternative calculation methods to the users.

Indeed, the approach used for the data entry regarding all buildings and facilities' energy consumptions is either based on existing aggregated data for a specific type of facilities (e.g. schools), either on the bottom up approach and/or use of appropriate estimations where considered necessary (Figure 2).

Buildings, Equipment/Facilities and Industries

- Municipal Buildings/Equipment/Facilities.
  - Schools.
    - Total energy consumption (aggregated data).
    - Bottom up approach - Individual energy consumptions for Nursery schools, Primary schools, Lower secondary schools, Upper secondary schools etc.

Figure 2. Energy baseline: Alternative calculation methods



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    - Municipal Buildings.
        - Total energy consumption (aggregated data).
        - Bottom up approach - Individual energy consumptions for Community Offices, Hospitals, Sports Facilities, Culture Buildings, Other.
    - Equipments/Facilities.
        - Total energy consumption (aggregated data).
        - Bottom up approach - Individual energy consumptions for Water treatment units, Recycling centres, Composting plants, Sewage treatment, Other.
- Tertiary (non Municipal) Buildings, Equipment/Facilities.
    - Total energy consumption (aggregated data).
    - Energy consumption at district level (estimation based on population ratio).
        - Energy consumption at district level, calculation of the municipality consumption based on the population of community and district ratio.
    - Estimations using the bottom up approach for each building category (e.g. Offices, Stores, Hotels, Hospitals, Other).
        - **Electricity Consumption Estimation:** Based on the number and area (m^2) of buildings for each category, use of average electricity consumption indicators for each building category (kWh/m^2).
        - **Space Heating:** Estimations based on: number and area (m^2) of buildings per building category, number (or percentage) of buildings with thermal insulation per building category, average energy consumption for heating per m^2 and building category, indicators regarding the % of each fuel (e.g. diesel, electricity, natural gas, biomass etc.) in the heating energy mix.
        - District heating aggregated data (from the suppliers).
        - **Water Heating :** Solar collectors (Solar collectors' installation - m^2 and energy saving through solar collectors - KWh/m^2 for each country).
- Residential Buildings.
    - Total energy consumption (aggregated data).
    - Energy consumption at district level (estimation based on population or building square meters' ratio).
        - Energy consumption at district level, calculation of the residential consumption based on the community/ district population or building square meters' ratio.
    - Individual energy consumptions.
        - **Electricity Consumption:** Estimation and bottom up approach based on the number and area (m^2) of detached houses and block of apartments and average electricity consumption in buildings (kWh/m^2). The electricity consumption may or may not include consumption for space heating (depending on the availability of indicator data).
        - **Space Heating:** Estimations and bottom up approach based on: area (m^2) and number of detached houses and apartments blocks with and without central heating; number of buildings with thermal insulation, for the categories with and without central heating; average energy consumption for heating (kWh/m^2), for buildings with and without central heating; indicators regarding the % of each fuel (e.g. diesel, natural gas, electricity, etc) in the heating energy mix; especially for biomass, indicators for the average use of fuelwood (tons per household) and number of households are used.

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        - District heating aggregated data (from the suppliers).
        - **Water Heating:** Solar collectors (Solar collectors' installation - m^2 and energy saving through solar collectors - KWh/m^2 for each country).
- Public Lighting.
    - Total energy consumption (aggregated data).
    - **Bottom up Approach:** Individual energy consumptions based on the location and relevant energy consumption (kWh per location).
- Industries (excluding industries involved in the EU Emission trading scheme - ETS):
    - Total energy consumption - (aggregated data).
    - Estimations based on the energy consumption at district level and use of ratio.

Transport

- Municipal fleet.
    - Total energy consumption (aggregated data).
    - Bottom up approach from the individual energy consumptions based on:
        - Vehicle Type (Road Grader, Excavator, Bus, Pickup Truck, Garbage Truck, Ambulance, Car, Fire Brigade truck),
        - Number of vehicle and km,
        - Average fuel consumption and fuel type.
- Public transport.
    - Total energy consumption (aggregated data).
    - Bottom up approach from the individual energy consumptions based on:
        - Bus Route (number of km and number of routes per year).
        - Average fuel consumption and fuel type.
- Private and commercial transport.
    - Total energy consumption (aggregated data)
    - Estimations based on the energy consumption at district level and use of community/ district population or vehicle ratio.
    - Bottom up approach from the individual energy consumptions based on:
        - Number of vehicles, motorcycles and vehicles for transport of goods.
        - Average energy consumption of each type of vehicle.
- Other transportation.
    - Total energy consumption (aggregated data).

Agriculture - Forestry - Fishery

- Agriculture.
    - Electricity (irrigation).
        - Total energy consumption (aggregated data).
        - Approximate energy consumption - Water Use (m^3) and relevant indicators (kWh/m^3).
    - Petroleum consumption (agricultural products).
        - Total energy consumption (aggregated data).

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        - **Estimated Energy Consumption – 1st Method:** Agricultural area for each product (cotton, wheat, maize etc – Ha) and relevant energy consumption indicators (kWh/Ha).
        - **Estimated Energy Consumption – 2nd Method:** Total agricultural area, power of tractors (kW) and operation Hours (machine-hours/Ha), as well as average energy consumption.
- Forestry.
    - Total energy consumption for the gathering and production of one ton of biomass (based on national studies).
- Fishery.
    - Total energy consumption (aggregated data).
    - Estimated energy consumption based on:
        - Number of the coastal fishing boats,
        - Average power of boats,
        - Annual operation hours,
        - Average energy consumption.

Other Emissions

- Total energy consumption (aggregated data).

Local Energy Production

Data are required about the thermal power stations operating in the examined municipality, in order to produce electricity. According to the Covenant's guidelines, the end-user should include a project in the baseline emission inventory only if the installed capacity is below 20MW. In this respect, for a group of small (<20MW) similar projects the proposed approach gives the option of adding a group of projects as one only if the installed capacity of each one of the projects participating in the group is below or equal to 20 MW.

In addition, all the currently operating renewable energy and rational use of energy projects in the municipality are taken into consideration. It works exactly the same way like before as far as the projects' grouping is concerned but now there are some differences depending the projects' category. In case the project concerns wind power or hydroelectric or photovoltaic, then the end-user should fill in the fields precisely as in the previous step with the slight exception that now, the end-user does not have to fill in the energy carrier input since this info is now not applicable. If the project relates to combined heat and power units there is a small differentiation, since now the end-user has to fill in separately the data for the power produced and the heat produced (Figure 3).

Baseline Emission Inventory

Two different approaches have been proposed to calculate the energy balance analysis of the region and to identify the principal sources of CO_2 emissions, as well as their respective reduction potentials. The first method considers the "standard" emission factors according to the Intergovernmental Panel on Climate Change (IPCC) principles (IPCC, 2006), whilst the latter one considers the Life Cycle Assessment (LCA) emission factors (Table 1).

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Figure 3. Local energy production

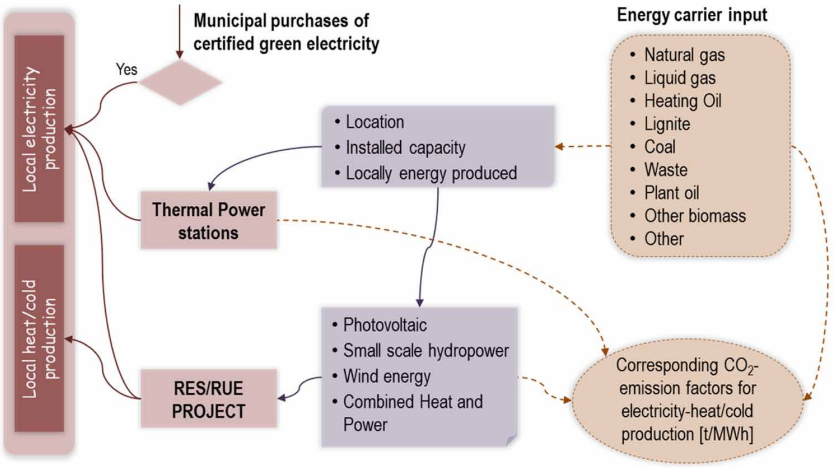


Table 1. Emissions factors

Fuel	IPCC ($tnCO_2$/MWh)	LCA ($tnCO_2$-eq/MWh)
Gasoline	0.249	0.299
Diesel	0.267	0.305
Lignite	0.364	0.375
Natural gas	0.202	0.237
Biomass	0 – 0.403	0.002 – 0.405
Biodiesel	0	0.156
Solar heating	0	-
Geothermal	0	-

The IPCC method covers all the CO_2 emissions that occur due to energy consumption within the territory of the local authority, either directly due to fuel combustion within the local authority or indirectly via fuel combustion associated with electricity and heat/cold usage within their area. The standard emission factors that are used in this method are based on the carbon content of each fuel and it is assumed that all carbon in the fuel forms CO_2. In this approach, CO_2 is the most important greenhouse gas, and the emissions of CH_4 and N_2O are not calculated. Furthermore, the CO_2 emissions from the sustainable use of biomass/biofuels, as well as emissions of certified green electricity, are considered to be zero. The standard emission factors that are used in this method are based on the IPCC Guidelines (IPCC, 2006). It has been widely used in different fields, such as agriculture (Brown et al., 2001; Nevison, 2000), fossil fuel technologies (La Mottaa et al., 2005; Olivier et al., 2005) and waste management (Papageorgiou et al., 2009).

LCA approach includes not only the emissions of the final combustion, but also all emissions of the supply chain. It includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion. This hence includes also emissions that take place outside the location

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where the fuel is used. In this approach, the Green Greenhouse Gas (GHG) emissions from the use of biomass/biofuels, as well as emissions of certified green electricity, are higher than zero. In the case of this approach, other greenhouse gases than CO_2 may play an important role. Therefore, the local authority that decides to use the LCA approach can report emissions as $CO_{2\text{-eq}}$.

LCA method has been widely used in different sectors, such as fossil fuel and renewable energy technologies (Sobrinoa et al.,2011; Martíneza et al., 2010; Weisser, 2007; Dones et al., 2004; Varun, et al., 2009; Cherubinia et al., 2009; Babusiaux et al., 2007; Lenzen et al., 2004; Góralczyk, 2003; Pehnt, 2006; Masruroh et al., 2006; Ardente et al., 2005; Ardente et al., 2005; Khan et al., 2005; Martínez et al., 2009), waste management (Ozeler et al., 2006; Borghi et al., 2005; Björklund et al., 2003), as well as construction industry (Ortiza et al., 2009; Erlandssona et al., 2003; Zabalza Bribián et al., 2009), communication systems (Emmenegger M.F et al., 2004) and food products (Poritosh et al., 2009).

Based on the emission factors (national and/or local), the inventory quantifies the amount of CO_2 emitted due to energy consumption in the territory of the Covenant signatory.

"PLAN" COMPONENT

Actions and Measures

The proposed approach includes the development of alternative Scenarios though a knowledge-based process. More specifically, based on desktop analysis (experience, studies, reports, best practices, etc.), different renewable energy and rational use of energy actions for the local authorities, as well as interventions for the local population have been identified (Table 2).

Creation of Scenarios of Actions

Following the identification of renewable energy and rational use of energy actions, there is the need for a modelling process, so as all the proposed actions to take an "editable" form. In this way, the development of alternative scenarios is possible. To this end, all the factors that affect the final energy saving and production from the implementation of these actions have to be identified.

The implementation of all the proposed actions from the local authorities cannot be feasible at economical and organizational level, taking into consideration that each municipality has different characteristics in terms of population, infrastructures, construction of buildings, etc. In this respect, a number of alternative scenarios are created. The scenarios includes different range of application of each action in the relevant sectors, approaching the real needs and opportunities of each municipality, as possible. This means that there are scenarios with emphasis on the residential and/or tertiary sector, other scenarios focused on actions from the local authorities (e.g. municipal buildings, equipment/facilities and public lighting), etc.

Figure 4 depicts a qualitative representation of the range of application in each sector for the initial design of alternative Scenarios. The selection of the range was based on the experience from the development and elaboration of the Sustainable Energy and Climate Action Plans within the framework of the Covenant's initiative, as well as other related activities, such as the Intelligent Energy Europe (IEE) programme.

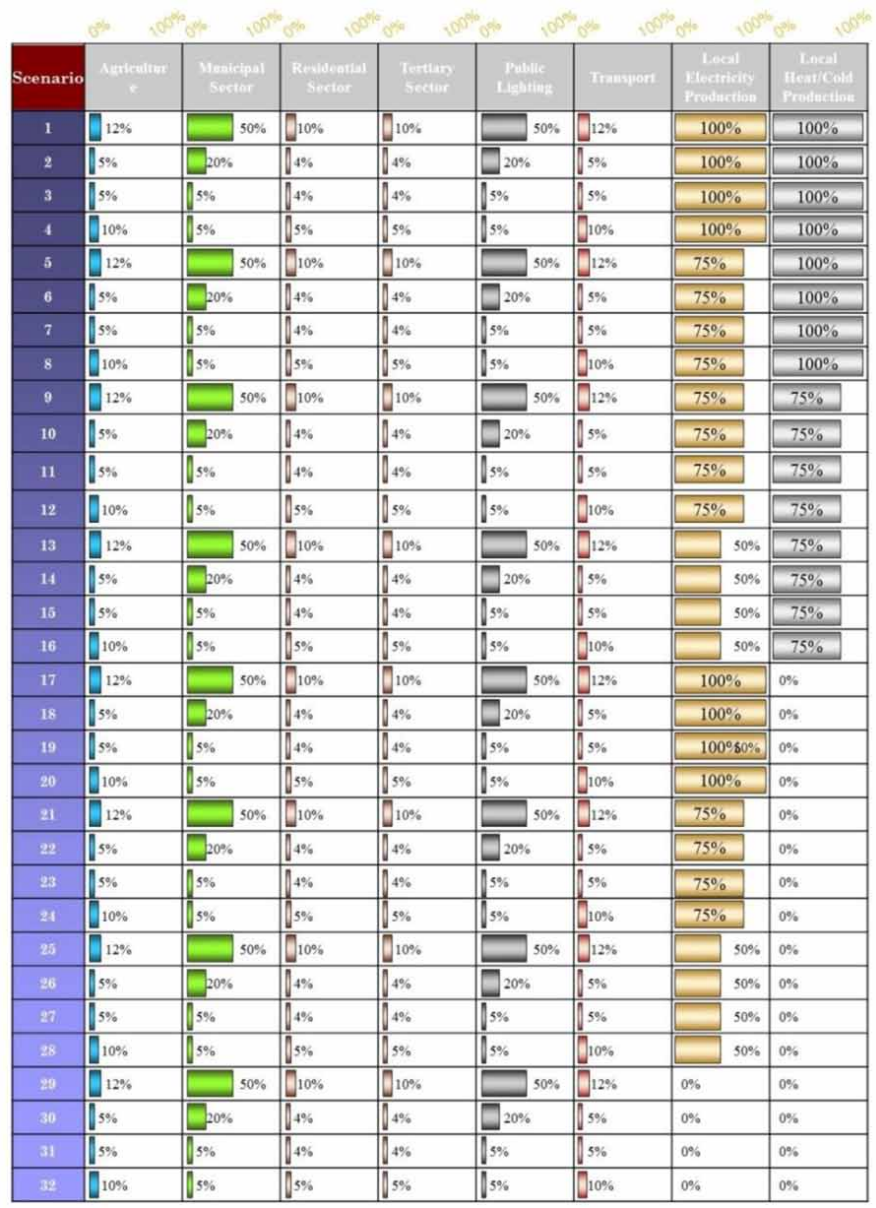
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Table 2. Sectors' and actions' identification

Sector	Actions by the Local Authorities	Interventions by the Local Population
S_1 - Agricultural/ Fishery/ Forestry Sector	A_{11} Establishment/adjustment of a Department for Rural Development in the municipality. A_{12} Training seminars regarding the agricultural tractors' modernization and irrigation techniques. A_{13} Implementation of wide informational campaign. A_{14} Installation of an electronic water-supply system for irrigation based on debit cards.	I_{11} Modernization and replacement of tractors. I_{12} Replacement of surface irrigation and sprinkler irrigation with drip irrigation.
S_2 - Municipal Buildings, Equipment/ Facilities	A_{21} Energy certification and improvement of the municipal buildings' energy performance. A_{22} Actions and campaigns for awareness raising of municipal employees. A_{23} Improvement of the school buildings' energy performance. A_{24} Actions and campaigns for awareness raising of pupils and students. A_{25} Energy Management System (in accordance with the ISO 50001). A_{26} Improvement of the sports facilities' energy performance. A_{27} Improvement of the energy performance of the water system and sewage treatment facilities. A_{28} Establishment of the Energy Efficiency Department in the Municipality. A_{29} Appointment of the municipality energy manager. A_{210} Remote configuration and control of the water system.	Not applicable
S_3 - Residential & Tertiary Sector	A_{31} Implementation of campaigns, events, energy days for the citizens. A_{32} Design and distribution of brochures about the benefits of interventions in the residential buildings. A_{33} Targeted seminars to professional groups. A_{34} Initiatives to support the citizens' actions. A_{35} Energy efficiency criteria for the purchase of electrical appliances	I_{31} Improvement of the building envelope (thermal insulation of walls, windows, roofs; external shading). I_{32} Retrofitting of residential buildings, bundling together technology improvements (lighting, electrical equipment, heat/cold systems, etc.). I_{33} Deployment of smart meters in households. I_{34} Installation of BEMs in commercial buildings.
S_4 - Public Lighting	A_{41} Gradual replacement of the existing bulbs in the public lighting with more efficient ones. A_{42} Dimmers depending on ambient conditions. A_{43} Installation of a public lighting management system. A_{44} Study of the municipal lighting.	Not applicable
S_5 - Industry	Not applicable	I_{51} Interventions by the relevant companies, including among others, replacement of boilers or installation of CHP for heating. I_{52} Ventilation with heat recovery. I_{53} Solar cooling for industrial processes. I_{54} BEMS.
S_6 - Municipal Fleet and Public Transport	A_{61} Eco-driving seminars for the drivers of the municipal fleet. A_{62} Replacement of the municipal vehicles with new, more efficient vehicles. A_{63} Converting diesel municipal vehicles to LPG. A_{64} Efficient management of the municipal fleet. A_{65} Municipal fleet maintenance.	Not applicable
S_7 - Private and Commercial Transport	A_{71} Eco-driving promotion in the private transportation. A_{72} Information events on the new vehicle technologies. A_{73} Cycle paths. A_{74} Traffic study. A_{75} Increase the use of public transport and alternative modes of transport. A_{76} Use of biofuels.	I_{71} Adoption of the eco-driving. I_{72} Use of LPG, hybrid, new technology vehicles. I_{73} Use of bikes and public transportation. I_{74} Use of the "car sharing" or "car pooling" concept.
S_8 - Local electricity production	A_{81} Installation of photovoltaic in the municipal buildings. A_{82} Installation of lighting points with photovoltaic panel. A_{83} Promotion of the installation of small PV parks in agricultural lands.	I_{81} Photovoltaics. I_{82} Wind farms. I_{83} Small dams and hydroelectric power plants. I_{84} Power plants using biomass. I_{85} CHP unites using natural gas.
S_9 - Local District Heating / Cooling	A_{91} CHP units using natural gas. A_{92} Heating / cooling production unit using biomass. A_{93} Development / enhancement of district heating network.	Not applicable

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Figure 4. Range of application for each alternative scenario



Scenario	Agriculture	Municipal Sector	Residential Sector	Tertiary Sector	Public Lighting	Transport	Local Electricity Production	Local Heat/Cold Production
	0% 100%	0% 100%	0% 100%	0% 100%	0% 100%	0% 100%	0% 100%	0% 100%
1	12%	50%	10%	10%	50%	12%	100%	100%
2	5%	20%	4%	4%	20%	5%	100%	100%
3	5%	5%	4%	4%	5%	5%	100%	100%
4	10%	5%	5%	5%	5%	10%	100%	100%
5	12%	50%	10%	10%	50%	12%	75%	100%
6	5%	20%	4%	4%	20%	5%	75%	100%
7	5%	5%	4%	4%	5%	5%	75%	100%
8	10%	5%	5%	5%	5%	10%	75%	100%
9	12%	50%	10%	10%	50%	12%	75%	75%
10	5%	20%	4%	4%	20%	5%	75%	75%
11	5%	5%	4%	4%	5%	5%	75%	75%
12	10%	5%	5%	5%	5%	10%	75%	75%
13	12%	50%	10%	10%	50%	12%	50%	75%
14	5%	20%	4%	4%	20%	5%	50%	75%
15	5%	5%	4%	4%	5%	5%	50%	75%
16	10%	5%	5%	5%	5%	10%	50%	75%
17	12%	50%	10%	10%	50%	12%	100%	0%
18	5%	20%	4%	4%	20%	5%	100%	0%
19	5%	5%	4%	4%	5%	5%	100%60%	0%
20	10%	5%	5%	5%	5%	10%	100%	0%
21	12%	50%	10%	10%	50%	12%	75%	0%
22	5%	20%	4%	4%	20%	5%	75%	0%
23	5%	5%	4%	4%	5%	5%	75%	0%
24	10%	5%	5%	5%	5%	10%	75%	0%
25	12%	50%	10%	10%	50%	12%	50%	0%
26	5%	20%	4%	4%	20%	5%	50%	0%
27	5%	5%	4%	4%	5%	5%	50%	0%
28	10%	5%	5%	5%	5%	10%	50%	0%
29	12%	50%	10%	10%	50%	12%	0%	0%
30	5%	20%	4%	4%	20%	5%	0%	0%
31	5%	5%	4%	4%	5%	5%	0%	0%
32	10%	5%	5%	5%	5%	10%	0%	0%

Future Estimated Progress of the Consumptions and CO_2 Reductions

The proposed model integrates data from the final energy consumption of each sector for the baseline year, a number of external key parameters, as well as the expected energy and CO_2 emissions reduction from the application of examined renewable energy and rational use of energy actions. The adopted approach for the development of the proposed model was based on experts' engagement though the Delphi method. The Delphi Method includes a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback

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(Adler and Ziglio, 1996). Delphi represents a useful communication device among a group of experts and thus facilitates the formation of a group judgement (Helmer, 1977). According to Fowles study anonymity, controlled feedback, and statistical response characterize Delphi (Fowles, 1978). Delphi Method has been applied to a number of problems, such as primary-energy sources and socio-economic development (de Oliveira Matias and Devezas, 2007) and small-sized biogas systems (Cheng et al., 2014).

More specifically, the adopted approach includes the following steps:

Step 1: Experts' Identification – Identification of a number of key experts, mainly from Austria, Bulgaria, Germany, Greece and Portugal, including the following categories: "Energy agencies, utilities and energy companies", "Planners, developers" and "National, regional, municipal institutions".

Step 2: Questionnaires for the Key Parameters' Selection – The identified experts were asked to evaluate key parameters of each sector (municipal, tertiary, residential, transport, agriculture/forestry/fishery and industry sector). A number of questions was developed. Each question could be answered with only one of the following ways: objective multiple choice marking the desired option with an "x", alternatives' rating based on Likert scale from 1 to 5 (the value of 1 is assigned to the lowest importance/impact and value of 1 is assigned to the highest importance/impact).

Step 3: Questionnaires' Distribution & Analysis – Distribution of the questionnaires to the experts with various methods, such as through email, direct interviews with selected experts, etc. Data gathered from the questionnaires were processed (e.g. use of SPSS Statistics, a software package used for statistical analysis) through the calculation of the descriptive statistics (e.g. averages, standard deviations etc).

Step 4: Development of the Proposed Model – The overall algorithm for the future scenarios was developed.

Step 5: Comments and Feedback from Experts on the Proposed Model – The key experts were asked to comment and provide feedback on the proposed model, generating new ideas and solutions. The responses are compiled and analyzed.

In depth analysis of the key stakeholders in each country was carried out and for each country a number of different experts were identified. A total of 210 experts (national, regional, municipal institutions; energy agencies, utilities and energy companies; planners, developers) were identified. The experts were asked to provide their preferences and options for a number of parameters, such as:

- Rate of population growth at national level by 2020;
- Rate of electricity and fuels prices by 2020;
- Rate of energy consumption growth by 2020 of the tertiary, residential, industry, transport and agriculture sector;
- Rate of per capita gross domestic product by 2020;
- Annual heating and cooling degree days.

The contribution of the key parameters to each sector (tertiary, residential, transport, agriculture/forestry/fishery and industry sector) is described in Table 3:

- **Municipal Buildings, Equipment/Facilities:** The estimated energy consumption of the municipal buildings, equipment and facilities is related to the aggregation of the energy consumption of

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Table 3. Contribution of each parameter to the estimated energy consumption

	Tertiary	Residential	Industry	Transport	Agriculture/ Forestry/ Fishery
Rate of population growth at municipal level	20%	35%	-	35%	30%
Rate of per capita gross domestic product at municipal level	35%	25%	-	15%	-
Annual heating and cooling degree days at municipal level	10%	10%	-	-	-
Rate of electricity and fuel prices	10%	10%	40%	20%	20%
Rate of energy consumption growth of the relevant sector at national level	25%	20%	60%	25%	50%
Development of the road network	-	-	-	5%	-

each category (schools, municipal buildings and equipment/facilities), taking also into consideration the following parameters:

- **Schools:** Rate of population growth (age 0-19) at municipal level;
- **Municipal Buildings:** Stable energy consumption;
- **Equipment/Facilities:** Rate of population growth at municipal level.

- **Tertiary or Residential Sector:** The estimated energy consumption of the tertiary or residential sector is related to the relevant energy consumption in the baseline year, in combination with a number of local parameters and the rate of energy consumption growth at national level adjusted to the municipal level, as follows:
  - Rate of population growth at municipal level;
  - Rate of per capita gross domestic product growth at municipal level, taking also into consideration a correction factor;
  - Annual heating and cooling degree days at municipal level multiplied by the rate of per capita gross domestic product growth at municipal level and divided by the heating and cooling degree days at national level, respectively;
  - Rate of electricity and fuels prices, taking also into consideration a correction factor;
  - Rate of energy consumption growth by 2020 of the tertiary sector at national level adjusted to the municipal level, according to the following parameters.
  - Per capita gross domestic product at municipal level divided by per capita gross domestic product at national level;
  - Annual heating degree days at municipal level divided by annual heating degree days at national level, taking also into consideration the rate of per capita gross domestic product growth at municipal level;
  - Annual heating degree days at municipal level divided by annual heating degree days at national level, taking also into consideration the rate of per capita gross domestic product growth at municipal level.

It should be noted that the impact of the population growth is considered higher in the residential sector compared to the tertiary sector. On the other hand, the per capita gross domestic product growth will contribute significantly in the estimated energy consumption of the tertiary sector. Moreover, the annual heating degree days have increased impact on the estimated energy consumption for heating (heat-

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ing oil, natural gas, etc), while the annual cooling degree days contribute significantly to the estimated electricity consumption.

- **Public Lighting:** The rate of population growth at municipal level is the key parameter.
- **Industries:** The estimated energy consumption of the industry sector is related to the energy consumption in the baseline year, in combination with the rate of electricity and fuels prices and the rate of energy consumption growth by 2020 of the industry sector at national level.
- **Municipal Fleet or Public Transport:** The estimated energy consumption of the municipal fleet is considered stable.
- **Private and Commercial Transport:** Similar to the tertiary or residential sector, the estimated energy consumption of the transport sector is related to a number of local parameters and the rate of energy consumption growth at national level, as follows:
  - Rate of population growth at municipal level;
  - Rate of per capita gross domestic product growth at municipal level, taking also into consideration a correction factor;
  - Rate of fuels prices, taking also into consideration a correction factor;
  - Rate of energy consumption growth by 2020 of the transport sector at national level, adjusted to the municipal level according to the per capita gross domestic product at municipal level divided by per capita gross domestic product at national level and a correction factor;
  - Development of the road network.
- **Agriculture/Forestry/Fishery:** The rates of population growth at municipal level, electricity and fuels prices, as well as energy consumption growth by 2020 of the agricultural sector are the key parameters, taking also into consideration the relevant correction factors.

Following the identification of key parameters, the overall algorithm for the future estimated progress of the consumptions and CO_2 reductions was developed (Marinakis et al., 2016).

Municipal Buildings, Equipment/Facilities

$$\mathrm{ECM}_{\mathrm{es-e}} = \mathrm{EC}_{\mathrm{Ms-e}}\ \mathrm{x}\left(1+\mathrm{PG}_{0-19}\right)+\mathrm{EC}_{\mathrm{Mb-e}}+\mathrm{EC}_{\mathrm{Mef-e}}\ \mathrm{x}\left(1+\ \mathrm{PG}\right) \tag{1}$$

$$\mathrm{EC}_{\mathrm{Mes-h}} = \mathrm{EC}_{\mathrm{Ms-h}}\ \mathrm{x}\left(1+\ \mathrm{PG}_{0-19}\right)\ +\ \mathrm{EC}_{\mathrm{Mb-h}} \tag{2}$$

$$\mathrm{EC}_{\mathrm{Mes-ng}} =\ \mathrm{EC}_{\mathrm{Ms-ng}}\ \mathrm{x}\left(1+\ \mathrm{PG}_{0-19}\right)\ +\ \mathrm{EC}_{\mathrm{Mb-ng}}\ +\ \mathrm{EC}_{\mathrm{Mef-ng}}\ \mathrm{x}\left(1+\ \mathrm{PG}\right) \tag{3}$$

$$\mathrm{EC}_{\mathrm{Mes-b}} = \mathrm{EC}_{\mathrm{Ms-b}}\ \mathrm{x}\left(1+\ \mathrm{PG}_{0-19}\right)\ +\ \mathrm{EC}_{\mathrm{Mb-b}} \tag{4}$$

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$$EC_{Mes-d} = EC_{Mef-d} \text{ x} \left(1 + \text{ PG}\right) \tag{5}$$

Tertiary Sector

$$EC_{Tes-e} = 0.2 \text{ x } EC_{T-e} \text{ x} \left(1 + \text{ PG}\right) + 0.35 \text{ x } EC_{T-e} \text{ x}$$
$$\left(1 + \text{ GDP}_{pcM} \text{ x a}\right) + 0.1 \text{ x } EC_{T-e} \text{ x}$$

$$\left[1 + \left(0.15 \text{ x GDP}_{pc\,M} \text{ x HDD}_{M} \text{ / HDD}_{N} + 0.85 \text{ x GDP}_{pcM} \text{ x CDD}_{M} \text{ / CDD}_{N}\right)\right] +$$

$$0.1 \text{ x } EC_{T-e} \text{ x} \left(1 - \text{ P}_{e} \text{ x b}\right) + 0.25 \text{ x } EC_{T-e} \text{ x}[1 + \text{ ECG}_{T} \text{ x}(1 + 0.5 \text{ x GDP}_{pcM/N} +$$

$$0.1 \text{ x GDP}_{pcM} \text{ x HDD}_{M/N} + 0.4 \text{ x GDP}_{pcM} \text{ x CDD}_{M/N}) \text{ x c}] \tag{6}$$

$$EC_{Tes-h} = 0.2 \text{ x } EC_{T-h} \text{ x} \left(1 + \text{ PG}\right) + 0.35 \text{ x } EC_{T-h} \text{ x} \left(1 + \text{ GDP}_{pcM} \text{ x a}\right) + 0.10 \text{ x } EC_{T-h} \text{ x}$$

$$\left[1 + \left(0,9 \text{ x GDP}_{pcM} \text{ x HDD}_{M} + 0,1 \text{ x GDP}_{pcM} \text{ x CDD}_{M}\right) \text{ / HDD}_{N}\right] +$$
$$0.1 \text{ x } EC_{T-h} \text{ x} \left(1 - \text{ P}_{f} \text{ x b}\right)$$

$$+0.25 \text{ x } EC_{T-h} \text{ x}$$
$$\left[1 + \text{ ECG}_{T} \text{ x} \left(0.5 \text{ x GDP}_{pcM/N} + 0.45 \text{ x HDD}_{M/N} + 0.05 \text{ x CDD}_{M/N}\right) \text{ x c}\right] \tag{7}$$

$$EC_{Tes-b} = 0.2 \text{ x } EC_{T-b} \text{ x} \left(1 + \text{ PG}\right) + 0.35 \text{ x } EC_{T-b} \text{ x}$$
$$\left(1 + \text{ GDP}_{pcM} \text{ x a}\right) + 0.10 \text{ x } EC_{T-b} \text{x}$$

$$\left[1 + \left(0,9 \text{ x GDP}_{pcM} \text{ x HDD}_{M} + 0,1 \text{ x GDP}_{pcM} \text{ x CDD}_{M}\right) \text{ / HDD}_{N}\right] +$$
$$0.1 \text{ x } EC_{T-b} \text{ x} \left(1 - \text{ P}_{b} \text{ x b}\right)$$
$$+0.25 \text{ x } EC_{T-b} \text{ x}$$
$$\left[1 + \text{ ECG}_{T} \text{ x} \left(0.5 \text{ x GDP}_{pcM/N} + 0.45 \text{ x HDD}_{M/N} + 0.05 \text{ x CDD}_{M/N}\right) \text{ x c}\right] \tag{8}$$

$$EC_{Tes-ng} = 0.2 \text{ x } EC_{T-ng} \text{ x} \left(1 + \text{ PG}\right) + 0.35 \text{ x } EC_{T-ng} \text{ x}$$
$$\left(1 + \text{ GDP}_{pcM} \text{ x a}\right) + 0.10 \text{ x } EC_{T-\,ng} \text{ x}$$

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$$\left[1 + \left(0,9 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{HDD}_{\text{M}} + 0,1 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{CDD}_{\text{M}}\right) / \text{ HDD}_{\text{N}}\right] +$$
$$0.1 \text{ x } \text{EC}_{\text{T- ng}} \text{ x}\left(1 - \text{ P}_{\text{ng}} \text{ x b}\right)$$
$$+0.25 \text{ x } \text{EC}_{\text{T- ng}} \text{ x}$$
$$\left[1 + \text{ ECG}_{\text{T}} \text{ x}\left(0.5 \text{ x } \text{GDP}_{\text{pcM/N}} + 0.45 \text{ x } \text{HDD}_{\text{M/N}} + 0.05 \text{ x } \text{CDD}_{\text{M/N}}\right) \text{ x c}\right] \quad (9)$$

Residential Sector

$$\text{EC}_{\text{Res-e}} = 0.35 \text{ x } \text{EC}_{\text{R-e}} \text{ x}\left(1 + \text{ PG}\right) + 0.25 \text{ x } \text{EC}_{\text{R-e}} \text{ x}\left(1 + \text{ GDP}_{\text{pcM}} \text{ x a}\right) + 0.1 \text{ x } \text{EC}_{\text{R-e}} \text{ x}$$

$$\left[1 + \left(0.15 \text{ x } \text{GDP}_{\text{pc M}} \text{ x } \text{HDD}_{\text{M}} / \text{ HDD}_{\text{N}} + 0.85 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{CDD}_{\text{M}} / \text{ CDD}_{\text{N}}\right)\right] + 0.1 \text{ x } \text{EC}_{\text{R-e}} \text{ x}$$

$$\left(1 - \text{ P}_{\text{e}} \text{ x b}\right) + 0.2 \text{ x } \text{EC}_{\text{R-e}} \text{ x}[1 + \text{ ECG}_{\text{R}} \text{ x}(1 + 0.5 \text{ x } \text{GDP}_{\text{pcM/N}} + 0.1 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{HDD}_{\text{M/N}}$$

$$+ 0.4 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{CDD}_{\text{M/N}}) \text{ x c}] \quad (10)$$

$$\text{EC}_{\text{Res-h}} = 0.35 \text{ x } \text{EC}_{\text{R-h}} \text{ x}\left(1 + \text{ PG}\right) + 0.25 \text{ x } \text{EC}_{\text{R-h}} \text{ x}$$
$$\left(1 + \text{ GDP}_{\text{pcM}} \text{ x a}\right) + 0.1 \text{ x } \text{EC}_{\text{R-h}} \text{ x}[1$$

$$+\left(0,9 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{HDD}_{\text{M}} + 0,1 \text{ x } \text{GDP}_{\text{pcM}} \text{ x } \text{CDD}_{\text{M}}\right) / \text{ HDD}_{\text{N}}]$$

$$+0.1 \text{ x } \text{EC}_{\text{R-h}} \text{ x}\left(1 - \text{ P}_{\text{f}} \text{ x b}\right) +$$

$$0.2 \text{ x } \text{EC}_{\text{R-h}} \text{ x}$$
$$\left[1 + \text{ ECG}_{\text{R}} \text{ x}\left(0.5 \text{ x } \text{GDP}_{\text{pcM/N}} + 0.45 \text{ x } \text{HDD}_{\text{M/N}} + 0.05 \text{ x } \text{CDD}_{\text{M/N}}\right) \text{ x c}\right] \quad (11)$$

$$\text{EC}_{\text{Res-b}} = 0.35 \text{ x } \text{EC}_{\text{R-b}} \text{ x}\left(1 + \text{ PG}\right) + 0.25 \text{ x } \text{EC}_{\text{R-b}} \text{ x}$$
$$\left(1 + \text{ GDP}_{\text{pcM}} \text{ x a}\right) + 0.1 \text{ x } \text{EC}_{\text{R-b}} \text{ x}$$

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$$\left[1+\left(0,9\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM}}\ \mathrm{x}\ \mathrm{HDD}_{\mathrm{M}}+0,1\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM}}\ \mathrm{x}\ \mathrm{CDD}_{\mathrm{M}}\right)\ /\ \mathrm{HDD}_{\mathrm{N}}\right]+$$
$$0.1\ \mathrm{x}\ \mathrm{EC}_{\mathrm{R-b}}\ \mathrm{x}\left(1-\ \mathrm{P}_{\mathrm{b}}\ \mathrm{x}\ \mathrm{b}\right)+$$
$$0.2\ \mathrm{x}\ \mathrm{EC}_{\mathrm{R-b}}\ \mathrm{x}$$
$$\left[1+\ \mathrm{ECG}_{\mathrm{R}}\ \mathrm{x}\left(0.5\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM/N}}+0.45\ \mathrm{x}\ \mathrm{HDD}_{\mathrm{M/N}}+0.05\ \mathrm{x}\ \mathrm{CDD}_{\mathrm{M/N}}\right)\ \mathrm{x}\ \mathrm{c}\right] \quad (12)$$

$$\mathrm{EC}_{\mathrm{Res-ng}}=0.35\ \mathrm{x}\ \mathrm{EC}_{\mathrm{R-ng}}\mathrm{x}\left(1+\ \mathrm{PG}\right)+0.25\ \mathrm{x}\ \mathrm{EC}_{\mathrm{R-ng}}\mathrm{x}\left(1+\ \mathrm{GDP}_{\mathrm{pcM}}\mathrm{x}\ \mathrm{a}\right)$$

$$+0.1\ \mathrm{x}\ \mathrm{EC}_{\mathrm{Rng}}\ \mathrm{x}\left[1+\left(0,9\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM}}\ \mathrm{x}\ \mathrm{HDD}_{\mathrm{M}}+0,1\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM}}\ \mathrm{x}\ \mathrm{CDD}_{\mathrm{M}}\right)\mathrm{HDD}_{\mathrm{N}}\right]$$

$$+0.1\ \mathrm{x}\ \mathrm{EC}_{\mathrm{Rng}}\ \mathrm{x}\left(1-\ \mathrm{P}_{\mathrm{ng}}\ \mathrm{x}\ \mathrm{b}\right)+0.2\ \mathrm{x}\ \mathrm{EC}_{\mathrm{Rng}}\ \mathrm{x}$$

$$\left[1+\ \mathrm{ECG}_{\mathrm{T}}\ \mathrm{x}\left(0.5\ \mathrm{x}\ \mathrm{GDP}_{\mathrm{pcM/N}}+0.45\ \mathrm{x}\ \mathrm{HDD}_{\mathrm{M/N}}+0.05\ \mathrm{x}\ \mathrm{CDD}_{\mathrm{M/N}}\right)\ \mathrm{x}\ \mathrm{c}\right] \quad (13)$$

Public Lighting

$$\mathrm{EC}_{\mathrm{PLes-e}}=\ \mathrm{EC}_{\mathrm{PL-e}}\ \mathrm{x}\left(1+\ \mathrm{PG}\right) \quad (14)$$

Industries

$$\mathrm{EC}_{\mathrm{Ies-e/h/d/ng/g}}=0.6\ \mathrm{x}\ \mathrm{EC}_{\mathrm{I-e/h/d/ng/g}}\ \mathrm{x}\left(1+\ \mathrm{ECG}_{\mathrm{I\ x\ a}}\right)+$$
$$0.4\ \mathrm{x}\ \mathrm{ECI}\ \mathrm{x}\left(1+\ \mathrm{P}_{\mathrm{e/h/d/ng}}\ \mathrm{x}\ \mathrm{b}\right) \quad (15)$$

Municipal Fleet or Public Transport

$$\mathrm{EC}_{\mathrm{MLPTes-d/g/ng/lg}}=\ \mathrm{EC}_{\mathrm{MLPT-d/g/ng/lg}}\ \mathrm{x}\left(1+\ \mathrm{PG}\right) \quad (16)$$

Private and Commercial Transport

$$\mathrm{EC}_{\mathrm{PCTes-d/g/ng/lg}}$$

$$=0.35\ \mathrm{x}\ \mathrm{EC}_{\mathrm{PCT-d/g/ng/lg}}\ \mathrm{x}\left(1+\ \mathrm{PG}\right)+0.15\ \mathrm{x}$$
$$\mathrm{EC}_{\mathrm{PCT-d/g/ng/lg}}\ \mathrm{x}\left(1+\ \mathrm{GDP}_{\mathrm{pcM\ x\ a}}\right)$$

$$+0.2\ \mathrm{x}\ \mathrm{EC}_{\mathrm{PCT-d/g/ng/lg}}\ \mathrm{x}\left(1-\ \mathrm{P}_{\mathrm{d/ng\ x\ b}}\right)+0.25\ \mathrm{x}\ \mathrm{EC}_{\mathrm{PCT-d/g/ng/lg}}\ \mathrm{x}[1$$

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$$+ \mathrm{ECG}_{\mathrm{PCT}} \text{ x} \left(1 + \mathrm{GDP}_{\mathrm{pcM/N}}\right) \text{ x c}] + 0.05 \text{ x } \mathrm{EC}_{\mathrm{PCT-d/g/ng/lg}} \text{ x} \left(1 + 0.01 \text{ x } \mathrm{DV}_{\mathrm{rn}}\right) \quad (17)$$

Agricultural Sector

$$\mathrm{EC}_{\mathrm{Aes-\ e/d/g/ng}} = 0.3 \text{ x } \mathrm{EC}_{\mathrm{A-\ e/d/g/ng}} \text{ x} \left(1 + \mathrm{PG}\right) + 0.2 \text{ x } \mathrm{EC}_{\mathbf{A}\mathrm{-\ e/d/g/ng}} \text{ x} \left(1 - \mathrm{P}_{\mathrm{\bullet\ x\ a}}\right) + 0.5 \text{ x } \mathrm{EC}_{\mathrm{A-\ e/d/g/ng}} \text{ x} \left(1 + \mathrm{ECG}_{\mathrm{A\ x\ b}}\right) \quad (18)$$

where:

- $\mathrm{EC}_{\mathrm{Mpr-e/h/ng/b/d}}$: Estimated electricity / heating oil / natural gas / biomass / diesel consumption in the municipal buildings, equipment/facilities.
- $\mathrm{EC}_{\mathrm{Tpr-e/h/b/ng}}$: Estimated electricity / heating oil / biomass / natural gas / consumption in the tertiary sector.
- $\mathrm{EC}_{\mathrm{Rpr-e/h/b/ng}}$: Estimated electricity / heating oil / biomass / natural gas / consumption in the residential sector.
- $\mathrm{EC}_{\mathrm{PLpr-e}}$: Estimated electricity consumption in the public lighting.
- $\mathrm{EC}_{\mathrm{Ipr-e/h/d/ng/g}}$: Estimated electricity / heating oil / natural gas / gasoline consumption in the industrial sector.
- $\mathrm{EC}_{\mathrm{MLPTpr-d/g/ng/lg}}$: Estimated diesel / gasoline / natural gas / liquid gas consumption in the municipal fleet or public transport.
- $\mathrm{EC}_{\mathrm{PCTpr-d/g/ng/lg}}$: Estimated diesel / gasoline / natural gas / liquid gas consumption in the private and commercial transport.
- $\mathrm{EC}_{\mathrm{Apr-e/d/g/ng}}$: Estimated electricity / diesel / gasoline / natural gas consumption in the agricultural sector.
    - $\mathrm{EC}_{\mathrm{Ms-e/h/ng/b}}$: Current electricity / heating oil / natural gas / biomass consumption in schools.
    - $\mathrm{EC}_{\mathrm{Mb-e/h/ng/b}}$: Current electricity / heating oil / natural gas / biomass consumption in municipal buildings.
    - $\mathrm{EC}_{\mathrm{Mef-\ e/d/ng}}$: Current electricity / diesel / natural gas consumption in equipment/facilities.
    - $\mathrm{EC}_{\mathrm{T-\ e/h/b/ng}}$: Current electricity / heating oil / natural gas / consumption of the tertiary sector.
    - $\mathrm{EC}_{\mathrm{R-e/h/b/ng}}$: Current electricity / heating oil / natural gas / consumption of the residential sector
    - $\mathrm{EC}_{\mathrm{PL-e}}$: Current electricity consumption in the public lighting.
    - $\mathrm{EC}_{\mathrm{I-e/h/d/ng/g}}$: Current electricity / heating oil / natural gas / gasoline consumption in the industrial sector.

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- $EC_{MLPT-d/g/ng/lg}$: Current diesel / gasoline / natural gas / liquid gas consumption in the municipal fleet or public transport.
- EC_{PCT} : Current diesel / gasoline / natural gas / liquid gas consumption in the private and commercial transport.
- $EC_{A-e/d/g/ng}$: Current electricity / diesel / gasoline / natural gas consumption in the agricultural sector.
- PG: Rate of population growth at municipal level.
- PG_{0-19} : Rate of population growth (0-19 years old) at municipal level.
- $P_{e/h/d/ng}$: Rate of electricity / diesel / natural gas price.
- HDD_{M} : Annual heating degree days at municipal level.
- CDD_{M} : Annual cooling degree days at municipal level.
- HDD_{N} : Average value of annual heating degree days at national level.
- CDD_{N} : Average value of annual cooling degree days at national level.
- $HDD_{M/N}$: Annual heating degree days at municipal level / Average value of annual heating degree days at national level.
- $CDD_{M/N}$: Annual cooling degree days at municipal level / Average value of annual cooling degree days at national level.
- GDP_{pcM} : Rate of per capita gross domestic product at municipal level.
- $GDP_{pcM/N}$: Per capita gross domestic product at municipal level / Per capita gross domestic product at national level.
- ECG_{pct} : Rate of energy consumption growth of the transport sector at national level.
- $ECG_{T/R/I/PCT/A}$: Rate of energy consumption growth of the tertiary/residential/industry/private and commercial transport/agricultural sector at national level.
- DV_{rn} : Development index of road network.
- a, b, c: Correction factors (different in each sector).

Stakeholders' Engagement

Stakeholders' engagement in the decision-making process of the Action Plan's elaboration and development is crucial. To this end, a participatory planning approach can be used, in order to have a first evaluation of the alternative scenarios. A mix of qualitative and quantitative techniques are proposed in this step to approach stakeholders, including emailing, phone interviews, face-to-face meetings, questionnaires, focus groups, consultation meetings, workshops.

Aspiration Level

Following the development of alternative scenarios and the participatory planning, all the proposed scenarios are evaluated, initially, through aspiration levels. The approach involves the decision-maker choosing level of the objective that he desires to achieve regarding CO_2 emissions reduction (aspiration level).

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"CHOOSE" COMPONENT

Criteria Selection

A number of criteria have been identified, according to the needs and opportunities of the sustainable development dimensions, namely the economic, social and environmental (Marinakis et al., 2017). The selection of criteria is based on the proposed indicators by the Covenant that could be used by the local authority to describe key actions highlighted as Benchmarks of Excellence. Most of these criteria have been also applied to solve multicriteria problems in other related energy aspects, such as the formulation of sustainable technological energy priorities (Doukas et al., 2010; 2007), identification of sustainable energy technology priorities for electricity generation under Clean Development Mechanism (Karakosta et al., 2009), ranking of renewable energy supply systems (Şengül et al., 2015) and evaluation of thermal-energy storage (Cavallaro, 2010).

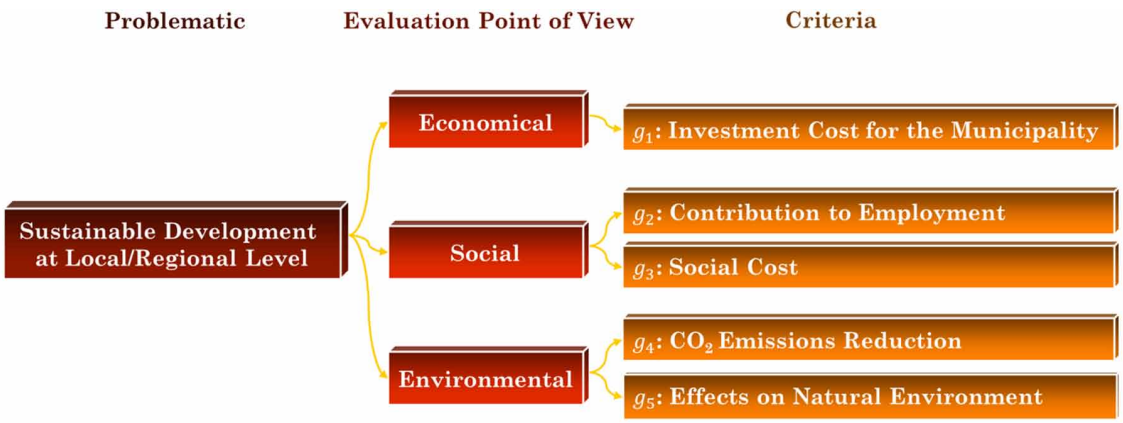
The selected criteria satisfy the following requirements: monotony; exhaustiveness; cohesiveness; and non redundancy (Roy, 1985). Under these requirements we ensure consistency of the family. Moreover, the selected criteria are preferentially independent, namely the trade-offs between the g_i and g_j criteria are not dependent on the values of the rest of the criteria (Siskos et al., 2014).

More specifically, the necessary hypothesis to validate an additive value function for a given decision maker is the preferential independence of all criteria.

The identified criteria are the following (Figure 5):

- g_1 – *Investment Cost for the Municipality (Quantitative Criterion - €):* Economic magnitude, expressing the cost for the implementation of renewable energy and rational use of energy actions by the local authorities. The cost may include actions in the municipal buildings, equipment/facilities, public lighting, municipal fleet and public transport, local energy production, as well as awareness raising activities in the agricultural, residential, tertiary sector and transport. The estimated investment cost for the municipality can be calculated by the following equation:

Figure 5. The multicriteria evaluation system



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$$IC = \sum_{i=1}^{m}\sum_{k=1}^{l} IC_{A_{ik}} \tag{19}$$

where $IC_{A_{ik}}$ the investment due to the implementation of the action A_{ik} by the local authorities; i represent the number of sector and k the number of action within the relevant sector (S_1 - Agricultural/ Fishery/ Forestry Sector; S_2 - Municipal Buildings, Equipment/ Facilities; S_3 - Residential & Tertiary Sector; S_4 - Public Lighting; S_5 – Industry; S_6 - Municipal Fleet and Public Transport; S_7 - Private and Commercial Transport; S_8 - Local electricity production and S_9 - Local District Heating / Cooling). All the actions A_{ik} are presented in Table 2. The higher the cost of the examined Scenario, the lower is its performance to this criterion.

- g_2 – *Weighted Average Cost of Energy Saving (Quantitative Criterion - €/kWh):* Evaluation of the potential profitability of the examined Scenario through the following equation.

$$\begin{pmatrix}\text{Weighted}\\ \text{Average}\\ \text{Cost of}\\ \text{Energy Saving}\end{pmatrix} = \frac{\begin{pmatrix}\text{Initial Investment}\\ \text{Cost}\end{pmatrix} \text{x} \dfrac{ir}{1-\left(ir+1\right)^{-Duration}} + \begin{pmatrix}\text{Annual Maintenance}\\ \text{Cost}\end{pmatrix}}{\text{Annual Energy Saving}} \tag{20}$$

where ir is the interest rate.

It should be note that this criterion integrates the present value of the Scenarios' cash flow, ensuring in this way the independence property among criteria. It was selected since represents the minimum rate of return at which the authority produces value for its investors. The higher the value of the examined Scenario, the lower is its performance to this criterion.

- g_3 – *Contribution to Employment (Qualitative Criterion):* Reflects the impact of the examined Scenario in the social dimension regarding the creation of new jobs. The employment generated is often divided into two categories: investment (the most employment intensive part) and operation / maintenance (which last for the entire project's lifetime). It is a qualitative criterion and is derived as average value of the proposed actions in each Scenario. The performance of this criterion is assigned based on a 1-5 ordered qualitative scale, namely "1" very low (lower than 1%[1]), "2" low (higher than 1% and lower than 2%[2]), "3" moderate (higher than 2% and lower than 3%[2]), "4" high (higher than 3% and lower than 4%[2]) and "5" very high (higher than 4%[2]) contribution to employment regarding the particular Scenario.
- g_4 – *Social Cost (Quantitative Criterion - €/resident):* Reflects the total investment cost from the interventions of the local population (agricultural and residential sector, transport, etc). The estimated social cost can be calculated by the following equation:

$$IC = \sum_{i=1}^{m}\sum_{k=1}^{l} IC_{I_{ik}} \tag{21}$$

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where $IC_{I_{ik}}$ the social cost due to the implementation of the intervention I_{ik} by the local population. i represent the number of sector and k the number of action within the relevant sector. All the actions I_{ik} are presented in Table 2. The higher the social cost of the examined Scenario, the lower is its performance to this criterion.

- $g_5 - CO_2$ *Emissions Reduction (Quantitative Criterion - %):* Estimated reduction of the CO_2 emissions that will be achieved through the implementation of all the proposed renewable energy and rational use of energy actions of each Scenario by 2020. The calculation of this criterion is based on the following data:
  - Development of the baseline *emission* inventory;
  - Estimation of the total CO_2 emissions reduction by 2020 using the calculations for the energy saving and production and related emissions factors.

$$CO2_{\%} = \frac{CO2_{base} - CO2_{reduction}}{CO2_{base}}$$

$$CO2_{base} = \sum_{i=1}^{m}\sum_{j=1}^{n} EC_{S_i j}\, x\, EF_j$$

$$CO2_{reduction} = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(\sum_{k=1}^{l} ER_{A_{ik}j}\, x\, EF_i + \sum_{k=1}^{l} ER_{I_{ik}j}\, x\, EF_i\right) \quad (22)$$

where:

$CO2_{\%}$: Percentage of CO_2 emissions reduction due to the implementation of the Scenario (%)

$CO2_{base}$: Total CO_2 emissions in the baseline year ($tnCO_2$)

$CO2_{reduction}$: Total CO_2 emissions reduction due to the implementation of the Scenario ($tnCO_2$)

$EC_{S_i j}$: Consumption of the type of energy j in the sector S_i (MWh); for j = 1: electricity, 2: heat/cold, 3: natural gas, 4: liquid gas, 5: heating oil, 6: diesel, 7: gasoline, 8: biomass, 9: solar thermal, 10: electricity, 11: other.

EF_j : Emission factor for the type of energy j ($tnCO_2$/MWh).

$ER_{A_{ik}j}$, $ER_{I_{ik}j}$: Energy reduction of the type of energy j due to the energy saving/production of the action A_{ik} and / or the intervention I_{ik} .

The higher the emissions reductions of the examined Scenario, the higher is its performance to this criterion.

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- g_6 – *Effects on Natural Environment (Qualitative Criterion):* Reflects the Scenarios' interference level regarding the natural environment (e.g. visual intrusion, pressure on land resources and excessive land use). The performance of this criterion is assigned based on a 1-5 ordered qualitative scale, namely "1" very high, "2" high, "3" moderate, "4" low and "5" very low impact regarding the particular Scenario.

Following the criteria descriptions, the relevant evaluation scales are depicted in Table 4.

Multicriteria Ordinal Regression Approach

An additive value model is proposed. A number of methods to obtain the proposed value system can be found in the literature (Figueira et al., 2005; Keeney, 1992; Farquhar, 1984), which requires explicit trade-offs between economic, political and social criteria. Taking into account the amount of cognitive effort needed, or for ethical reasons, their application in real world decision environments remains questionable. To this end, the analysts prefer to infer the additive value model from global preference structures, by applying disaggregation or ordinal regression methods. A survey of these methods and synergy of methods for the assessment of additive value models was recently presented by Hurson and Siskos (2014), such as MACBETH technique, the standard MAUT trade-off analysis and UTA-based methods (UTA I, UTA II, UTAGMS, GRIP, RUTA, etc.). UTA methods not only adopt the aggregation disaggregation principles, but they may also be considered as the main initiative and the most representative example of preference disaggregation theory (Siskos, 2005).

The proposed additive value model is described by the following form:

$$\mathrm{u}\left(\mathbf{g}\right) = \sum_{i=1}^{n} p_i u_i\left(g_i\right) \tag{23}$$

subject to normalization constraints:

$$\sum_{i=1}^{n} p_i = 1$$

Table 4. Criteria evaluation scale

	Index	Worst Level	Best Level
G1	Quantitative (€)	120,000,000	0
G2	Quantitative (€/kWh)	0.2	0
G3	Qualitative	1	5
G4	Quantitative (€/resident)	2,000	0
G5	Quantitative (%)	20	100
G6	Qualitative	1	5

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$$u_i\left(g_{i_*}\right)=0\,,\ u_i\left(g_{i^*}\right)=1,\forall i=1,2,\ldots,n \tag{24}$$

where $\boldsymbol{g}=\left(g_1,g_2,\ldots,g_n\right)$ is the performance vector of an alternative scenario on the n criteria; g_{i_*} and g_{i^*} are the least and most preferable levels of the criterion g_i, respectively; $u_i, i=1,2,\ldots n$ are non-decreasing real valued functions, named marginal value or utility functions, which are normalized between 0 and 1, and p_i is the relative weight of u_i.

Both the marginal and the global value functions have the monotonicity property of the true criterion. For instance, in the case of the global value function the following properties hold:

$$u\left[\boldsymbol{g}\left(a\right)\right]>u\left[\boldsymbol{g}\left(b\right)\right] ifa\succ b\left(preference\right)$$

$$u\left[\boldsymbol{g}\left(a\right)\right]=u\left[\boldsymbol{g}\left(b\right)\right] ifa\sim b\left(indifference\right) \tag{25}$$

The existence of the preference model assumes the preferential independence of the criteria for the decision maker (Keeney and Raiffa, 1976), while other conditions for additivity have been proposed by Fishburn (1966, 1967). This assumption does not pose significant problems in a posteriori analyses such as disaggregation analyses.

A number of methods to obtain the proposed value system can be found in the literature (Figueira et al., 2005; Keeney, 1992; Farquhar, 1984), which requires explicit trade-offs between economic, political and social criteria. Taking into account the amount of cognitive effort needed, or for ethical reasons, their application in real world decision environments remains questionable.

To this end, the analysts prefers to infer the additive value model from global preference structures, by applying disaggregation or ordinal regression methods. A survey of these methods and synergy of methods for the assessment of additive value models is recently presented by Hurson and Siskos (2014), such as MACBETH technique, the standard MAUT trade-off analysis and UTA-based methods (UTA I, UTA II, UTAGMS, GRIP, RUTA, etc).

Over the past three decades UTA-based methods have been applied in several real-world decision-making problems (see Siskos et al., 2005 for a comprehensive survey on UTA methods and applications), with the most recent efforts focused on e-government (Siskos et al., 2013; 2014). Although, UTA method has been applied to a number of problems regarding sustainable development, such as energy efficiency, wastewater treatment and environmental issues (Sola & Mota, 2012; Demesouka et al., 2013; Kholghi, 2001), there are not studies regarding sustainable energy planning at local / regional level.

In this context, a flexible and transparent approach is the UTA II method, proposed by Siskos J. (1980), which has been used for the examined decision aiding problem. This method aims at inferring one or more additive value functions from a given ranking on a reference set of actions A_R (Jacquet-Lagrèze and Siskos, 1982). It uses special linear programming techniques to assess these functions so that the ranking(s) obtained through these functions on A_R is as consistent as possible with the given one. UTA II method includes the following two phases:

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- *Phase I: Construction of the marginal value functions* $u_i\left(g_i\right)$. The idea of least square approximation is used, in order to fit a polynomial function P(x) to a set of data points (x_i, y_i) having a number of theoretical solution (provided by the decision maker through an interactive process).
- *Phase II: Estimation of the criteria weights* p_i
  - Selection of a reference set*:* For the construction of the reference set by the analyst, virtual scenarios are selected. The decision maker is asked to provide a ranking (weak order) of the virtual scenarios. In each comparison, the two scenarios are differed in two or at most three criteria values, so as to be possible by the decision maker to evaluate the scenarios. As result, the scenarios of the reference set $A_R = \left\{a_1, a_2, \ldots, a_m\right\}$ are rearranged in such a way that $a_i \succ a_{i+1}$ or $a_i \sim a_{i+1}$.
  - Linear programming techniques*:* UTA II introduces two error functions σ^+ and σ^- on A_R by writing for each pair of consecutive actions in the ranking the analytic expressions:

$$\Delta\left(a_i, a_{i+1}\right) = \sum_{i=1}^{n} p_i \left\{u_i\left[g_i\left(a_i\right)\right] - u_i\left[g_i\left(a_{i+1}\right)\right]\right\} - \sigma^+\left(a_i\right) + \sigma^-\left(a_i\right) + \sigma^+\left(a_{i+1}\right) - \sigma^-\left(a_{i+1}\right) \quad (26)$$

where:
$a_i \in A_R$ and $\sigma^+\left(a_i\right), \sigma^-\left(a_i\right)$ are the overestimation and the underestimation error respectively.
Then, the following linear program is solved:

$$\left[min\right] F = \sum_{i=1}^{m} \sigma^+\left(a_i\right) + \sigma^-\left(a_i\right)$$

subject to:

$$\Delta\left(a_i, a_{i+1}\right) \geq \delta, if\ a_i \succ a_{i=1}$$

$$\Delta\left(a_i, a_{i+1}\right) = 0, if\ a_i \sim a_{i=1}$$

$$\sum_{i=1}^{n} p_i = 1,\ p_i \geq 0\ ,\sigma^+\left(a_i\right) \geq 0, \sigma^-\left(a_i\right) \geq 0\ \forall a_i \in A_R$$

with δ being a small positive number. (27)

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Moreover, the existence of multiple or near optimal solutions of the above linear program is evaluated. To this end, the mean additive value function of near optimal solutions which maximize the functions $u_i\left(g_i^*\right)$ on the polyhedron of the constraints of the linear program (8) is calculated.

Robustness Analysis

Another important issue is the robustness of the evaluation model. UTA^{GMS}, GRIP, RUTA, extreme ranking analysis and the robustness measurement control are the most recent UTA-type methods (Greco et al., 2008; Figueira et al., 2009; Kadzinski et al., 2013; Kadzinski et al. (2012); Kadzinski & Tervonen, 2013a, 2013b; Greco et al., 2012). In this context, the adopted approach search for multiple solutions based on the use of the extreme ranking analysis of Kadzinski et al. (2012). The approach evaluates the performance of each alternative relative to all other alternatives in a reference set A, determining the best and the worst ranks, and the score that an alternative can attain.

In order to identify the highest rank of an alternative in the ranking provided by any compatible value function (or any compatible outranking mode) the following mixed integer linear program is calculated:

$$\left[min\right]F = \sum_{b \in A \setminus \left\{a\right\}} u_b$$

Subject to:

$$E_u^{A_R}$$

$$U\left(a\right) \geq U\left(b\right) - Mv_b$$

$$\text{for all } b \in A \setminus \left\{a\right\} \tag{28}$$

where M is an auxiliary variable equal to a big positive value and v_b is a new binary variable associated with comparison of a to alternative b. In order to identify the lowest rank of an alternative in the ranking provided by any compatible value function (or any compatible outranking mode) the following mixed integer linear program is calculated:

$$\left[min\right]F = \sum_{b \in A \setminus \left\{a\right\}} u_b$$

Subject to:

$$E_u^{A_R}$$

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$$U\left(b\right) \geq U\left(a\right) + \varepsilon - Mv_b$$

for all $b \in A \setminus \left\{a\right\}$ (29)

where M is an auxiliary variable equal to a big positive value, ε is equal to a small positive value, and v_b is a new binary variable associated with comparison of a to alternative b.

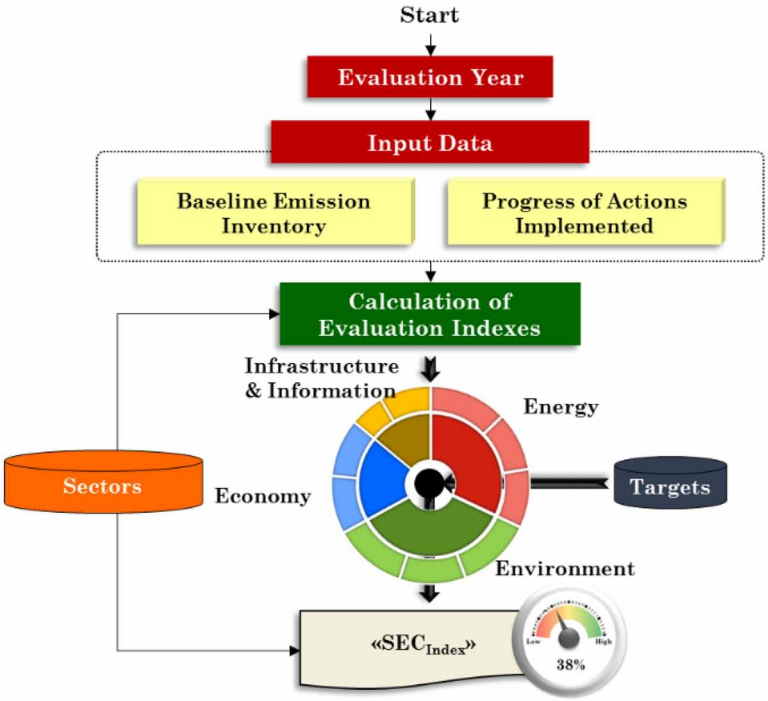
"CHECK" COMPONENT

The final stage of the proposed framework includes the "Methodological Approach for Monitoring SEC Targets". The overall philosophy of the proposed approach is presented in Figure 6.

Indicators

The methodological approach consists of monitoring indicators that are structured in four main categories "Energy", "Environment", "Economy"," Infrastructure and ICT". Table 5 presents the indicators (I_{ij}) for each category "i".

Figure 6. Philosophy of the methodological approach for monitoring SEC targets



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Table 5. Monitoring indicators

Symbol	Evaluation Indicators
I_1	**Energy**
I_{11}	Energy consumption per capita
I_{12}	Electricity use in final energy consumption
I_{13}	Use of fossil fuels in final energy consumption
I_2	**Environment**
I_{21}	CO_2 emissions per capita
I_{22}	CO_2 emission intensity
I_{23}	Use of renewable energy sources
I_3	**Economy**
I_{31}	Total budget spent
I_{32}	Actions funding through external sources
I_4	**Infrastructure and ICT**
I_{41}	Level of integration of automations, smart meters and ICT solutions
I_{42}	Level of awareness

The indicators are described more extensively in Table 6.

The analysis descripted before, is summarized in the following Figure 7.

Description of the "SEC_{Index}"

The composite index "SEC_{Index} (Sustainable Energy Community Index)" was introduced. The procedure for the development of the "SEC_{Index}" was based on a "proximity-to-target" approach. More specifically, for each indicator, the distance from the setting target is calculated. Thus, the values of the evaluation indicators are transformed into a scale of "0-100" with "100" to be the maximum efficiency and "0" the minimum efficiency.

The "SEC_{Index}" is calculated based on a cumulative two-scale procedure. By taking as reference the ten evaluation indicators; the scores of the four categories are calculated, and thus the "SEC_{Index}" composite index. It is noted that each evaluation indicator is assessed in each category with a different weighting factor. The determination of the weighting factors is completed with the participation of experts, through filling in appropriate questionnaires (in parallel with the procedure that was followed for the equations of the future estimated progress of the consumptions and CO_2 reductions. The values of the weighting factors are shown in Table 7.

Based on the previous analysis, the equation for the calculation of the "SEC_{Index}" in each activity sector is the following:

$$SEC_{Index_k} = \sum_{i=1}^{4} \sum_{j=1}^{2\blacklozenge3} w_{ij} \frac{I_{evaluation_ij} - I_{base_ij}}{I_{target_ij} - I_{base_ij}} \tag{30}$$

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Table 6. Description of the monitoring indicators

I_{11}: Energy Consumption Per Capita	
Description	It reflects the final consumption of energy in each sector of the municipality.
Calculation	It comes as a result of the sum of individual consumptions per type of energy, divided with the total population of the municipality during the year of evaluation.
Units	MWh/capita
I_{12}: Use of Electricity in the Final Energy Consumption	
Description	It expresses the percentage of electricity usage in the final energy consumption.
Calculation	It comes as a result of the electricity energy consumption, divided by the total energy consumption in the sector of interest.
Units	Percentage (%)
I_{13}: Use of Fossil Fuels in Final Energy Consumption	
Description	It reflects the percentage of fossil fuel (gasoline, heat oil, diesel, etc.) in final energy consumption.
Calculation	It comes as a result of the consumption of fossil fuels, divided by the total energy consumption in the specific sector.
Units	Percentage (%)
I_{21}: CO_2 Emissions Per Capita	
Description	It indicates the total CO_2 emission in the specific area
Calculation	It comes as a result of the sum of CO_2 emission per form of energy, divided by the total population of the municipality during the year of evaluation.
Units	$tnCO_2$/capita
I_{22}: CO_2 Emissions Intensity	
Description	It expresses the scale of CO_2 emission per unit of consumption.
Calculation	It comes as a result of the sum of CO_2 emission per energy form, divided by the total energy consumption.
Units	$tnCO_2$/MWh
I_{23}: Use of Renewable Energy Sources	
Description	It reflects the penetration of renewable energy sources in the area.
Calculation	It comes as a result of the total production of energy from renewable energy sources (for electricity and heat/cooling), divided by the total population of the area during the year of evaluation.
Units	MWh/capita
I_{31}: Total Budget Spent	
Description	It indicates the total budget that has been exploited for the implementation of the expected measures and actions in each sector of activation.
Calculation	It comes as a result of the total budget spent, divided with the total population of the year during the year of evaluation.
Units	€/capita
I_{32}: Actions Funding Through External Sources	
Description	It indicates the total amount of funding for action through external sources.
Calculation	It comes as a result of the total amount of funding, divided with the total population of the area during the year of evaluation.
Units	€/capita
I_{41}: Level of Integration of Automations, Smart Meters and ICT Solutions	
Description	It expresses the level of integration of Automations, Smart Meters and ICT Solutions, etc.
Calculation	It comes as a result of the total energy monitored by the smart meters, BEMS, ICT, divided with the total energy consumption.
Units	Percentage (%)
I_{42}: Level of Awareness	
Description	It reflects all the final users in each sector that have participated in actions of orientation and awareness.
Calculation	It comes as a result of the percentage of final users that have participated in actions of orientation and awareness.
Units	Percentage (%)

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Figure 7. Monitoring indicators

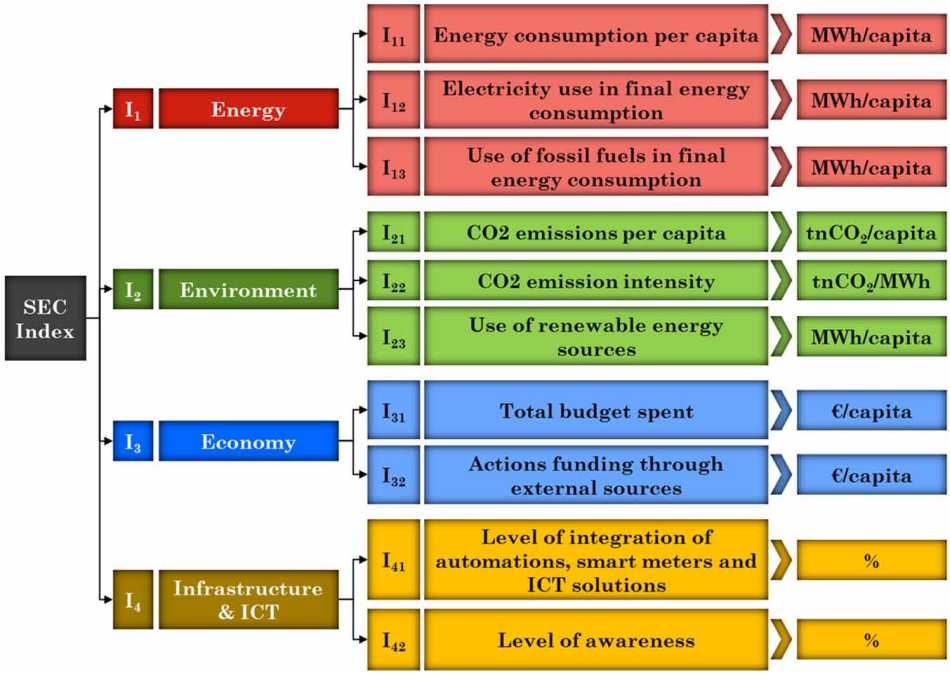


Table 7. Weights of the monitoring indicators

Category	Monitoring Indicator	Weight
Energy (32%)	Per capita energy consumption	12,8%
	Percentage of electricity use in final energy consumption	9,6%
	Percentage of fossil fuel use in final energy consumption	9,6%
Environment (35%)	Per capita CO_2 emissions	12,25%
	CO_2 emission intensity	10,85%
	Use of renewable energy sources	11,9%
Economy (19%)	Total budget spent	9,5%
	Percentage of funding from external sources	9,5%
Infrastructure & Information (14%)	Level of integration of automations, smart meters and ICT solutions	5,6%
	Level of awareness	8,4%

where:

SEC_{Index_k} The value of the complex index "SEC_{Index}" for each activity sector k

w_{ij} The weighting factor of index j of category i

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I_{target_ij} The target for evaluation index I_{ij}

I_{base_ij} The value of evaluation index I_{ij} for the base year

$I_{evaluation_ij}$ The value of evaluation index I_{ij} for the evaluation year

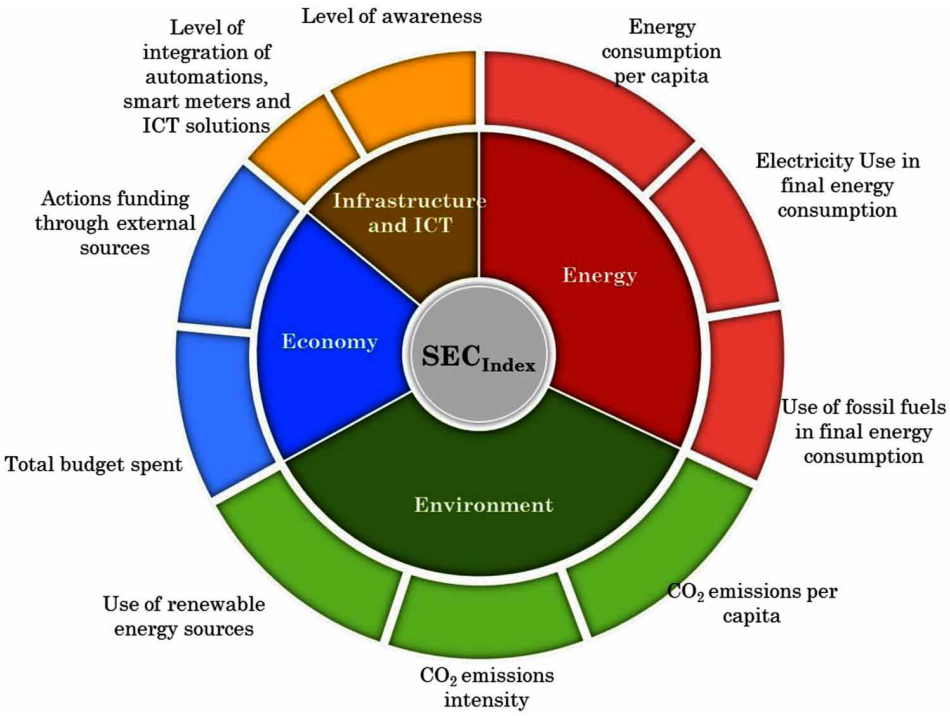
Thus, the "SEC_{Index}" index shows the progress achieved in the specific activity sector in regards to the accomplishment of the targets which were defined during the development of the Sustainable Energy and Climate Action Plan (Figure 8).

Finally, for better visualization of the final results, the following graph is used (Figure 9). It is noted that based on the values of "SEC_{Index}" of each activity sector, it is possible to calculate the total "SEC_{Index}" of the municipality.

CONCLUSION

The potential replication of the proposed framework relies on the necessity for the cities and communities to create their Sustainable Energy and Climate Action Plan. This stepwise framework, which

Figure 8. General philosophy of the "Methodological Framework for Approach SEC Targets"



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Figure 9. Visualization of the final results from the "SECIndex" index



guides the local and regional authorities in the development of the alternative Scenarios for the region and their evaluation, is simple, concise and comprehensive. The MPC+ framework can be widely used by and support different types of municipalities. Moreover, its general formation is strictly based on the Guidelines provided by the Covenant of Mayors, while it has been enhanced with additional aspects, as summarized below:

- Integration of the multicriteria analysis and robustness analysis in the Action Plan's development, providing a comprehensive evaluation of alternative Scenarios; support to the decision making for the selection of the most appropriate sustainable renewable energy and rational use of energy technologies for the Sustainable Energy and Climate Action Plan.
- A knowledge-based process for the initial design of alternative Scenarios in the region, taking into consideration its specific characteristics and main priorities (energy baseline, etc.).
- Integration of the local stakeholders' views on the formulation of alternative Scenarios for the region, raising the public awareness and making their citizens more self-conscious about the energy they consume and the new projects in the area.

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ENDNOTE

[1] Increase of employment.

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Chapter 18
Enablers of Sustainable Manufacturing Overview, Framework and Further Research Directions

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ABSTRACT

The aim of this paper is to develop a conceptual sustainable manufacturing (SM) framework, which is the pressing need of highly competitive and natural resource scarce world. Systematic literature review has been adopted to identify enablers of SM. The enablers identified through systematic literature review includes product design, material selection & procurement, customer requirements, regulatory norms, social values & ethics, environmental priorities, energy costs, natural resource scarcity, supply chain & logistics systems, fuel price regulations, public awareness, technology and total quality management. Author has attempted to develop a contextual relationship among enablers of SM using interpretive structural modeling. The author has further classified enablers into four categories using MICMAC analysis. The author has also outlined the limitations of present study and identified further research directions.

1. INTRODUCTION

Sustainable manufacturing is the need of the current era as global warming, manmade pollution and natural resource scarcity are becoming like a sword of Damocles to the world. Insights from the literature on the topic show that, sustainability in manufacturing must be taken into consideration from the product design stage through production to the logistics stage. Sustainability has got three aspects in manufacturing. These aspects includes: 1) the manufacturing sustainability in the production process; 2) sustainability during the use of the product, 3) sustainability for the recycling and logistics point of view. We can say that product design, material selection, manufacturing process design and resource

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utilization as the factors of first aspect; environmental emission from the product, ease of maintenance etc. as the factors of second aspect and ease of disassembly, recyclability, reusability of materials as the factors of third aspect. According to Garbie (2014); Carter and Easton (2011); Dyllick and Hockerts (2002), Environment, society and economy are the three widely accepted components of sustainability. Manufacturing can be defined as the process of converting raw materials into value added useful tangible finished products for a specific use through one or more operations. Hence, sustainable manufacturing can be defined as the innovative technology and organizational practices which ensures zero negative impact to the environment, community, employees with the minimum use of raw materials and energy and which produces high quality recyclable finished products. Different viewpoints and definitions on sustainability and sustainable development from different literature are listed in Table 1. Through

Table 1. Definitions of Sustainability

Author(s), (Year)	Definition
IPCC, Copenhagen, Denmark (2014).	Sustainable Development is defined as the one which is based on three pillars such as economic, social and environmental and preserves the interests of future generations and ecosystem services and balance on which the existence of human kind is dependent on.
Institute for Sustainability (2011)	Sustainability can be defined as increasing the productivity by minimizing the resources used without compromising on service quality, profitability and competitiveness to help to preserve the environment.
Jayal et al. (2010)	Sustainability is the term which can be achieved only through an integrated approach incorporating closed loop supply chain, manufacturing process and systems, multiple product life-cycles etc. at product process and system levels with the objective of reduce, reuse, recover, redesign, remanufacture and recycle.
Ciceri et al. (2010)	Sustainability is a quality which helps to preserve, save and keep.
Hutton et al. (2007)	Sustainable development can be defined as the one which helps to fulfill the needs of the present without compromising the capability of the future to fulfill their own needs.
Barber (2007)	Sustainable production and consumption is defined as the system which helps to meet the human needs and improve the quality of life through social and economic improvement for all, including future generations, while maintaining the ecosystems on which human life is depended up on.
Asheim et al. (2007)	Sustainability is defined by using the framework of ethical social choice theory and explains that sustainable behavior is the ethically justifiable treatment of all future generations with equity and efficient consistent consumption of natural resources.
Seliger (2007)	Sustainability is defined as the direction in which the living standards of human being is improved at the same time the availability of natural resources and ecosystems are also preserved and improved for future generations.
Jenkins and Yakovleva (2006)	Sustainable development is defined as the progress in economic development, environmental protection and social consistency.
Szekely and Knirsch (2005)	Sustainability is the process by which organizations amalgamate their social, economic and environmental objectives with the organization strategic goals and balances all these three dimensions in an optimum way.
Stavins et al. (2003)	Sustainable growth is defined in an economic framework as the one which is both dynamically efficient and non-decreasing over time.
Deloitte and Touche (1992)	Sustainability can be defined as the process of adopting new business strategies and ideas which will fulfill today' needs of the organization and all other stakeholders, which will protect, sustain and enhance all natural and human resources for the requirement of the future.
UN - The World Commission on Environment and Development (1987)	Sustainable development can be defined as the usage of resources, investment guidelines, technological advancement and organizational changes are made to meet the need of the present as well as of future generations consistently.

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systematic literature review, the authors have identified twelve key driving factors of sustainable manufacturing. Since these factors are much broad in their sense, sub-dimensions of these variables are also elaborated from literature.

2. LITERATURE REVIEW

As a part of systematic literature review, the authors started the review from analyzing the history of manufacturing itself, which helps to give insights into the evolution of sustainable manufacturing. According to Brundtland Commission (1987), the word sustainable implies the use of consistent practices which will ensure zero negative repercussions to the future generations due to the prevailing practices. Davidson et al. (2010) foresee the need to educate future engineers and new generation about sustainable development (SD) practices by including SD workshops and educational materials in their curriculum to meet increasing environmental, resource scarcity and social threats of 21st century. Miller et al. (2010) show how the theories of sustainable manufacturing help to attain competitive advantage for a small scale industry through waste reduction, supply chain network optimization and recycling of waste materials by using discrete event simulation and mathematical modeling technique. Pham and Thomas (2011) and Thomas et al. (2012) also explain the sustainability issues with small and medium scale industries and propose a fit manufacturing strategy starting from strategy development through financial planning to operationalization with one team one vision for better coordination. Joung et al. (2013) classifies the sustainability indicators into five major enablers of sustainable manufacturing such as environmental, social, economic, technology and performance but didn't go in detail about the interrelationship among the indicators.

2.1. Evolution of Sustainable Manufacturing

At the start of industrial revolution in the 17th century, the one and only one objective of manufacturers was to somehow explore the available natural resources and to convert them into to useful end products to meet the human need. As time passed, during the era of 18th century, manufactures tried to increase efficiency and productivity through automation and scientific industrial engineering techniques. As the living standard of people and the competition between manufactures increased, the major focus was on the product quality and price control during the 19th century. Pressure of competition forced manufactures to strive for excellence through various manufacturing concepts such as world class, agile, flexible, lean, and green manufacturing techniques. Jin-Hai et al. (2003) and Parkinson (1999) define agile manufacturing as a concept which is driven by competition and is designed to meet quickly changing customer tastes with a faster response rate and more flexibility. Slack (2005); Kaighobadi and Venkatesh (1994) explain the concept of flexible manufacturing systems as the one which helps manufactures to have wider variety and faster response to market changes and to get economic advantage of batch manufacturing through technology flexibility, labor flexibility and infrastructure flexibility. Hayes and Wheelwright (1985) classified manufacturing organizations into four stages, and used the term "world class manufacturing firms" for the first time, to refer to the fourth stage organizations. According to Hayes and Wheelwright, those organizations which are very progressive and having long range business plans through continuous improvement and newer technologies and strive to make manufacturing

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as a major competitive success factor of the organization can be called as world class organizations. The next challenge was to quantify the term world class, which resulted to the origin of a new term known as 'lean manufacturing'. Oliver et al. (1996); Pettersen (2009) and Womack et al. (1990) define lean as a management concept originated from Japan's Toyota Production System (TPS) which tries to minimize wastage or non-value adding processes and use less of everything including inventory through techniques such as Just in Time (JIT) to produce high quality products. According to National Oceanic and Atmospheric Administration report published in 2005, since industrial revolution there is a 35% increase in the level of carbon dioxide all over the world within a period of three centuries. Houe and Grabot (2009) show that the increased customer awareness on environmental issues forced companies for go for more natural friendly products and production processes. To get competitive advantage, Zhu et al. (2007) emphasizes that: with the new regulatory norms put by various governments to reduce carbon emissions and to control global warming also forced manufactures to shift their manufacturing strategy from merely output based to a more environmental friendly one. This resulted in the evolution of green manufacturing concept. Dubey and Bag (2014) define green manufacturing concept as the one which intends to achieve environmental sustainability and to minimize carbon emission by eliminating environmentally harmful wastages and using innovative technologies to change the existing processes. Deif (2011) elaborates the green manufacturing concept as the one which is eco-efficient, uses less non-toxic energy and material which produces no unwanted outputs and byproducts, and output to input conversion is possible. Sustainable manufacturing philosophy is evolved in twentieth century, which considers not only the environment like green manufacturing; but all other factors such as social and economic. Garbie (2014); Garetti and Taisch (2011) explicitly state that the three pillars of sustainability includes social, environment and economic. Molamohamadi and Ismail (2013) propose to add technology, education, ethic and accountability along with the main three pillars of social, environment and economic. Jayal et al. (2010) differentiates all these manufacturing concepts more clearly and in a very simple way as: traditional manufacturing is substitution-based; lean-manufacturing as waste reduction based; green manufacturing as environmentally begin and based on 3Rs such as Reduce, Reuse and Recycle; and finally sustainable manufacturing as based on 6R such as Reduce, Reuse, Recycle, Recover, Redesign, and Remanufacture with innovation. Kuik et al. (2011) further develop a clear framework by dividing the first 3Rs of Reuse, Recover and Redesign for product design and Reduce, Recycle and Remanufacture for process improvement towards the journey to sustainability. Stoughton and Ludema (2012) use a grounded theory approach to model and analyze perceptions of sustainability at senior leadership level, functional level and individual level of an organization and how to integrate all these views to achieve sustainable development within an organization. Literature reviewed on sustainable manufacturing and the brief description regarding the objective and findings of each paper is described in Table 2.

2.2. Classification of Literature

All the literature are classified under four broad pillars of sustainable manufacturing such as economy, social, environment and technology based on ESET context proposed by Jovane et al. (2008). According to the global survey conducted by Kiron et al. (2013) from MIT Sloan Management Review and the Boston Consulting group, shows that the main three social issues in achieving sustainability as the health and well-being of employees, the community and customers; the top most environmental issues in achieving sustainability as energy efficiency, pollution and waste management and the top most economic concern in achieving sustainability as competitiveness. According to Kara et al. (2014), even though the sustain-

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Table 2. Research in Sustainable Manufacturing

Author(s), (Year)	Research Objective	Research Findings
Garbie (2014)	To model the components of sustainable manufacturing and to make a performance assessment framework up to sustainable development level from a micro-level point of view based on the three pillars of social, economic and environment.	Sustainable development index is developed by considering social, environmental and economic factors. Using analytical hierarchy Process weight of each sub-factors under each pillars are found out.
Garetti et al. (2012)	To identify the main aspects of sustainable manufacturing from literature review.	Review of selected papers is done and different viewpoints of sustainable manufacturing systems are explained.
Gunasekaran and Spalanzani (2012)	To build a framework for sustainable business development by using the methodology of literature review.	A classical review is made which helps to give the research areas and techniques used in sustainable business development in manufacturing and service. A framework is made for sustainable business development in service and manufacturing through literature review technique.
Garetti and Taisch (2011)	To make the roadmap and strategy for the manufacturing research by 2020 for achieving smart, sustainable and inclusive growth.	Sustainable manufacturing framework is made with technology and education as enablers and by using four broad research clusters for sustainable manufacturing.
Jayal et al. (2010)	To present an overview of recent trends in sustainable manufacturing product, process and system development.	Evolution of sustainable manufacturing is explained with the 6R concept for sustainable manufacturing product, process and systems development. Performance measurement for processes for achieving sustainability is also explored by the author.
Garbie (2013)	Development of enterprise level sustainability model for manufacturing firms, to become globalized sustainable enterprise in economic point of view.	Mathematically modeled the sustainability index by considering seven factors and suggests considering the sustainability from the starting of the design of an enterprise itself.
Davies and Kochar (2002)	To review the methodologies adopted so far to define the best practices in the manufacturing industry and to find out how these best practices can be used to improve the company performance.	A particular common best practice method can't be applied to all types of industries in general. Best practices must be tailor made to best suit to the particular company under study. Effectiveness of best practices must be evaluated by checking the overall performance improvement of the company.
Azzone and Noci (1998)	To define different green manufacturing strategies and to analyze, how to make an environmental performance measurement system framework for various green manufacturing strategies.	Environmental performance measurement system (PMS) design architecture is developed for each manufacturing strategies and concludes that it is more difficult to design PMS in pro-active companies rather than re-active companies.

able product design strategy is different for different companies based on their size, regional location etc. some common driving factors are considered by every manufactures for sustainable product development, which include: customer awareness, legislation, economic benefits and competitive strategies and life cycle assessment. So, all the driving factors of sustainable manufacturing identified through systematic literature review are classified under these four different dimensions. Environment dimension includes Environmental priorities, Natural resource scarcity; Social dimension includes Regulatory norms, Fuel price regulations, Public awareness, Social values & ethics; Economic dimension includes Material selection & procurement, Energy costs and Technology & Operations includes Customer requirements, Product design, Supply chain & logistics systems and Technology & total quality management.

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2.2.1. Environment Dimension

Most of the literature reviewed on sustainability gives very high weightage for environment factor. The main factors discussed under environment dimension are carbon footprint concerns and the requirements for energy efficiency. Intergovernmental Panel on Climate Change Copenhagen, Denmark (2014) demands the full stoppage of fossil fuel usage by 2100, to control the world carbon footprint. According to Gotschol et al. (2014) environmental management is an economically sustainable business, because any investment in environmental management programs helps to gain economic benefits for companies in their long run. Flint and Golicic (2009) explain the success story of carbon zero certification program for wine companies in New Zealand, for achieving zero carbon footprint and environmental awareness and habitat rehabilitation programs to achieve sustainability. Halldorsson and Kovacs (2010) illustrate the importance of energy efficiency and minimizing carbon footprint in logistics and supply chain context. All 'green' concepts are fundamentally based on eco-friendliness concept and thus can be classified under the environment pillar of sustainability. According to Deif (2011); Houe and Grabot (2009), companies must consider the term 'green' as a tool for achieving competitive advantage to go global and to increase the market share as today's highly educated and highly aware customers prefer eco-friendly products. Unruh and Ettenson (2011) mention three ways to achieve green goals such as "accentuate" which means the re-positioning of the existing product portfolio by extending green attributes; "acquire", which means the complete acquirement of an existing green company and their product portfolios; "architect", which means the building of new green products from scratch. They also add that, going green doesn't mean that companies have to sacrifice their profit margin, but rather it improves the profitability through waste minimization and recycling of products and byproducts. In a case study from the wine industry in United States, Cholette and Venkat (2009) show the need to incorporate third party logistics providers in the supply chain network, the need to optimize the package, route and load of transport system and the need to encourage direct delivery of end products to consumers to minimize carbon emissions and maximize energy efficiency. According to Wu and Pagell (2011) environmental strategies adopted by organizations have a direct impact on the supply chain and competitiveness of the organization. They also adds that top level managers should benchmark and get insights from the practices and policies that are successfully implemented in top leading companies in achieving sustainability in their own organization. Law and Gunasekaran (2012) illustrates the need of clear strategic level policy and the need of coordination of the strategic level team with the tactic and operations levels of the organization for the introduction and implementation of sustainable development in an organization. According to Rimanoczy and Pearson (2010), change in organizational culture is required to achieve the sustainability goals of profit, people and planet and human resource department has a major role in institutionalization of sustainability. According to Dekker et al. (2012), in supply chain, transportation is the most important factor with respect to environment. Because transportation accounts fourteen percentages of total CO_2 emissions across the globe and the three factors such as mode of transportation, type and size of transportation unit and fuel choice must be optimized to minimize the CO_2 emissions. Edwards et al. (2010) indicates that e-commerce and online shopping practices has got the advantage of lesser carbon footprint than conventional shopping practices in logistics and supply chain aspect. According to Ramani et al. (2010), sustainability view point must be considered from the early stage of the design itself and along with Design for Assembly and Manufacturing (DFAM), Design for Environment (DFE) must also be carried out. Gudmundsson and Roheim (2000) explain the effective way of using

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the eco-labeling practice to maintain sustainable fisheries resource, which can be carried over for other resources as well to encourage customer to go for environmentally sustainable products.

Kaebernick et al. (2003), illustrates a four step methodology for sustainable product development which include: 1) making environmental awareness to consumers 2) assessing environmental performance as a design objective by modifying quality function deployment matrix into environmentally conscious quality function deployment matrix 3) conducting life cycle assessment during design process 4) evaluating the recycle, reuse potential of the product. Feng & Joung (2009) measure the performance of sustainable manufacturing only by considering energy used and Co_2 emission without considering other social and economic factors. Smith and Ball (2012); Despeisse et al. (2012) and Despeisse et al. (2013) elaborate a process flow mapping methodology to quantify environmental performance of sustainability through material, waste and energy flow in a manufacturing firm, despite considering social and economic and technology factors in par with environment factor. Yuan et al. (2012) also consider only the environmental aspect of sustainable manufacturing by considering three major components of manufacturing such as technology, energy and material. Kim et al. (2010) emphasize for DFE method to reduce the environmental impact of manufacturing processes, but only consider the environmental aspect of sustainability. Paju et al. (2012) propose a process mapping method and quantify the sustainability indicators based on discrete event simulation, lifecycle assessment, and value stream mapping methodologies, but didn't consider economic and social indicators at all.

2.2.2. Social Dimension

According to Law and Gunasekaran (2012), external factors such as laws, regulation, social pressure, market trend and competition determines the internal factors of an organization such as performance, organization system etc. and strategic level policies must be made in line with the same to implement sustainable development in an organization. O'Brien (1999) emphasizes the need to have coordination between governments to make a common single worldwide regulation for the sustainable industrial development, regardless of the size and nature of the countries. He also adds the need to organize public awareness programs, to change the consumer buying behavior and to make the customers motivated to adopt green products. According to Hong et al. (2012), for achieving greater social reputation, organizations must implement sustainability practices not only at the strategic level, but at the employee level also. In most of the literature social dimension of sustainability is considered as corporate social responsibility (CSR) initiatives. Biggemann et al. (2014) show the importance of CSR initiatives in achieving sustainability through value creation by the integration of all stake holders. According to Adams et al. (2014) ecological and social factors are least considered for the performance measurement of sustainability. Very few organizations are voluntary going for social sustainability since they believe that social sustainability won't help out them much to gain any competitive advantage. According to Deif (2011), because of the rules and regulations by various governments and by United Nations, green manufacturing has become a mandatory thing for manufacturing firms to go globally. Strong rules and regulations by government are necessary to encourage organizations to go for social sustainability, through which sustainable development can be achieved. Labor sustainability and health and well-being of the society in which the organization is operating are coming under the social aspect of sustainability. Labor sustainability was considered by Tapiero and Kogan (2008). Health and well-being factor was explained by Labuschagne and Brent (2008), and socially responsible purchasing by Mont and Leire (2009). Socially responsible purchasing implies the selection and purchasing of materials which are not harmful and which will make

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zero negative effect on the customers and internal employees of the organization. McWilliams and Siegel (2001); Van De Ven and Jeurissen, (2005) add that social responsibility is closely related with the firm's business strategy. Labuschagne and Brent (2008) developed a social sustainability criteria frame work, which shows the importance of social assessment for the project and technology life cycle management.

2.2.3. Economic Dimension

Competition and profitability are the two major factors that must be taken into account while discussing the economic dimension of sustainability. According to Nidumolu et al. (2009) in Harvard Business Review, companies are considering sustainability as a part of corporate social responsibility because they fear that they will be forced to go for major process and technology changes to achieve sustainability, for which customer won't be ready to pay for. But he further explains that, environmental friendly manufacturing and sustainable development cost must be included in mainstream business practices, as the one who is successful at the earliest in developing sustainability will definitely get a competitive advantage and economic advantage gradually. Garetti and Taisch (2011) explain that energy recovery by cross plant analysis, co-operation between industries to optimize the energy at various heat levels, re-manufacturing of products, optimization of the speed, load and nature of transport, use of fuels from waste materials instead of fossil fuels, etc. will significantly contribute to the profitability margin of the business organization. According to Clelland et al. (2000), waste and pollution minimizing practices will reduce the operational cost and indirectly create economic value to the firm. Dos Santos et al. (2014) show that Woolworths Company was able to save 9.3 million US Dollars after starting the triple bottom line sustainable business initiative, which include ecological, social and economic indices. According to Stavins et al. (2003) an economy is sustainable only if it is dynamically stable and efficient and total social welfare is non-decreasing over time. The path for sustainability through the above mentioned steps are economical not only through operating cost reduction perceptive, but also through the branding of the company as a green and environment friendly one among all stake holders. Heilala et al. (2008) demonstrate how energy usage and environmental impact can be quantified through a simulation technique.

2.2.4. Technology and Operations Dimension

Technology and innovation has an important role in achieving sustainability in manufacturing. Flexible technologies and new innovative ideas help to reduce cost and other efforts tremendously. According to Westkamper (2008), emerging technologies are the key enablers behind the efficient economic, social and environmental performance of a manufacturing organization. Lee et al. (2011) shows that digital manufacturing technique as a key technique to integrate product design with enterprise resource, facility, and process planning. Digital manufacturing helps to validate each and every design aspect of a new product in line with the existing processes in a virtual world before going for real life expensive implementations. Liu et al. (2011); Koren et al. (1999) and Liu & Liang (2008) assert the importance of reconfigurable manufacturing systems. These systems are another aspect of new technology which helps to minimize waste, operational cost, and improves responsive time and helps to produce a variety of products in comparatively short span of time. According to Gupta and Palsule-Desai (2011) remanufacturing can be considered as an effective tool to tackle the rapidly growing competitive pressure, and is the area, where the OEMs going to concentrate in future. Mani et al. (2013) emphasize that organizations must design sustainable processes to manufacture sustainable products and a clear well defined parameter must also be there to measure the sustainability level of the processes designed.

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Veleva et al. (2001) propose a frame work to measure the performance of sustainable production, with twenty two indicators and well defined parameters for the measurement of each indicator. Vinodh and Rajanayagam (2010), through a case study find that computed aided design (CAD) along with design for manufacturing (DFM) can significantly contribute in the sustainable product development process, and can ensure minimum environmental impact. According to Hong at al. (2012) lean production and restructuring of supply chain helps to achieve responsive product strategy, which in turn increases the enterprise performance. They also add that benchmarking is an effective practice to institutionalize sustainability practices. Pumar (2005) explains the way to operationalize the sustainable development ideas and theories through group interaction and social networking. Despeisse et al. (2012) argue that there are limited works which explain about the operationalization of sustainability theories and explains the sustainability practices followed in industry the importance of capturing such practices systematically. Beachy (2010) emphasizes the need to use science and technology effectively in achieving agricultural sustainability. Gonzalez-Torre et al. (2004); Dowlatshahi (2000) shows how reverse logistics helps to increase the utilization of resources for reuse and recycling of the product. These new innovative ideas in supply chain and manufacturing ensure minimum waste and high operational efficiency. According to Westkamper et al. (2001), the future challenge is to reduce the cost of manufacturing technology to a level suitable for the mass production of sustainable products by using sustainable technologies such as solar energy, hydrogen technologies and other renewable-energy systems. Ijomah et al. (2007) illustrate the key indicators that are to be taken care in product design stage as durable material selection, use of joining technologies that won't damage components during separation and discouraging the use of banned substances and processes based on the classification of design subassemblies into three categories such as repair, reconditioning, and remanufacturing to produce sustainable products. Marksberry and Jawahir (2008) develop methodology to measure tool wear and tool life with near dry machining concept to achieve process sustainability to avoid the usage of harmful metal working fluids. According to Seliger et al. (2008) modularity, easy diagnose and standardization are the three main steps to develop efficient remanufacturing products. Fang et al. (2011) explain the use of travelling sales man problem in productivity and environmental performance improvement of manufacturing processes by optimum job scheduling to improve sustainability performance. Gungor and Gupta (1999) elaborate the challenges in recycling and remanufacturing of the used products as collecting the used products to a single point, disassembly level fixing, and in the optimization of disassembly processes.

3. METHODOLOGY

Since the objective of the research in this paper is to find out the interrelationships among variables, Interpretive Structural Modeling (ISM) is adopted as the methodology. In ISM methodology, group expert judgment is used as a tool to predict the relationships among variables under study. Since there are limited literature which explains the interrelationships among the variables of Sustainable Manufacturing, this paper will contribute significantly by using ISM methodology. ISM was first introduced by Warfield (1974) and Malone (1975). The steps involved in ISM are:

- Literature collection on the topic
- Systematic literature review and identification of variables
- Approaching experts and explaining the guidelines of VAXO matrix formulation to them to make the structural self-interaction matrix.

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- Experts were asked to fill the matrix by using V, A, X and O letters based on their expert knowledge in the area to define the relationship among two variables of the matrix.
- The structural self-interaction matrix was first converted to a binary matrix and then to a final reachability matrix by considering transitivity property.
- Identifying the level of variables depending on the dependence power and driving power of the variable from the final reachability matrix.
- Based on the levels of variables identified from the reachability matrix directed graph (DIGRAPH) is made.
- Converting the DIGRAPH into ISM Model which is self-explanatory about the relation amongst the variables.
- Reviewing the ISM model to validate the conceptual stability and make necessary changes in the model.

Opinion from five experts from TATA Motors having fifteen plus years of experience in manufacturing and three experts from TATA Technologies having twelve plus years of experience in manufacturing service industry are collected. The respondents of the survey include two experts from product design field, two from process design field, two from productivity improvement department and two from engineering research center vehicle integration and testing team.

Variables identified in sustainable manufacturing: V1 - Product design, V2 - Customer requirements, V3 - Supply Chain & Logistics systems, V4 - Energy costs, V5 - Technology & total quality management, V6 - Material selection & procurement, V7 - Natural resource scarcity, V8 - Environmental priorities, V9 - Regulatory norms, V10 - Fuel price regulations, V11 - Public awareness, V12 - Social values & Ethics

The variables of the models are identified through systematic literature review process and are listed out in Table 3. The two parameters amongst which the relationship is checked is represented by say *i* and *j*. Four variables are used to represent the relationship among the variables in the survey, which includes V, A, X, O. The matrix is to be filled with:

V: If *i* leads to *j* but *j* doesn't lead to *i*
A: If *i* doesn't lead to *j* and *j* leads to *i*
X: If *i* and *j* lead to each other
O: If *i* and *j* are not related each other

Using the above criteria, we have developed Table 4. The next step is to convert the Structural Self Interaction Matrix (SSIM) into binary matrix for which the below rules are followed:

- If the *i,j* relationship in SSIM Matrix is V, the corresponding binary relationship is 1 for *i, j* and is 0 for *j,i* .
- If the *i,j* relationship in SSIM Matrix is A, the corresponding binary relationship is 0 for *i, j* and is 1 for *j,i* .
- If the *i,j* relationship in SSIM Matrix is X, the corresponding binary relationship is 1 for both *j,i* and *i,j* .
- If the *i,j* relationship in SSIM Matrix is O, the corresponding binary relationship is 0 for both *j,i* and *i,j* .

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Table 3. Dimensions of Sustainable Manufacturing

Sustainable Manufacturing Drivers/Variables	Authors (Year)	Dimensions/Sub-Variables
Product design	Garetti and Taisch (2011)	• Mass customization • Eco-design: easiness of serviceability, disassembly. • Recyclability.
Customer requirements	Garetti and Taisch (2011); Garbie (2014)	• Involvement of customers in design, Innovative products
Supply chain & logistics systems	Dubey and Gunasekaran (2014); Jeffrey and Choi (2004)	• Green Logistics • Reverse Logistics • Supplier selection • Logistics network design
Energy costs	Garetti and Taisch (2011)	• Energy Conservation • Minimization fossil fuel energy use • Energy production from waste & garbage.
Technology & total quality management	Garetti & Taisch (2011); Garbie (2014); Garbie (2013); Law & Gunasekaran (2012)	• Advanced automation for high product quality • High-performance and quality-embedded manufacturing, • Minimization of customer complains • Reconfigurable & Flexible Manufacturing Systems • Strategic level management policies
Material selection & procurement	Kara et al. (2014)	• Environmental friendly material selection • Reusable & recyclable material usage • Material selection to minimize energy consumption & operating cost
Natural resource scarcity	Azzone and Noci (1998)	• Minimization of the impact on the state of natural resources
Environmental priorities	Mittal and Sangwan (2014a); Mittal and Sangwan (2014b)	Minimization of • Greenhouse gas emission • Degradation of soil and water
Regulatory norms	Zhu et al. (2007)	• Environmental rules & regulations by government
Fuel price regulations	Garetti and Taisch (2011)	• To promote bio-fuels & to discourage fossil fuels usage
Public awareness	Santos et al. (2014), Houe and Grabot (2009)	• Customers' awareness on environmental issues • Internal employee awareness
Social values & Ethics	Hoejmose et al. (2013)	• Social responsible supply chain

Table 4. Structural self-interaction Matrix

	V12	V11	V10	V9	V8	V7	V6	V5	V4	V3	V2	V1
V1	O	A	V	A	V	X	X	V	X	X	X	-
V2	A	X	A	O	O	V	V	V	V	V	-	
V3	O	O	A	A	A	O	V	X	O	-		
V4	O	O	X	A	O	A	O	A	-			
V5	O	O	V	V	V	O	X	-				
V6	A	A	O	A	V	V	-					
V7	A	A	X	O	A	-						
V8	A	A	O	V	-							
V9	O	O	O	-								
V10	O	O	-									
V11	O	-										
V12	-											

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Transitivity Principle

Farris and Sage (1975); Sushil (2005a,b) say that to maintain the consistency of the model developed, transitivity property is always used in the ISM modeling. Transitivity principle can be explained with an illustrative example as: if a leads to b and b leads to c, the transitivity property implies that a leads to c. Transitivity property helps to remove the gaps among the variables if any. By adopting the above criteria and transitivity property, final reachability matrix is prepared and is shown in Table 5.

Level Partitioning

The ranking of different variables into different levels is known as level partitioning. Reachability set and antecedent set are found out from the final reachability matrix (Warfield 1974). In any iteration, if the reachability set intersection antecedent set is the reachability set itself then those variables occupies the top levels of the hierarchy. The final output of level partitioning is shown in Table 6.

Table 5. Final reachability matrix

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	Driving Power
V1	1	1	1	1	1	1	1	1	1*	1	1*	0	9
V2	1	1	1	1	1	1	1	1*	1*	1*	1	0	8
V3	1	1*	1	1*	1	1	1*	1*	1*	1*	0	0	4
V4	1	1*	1*	1	1*	1*	1*	1*	0	1	0	0	3
V5	1*	1*	1	1	1	1	1*	1	1	1	0	0	7
V6	1	1*	1*	1*	1	1	1	1	1*	1*	0	0	5
V7	1	1*	1*	1	1*	1*	1	1*	0	1	0	0	4
V8	1*	0	1	1*	1*	1*	1	1	1	1*	0	0	4
V9	1	1*	1	1	1*	1	1*	1*	1	1*	0	0	5
V10	1*	1	1	1	1*	1*	1	0	0	1	1*	0	5
V11	1	1	1*	1*	1*	1	1	1	1*	1*	1	0	6
V12	1*	1	1*	1*	1*	1	1	1	1*	1*	1*	1	5
Dependence Power	8	5	7	7	5	8	8	6	3	5	2	1	

Table 6. Level matrix

V1,V3,V4,V6,V7,V10	Level 1
V5,V8,V9	Level 2
V2,V11	Level 3
V12	Level 4

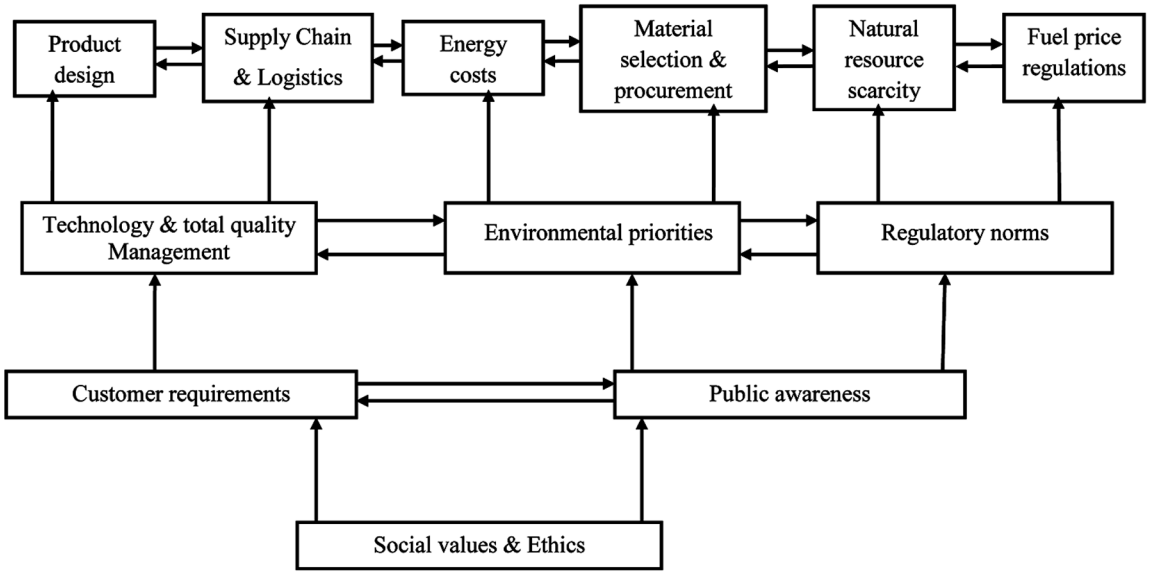
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CMAC Analysis

After preparing the ISM model (Figure 1), MICMAC diagram of the variables is prepared based on their driving power and dependence power. Driving power and dependence power is calculated in the final reachability matrix and is shown in Table 5. Duperrin and Godet (1973) developed the MICMAC method for the first time. According to Warfield (1994) MICMAC Analysis is used to categorize variables in a complicated system. Mandal and Deshmukh (1994) explain that MICMAC will also help to analyze the driving and dependence power of variables of a complex system. According to Jharkharia and Shankar (2005), depending on the value of dependence power and driving power the variables can be classified into four categories such as autonomous, linkage, dependent and independent barriers. The first category known as 'autonomous barriers' include the variables having weak driving as well as dependence power. MICMAC Diagram for the sustainable manufacturing variables under study is shown in Figure 2, and there is no variables coming in the first quarter which means that, there is no autonomous variable.

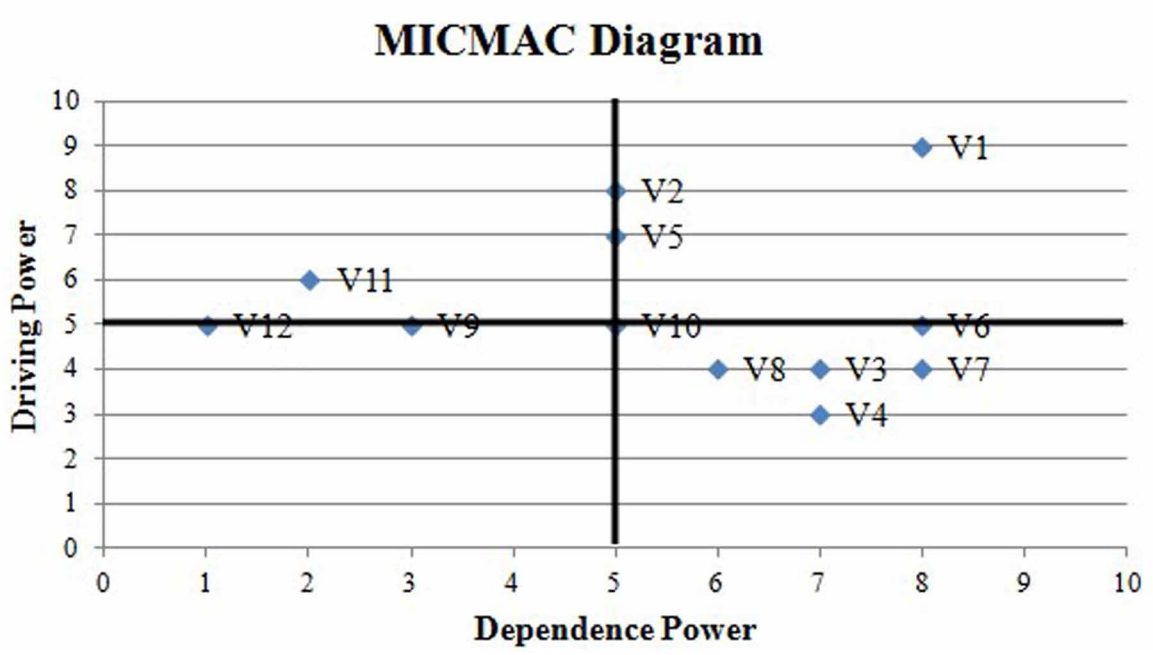
The variables coming in first quarter won't be having much connection with the system or with other variables. The variables V3, V4, V7 and V8 are coming in second quarter which is known as 'dependent barrier'. Dependent barrier variables are having weak driving power and strong dependence power. Since these variables depend heavily on other variables, any change on other variables will affect these variables. The variable V1 is coming in third quarter and is known as 'linkage variable'. These variables are characterized by their strong driving power and strong dependence power. These variables are highly sensitive. Any change in the system or other variables will affect linkage variables. The fourth quarter contains variable V11 which is known as 'independent barriers'. These variables have strong driving power and weak dependence power.

Figure 1. Model generated by interpretive structural modeling (ISM)



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Figure 2. MICMAC Diagram



4. RESULTS AND CONCLUSION

The study helps to identify the driving factors of sustainable manufacturing system, and the frame work model built through ISM technique will help policy makers to get a clear overall picture of the system to develop and implement the sustainable manufacturing philosophy. From MICAMC analysis, we found that there are no autonomous variables, which implies that all the variables stated in the study will influence the development of sustainable manufacturing system. Product design is coming in the third quarter which implies that it is a linkage variable and is highly unstable. This implies that product design strategy must be changed in accordance with the other driving factors to achieve the manufacturing sustainability. The variable public awareness has high driving power and this factor will affect other enabling factors. Supply chain and logistics systems, Energy costs, Natural resource scarcity and Environmental priorities are coming in second cluster and are having high dependence power.

5. RESEARCH GAPS IDENTIFIED AND SCOPE OF FURTHER RESEARCH

From the global survey conducted by Kiron et al. (2013) from MIT Sloan Management Review and the Boston Consulting group, it can be seen that for thirty five percentages of the companies sustainability efforts are adding profits to business for consistently over the years. But, the percentage of companies that have successfully established a sustainability business case is only thirty seven percentages, and twenty percentages of companies are failing to establish a successful sustainability business case in their organization. This shows the requirement for a clear well defined framework for sustainable manufacturing, the relationship among driving variables and their relative importance in framing a sustainable

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manufacturing systems, which will help the organizations to achieve sustainability. We have found that many of the articles are focused only on environmental factor of sustainability rather than considering social, economic and technology factors in equal par to achieve better sustainability performance. So, future studies must focus on all the three factors of sustainability simultaneously to make better meaningful theoretical contributions. According to Nakano (2010), definition of sustainable manufacturing is not clear and technical approaches for tackling risks and sustainability issues in manufacturing must be explored further in detail. We acknowledge the same based on the review done and hence we have developed a comprehensive definition of sustainable manufacturing by reviewing the available definitions of sustainability, sustainable development, and sustainable manufacturing. We have found that at present there are limited literature on sustainable manufacturing which uses simulation and mathematical modeling techniques. Jimenez-Gonzalez et al. (2011) argue that there is a lack of total systems approach and emphasize the need to coordinate different engineering and science professionals to develop better sustainable products and processes. Throughout the literature we have identified the gap of total systems approach in developing the sustainable manufacturing models. In further research, the relative importance of all driving factors and the effect of one over the other variables are also to be explored. Design for Environment (DFE) method is getting much importance in the early product design stage along with Design for Assembly (DFA) and Design for Manufacturing. Future researches can be extended to make complete guidelines and check points for DFE methodology and to develop better ecofriendly products. There are limited works which consider the effect of soft dimensions such as top management strategic policies, organization human resource policies etc. on the sustainable manufacturing system development in an organization. From the literature review we understood that sustainable product and process design didn't get enough focus and attention as much as they were supposed to get. Our research aims to fill these gaps and to formulate a clear framework for sustainable manufacturing systems. ISM and MICMAC analysis is done only by taking opinion from eight experts, which is not sufficient to derive any statistical conclusion. So to overcome the same, Structured Equation Modeling (SEM) analysis must be performed by taking sufficient survey based on structured questionnaire.

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Chapter 19
Green Energy in Data Centers

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ABSTRACT

Green energy paradigm has been gaining popularity in the computing system from the software, hardware, infrastructure and application perspectives. Within that concept, data center greening is of utmost importance at the moment since data centers are one of the most energy conserving elements. Data centers are seen as the technology era's black energy-swallowing secret. Reducing energy consumption at data centers can reduce carbon footprint effect tremendously. Not addressing the issue immediately will lead to significant energy usage by data centers and will hinder the growth of data centers. The call for sustainable energy efficient data center leads to venturing into data center green computing. The green computing concept can be achieved by using several methods adopted by researchers including renewable energy, virtualization through cloud computing, proper cooling system, identifying suitable location to harvest energy whilst reducing the need for air-conditioning and employing suitable networking and information technology infrastructure. This paper focuses into several approaches used by researches to reduce energy consumption at data centers while deploying efficient database management system. This paper differs from others in the literature by giving some suitable solutions by looking into a hybrid model for green computing in data centers.

INTRODUCTION

The increase in need of data processing has led to a demand in obtainability for cheaper, faster, efficient and larger data management system. This has further introduced a significant problem in terms of energy consumption and energy usage as mentioned in (Barroso. L.A, 2005). Since the trend of Internet Infrastructure is moving towards services-based computing, data center plays a key role in this new

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computing architecture. It is used widely in variety of services independent encapsulating any vendor, product and technology including web hosting, application services, electronic markets, outsourced storage, online-monitoring system, mashups, digital nervous system and other network services. Fostering renewable energy production, developing better renewable technologies and improving the environmental performance of conventional electricity benefits heightened through improving the long-term strategy of data center performance. Environmental Protection Agency (EPA) shows that the data center and database management system in the US consume power doubled between 2000 and 2006 and may multiply again within the next decade. According to EPA, it is projected that energy consumption by data centers for the year 2008 is more than 80 billion kWh. (US Department, 2013). Report to the Congress, EPA's Energy Star Program estimates that increase efficiency in data centers could yield energy savings as the burgeoning efforts to make data centers greener is the energy and the word 'green' adds multiple meaning when applied to the data centers. (Koomey J, 2011).

Many works have been done to produce efficient result in reducing the energy usage for the purpose of data center and data management for example by Cisco System Inc., Google Inc., and many more (Barroso.L.A,2005). Some of the approaches were to design highly efficient systems at the peak performance point with maximum utilization of resources. But very few studies have addressed the energy problem comprehensively (US Department, 2013).

PROBLEM STATEMENT

In today's technological world, it is proven that there is a significant relationship between data center and investment in capital overlay and outgoing costs. Table 1 shows the detailed breakdown on the distribution of the cost from data center (Greenberg et al., 2008).

The design of computing system is being optimized based on the execution time and operates at low consumption due to entrapment of resources and fragmentation of data. No concern was made for the issue of energy consumption by the system. Uncontrolled usage of energy in data centers has negative effects on the reliability, density, scalability of information processing and the environment. Need and awareness are raised across nation through multiple solution and disciplines to optimize and save energy use in data management system (Barroso. L.A, 2005). System or even its components like CPUs, memory and disk are hardly distributing energy efficiently. It trades power for performance (US Department, 2013). Power management has become a critical issue due to large energy usage and all over the world government has started imposing the taxes on the carbon emission, ultimately aiming to reduce the emission and help make computing into green computing (Bansal et al., 2011).

Table 1. Guide on the distribution of data center costs

Amortized Cost	Component	Sub-Component
~ 45%	Servers	CPU, memory, storage systems.
~ 25%	Infrastructure	Power distribution and cooling.
~15%	Power draw	Electrical utility costs.
~15%	Network	Links, transit, equipment.

a. Source of data: A. Greenberg et al, "The cost of a cloud: research problems in data center networks", ACM SIGCOMM Computer Communication Review, 39(1), pp. 68, 2008

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Although research was conducted in designing power aware applications, an effort for implementing has not been taken place. Large expenses and allocations need to be augmented when data center reaches maximum provisioned power (Bansal et al., 2011). In the very near future, energy efficiency is expected to be one of the key procuring arguments in the society. Research should focus in building power-aware database management systems (DBMS) or GreenDB.

Analysis shows that giant companies are also working towards energy efficiency using green database system. Huge volume of energy usage goes to the data center. The global business market intelligence is a billion dollar market and still growing to see double-digit growth rates (US Department, 2013). With the growth of the internet data center (IDC), data systems are also running its management workload such as search engines, storage of multimedia like video and audio, streaming, web analytics, and cloud computing. Dataset are growing rapidly and workload is also increasing. Together with it, the energy usage has increased. Companies like Google are working towards reducing the energy usage excessively in data centers (US Department, 2013). Data center has become the major immobilizer in the topic of energy wastage.

Clients particularly are searching for high scalability setup, lower unit price and simplicity of management. As to maintenance costs, the second largest bill for large database centers comes from the power company. Statistic shows that in US alone, data centers consumed about 60 billion kilowatt-hours of electricity in 2006 which equaling to 1.5% of electricity consumption in US (US Department, 2013). Demand for a solution is in the high urge and is being researched by many giant companies

OBJECTIVES

This research is not to reinvent the wheel to conduct a critical analysis on the existing research to integrate the idea proposed to produce wholesome elucidation. Modules from many different researches have been integrated and evaluated to enhance its components to be fully functional with fewer flaws. Therefore, it is a better solution to show the benefits of energy efficiency through green database. The main objectives of this research are as follows;

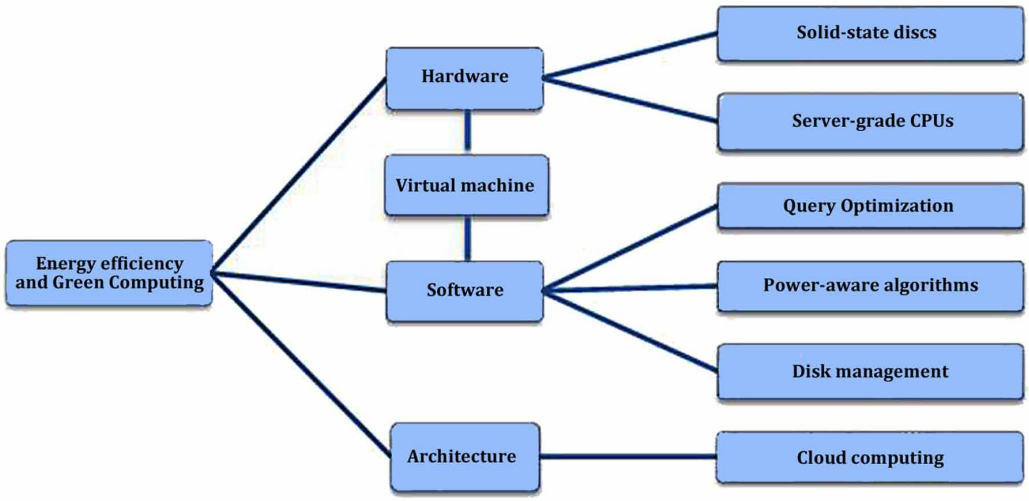
1. To initiate and analyse energy-aware research conducted on database management in a way that improves energy efficiency of a data center.
2. To propose solution in implementing the energy efficiency through green computing and green database system.

Many companies, organizations and individuals have proposed methodology to resolve this problem based on the categories shown in Figure 1. This research paper analyzes similar papers which has solution but needs minor integration to propose new innovation with better and efficient energy saving. Analysis focuses on power consumption patterns and identification of power-saving opportunity in GreenDB. Critical analysis done based on the following observation.

- Power-aware database.
- Data management through software and hardware.
- Data management through disk power management.
- Green computing architecture.
- Renewable energy.

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Figure 1. Critical analysis flow model



Power-Aware Database

Power-aware computing research at the application level in the aspect of hardware and operating system level found to be synergistic for energy proficiency in the core systems. Xu. Z., 2011 describes on creating a power-aware database management (P-DBMS) and initial ideas on the design as such systems, with the focus on a power-aware query optimization module in the DBMS. This particular paper has proposed and created a power model to accurately measure the energy costs of query executions and plan selection. It is in contrast with the heuristic-based adaptive solutions that rely on manual timing and extensive empirical evaluation. It is meaningless without considering the database performance. It is either to make the query run faster by optimizing the query execution or let the system run in lower power state while sacrificing the performance to some extent. They proposed that the throughput is improved while maintaining the power line. It indirectly reduces the power cost while not sacrificing the throughput performance. Implementation has been taken place through initial design in algorithm based software named PostgreSQL rather than power-saving through hardware and operating system levels modification. The proposed solution resolves the power aware of the database as seen in Table II. Only setback would be database management system needs to be revisited or redesigned and initial efforts be invested. The plan evaluation model has a stumbling block where the system is stable and foreseeable but the database is barely stable and predictable. Thus, modeling error occurs and estimation per operation cost cannot be 100% correct.

Data Management Through Software and Hardware

Synergy between database management through algorithm and hardware architecture are promising in energy efficiency computing. Harizopoulus, S. et al., 2009 recommends that adjusting existing system-wide configuration and design algorithm for energy proficiency is not the same as designing algorithm based on the throughput and performance. Deploying an energy-efficient data management platform is by choosing hardware components with good performance-per-watt characteristics by choosing high-

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Table 2. Critical overview on PostgreSQL system

Attribute	PostgreSQL System	
	Description	*Analysis*
Hardware	Hardware Optimisation	x
	Power Management	x
Software	Software Optimisation	/
	Query management and optimisation	/
Architecture	Architecture Manuveuring	x
	Distributed System	x

a. Evaluation based on the result of proposed research paper by Author

performance components (server-grade CPUs, solid-state disks etc.). Installing an energy-efficient system was also done through software-based approaches for reducing wasted energy in data management systems. This paper proposes to power down the unused hardware components, revisit and redesign data structures and algorithm from a wider perspective. The 'push-to' design components offers more control over power performance trade-offs for example usage of multicore chips which can be activated at any time. The increase of hardware heterogeneity offers technology refresh cycle like the virtual machine. The disadvantage here is that some workloads may be able to use these additional resources while others will underutilize them and create a waste of power. Table III shows that hardware configuration and application-agnostic power management is only part of the solution proposed in this paper.

Data Management Through Disk Power Management

Reducing energy consumption through hardware depends on many aspects. Earlier research shows that the result from monitoring data center is that the average idle period for a server disk is very small compared to the time taken in spinning up and down. This significantly limits the conservation of energy. Zhu, Q. et al., 2004 proposed reducing energy consumption of disk storage using power-aware cache management with algorithm which provides more opportunities for causal disk power management structures in energy efficiency. So far only a few studies (D. Colarelli and D. Grunwald, 2002 ; Gurumurthi et al., 2003 ; Gurumurthi et al. 2003 ; Carrera et al., 2003) addressed the problem in energy efficiency for the storage systems at the data centers. Based on these studies, multi-speed disks or multiple rotational speed disks shown promising results by using synthetics workloads. Therefore, power-aware cache management algorithm was designed whereby it is aware of the base disk energy ingestion and power management plan for read and writes accesses.

It is an energy-optimal cache replacement algorithm which uses the dynamic programming in polynomial time leading to 16% less energy and lead to 50% better average response time. But this study has its limitation such as it is only designed for multiple disks and focuses on high-end storage systems. Single disk may not work with this algorithm. Also it has low effect on prefetching as well. It does not consider the storage cache energy consumption and focuses on smaller part of the overall management as shown in Table IV.

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Table 3. Critical overview on Stavros review

Attribute	Synergistic System	
	Description	*Analysis*
Hardware	Hardware Optimisation	/
	Power Management	x
Software	Software Optimisation	/
	Query management and optimisation	/
Architecture	Architecture Manuveuring	x
	Distributed System	x

Green Computing Architecture

Virtual machine (VM) has been globally used in the data center environment due to its important feature and architecture. Liu. L. et al. 2009 uses the latest technology trend which is the cloud computing as a guaranteed performance and designed to reduce the data center energy consumption. It is effective and enables the widespread online-monitoring, live VM migrating and placement optimization. It utilizes the live migration feature of VM Technology such as XEN (Bansal et al.,2011) to implement the architecture for example Amazon Elastic Compute Cloud (Zu. Z. 2011) provides a virtualized computing environment hosted with different kind of Linux-based service. Evaluation results show that 27% energy can be saved when applying Green computing architecture. VM Migration allows lesser usage of computer. This architecture assures real-time performance requirement as well as saves the consumption of energy by Internet Data Center (IDC). Green computing architecture with the integration of VM technology is an effective method in reducing server power consumption.

The problem may arise in the angle of automatic scheduling decision on dynamic migration or consolidating the VMS among physical servers to meet the workload requirements meanwhile saving energy, especially for performance sensitive. The aspect of performance trade-off between the operating system and applications or middleware has not been tested which can be a flaw. But based on Table V, this technology alone may not be sufficient to provide efficiency.

Table 4. Critical overview on power-aware cache management algorithm

Attribute	Synergistic System	
	Description	*Analysis*
Hardware	Hardware Optimisation	x
	Power Management	/
Software	Software Optimisation	/
	Query management and optimisation	x
Architecture	Architecture Manuveuring	x
	Distributed System	x

a. Evaluation based on the result of proposed research paper by Author

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Renewable Energy

Exploiting green energy sources is another opportunity but it is variable and intermittent. So far, there has been less work on integrating renewable energy with database system. Chen, C., et al., (2012) uses the hardware optimization to save energy and retaining the execution part of the hardware. They proposed through integration of renewable energy which is the solar to power the execution of database management system. This research bridges the gap between renewable energy and database management system with ReinDB (Renewable Energy Integrated Database). The purpose would be to minimize the usage on carbon intensive energy consumption on a database server with both renewable energy and carbon intensive energy supplies. This works on Supply Driven Execution (SDE) on a database server with two mechanisms.

1. Workload scheduling to meet workload deadlines.
2. Dynamic configurations on hardware setting.
3. Brown-aware workload shifting.
4. Battery-aware workload shifting.

Although it increases the usage of renewable energy (solar usage) but there are still some disadvantages to take into consideration. Studies show that the mismatch between workloads and green energy supplies challenges in the utilization of energy. Divergence in the context of data center from brown energy and green causes excessive usage of energy (Goiri et al,. 2011; Goiri et al,. 2012 ; Krioukov et al 2012 ; Liu et al. 2011). Clients are required to change the hardware to new system which may need initial investment that may cost high. Also the latency time (slack time) is also another issue whereby the clients have to tolerate a large slack time to complete a task with the green techniques. In the economical aspect, the cost involves in manufacturing solar panel and battery provision. Table VI, shows that, there are many other aspect to be incorporated.

Table 5. Critical overview on green computing and VM technology

Attribute	**Green Computing and VM Technology System**	
	Description	*Analysis*
Hardware	Hardware Optimisation	/
	Power Management	/
Software	Software Optimisation	/
	Query management and optimisation	x
Architecture	Architecture Manuveuring	/
	Distributed System	x

a. Evaluation based on the result of proposed research paper by Author

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ANALYSIS AND PROPOSED GREEN SOLUTIONS

The concept of green database and energy efficiency is emerging high and gaining more popularity and everyone wants to be on top of it and they have started researches on the concept of energy saving in the DBMSs. Companies like IBM, Oracle that develops their own DBMSs want to decrease the energy consumption. All researches are focusing on individual area only. Integration of success methods from each research can result in wholesome solution.

Evaluation and analysis done to multiple proposal and project paper resulting in integration of the best modules for many different sources tosses excellent solution. Comparisons shown in Table VII, VIII, IX, X and XI define the strength and weakness based on the critical analysis done.

Virtualization and Green Cloud

Virtualization allows software and hardware virtualization by providing virtual environment. This reduces the need for overwhelming use of servers. More processing can be done with lesser energy consumption. Every single component of IT can be virtualized from the servers, routers, switches, input-output, applications, operating systems and desktop. Virtual machine allows more than one operating system to be operated in one computer. Each operating system runs its own virtual machine and resources like I/O, storage and processor can be assigned to each virtual machine. It is to automatically make the scheduling decision on dynamically migrating or consolidating Virtual Machines among physical servers to meet the workload requirements while saving energy, especially for performance sensitive. The heuristic algorithm is used in virtual machine migration to achieve the optimization. States of server power is adjusted through the dynamic voltage or frequency scaling.

Table 6. Critical overview on integration of renewable energy

Attribute	**Integration of Renewable Energy**	
	Description	*Analysis*
Hardware	Hardware Optimisation	/
	Power Management	x
Software	Software Optimisation	/
	Query management and optimisation	x
Architecture	Architecture Manuveuring	/
	Distributed System	x

a. Evaluation based on the result of proposed research paper by Author

Table 7. Physical usage

Project/ Attribute	*Hardware Modification*	*Software Modification*	*Solar Integration*
Zichen Xu	No	No	No
Cheng Chen	Yes	Yes	Yes
Liang Liu	No	Yes	No
Stavros Harizopoulos	Yes	Yes	No
Qingbo Zhu	No	Yes	No

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Table 8. Power coverage

Project/ Attribute	*Power State*	*Power Cost*	*Power efficiency*
Zichen Xu	Low	Reduced	30%
Cheng Chen	Very low	Reduced	28-53%
Liang Liu	Low	Reduced	27%
Stavros Harizopoulos	Low	Reduced	45%
Qingbo Zhu	Low	Reduced	16-35%

Table 9. Query and throughput

Project/Attributes	Query Execution Speed	Query Optimizer	Throughput time
Zichen Xu	Faster	Increased	Maintain
Cheng Chen	No change	Scheduled Query	peak performance
Liang Liu	No change	Optimized	Guaranteed real time
Stavros Harizopoulos	No change	Optimized	Peak performance
Qingbo Zhu	Faster	Optimized	Limited

Table 10. Other aspects

Project/Attributes	Scalability	Reliability	Slack time
Zichen Xu	Inefficient	Inefficient	Retained
Cheng Chen	Efficient	Efficient	Retained
Liang Liu	Efficient	Efficient	Retained
Stavros Harizopoulos	Efficient	Efficient	Retained
Qingbo Zhu	Efficient	Inefficient	Retained

Table 11. Application and remark

Project/Attributes	Application Level	Remark/ New Invention
Zichen Xu	Very little	Cost evaluation model and power evaluation model
Cheng Chen	Very little	ReinDB – brown and green energy usage with additional equipment to be installed
Liang Liu	Increasing	VM, Heuristic search algorithm and performance sensitive
Stavros Harizopoulos	Low	Algorithm based and redesign the system component
Qingbo Zhu et al.	Low	Works only for multiple disk and focuses on high-end storage system.

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Renewable Energy Sources

Datacenters can be equipped with renewable energy sources such as solar powered energy and hydro-electric energy supply. Solar powered energy can be good source of energy for data centers located at locations that has wide availability of solar energy. The solar panel nodes can be charged during the day with the sunlight and stored in backup sources to be supplied during the absence of sunlight. Although installation of such facility is comparatively costly, but the outcome can be very promising as these are renewable energy sources. Moreover energy generation through hydroelectric source is another promising factor. This is applicable in areas where there plenty of water sources for hydro energy generation. A good example would be the Facebook datacenter located in Sweden which is supplied with hydroelectric power without interruption due to the abundant resources of hydroelectric power. In conclusion, the choice of renewable energy is very much dependent on the geographical areas where the datacenters are located (1). More research work can be carried on vibration energy generation from the vibration caused by the servers and the other high end equipment present in the datacenter. This requires extensive research on the strength of vibration generated and amount of energy can be drawn from that.

Disk Power Model and Management

Managing the multi disks speed to increase the amount of energy saved with data center workloads by identifying the active, idle and standby mode of the disk. During the active mode, read and write mode is actively processing in the platters spin and the head. Likewise, during the idle, no disk is required whereby energy can be saved by idling the rotation and spinning. Mathematically, a lower rotational speed mode consumes lesser energy compare to higher rotations. Reduction in Input/ Output Operations per Second (I/Ops) directly leads to reduction in the energy consumption which is shown in (1). An average latency is the time taken by the disk that is accessed to rotate to the position under read/ write head. Meanwhile the average seek time would be the time (ms) taken for the hard drive's read/write head to locate itself over the read/ write track.

I/Ops Calculation:

$$1 / ((\text{σεεκ τιμε} / 1000) + (\text{λατενχψ} / 1000) = \text{I/Oπσ} \quad (1)$$

$$\text{Ενεργψ Χονσυμπτιον} = \text{Ποωερ (Ωαττ)} \; \xi \; \text{I/Oπσ}$$

Power-Aware Database Management System

It monitors the query optimizer, buffer manager, storage manager and many other database query optimization modules.

Cost can be reduced by improving the query optimization time whereby the processing time can be improved and obtained through the setup of the server which is shown in (2).

Cost estimation, C:

$$X = (\text{Θυερψ Οπτιμιζατιον} \; \xi \; \text{τιμε}) \; \xi \; \text{Προχεσσινγ Τιμε} \quad (2)$$

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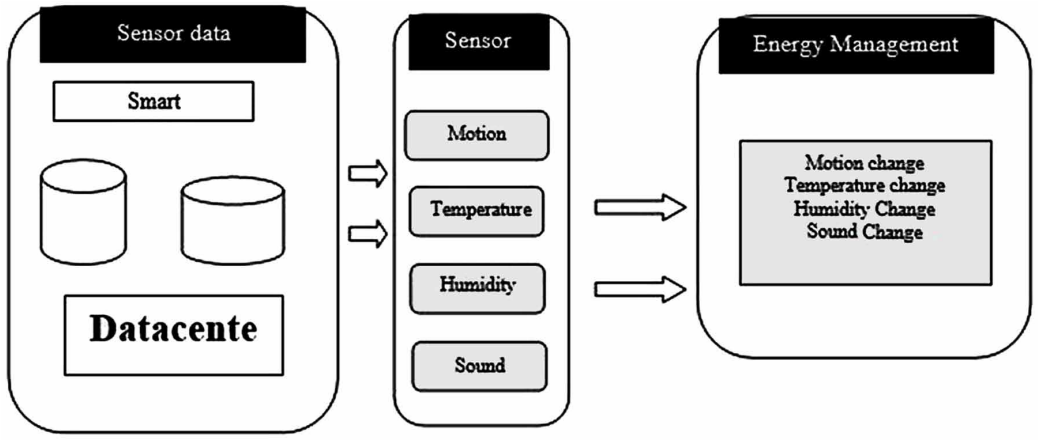
Datacenter Cooling System

Cooling system in the datacenter is very important aspect as it guarantees proper operation of datacenter equipment such as servers and storage devices. A suitable cooling method to maintain the thermal condition of the CPU's can provide efficient energy usage. The Facebook datacenter in northern Sweden provides an energy efficient cooling system as compared to other datacenters. Besides that, the arctic climate in the northern region allows the Facebook datacenter to be in a colder temperature condition requiring less cooling needs. The river along Lulea provides a lot of resources for hydroelectricity supply for the entire datacenter without the need for generators. The datacenter depends on the climate chilling system rather than depending on air conditioning system. An intelligent heat, ventilation and air conditioning (HVAC) system can be designed with proper cooling system (Parisio et al.; Mousavi et al.) Datacenters with central air systems, direct liquid cooling and humidification can allow for proper cooling system.

Power Management Using Wireless Sensor Network

One way to make datacenters energy efficient is by providing good network infrastructure. The servers, routers, switches and other equipment linked with an efficient networking facility can decide the energy consumption of the datacenter. Congested network linkage allows unnecessary communication among devices and allows for additional energy consumption. One potential networking infrastructure that could facilitate with proper energy management is through employing wireless sensor networks (WSN). WSN provides intelligent services by deploying various types of sensors to monitor the environment in the datacenter to make it a smart datacenter. The smart datacenter is intended to be designed to create a system that performs energy management in terms of energy consumption and optimizing power consumed by datacenter devices. The framework of the system is shown in Figure 2. The system is categorized into fault detection and energy management. Fault detection stage should identify malfunctioned datacenter equipment and resources that is unnecessarily consuming power and wasting energy. The energy management stage should be able to manage energy consumption, optimize power consumption and perform automated notification. The fault detection system consists of data acquisition from various

Figure 2. WSN data center monitoring system



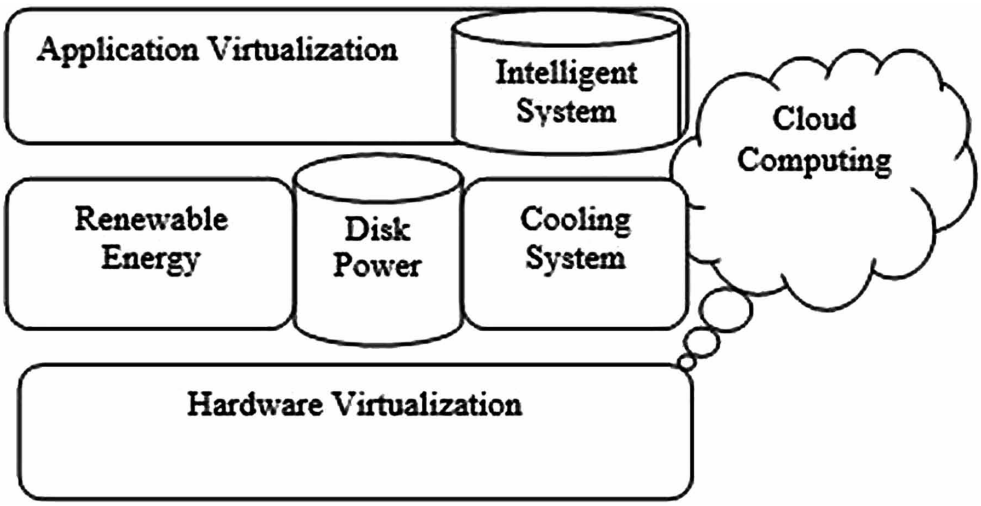
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sensors and information processing using fuzzy logic engine. The energy management system performs event detection and action mechanism based on changes in the sensor data and motion detection. In this system, datacenter environment parameters such as temperature, humidity, light and sound are detected for deciding whether electrical appliances and lights to be switched on or off for energy management in buildings. Besides that, motion sensors are used for detecting movement so that lights can be switched on and off based on occupancy. Motion sensors can also be used to detect heat emitted from the equipment so that notification alarm is triggered to take necessary action. The temperature and humidity sensors can be used to decide whether the datacenter cooling system to be turned on or off. This system can be created using some machine intelligent capabilities to make the system self-autonomic. Moreover WSN is a cost effective solution as it does not require extensive IT infrastructure and data communication.

Hybrid Model

A hybrid model (Figure 3) can take advantage of a combination of energy efficient solutions including virtualization by cloud, WSN monitoring system and renewable energy system (Gholamhosseinian, and Khalifeh, 2012). Machine learning systems such as Case Based Reasoning (CBS) or decision trees can be integrated together with the virtualization concepts so that lesser servers are needed for data storage and processing (Pawlish et al., 2014). These intelligent systems allow servers to make automatic decisions and require lesser tasks. Moreover intelligent agents such as pattern recognition, fuzzy logic and neural network can be integrated with WSN so that energy usage at datacenter can be monitored intelligently. A proper selection hardware that requires less cooling system is also an added advantage. For example the Open Computer hardware has been designed in a simplified way for energy efficiency. It is just a piece of metal sheet with the motherboard that allows for proper air flow. A casing free system can allow for faster cooling process in datacenters. In conclusion the hybrid model should provide the following advantage:

Figure 3. Datacenter hybrid model



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1. Reducing energy consumption compared to the traditional datacenter model
2. More utilization of virtualization by employing green cloud architecture by allowing lesser usage of storage, machines and processing without compromising the number of applications can be operated
3. Utilizing natural resources for renewable energy for datacenter. Since natural resources are ample depending on the geographical location, a proper energy harvesting method could solve energy usage at datacenters

FUTURE WORK

Looking at the hybrid model proposed, a complete framework and simulation of the model will prove the feasibility of the model. Taking renewable energy into consideration, future work in constructing data centers should focus on natural resources available. More emphasis should be given to locations near the northern poles to reduce the need for cooling system. Focus on areas that have plenty of sunlight to harvest energy using solar system or locating data centers near hydroelectric power generators. Virtualization should be highest importance by deploying systems using cloud computing infrastructure. Provide an integrated system operation with software, hardware, controls and sensors to be coupled together with the grid electricity. An automation system using self-healing energy management can be considered in this case. The system stores huge amount of energy in the storage via renewable energy and constantly monitor the level of energy at the grids and allowing power to be supplied during energy crisis.

CONCLUSION

The green energy at data centers will help to reduce the serious energy consumption issues at data centers to reduce the critics from authorities. Total energy consumption of data centers in the US for example can be reduced from 2% to even lower. The suggested solutions may not only reduce the greenhouse effect but offer a more cost effective data center setup. In this paper, several approaches of reducing energy consumption at data centers have been proposed. The proposals are validated by adopting some of the solutions addressed in the literature providing reasonable metrics. Ultimately the aim and objectives are to minimize the wastage of energy and to retain the efficiency. It is foreseen that implementation of technology collaborated with the green energy will ultimately enhance the technology to be ecofriendly.

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Chapter 20
Mainstreaming Development Policies for Climate Change in Fiji:
A Policy Gap Analysis and the Role of ICTs

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ABSTRACT

Fiji is a Party to the United Nations Framework Convention on Climate Change (UNFCCC), and to the Kyoto Protocol. This chapter examines the development policies implemented since ratifying these agreements to mitigate greenhouse gas and carbon emissions. This includes an analysis of Fiji's effort in mitigating climate change issues by "mainstreaming" - an operational approach for making development more sustainable. A country's use of renewable energy sources is a good indicator of its efforts to mitigate greenhouse gas and carbon emissions. Fiji's renewable energy projects and agricultural sector are examined. Identification is made of the gaps in development policies that take control of climate change issues with the process of mainstreaming. Suggestions are provided to close the gaps. ICT (information communications technology) has a critical role to mitigate the impacts of climate change by advancing renewable energy efforts and reducing emissions. Social media is now widely used to inform and educate about sustainable development efforts and to address broader development challenges.

INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC) was decided by world leaders and decision makers at the Earth Summit in Rio de Janeiro in 1992. The ultimate objective of the convention is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference. Fiji is a party to this Convention as well as to the Kyoto

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Protocol. The Kyoto Protocol is an international agreement linked to the UNFCCC, which commits its Parties by setting internationally binding emission reduction targets (UNFCCC, 2015). What has Fiji done and achieved so far in terms of fulfilling its obligations of the Climate Change Convention?

This paper examines the development policies that Fiji has implemented to mitigate greenhouse gas emissions since ratifying the convention. What changes have Fiji brought to its laws and legislations? What new rules, regulations and acts have Fiji passed to show genuine efforts in its ratification of the convention? According to the convention, sustainable development efforts have been suggested for small island nations like Fiji. This is to ensure that such countries grow economically, and are able to provide social welfare to its citizens, while taking care of the environment. Has Fiji been able to develop as suggested?

The intent of this paper is to analyze Fiji's effort in mitigating climate change issues with a process known as "mainstreaming". Mainstreaming is an operational approach suggested by Metz (2010) for making development more sustainable. According to Metz, the best practical way to achieve this is through integrating all relevant elements of sustainability into development decisions. This process does not require governments to do anything extra or to spend any more. It simply suggests incorporating policies that take care of the environment into existing ministries and departments.

One of the ways in which we can really limit the emission of greenhouse gases into the environment is by burning less fossil fuel. Therefore, a country's use of renewable energy sources is a good indicator of its efforts to mitigate greenhouse gas and carbon emissions. To establish Fiji's status, its renewable energy projects are explored to identify how much fossil fuel Fiji is burning and how much energy it is generating from renewable sources. The agricultural sector is another major producer of carbon and greenhouse gases. What is Fiji doing within its sugar and agriculture industry to take care of the environment?

After ascertaining what Fiji has done and achieved so far, discussion focuses on what remains to be done and what has not been done properly. The gaps are identified in Fiji's development policies to take control of the climate change issues within the process of mainstreaming. Suggestions are provided on what can be done to close the gaps that remain, so that Fiji can fulfill its climate change mitigation obligations. There is not an easy way out as development and sustainability do not positively correlate to each other (Kubiszewski et al., 2013). Some best practices applied elsewhere are recommended; one size however, does not fit all.

It has been 20 years since the first Earth Summit and the UNFCCC in Rio de Janeiro. The June 2012 Earth Summit reports that we have not made much difference since then and are still on track for all the climate change woes predicted. ICT (information communications technology) can play a critical role in avoiding future climate change disasters by identifying solutions to advance our renewable energy efforts and reduce emissions. ICTs can also provide early warning systems to mitigate the impacts of climate change. What can ICT do for countries like Fiji and the rest of the world to ensure that our future generations can experience the same or an even better environment than we do? At present Fiji has 333 islands. Will our children and grandchildren be able to have the same number of islands?

BACKGROUND

Since the establishment of the UNFCCC and the Kyoto Protocol, there has been significant progress towards understanding the impacts of climate change in the Pacific region, and developing programs to both mitigate and adapt to it. The establishment of the Alliance of Small Island States (AOSIS) has provided a forum allowing Fiji to collaborate with other small island states and negotiate agreements at the UNFCCC Conference of Parties (Fiji – NCCP, 2012).

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The Mauritius strategy 2005–2015 and the Barbados Plan of Action address the problems of small island developing states (SIDS), with climate change as a significant issue. Fiji will contribute to the implementation of the Mauritius Strategy 2005–2015 and the Barbados Plan of Action through this policy (Fiji – NCCP, 2012).

The Pacific Islands Framework for Action on Climate Change 2006–2015 (PIFACC) was developed with the stated goal: 'Ensure Pacific island people build their capacity to be resilient to the risks and impacts of climate change'. The framework is seen as the overarching guide on climate change at the regional level (Fiji – NCCP, 2012).

Fiji's People's Charter for Change, Peace and Progress serves as the umbrella framework for its national development. The Charter prescribes the roadmap for Democracy and Sustainable Socio-Economic Development 2009–2014. This roadmap defines the implementation framework for the charter. The National Climate Change Policy (Fiji – NCCP, 2012) will serve as an implementing tool for many of the strategies outlined in the charter, such as:

- Environmental protection, sustainable management and utilization of natural resources;
- Strengthening institutional capacity for environmental management;
- Strengthening food security.

Fiji's Minister for Foreign Affairs and International Cooperation wrote in the foreword to the document presenting Fiji's National Climate Change Policy (NCCP) launched in 2012 (Kubuabola, 2012):

Climate change constitutes some of the greatest barriers to sustainable development with widespread and cross-sector effects, putting the biodiversity and ecosystems of Pacific Islands at risk, especially marine and coastal. This has severe implications for Fiji's economic development because of the country's dependence upon natural resources for its primary industries of fisheries, forestry and agriculture.

As reported by the Secretariat of the Pacific Community's Land Resources Division, (SPC – LRD, 2012)

Fiji is on track to be 'REDD-ready' (REDD - Reducing Emission from Deforestation and forest Degradation) by the end of 2012 with the finalization of its national REDD-plus policy currently underway. The development of this policy is in recognition of the need for robust and effective policy and regulatory frameworks to ensure REDD initiatives contribute optimally to the social, economic and ecological development of the country. Fiji's overall objective of the REDD-plus policy will be to effectively address the drivers of deforestation and forest degradation and encourage the drivers of forest-based carbon sinks.

Fiji's continued commitment towards renewable energy is evident in the 2012 National Budget. The Prime Minister in his Budget Address to the nation announced the following:

The existing incentives provided for the setting up of renewable energy companies will continue. The tariff incentives provided for the importation of energy equipment will continue. The concession on duty on diesel for the production of biodiesel will be extended for the next five years, as opposed to on an annual basis. USD 1.5 million is allocated for the Biodiesel Implementation Project. Through Japanese aid, USD 2 million will be provided for the installation of solar home systems in rural homes and schools. USD 150,000 will be allocated for the Renewable Energy Development Project. (Fiji - National Budget, 2012).

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SimCLIM, a climate change model was used (Koshy, 2007) to assess the impacts of climate change in two areas, Natadola and Navua, in Fiji and Aitutaki in the Cook Islands. Koshy stated that:

Although, complete vulnerability and adaptation assessments using SimCLIM could not be performed on each site, the flood-risk maps, flood maps and the evaluation of water tank performance under present climate and climate change conditions for Natadola (Fiji), Navua (Fiji) and Aitutaki (Cook Islands) indicated significant impact.

(Dornan & Jotzo, 2011), applied the portfolio theory method to assess the potential contribution and measure the impact of renewable energy technologies on energy security in the form of electricity in Fiji. They concluded that investment in low cost renewable energy such as bagasse, biomass, geothermal and hydro-power technologies has the potential to modestly lower expected average generation costs, and to significantly reduce financial risk for Fiji's electricity grid. Their findings suggested that the Government of Fiji should

1. Promote investment in low cost renewable energy (bagasse, biomass, geothermal and hydro-power), and
2. Actively investigate the costs and benefits of energy efficiency measures.

Renewable energy technologies provide a cost-effective source of electricity in rural areas where distances are large, populations are small, and demand for energy is low. These technologies are ideal for Fiji whose inhabitants are spread widely in remote rural areas and small outer islands. As a result, a large proportion of households living in rural areas still lack access to modern forms of energy. However, access to basic energy services has been identified as a necessary condition for the achievement of many of the Millennium Development Goals. This is because access to energy can promote improved outcomes in the areas of health, education, and economic development. (Woodruff, 2007).

The Secretary General of the United Nations wrote the following in his foreword in "Energy for a Sustainable Future" (Moon, 2010).

Energy lies at the heart of achieving the Sustainable Development Goals (SDG) and mitigating climate change impacts. The decisions we take today on how we produce, consume and distribute energy will profoundly influence our ability to eradicate poverty and respond effectively to climate change. Addressing these challenges is beyond the reach of governments alone. It will take the active engagement of all sectors of society: the private sector; local communities and civil society; international organizations and the world of academia and research. To that end, in 2009 I established a high-level Advisory Group on Energy and Climate Change.

The United Nation's Advisory Group on Energy and Climate Change identified two key goals:

1. Ensuring universal energy access, and
2. Reducing global energy intensity.

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To achieve these goals, the Advisory Group recommended that energy consumption can be reduced through energy efficiency and a transition to a stronger reliance on cleaner sources of energy, including renewable energy and low greenhouse gas emitting fossil fuel technologies, such as a shift from coal to natural gas. The Advisory Group (AGECC, 2010).identified various sources of funding assistance that countries like Fiji can use to advance their renewable energy efforts. These include existing energy programs and funds (such as the Renewable Energy and Energy Efficiency Fund (REEF), the Climate Investment Funds of the World Bank and other Development Banks and GTZ's Energizing Development

Cloin (2007) stated that there are great opportunities to utilize coconut oil as a fuel in the Pacific. Coconut oil can be blended with diesel fuel, and under certain conditions totally replace it. Coconut oil in Pacific islands countries is increasingly used in both transport and electricity generation because of its lower local cost. Benefits include the support to local agro-industries and a decrease in emissions. All of Fiji's islands are lined with coconut palms.

An investigation was carried out by (Raturi & Lal, 2012) to assess the feasibility of wind/solar photovoltaic/diesel generator-based hybrid power system in a remote location in Fiji. They used the Hybrid Optimization Model for Electric Renewables (HOMER) software to simulate the system and perform system optimization analysis. They concluded that it is possible to alleviate the energy poverty by utilizing abundant renewable energy resources available in the region. The addition of renewable energy components results in greenhouse gas reduction which could be used for carbon trading.

Politics aside, the land lease issue has been the most problematic for the sugar industry in Fiji. The native land owners refused to renew the land leases for sugar cane farming claiming that their land was not being sustainably used and upon its return would be infertile and have no value. This has been ascertained by (Campbell & Doswald, 2009), who reported that continued use of land for sugar cane farming reduces the carbon in the soil. According to Stein, biodiversity and high conservation value areas are also among the main concerns of many stakeholders since sugar cane cultivation has been encroaching onto these lands.

A World Bank Report (2011) recommended integrating climate change and disaster risk reduction policies for the poor, into better urban planning and management. Policies to mitigate such risks have links to multiple sectors and thus can come with important synergies. For example, policies can be designed to have co-benefits with climate change mitigation policy goals. However, they warn, such policy choices come with tradeoffs and often difficult decisions. The outcomes of policy choices will have both positive and negative consequences that decision makers must carefully weigh.

The United Nations Environment Programme report (UNEP, 2011) "Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication" suggested incorporating renewable energy and sustainable agriculture policies at the national level. It emphasized that growth in investment and deployment of renewable energy technologies has been driven by an increasing number and variety of policies (IPCC, 2011). Individual policies to overcome various barriers to renewable energy development and deployment are most effective when they are part of a broad enabling policy framework, which builds on complementarity between a range of measures operating at multiple stages of the chain, from research and development, through to deployment and diffusion.

For sustainable agriculture, UNEP (2011) recommended that at the domestic public policy level, the key challenge is creating the conditions that would encourage more farmers to adopt environmentally sound agriculture practices instead of continuing to practice unsustainable conventional farming methods. To achieve sustainable agriculture development, a nation must develop policies that provide:

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1. Support for improved land tenure rights of smallholder farmers;
2. Target programs for women smallholder farmers; and
3. Ensure public procurement of sustainably produced food.

There is thus a strong argument for incorporating renewable energy and sustainable agriculture policies into a nation's development policies.

The Energy Sector in Fiji

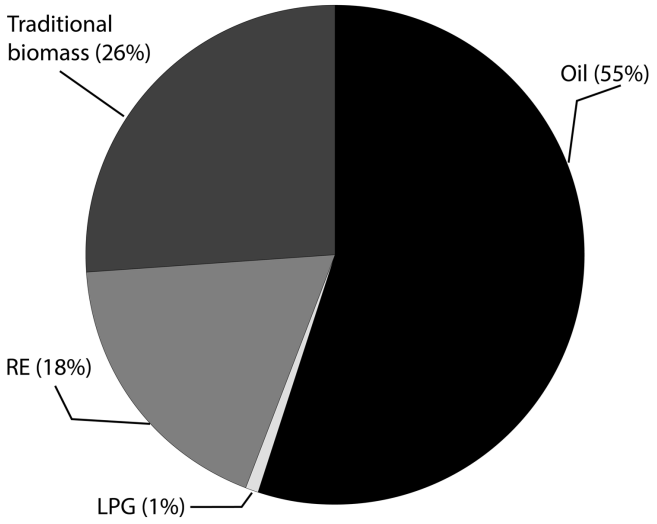
Fiji at the moment is largely dependent on imported oil (Figure 1) to provide energy in the form of electricity and fuel to its citizens. Energy in the form of electricity is provided by diesel generators to home users, industries, manufacturing sector, agricultural sector, fisheries and the service sector (Figure 2). Energy in the form of fuel is provided to:

- Individual car owners,
- Taxis,
- Buses,
- Goods transportation, and
- Shipping services.

Fiji has no fossil fuels.

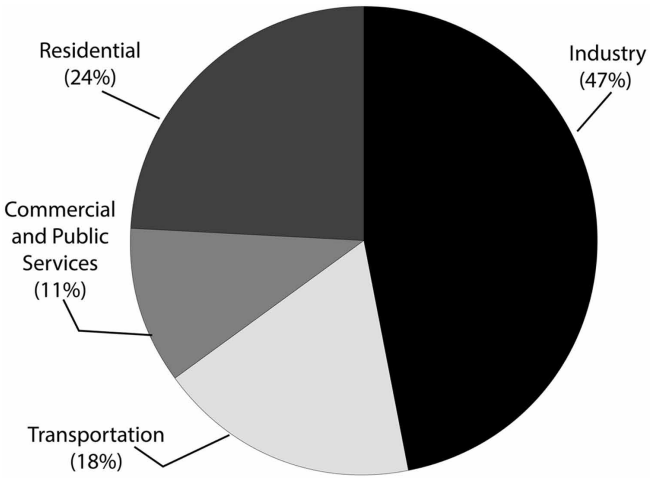
According to Fiji - BoS (2012), every month, Fiji imports around $131.5 million FJD (Fijian Dollars) worth of fuel from Singapore. This is 33.3% of all imports per month for Fiji. However, this is only for 60% of Fiji's population of 868,406 (World Bank, 2011). Forty percent of Fiji's population do not have access to electricity and 75% of Fiji's populations do not own cars (UNDP, 2011). Those that do not have access to modern energy sources rely on traditional biomass.

Figure 1. Energy sources
(RECIPES, 2006)



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Figure 2. Energy consumption
(RECIPES, 2006)



Energy contributes to a virtual cycle of human, economic and social improvements that are essential to sustainable development in developing countries, reports (OECD, 2007). It further states that

Sufficient supplies of clean energy are the basis for raising standards of living, improving the quality and quantity of human capital, enhancing the business and natural environment, and increasing the efficiency of government policies.

The contribution of the energy sector to Fiji's economic and social development is an example of the above. The contribution of the energy sector towards Fiji's GDP was 3.6% in 2005 and was expected to rise to 3.8% in 2007 and continue rising at a rate of 2.5% per annum thereafter (Fiji-SDP, 2006). The amount of electricity generated and sold by the Fiji's Electricity Authority (FEA) is an indicator of the level of economic activity in the country.

Access to electricity in rural areas has improved, with over 100 schemes each year under Government's Rural Electrification Programme. Major changes have taken place within the FEA, following its restructuring. Measures have also been put in place to improve the efficiency and effectiveness of FEA's operations. FEA plans to invest USD 170 million up to 2011 in parallel with some $150 million of private investment in IPP (Independent Power Producers) and PPP (Public Private Partnership) arrangements.

In 2006, the Fiji government developed and implemented in 2007, a national energy policy and a strategic action plan that provided the framework for energy sector activities.

Renewable Energy Efforts in Fiji

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. The Director-General of IRENA (Amin, 2015), states the following on Fiji's Renewable Readiness Assessment "As the costs of renewable energy technologies

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continue to decline, Fiji is increasingly able to make use of its full range of renewable energy resources. These include large and small hydropower resources, as well as biomass, geothermal, solar and wind energy. All of these can help to ensure a reliable, affordable energy supply". He further adds "The National Energy Plan tabled in 2014 offers a promising path that would lower the risks, both real and perceived, for renewable energy investments. Reducing investment uncertainty is crucial for Fiji to create an enabling environment in which renewable energy flourishes.

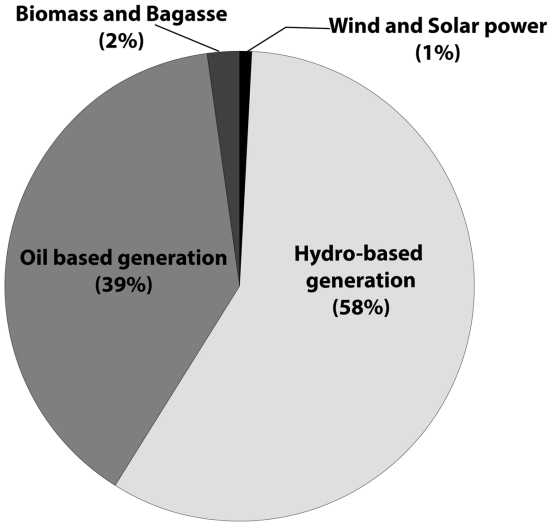
Several renewable energy projects were planned and a number of them have been implemented under Fiji's National Energy Policy and Strategic Action Plan. With Fiji being a tropical island in the South Pacific and being endowed with an abundance of natural resources, renewable energy alternatives are many. Some renewable energy alternatives that have been successfully implemented and currently in use are hydro, solar, and wind (Figure 3). Bagasse is being used in sugar mills, bio-mass in timber mills and trials are being done on ethanol from sugar cane and bio-fuel from coconuts (Figure 4) and cassava.

Other potential renewable energy sources that can be considered in Fiji are:

- Municipal waste,
- Geothermal,
- Tidal power,
- Wave power, and
- Ocean thermal energy.

A charter for Renewable Energy-Based Rural Electrification with participation of the private sector was developed with UNDP-GEF (Global Environment Facility) assistance, and approved by Government in March 2003. The charter provided a mechanism for renewable energy service companies to install and maintain renewable energy-based projects. The formulation of a 'Renewable Energy-Based Rural Electrification Bill' was also approved in 2007 and consultations are ongoing. With Asian Development

Figure 3. Electricity Generation
(Dornan & Jotzo, 2011)



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Figure 4. Coconut Bio-Fuel Generator
(Woodruff, 2007)



Bank (ADB) support, Fiji completed a Renewable Energy and Energy Efficiency Programme (REEP), aimed at building capacity to develop, fund and implement renewable energy and energy efficiency projects, emphasizing market driven structures (Fiji-SDP, 2006).

Depending on rainfall patterns, hydro-power generates between 48 and 65% of Fiji's grid electricity in any given year (Dornan & Jotzo, 2011). Another hydro-power project will generate an additional 42 MW of power by the end of 2012, enough to meet another 20% of the island's electricity needs (Fiji Sun, 2012).

Wind and solar technology provide less than 1 per cent of FEA power (Dornan & Jotzo, 2011). The Pacific Environment Community (PEC) Fund will contribute USD $2.3 million towards a rural solar home systems project in Fiji (PIFS, 2012). FEA proposes to install hundreds of Vergnet GEV MP 275 kW turbines to create a 100 MW wind farm anticipated to produce 111.5GWh of electricity a year (FEA, 2012).

The Agricultural Sector in Fiji

Agriculture is the mainstay of Fiji's economy and contributes around 28% to total employment in the formal sector and indirectly employs many more. This agricultural sector which was once a major stronghold of Fiji's economy is the third largest now, contributing USD $250 million (9%) annually to the nation's GDP. Agriculture has potential in other sectors such as tourism and agro-industries and as

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a major economic activity in the rural areas; agriculture plays an important role in the process of rural development. (Investment Fiji, 2015). According to Fiji's Minister for Industry and Trade, Faiyaz Koya

The Agriculture sector in Fiji is emerging from predominantly subsistence based and on average continues to contribute about 9% of GDP and accounts for 3% of domestic export.

The agricultural sector in Fiji continues to represent the principal economic mainstay of the country and is regarded as its economic backbone. Sugar cane farming is one of the major agricultural activities. In addition, the sector impacts other sectors such as tourism and agro-industries. As the major economic activity in the rural areas, agriculture plays an important role in the process of rural development. The agricultural sector is being relied upon for economic prosperity as it has huge potential for export revenue (Table 1).

The sugar industry directly engages about one fifth of the total labor force in Fiji and creates significant multiplier effects within its economy. The sector production performance is projected to improve in the medium term as a result of expected improvement in cane quality, efficiency gains through the restructure programme within the sugar industry and increases in the production of various other crops. The Sugar Industry is also important to Fiji's economy as it contributes about 1.7 percent of GDP, generates about 8% of total exports with a total foreign earning of USD $80 million in 2013 based on the provisional data from the Reserve Bank of Fiji. Unlike many other export-oriented industries, most production inputs are domestic and have a high regional impact and cross-sectoral linkages (Fiji Sugar Corporation, 2014).

Fiji is known as the 'garden islands' because it has the potential to grow anything. Fiji is potentially on the verge of an exciting new era of growth and diversification in the production and export of agricultural products. The agricultural sector constitutes of two main sub sectors:

- Crops, and
- Livestock.

The crops sub-sector includes sugar and non-sugar:

- Traditional root crops (dalo, cassava and yaqona),

Table 1. Fiji's GDP contribution by the agricultural sector

Fiji's GDP Contribution by the Agricultural Sector USD (Millions)					
	Base Weight	Years			
		2011	2012	2013	2014
GDP	100.0	2,869.4	2,909.9	3,047.7	3,208.9
Agriculture	8.2	236.3	232.6	248.5	242.7
Subsistence	2.7	76.3	76.6	77.3	76.6
Informal	0.7	18.9	18.9	19.1	19.0
General Government	0.1	4.1	3.9	4.4	5.0
Non-General Government	4.8	137.1	133.2	147.8	142.1

Source: *(Fiji – BoS, 2014)*

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- Tropical fruits (pineapple, pawpaw and mango),
- Vegetables,
- Rice,
- Spices,
- Cocoa, and
- Coconut products.

The livestock sub sector includes:

- Beef,
- Dairy,
- Pork,
- Poultry,
- Sheep,
- Goat, and
- Bee stocks.

However, so far, the agricultural sector in Fiji has performed below expectation. The sugar industry has suffered because of non-renewal of land leases for sugar cane farming and the removal of quota system and preferential price for sugar that Fiji used to get from the EU.

Sustainable Agricultural Efforts in Fiji

Fiji's efforts towards sustainable agriculture have been marginal. Costs associated with sustainable agricultural practices, lack of awareness and lack of assistance are some of the reasons behind these mediocre efforts. Farmers seeking higher profit margins with less investment do not care about exploiting the land, depleting its resources, dumping waste wherever they want, and harming the environment. Lack of rules and regulations with no severe penalties for such offences is a contributing factor as well.

Fiji's population growth over the past 40 years has resulted in increased demand for agricultural production, and consequently has put significant pressure on arable lands. Intensive application of fertilizers and pesticides, mono-cropping, and short fallow periods have depleted and prevented recovery of soil fertility, caused increased soil erosion, lowered yields, reduced food security, and increased rural poverty. A by-product of rural poverty has been an increased rural-urban drift, which has in turn led to other adverse social, economic, and environmental consequences. (Xing, 2015).

A host of unsustainable agricultural practices are on-going in Fiji. In addition to the intensive cultivation practices described above, the others include:

- Sloping land cultivation of sugar-cane, ginger and dalo;
- Commercial livestock farming without good pasture management;
- Reclamation of large freshwater swamps for growing rice; and
- Reclamation of large mangrove swamplands for agricultural use.

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Table 2. Soil loss in four major watersheds in Fiji

Watershed	Soil Loss (tons/ha/yr)	Soil Loss (mm/yr)	Total Soil Loss (millions tons/yr)
Rewa	32.2	2.2	9.3
Ba	69.0	4.6	6.4
Sigatoka	76.9	5.1	1.1
Nadi	81.4	5.4	4.2

Source: *(Fiji – BoS, 2014)*

Over the years, these practices have increased erosion, resulting in the loss of soil nutrients and thinning of top soils (Table 2), siltation of rivers, deterioration of drainage on river flats, and inundation of coastal areas (ADB, 2005).

The major agricultural sector, sugar cane farming, is the foremost contributor to unsustainable agricultural practices. Sugar cane farmers would have to adopt more efficient and sustainable cane farming methods. However, the sugar cane farmers will require some convincing to adopt such sustainable farming methods as it comes with associated costs and changes to existing farming methods. Rein (2012) suggested that in the long run it is expected that conforming to such standards (sustainable farming methods) will save money, as inputs such as energy and raw material are used more efficiently, losses and wastage are minimized and manpower is used more productively.

Greenhouse gas emissions from sugar mills is another issue that needs to be addressed. Eustice et al. (2011) have shown that cane burning reduces the organic carbon in the soil, while green cane harvesting can improve it. Sugar cane farmers in Fiji are notorious for burning their cane as it enables them to harvest and transport it to the mill rather than wait for their turn. One of the sugar production mills in Fiji is located on the banks of a major river. Tests conducted conclusively proved that there was a heavy sugar discharge into the river (Ralogaivau, 2008). The Mill Manager of the Sugar Mill at that time assured that they were going to change the discharge system. To date, nothing has changed.

GAP ANALYSIS IN ENERGY POLICIES

In business and economics, gap analysis is a tool that helps companies compare actual performance with potential performance. At its core are two questions:

- "Where are we?" and
- "Where do we want to be?" (Hyra, et. al. 2015).

A number of gap analyses in energy policies mostly looked at energy efficiency (ESCAP, 2011; Masood, 2010; Mesa, 2009; Jaffe & Stavins, 1994). Others looked at renewable energy (RERL, 2011; Santalco, 2012), biomass (Barber, 2007), and natural gas (Brock & Petak, 2007).

In analyzing Fiji's policy gap for energy, this paper will evaluate where Fiji is and where it wants to be in order to fulfill its obligations of ratifying UNFCCC – Energy Efficiency, Kyoto Protocol – Renewable Energy and Sustainable Development Goals (SDG) and Rural Electrification. Renewable energy,

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Table 3. Energy policy gap analysis

Renewable Energy		
Where Fiji Is? = 66% [(1)]	**Where Fiji Wants To Be? = 90%[(2)]**	**The Gap = 24%**
Hydro = 62% of Total Energy	Hydro = 59% of Total Energy	- 3% Decrease
Bio-Mass = 3.0% of Total Energy	Bio-Mass = 30% of Total Energy	+ 27% Increase
Wind = 1.0% of Total Energy	Wind = 1.0% of Total Energy	0% Policies Gap
Solar = 0.1% of Total Energy	Solar = No Forecast/Intention Report	Policies Needed
Bio-Fuel = Development/Trials	Bio-Fuel = No Forecast/Intention	Policies Needed
Energy Efficiency		
Where Fiji Is? [(3)]	**Where Fiji Wants to Be? [(4)]**	**The Gap**
5% Increase in Electricity Demand/Year	Reduction in Electricity Demand/Year	Policies Needed
50% Reliance on Imported Fuel	10% Reliance on Imported Fuel	- 40% Policies Gap
No Policies - GHG and Air Pollution	Reduced GHG and Air Pollution	GHG Policies Gap
No Energy Efficiency Service CO.	Energy Efficiency Service Companies	EESCO's Policies
Rural Electrification		
Where Fiji Is? = 79%[(5)]	**Where Fiji Wants to Be? 100%[(6)]**	**The Gap = 21%**
No PPP Power Supply Projects	Development of PPP Power Projects	PPP Policies Gap
Regulatory Framework Development	Regulatory Framework - Developed	Finalise Framework
79% Access to Reliable Electricity	100% Access to Reliable Electricity	+ 21% Policies Gap
No Renewable Energy Service CO	Renewable Energy Service CO	RESCO's Policies

Sources: (1) Fiji - DoE, 2009, (2) Fiji – DoE, (3) REEP – Fiji, 2006 (4) REEP – Fiji, 2006, (5) Fiji - DoE, 2009, (6) Fiji - DoE, 200

energy efficiency and rural electrification policies gap will be analyzed to lay the groundwork to scale up action in priority areas, undertake strategic reforms where needed, and attract new investments and financial support. Table 3 provides an indication of Fiji's effort and the remaining gap.

Fiji's renewable energy projects, energy efficiency programmes, and rural electrification schemes are being guided by its National Energy Policy (NEP), which comes under the Socio-Economic Development Charter. The strategic areas that NEP follows are:

- Energy planning,
- Energy security,
- Renewable energy, and
- The power sector.

NEP's objective is to ensure that the demand for reliable and affordable electricity is adequately met.

The policies have been in effect since its first draft in 2004. Twelve years on gaps exist in its achievement as is evident above. The policy analysis also identifies some policies whose outcomes would be in contravention to the UNFCCC convention and Kyoto Protocol.

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Gap Analysis in Agricultural Policies

The agricultural policies of Fiji were examined to analyze the policy gap in terms of where Fiji is and where Fiji wants to be to achieve sustainable development in agriculture. Sustainable agricultural development will ensure Fiji's economic and social development as well as address environment, climate and energy concerns of UNFCCC, Kyoto Protocol and Sustainable Development Goals (SDG).

A search for existing agricultural policy gap analysis to see if any could be applied in Fiji's context came up with interesting results. The policy gap analyses are varied and customized. Some of them look at the yield gap of global grain production (Neumann et al., 2010), the gap between policies recommended by external sources (donors) and those generated locally in Africa (AGRA, 2011), and policy gaps in the inclusion of climate change concerns in agriculture in Pakistan (IUCN, 2009). While in Fiji, land degradation from agriculture (Fiji – DoE, 2008) and food import substitution (Fiji – FAO, 2010) policies have been carried out.

Land use and improvement, yield productivity, food security, environment management, and incorporating climate change concerns into agricultural policies are all identified gaps in current policies. Table 4 highlights some agriculture policy gaps in the two major agricultural sector commodities in Fiji:

Table 4. Agriculture policy gap analysis

Sugar Industry		
Where Fiji Is? (1)	**Where Fiji Wants to Be? (2)**	**The Gap**
Lack of Sugar Cane Farming Land	Increase Availability of Land for Sugar	Land Use Policy Gap
Lack of Interest in Sugar Farming	Attract/Increase Sugar Cane Farming	Policies Needed
Low Yield Sugar Cane Stalks	High Yield Sugar Cane Stalks	Research Policies Gap
Sugar Mills Breakdowns/Inefficiency	Repair/Reform/Modernise Sugar Mills	Reform Policies Gap
Labour Intensive Planting/Harvesting	Machine Based Planting and Harvesting	Infrastructure Policies
Vegetable and Root Crops		
Where Fiji Is? (3)	**Where Fiji Wants To Be? (4)**	**The Gap**
Single Vegetable/Crop Farming	Diversification in Vegetables/Crops	Policies Needed
Importing Fruits & Vegetables	Self Sufficiency in Fruit & Vegetables	Policies Needed
Reliance on Vegetables/Root Crops	Add Ginger, Cocoa, and Apiculture	Policies Needed
Importing Rice & Other Food	Self Sufficiency in Rice & Food Security	Policies Needed
Land and Environment		
Where Fiji Is? (5)	**Where Fiji Wants To Be? (6)**	**The Gap**
Land Degradation/Soil Erosion	Land Conservation & Improvement Act	Act Enforcement
Environmental Pollution	Environment Management Act	Act Enforcement
Weak Penalties for Violations	Deterrent Penalties & Hefty Fines/Jail	Act Revision
No Policies or Plans for REDD (7)	REDD Plus Policy for Carbon Schemes	Policy Implementation

Sources: (1) Fiji – National Budget, 2012 (2) Fiji – National Budget, 2012 (3) Fiji – National Budget, 2012 (4) Fiji – National Budget, 2012 (5) Fiji – DoE, 2008, (6) Fiji – DoE, 2008. (7) Reducing Emissions from Deforestation and Forest Degradation Plus Policy

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1. Sugar; and
2. Vegetables & Root Crops; as well as in land and environment.

Fiji needs agricultural policies that focus on its food security so it is able to produce its own food. Being an isolated group of islands in the South Pacific, it cannot afford to rely on imported food. As the country moves to produce more agricultural commodities for export, it needs policies that take care of its land and environment. Policies are needed that provide incentives for people who want to engage in agriculture and mechanisms need to be in place for support and assistance. Training, research and development policies in agriculture should fill this gap.

WHAT IS THE WAY OUT AND HOW TO GET THERE?

The ozone layer has been depleted because of greenhouse gas emissions and we will get exposed to ultra violet radiation. There is global warming because of CO_2 emissions and the ice caps will melt causing the sea level to rise. Extreme weather events like floods, droughts, heat waves, wild fires, cold waves, tropical cyclones, hurricanes, tornadoes, and others will increase in frequency and intensity. Are we doomed? No!! What can we do? All we can do for now is come with the strategies to mitigate the effects of climate change, and adapt accordingly. Our planet has been resilient, its people need to build resilience as well.

The way out has challenges. The climate has been changing and will continue to do so. We cannot reverse the damage that we have caused to the environment so far. However, we can slow it down and prevent further damages. Our anthropogenic actions have emitted and accumulated greenhouse gases in the atmosphere to such an extent that natural carbon sinks and other absorption mechanisms will take many years to remove. Cubasch et al. (2001) modeled projections of future climate change for IPCC and reported that climate change is not only irreversible, but would intensify by the end of the 21st century.

A Fijian reading this chapter would question "what has Fiji done to suffer this fate – our contribution to the climate change phenomena has been negligible, almost nothing compared to other industrialized countries – but we have been suffering the most and would continue to suffer the most, given our geography". The answer is simple. We all share the same planet. Floods, tropical cyclones and drought have increased in frequency and intensity. Islands are being lost to rising sea levels and land is being lost due to coastal and river erosions. We all have common but differentiated responsibilities to do our part to manage climate change impacts as recommended in the report titled "Resilient Planet, Resilient People – A Future Worth Choosing" United Nations Secretary-General's High-Level Panel on Global Sustainability (2012). So what has Fiji done so far? Fiji has done a lot. A lot in terms of working with international, regional and local organizations and governments to establish committees, teams, programs and develop documents, papers, strategies and policies, acts, laws and legislations to mitigate, adapt and build resilience to climate change.

Fiji established a National Climate Change Committee and a National Climate Change Country Team that developed the National Climate Change Policies. Fiji has finalized its National REDD Plus Policy that aligns itself with the objectives of the Fiji Sustainable Economic and Empowerment Development Strategy (SEEDS) and the policies will also play an important role in supporting Fiji fulfilling other international commitments (aside from UNFCCC), such as CBD (Convention on Biodiversity) and UNCCD (Convention on Combating Desertification). As the costs of renewable energy technologies

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continue to decline, Fiji is increasingly able to make use of its full range of renewable energy resources (Amin, 2015).

Fiji is part of the Pacific Islands Climate Change Assistance Programme (PICCAP) and has a Fiji Country Team. Fiji also has:

- A Biodiversity Strategy and Action Plan;
- Sustainable Development Bill;
- Environment Management Act (EMA);
- National Council for Sustainable Development;
- Ozone Depleting Substances Act;
- National Land Use Policy and Plan;
- National Environmental Strategy;
- Comprehensive Hazard and Risk Management (CHARM);
- Integrated Coastal Zone Management Programme;
- Climate Change Vulnerability and Adaptation Assessment and Strategic Plan; and
- Drought Mitigation and Early Warning System.

For a full list, refer to www.fiji.gov.fj.

However, all Fiji has done so far is on paper. We have yet to see implementation and enforcement for many of the above. We have yet to see evaluations and results of the above. We have yet to see the monitoring of the policies and changes or improvements, if any, that they have achieved. Successful implementation, enforcement and monitoring of the policies and programs mentioned above will enable Fiji to mitigate, adapt and build resilience to the impacts of climate change.

There are many sectoral causes to the climate change phenomena, but in this paper, for Fiji, the focus is on the energy sector and the agricultural sector – the two main causes of climate change and the two main contributors of social and economic development and environmental degradation. What can we do about the policy gaps identified in the Gap Analyses in Energy and Agricultural Policies sections of this paper?

Energy Policies and Energy Policy Gaps

There are a number of energy policies under the umbrella of Fiji's National Energy Policy (NEP) and a number of projects with Fiji's Department of Energy (DoE) as well as Renewable Energy Projects and Programs with UNDP's Global Environment Facility (GEF). Other policies, programs and projects include:

- Rural Electrification and Energy Efficiency Program for the Pacific (REEP);
- Rural Electrification Policy (REP);
- Rural Electrification Unit (REU);
- Renewable Energy in Emerging and Developing Countries (RECIPES); and
- Office for the Promotional of Renewable Energy Technology (OPRET).

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In terms of policies, projects and programs, Fiji has done well. Implementation and operation of renewable energy projects, especially hydroelectricity schemes are going well. There have been many wind turbines and solar (photo voltaic) installations as well as biomass electricity and bio-fuel trials.

However, as mentioned earlier some of the energy policies are in contravention of UNFCCC and the Kyoto Protocol.

Renewable Energy

Hydro

Hydro power projects in Fiji alone can generate electricity sufficient for the entire country. However, Fiji cannot rely on hydroelectricity alone as its generation is depended on rainfall patterns and with climate change there are periods of drought. The energy policy prescribes that Fiji uses a lower percentage of electricity from hydro power than at present. This is quite odd. According to Kumar et al. (2011) hydro power offers significant potential for carbon emissions reduction and remains the largest source of renewable energy in the electricity sector. However, Bosshard (2011) claimed that large hydropower projects are not a renewable source of energy and can produce significant amounts of greenhouse gas emissions, a concern also raised by Lima et al. (2008).

Biomass

This policy is quite controversial and in contravention of UNFCCC and the Kyoto Protocol. In Fiji, energy from biomass is produced by burning bagasse and timber. This releases CO_2, GHGs and solid carbon combustion particles. Fiji wants to increase this activity by 27%. Burning biomass produces a large amount of air pollution that is probably responsible for 4–5% of the global burden of disease, as Diette, et al. (2012) reported. Similarly, nitrogen and sulphur emissions lead to acid deposition far from their sources. Such deposition is associated with damage to forests, soils, and lakes in various parts of the world.

Wind

There is no prescribed policy to generate any greater percentage of electricity from wind. Fiji's coastal areas and mountains are ideal for harnessing the power of the wind. As suggested by Narayan and Singh (2007), wind energy conversion system can also become a major source of energy for Fiji, as it is environmentally friendly and can be obtained at low cost. Small Island Developing States (SIDS), like Fiji, can use the Kyoto Protocol's Clean Development Mechanism (CDM) to attract wind energy projects like the one on the island of Santiago, Cape Verde, where they were able to produce around 30% of electricity from wind and reduce CO_2 emission from electricity production by the same percentage (Duic, 2003).

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Solar

Being a tropical island, Fiji has the potential to use solar energy throughout the year. Policies for solar energy projects have resulted in a number of photo voltaic installations in remote islands and mountains. Since Fiji's electricity grid cannot expand to everyone, more policies are needed to provide solar energy to people where the grids are uneconomical to operate at present. The Fiji – DoE (2009) determined that the use of solar electrical or photovoltaic (PV) panels in the rural sector, away from the FEA grid, is of major importance to rural development but at present, the installed capacity is negligible in the country.

Bio-Fuel

Successful trials have been conducted and coconut bio-fuel generation plants installed on Fiji's remote islands which have abundance of coconuts. Policies are now needed for bio-fuels to be integrated into the energy generation and consumption mix. Of particular interest to Fiji is the ability to mix bio-fuel with existing petrol and diesel for transportation. There are environmental, economic, social, energy efficiency benefits for Fiji in this policy (Cloin, 2007; Hill et al., 2006; Yee et al., 2009).

Energy Efficiency

For energy efficiency, a number of policies have been introduced. Rao and Rao (2009) reported that energy efficiency did improve in Fiji after the energy crisis, but this was not due to energy efficiency policies but rather due to higher energy prices. They used the structural breaks test to ascertain this. Therefore, they recommend the use of government policies to encourage energy saving through price increases and other policies like encouraging purchase of more energy efficient appliances and equipment. The scope for the latter is significant because most of the household appliances, vehicles and industrial equipment are old (Fiji – BoS, 2012).

The Fiji Electricity Authority introduced a three-tiered tariff system in 2007 in which there was no increase in tariffs for households whose electricity bills did not exceed 24 USD. For other households, tariffs were increased by a minimum of 3.2%, and commercial customers increased by 6.45%. However, there is no measure of how effective the three-tiered tariff system of electricity billing has been, even in conserving energy. Incentives need to be given to households to install solar power systems, including systems in which surplus power generated from homes can be fed into the national grid.

Rural Electrification

Providing electricity to 70% of Fiji's population is no ordinary task given Fiji's mountainous terrains and remote islands with pockets of villages. The policies have served well and improved their socio-economic conditions. In cases where the expansion of the electricity grid was impossible, stand-alone electricity services through renewable energy projects such as, coconut bio-fuel, biogas, solar and wind based systems were implemented (Fiji – DoE, 2009). PPP Power Projects and RESCO's establishment policy gaps remain.

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Agricultural Policies and Agricultural Policy Gaps

There are a number of policies in agriculture for economic growth and productivity. However, the policies lack the sustainable development requirements of the agricultural sector for socio-economic growth and environment conservation. Climate change policies have not been mainstreamed into existing policies, but rather side-streamed with the NCCP (Republic of Fiji, 2014).

Some of the existing agricultural policies are:

- Agricultural Landlord and Tenant Act (ALTA);
- Land Conservation and Improvement Act;
- Outer Island Agriculture Development Act;
- Watershed Management Master Plan;
- Sugar Industry Act;
- Integrated Pest Management Act;
- Land Development Act;
- Soil and Crop Evaluation Project; and
- Land Conservation Board.

The Sugar Industry

The sugar industry is riddled with problems at all levels. These include:

- Lack of land for sugar cane farming,
- Expiring leases for sugar cane farming land,
- Lower sugar yield in cane,
- Lower sugar cane tonnage/hectare of land,
- Lack of labor to plant, grow and harvest sugar cane,
- Sugar cane transportation problems to sugar mills, and
- Sugar mill efficiency problems.

These problems have existed for years and have led to a lack of interest in sugar cane farming. Gaps in policies exist for all the problems identified above however, existing policies are ineffective.

There are a number of publications investigating the sugar industry. These include the following:

- Performance, Problems, and Potentials in the Sugar Industry by (Prasad & Narayan, 2003);
- Poverty Implications of Expiring Sugar Cane Land Leases by (Reddy & Naidu, 2001);
- Fijian Sugar Cane Farmers Perception of their Future by (Naidu & Reddy, 2002);
- Reform of the Fiji Sugar Industry by Sugar Unit - Fiji (2011); and
- Farm Productivity in Fiji's Sugar Industry by Reddy (2004).

Policies can be developed from these publications.

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Vegetables and Root Crops

Policies, together with government support (training and development) and assistance (funds, seeds, resources) are needed for vegetable and root crop farmers to diversify to other crops. Farmers in Fiji do seasonal farming and flood the markets with their produce, obtaining very low prices. In the off-season, there is no production and consumers, especially hotels and resorts, have to import fruits and vegetables. Research and development policies are needed to cultivate off-season varieties of vegetables and explore alternative production systems such as hydroponics and greenhouses. Policies are needed to add non-traditional vegetables, fruits, and root crops for production and export. Policies are also needed for Fiji to become self-sufficient in producing rice for local consumption.

Gaps in policies exist for ensuring food security but it is achievable given Fiji's natural resources.

Land and Environment

Fiji at the moment has Land Conservation, Land Improvement and Environment Management policies. But enforcement is lacking. To date, no one has been prosecuted for violating these acts. The extent of soil erosion in Fiji, its river siltation, flooding and river, sea and land pollution would give an indication of the lack of enforcement. Squatter settlements in cities not served by the municipal council are left to their own mechanisms for waste disposal and sewerage systems. IMR – USP (2004) reported that urbanization in Fiji has led to subsequent waste disposal problems and pressure on land.

THE ROLE OF ICT'S IN ADJUSTING TO CLIMATE CHANGE

No matter what we do from now onwards, we will still face the effects of climate change (IPCC – WG I, 2001; Schneider, 2004; Solomon et al., 2009). But that does not mean we do nothing. If we do nothing, then the future generation will face:

- Extinction of certain plants and animals (Thomas et al. 2004);
- Extreme weather events will lead to reduction in carrying capacity of food, water, energy;
- And national security implications of one country trying to poach resources from another (Schwartz & Randall, 2003).

Therefore, given the above, our strategic approach is now focused on:

1. Mitigation – reduction in anthropogenic activities causing climate change (IPCC – WG III, 2001; (Canadell & Raupach, 2008); (Lutsey & Sperling, 2008);
2. Adaptation – learning how to live with the impacts (IPCC – WG II, 2001; Adger et al., 2005); and
3. Resilience – building human and ecological processes to absorb the effects of climate change (Tompkins & Adger, 2004).

ICTs (information communications technologies) can play a critical role in mitigating and adapting to climate change impacts. They can assist countries like Fiji to build resilience and adopt best practices through appropriate technology transfers and sustainable development.

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The Role of ICTs in Climate Change

Climate change awareness and education can be enhanced with the use of ICT enabled social media, for example Facebook, Twitter and Web 2.0 applications. Such education and awareness will enable long term sustainable changes (considering the demographics of social media users) in anthropogenic activities that cause climate change. ICTs can play a significant role in reducing the greenhouse gas emissions, in particular through enabling smart energy efficiency and by providing a substitute for the physical transport of goods (for example by the use of e-Books) and people (for example by the use of Skype). For developing countries like Fiji, it is the role that ICTs can play in climate change monitoring and adaptation that is likely to be more important.

The Climate Technology Program initiated by infoDev (infoDev Annual Report 2014-2015) examines the role that ICTs can play through the development and deployment of climate-smart technologies and business models. This can enable developing countries to increase their resilience to climate change while profiting from global demand for clean technology The Climate Technology Program (CTP) uses private sector development approaches to help countries develop effective and profitable solutions to climate challenges through Climate Innovation Centres. Sectors supported by Climate Innovation Centres include:

- Water management;
- Resource use efficiency;
- Energy efficiency and clean energy;
- Solar energy;
- Sustainable and climate - smart agriculture;
- Renewable technology (solar and wind);
- Transportation technology;
- Biofuels and biomass; and
- Adaptation technology.

The Role of ICTs in Climate Change Policy Formulation

Apart from ICT being used to formulate climate change policies, it can assist in developing appropriate policies. ICT has the potential to remodel key urban problems such as a deteriorating environment, congestion or lack of communications between citizens and institutions (Cohen et al., 2002) in developing appropriate policies. Otto et al. (2006) used Computable General Equilibrium (CGE) models to simulate the cost effectiveness of climate change policies and choose among the best. Other cases where ICTs has been used to formulate appropriate climate change policies are: Use of networked governance and public policy formulation (Wilikilagi, 2009); E-governance for adaptation; Citizen centric approach to public policy formulation (Marche & McNiven, 2003); Centeno et al., 2005).

The Role of ICTs in Climate Change Mitigation

Fiji is part of the Pacific Disaster Net – a Virtual Centre of Excellence for Disaster Risk Mitigation in the Pacific Region with comprehensive information resources. The Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) of the United Nations is designed to enhance capacity in the use of ICT for disaster risk management and climate change abate-

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ment (Labelle, 2011). Policies are proposed for the use of ICTs for abating climate change and promoting Green Growth.

Ospina and Heek (2010) explored the role of ICTs in Climate Change via the reduction of emissions through smart grids, dematerialization or intelligent transport systems and buildings. Experiences from vulnerable communities in developing countries point to the use of applications such as mobile phones, the internet and community radio for mitigation. ICTs are critical to providing tools for monitoring, modeling, communication, coordinating, visualizing, advocating and predicting climate change impacts (Hasan et al., 2009).

The Role of ICTs in Climate Change Adaptation

ICT software and model simulations project the extent of climate change impacts and forecast an estimate of when such impacts are likely to occur. Thus when Hurricane Sandy hit the United States of America in November 2012 there were fewer fatalities than Hurricane Katrina in 2005 because of projections made using ICTs (IEEE, 2012). Statistical Down-Scaling Model (SDSM) is used for assessing local climate change impacts using a robust statistical downscaling technique (Wilby et al., 2002).

The impact of climate change is quite complex as we live in an integrated ecosystem with inter-dependencies. Such complexities can be modeled and managed with environment modeling software (Wostl, 2007) for example, Sustainable Urban Development Planner for Climate Change Adaptation – SUDPLAN (Schlobinski et al., 2011).

The Role of ICTs in Building Resilience to Climate Change

Pacific Small Islands Developing States (SIDS) recognize that there are new opportunities afforded by the rapid new developments in ICT to overcome limitations of isolation and remoteness and build their resilience (Koshy, 2004). ICTs are revolutionizing the generation of, and access to data for researchers who are interested in ecological monitoring (Galaz et al., 2010). They can "mine" the internet to detect "early-warning" signs of ecological changes. Other climate change resilience building strategies using ICT have been identified by Allenby (2007), Karanasios (2011), and Yap (2011). They include:

- Energy - ICT can enable the integration of renewables onto the grid, improve efficiency and heighten transparency;
- Food - ICT can help raise productivity and reduce food waste;
- Manufacturing - ICT will place the customer at the centre of a user focused service, cutting resource inputs at the same time;
- Buildings – ICT will increase comfort and reduce energy and water bills; and
- Mobility and Logistics - ICT can help everyone reach their destinations faster, cheaper and safer (GeSI, 2015).

The Role of ICTs in Sustainable Development

ICT and ICT enabled technologies have already created unparalleled development opportunities in developing countries. Mobile phones have led to applications and provision of services such as m-Banking, m-Health, m-Learning, m-Agriculture and many others that would have been otherwise impossible.

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E-Learning has provided the potential for distance and flexible learning and opened up learning opportunities for those who do not have access to education and those who did not make it when they had the chance. Education leads to socio-economic growth and development. Climate change awareness and education will lead to sustainable economic growth, social welfare and sustainable development.

CONCLUSION

Fiji has done a lot under its obligations towards ratifying the UNFCCC and the Kyoto Protocol, but at the moment, they are on paper as policies, acts and legislations. Implementation of the policies, enforcement of the acts, monitoring and evaluation are yet to materialize. Once evaluations are carried out and changes and improvements are measured from the status quo, then we would get an idea of the effectiveness of the policies in place. Policies would then need adjustments to make them effective for Fiji to fulfill its obligation and reach its desired climate change objectives. Due to continuous climatic change and its impact, the agricultural sector is struggling to cope (FCCN, 2015). According to Narain (2015), Fiji has been active in addressing climate change at the policy and project level. However, it faces the challenges commonly experienced by developing countries, including problems associated with lack of funding and resource allocation.

Apart from mainstreaming some climate change policies into exiting ministries, acts and legislations, Fiji has created new policies, committees and programs to combat climate change impacts. It is recommended that Fiji reexamine its climate change policies after an evaluation and where possible mainstream them into existing ones. This would prevent duplication of efforts and costs, and reduce the occurrence of confusion and stakeholders blaming each other. The policy gap analysis identified some policies that are needed, some that need revision, for example the reliance on biomass for energy, and some that are totally ineffective, for example the policies in the Sugar Industry.

Energy and agriculture are the two major sectors in Fiji. They contribute the most to greenhouse gas and carbon emissions, while contributing the most to Fiji's economy. Taking stock and sustainably developing these sectors would fulfil Fiji's obligations and take care of the economy. Fiji was doing very well on the Renewable Energy front with hydro, solar and wind, but its greater reliance on biomass for energy is uncertain. Further investigation is needed in this regard. Agriculture is critical for Fiji's food security; as such, land improvement and sustainable agricultural practices are need for long-term growth and self-sufficiency.

Fiji can learn from best practices in renewable energy and agriculture that have been successful in other parts of the world. Fiji can request technology transfer instead of cash from donor countries/agencies and build capacity for the future. Fiji's sugar industry can learn from Brazil's sugar industries; especially with respect to yield productivity and ethanol production. Bio fuel in Fiji would enable Fiji to absorb oil price shocks and future energy crisis. Many 'Annex I' countries are looking for hosts for Clean Development Mechanism (CDM) projects. Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, as well as countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States. So far Fiji doesn't have any Annex I partner country to which it can sell its carbon credits. Income from selling carbon credits, climate change funding, and finance are available from many international donors.

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Climate change impacts are inevitable. Countries like Fiji would be the most affected, but contributed least to the cause. They should focus on mitigation (reducing the anthropogenic activities causing climate change), adaptation (learning to live with climate change impacts), and building resilience (human and ecological processes to absorb the effects of climate change). Fiji needs to incorporate climate change concerns in its policies that mitigate, adapt and build resilience to future climate change predicaments. Collaborative efforts created through awareness of the issues are needed as the government cannot do it on its own.

ICTs can play a critical role in the mitigation, adaptation and resilience building process. ICT enabled social media can create awareness of climate change issues and can help in formulating appropriate policies based on models and simulations. Early warning systems can prevent fatalities caused by extreme weather events. Resilient plant varieties and animal species developed with the assistance of ICT enabled research and development facilities would ensure food security and survival of the ecosystem in the future. Applications such as Skype and transport navigation systems enable reduction in carbon footprints of humans and the products they consume. Our developments have led us to this; can one of them save us?

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Chapter 21
Sustainable Development and the Integration of Normative Standards

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ABSTRACT

The sustainability definition is still unclear, and requires more in-depth studies to expand their understandings and their effective implementations. One of the means by which to achieve organizational sustainability presented in literature is the use of the concept of Integrated Management System (IMS). Normative management standards such as ISO 9000, ISO 14000, OHSAS 18000, and SA 8000 stand out with large numbers of accreditation by the companies targeted for joint establishment of an IMS, and more recently, normative standards have been identified as mechanisms to ensure the sustainable development of organizations by the integration of economic development, social progress, and environmental quality. This chapter aims to show the evolution of concept of sustainable development; present a definition for the organizational environment; highlight the interaction term "organizational sustainability" with basic normative standards systems management; and guide organizations by describing how interactions between normative standards and the dimensions of sustainability can occur.

INTRODUCTION

In last two decades, sustainability concept has been expanding and gradually embraced by organizations and governments worldwide (Gibson, 2006; Mullerat, 2010).

Sustainability is a relatively new, evolving concept and no consensus exists regarding its definition and a true meaning. A great deal of research has been committed to developing the theme, and research-

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ers have created their own definitions and principles (Xu, Zao, Dawson, Hao, Zang & Tao, 2006; Siena, 2008; Singh, Murty, Gupta &Dikshit, 2009; Barron, 2010) what has caused difficulties in understanding and implementing the concept in the organizational environment.

The term sustainability has inflated, and it is becoming ambiguous with contradictory and obscure associations (Smeraldi, 2009). This conflation occurs due to different definitions and applications the term sustainability, sustainable development and organizational sustainability have received depending on the purpose of the study. Clearly, a precise definition of sustainability still lacks (XU et al., 2006).

Although the concept of sustainability does not present a common definition, John Elkigton's 1987's definition, is widely used. It describes sustainability as mechanisms to ensure current actions do not limit the economic, social, and environmental options for future generations (Elkington, 1998).

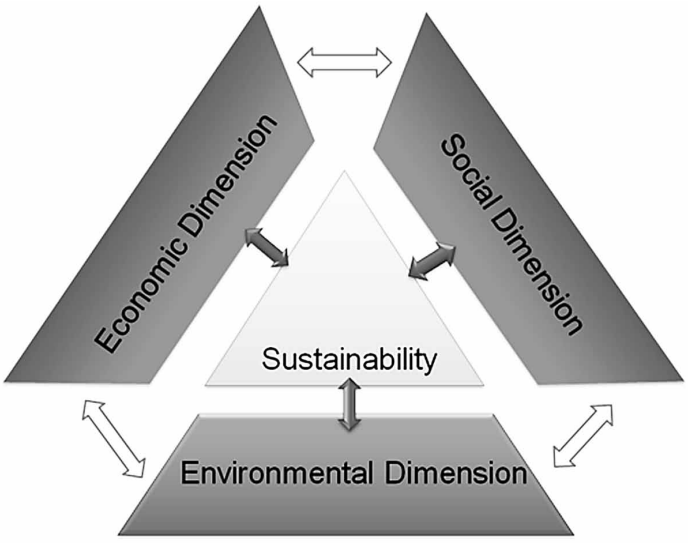
In the organizational environment, Barron (2010) explains that the key to sustainable development is to integrate economic development, social progress, and environmental quality. This integration is represented by the triple bottom line concept (Figure 1).

Economic dimension includes operating cost reduction through management of labor productivity, research and development expenses, and investments in training and other forms of human capital (Jamali, 2006). This dimension projects future prospects, as guided by the steady growth expectation; it also involves innovation concept as an essential element for its realization (Barron, 2010).

Environmental dimension primarily addresses the process, products and services impacts on the environment, biodiversity, and human health (Jamali, 2006). Performance improvement is associated to manufacturing and supply resources reductions in order to reduce pollution as much as possible (IISD, 2009; Dillard, Dujon & King, 2009).

Social dimension aims to guarantee workers' rights, promoting continuous improvement of workplace conditions through the establishment of adequate health conditions and safety. It involves effective engagement of stakeholders contributing to proactive participation of diverse actors, such as company, employees, associations, customers, government, and NGOs (Jamali 2006; IISD, 2009; Dillard et al. 2009).

Figure 1. Sustainability dimensions (adapted from Fresner & Engelhardt, 2004)



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These three dimensions are inter-related, and no single dimension should be prioritized over another. Current research does not allow one to state the three dimensions embrace all sustainability fields (Henriques, 2004). Nonetheless, Elkington (1998), emphasizes that companies managing these dimensions are more likely to succeed and have opportunities to gain new markets.

Sustainability applied to the business environment – called here organizational sustainability – is referenced in literature as corporate responsibility, and addresses mechanisms for displaying, measuring, and improving. Internationally, companies, governments, and non-governmental organizations have made many important improvements in various conduct code models, standards, and methods (Jamali, 2006; Siena, 2008).

Smeraldi (2009) presents data about sustainability's evolution between 2004 and 2009. The author used GetAbstract, considered the main service upon technical summaries for executives. Through this database, Smeraldi (2009) identified more than 5000 titles on sustainability. Between 2007 and 2009, the sustainability theme stood out as the most discussed topic, with over 450 new titles. 120 of them mentioned the organizational sustainability approach. This made sustainability the most popular theme in business literature, overcoming issues like trading, capital markets, marketing, recruitment, and project financing.

Expanding data collection conducted by Smeraldi (2009) for the period from 2010 to march 2013, the GetAbstract (2014) database published more than 266 new titles addressing the organizational sustainability theme keeping it in the leading position in business literature topics.

Linton, Klassen and Jayaraman (2007) identified, roughly 1300 scientific articles addressing sustainability, applied economics, business, and management, published in Scopus database from 2004 to 2005. Expanding the data collection from 2006 to 2013, Scopus database published 8337 articles, which shows an average annual growth of 23% between 2004 and 2013 (last 10 years). This recently collected data confirms and justifies the importance of organizational sustainability and researchers' growing interest.

It is very important to recognize that an organization should be prepared and well-structured to deal with sustainability issues. Organizations have basic needs that must be met in order to survive. These needs are met through interaction between the organization and the environment where it operates, which brings up the fact that an organization first needs to be structured internally before going to external environments. In other words, organizations should plan, implement, verify, and measure internal sustainability before deploying and measuring outward actions (Anderson, Bider, Johannensson & Perjons, 2005).

Lueneburger and Goleman (2010) recently confirmed these findings by indicating that achieving organizational sustainability relates primarily to operational reality; then comes public perception. Companies that develop an image unrelated to their actual achievements are at serious risk of harming their corporate reputation with impacts that go beyond the company's image.

Baron (2010) highlights that organizations, therefore, cannot understand sustainability as a mechanism only for external actions. It is important to get the necessary internal sustainability. Management systems standards have a strong synergy enabling organizations to achieve sustainable development and, therefore, it is important to measure the levels of sustainability in an organization.

Ferroli and Librelotto (2011) featuring sustainability by interdisciplinary, i.e. only through the integration of different disciplines and branches of knowledge it may be possible to obtain viable products that meet the demands of a constantly evolving market, without harming the environment and society.

One of the ways to make a sustainable system is performing its management in an integrated manner, ie, involving the environmental, economic and social dimensions. According Fresner and Engelhardt (2004), the integrated management system allows us to understand the needs of employees and set goals,

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enabling improved training, communication, quality and service assurance, having thus the requirements for sustainability of the sector.

The updated normative standards versions of quality management, environmental management, health and safety, and social responsibility, show that there is great similarity and compatibility between them, which led to the trend of integrating them. This would allow creating a common regulatory standard to promote more sustainable management systems. The integration of management standards is discussed through the concept of Integrated Management System (IMS), which seeks to integrate commonalities of various management systems and respect the individuality of each standard. Normative management standards such as ISO 9000, ISO 14000, OHSAS 18000 and SA 8000 stand out in organizational with a large number of accreditation by the companies being targeted for a joint establishment of a IMS and more recently these normative standards have been identified in literature as a mechanism to ensure the sustainable development of the organization by performing the integration of economic development, social progress and environmental quality.

The concept of IMS can be understood as the integration of various management systems, which combine to create an overview of the process, a systemic approach and focus of employees in order to put all management practices in a single system (Pojasek, 2006). This allows the management system created to be more efficient in achieving the objectives of that when there are several individual overlapping systems (De Cicco, 2004).

Within this theme, this chapter aims to (i) show the evolution of the concept of sustainable development, (ii) present a definition for the organizational environment, (iii) highlight the interaction term organizational sustainability with basic normative standards systems management, and (iv) guide organizations describing how interactions between normative standards and the dimensions of sustainability can occur.

EVOLUTION OF THE CONCEPT OF SUSTAINABILITY

The timeline on the concept of sustainability has strands advocated by some authors. A run of the concept was medial fifteenth century (Marquardt, 2006), others approach the origin from the eighteenth century (Grober, 2007). A third group of authors reported the story only from the twentieth century, when the concept became relevant for today's society (Xu et al., 2006).

These various strands are also found when analyzing the origin of the term. Although the terms sustainability and sustainable have first appeared in the Oxford Dictionary of English only during the second half of the twentieth century, the equivalent term in French (Durabilité and durable), German (Nachhaltigkeit and nachhaltig) and Dutch (and duurzaamheid Duurzaam) have been used for centuries (Du Pisani, 2006).

The aspect most frequently cited in the literature is the origin of the term in German (Nachhaltigkeit), first used in the eighteenth century by German jurist Hans Carlowitz that inspired the theory of English author John Evelyn and the French statesman Jean Baptiste Colbert, began to plan the optimal use of forests, which serve as a feedstock for power generation of iron and silver industries. In this theory, the authors argued that the industrial production could not exceed the playback speed of the woods. Thus, Carlowitz became known for creating the term, but not in its concept (Marquardt, 2006; Grober, 2007; Djalali & Vollaard, 2008).

Only in the 1970s, the concept of sustainability is replaced presence and global importance, being supported by the context of a growing awareness of impending ecological crisis. This occurs in conjunc-

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tion with the emergence of the term "sustainable development", credited to Barbara Ward, founder of the International Institute for Environment and Development (Du Pisani, 2006). From the emergence of terminology, several authors presented their definitions, such as Goldsmith et al, 1972; Meadows, 1972; Coomer, 1979 and Allen, 1980.

In 1987, the current World Commission on Environment and Development (Brundtland Commission called at the time) introduced the world to the concept of sustainable development as a mechanism for political and ethical guidelines for dealing with ecological and social crisis of the planet, through the report "Our Common Future", published by the United Nations (Djalali & Vollaard, 2008; Cerin & Scholtens, 2011).

The apex so that the concept of sustainability was widespread worldwide occurred during the execution of the UN Conference for Environment and Development, in 1992, which became the principle and concept of sustainability known through political and scientific discourses (Marquardt, 2006).

During the last two decades, the concept has evolved, particularly with global development forums, having reached consensus on the need to create procedures that contribute to societal change (Pope, Annandale & Morrison-Saunders, 2004).

ORGANIZATIONAL SUSTAINABILITY

Organizations are commonly referred to as economic entities whose main objectives relate to the production of goods and provision of services in the most efficient way possible.

In recent decades, business management, in addition to meeting the requirements and ensure customer satisfaction and customer loyalty, begin to consider the welfare of employees and the work environment and worry about the impact generated for society and the local community (Wilkinson & Dale, 1999).

These changes become noticeable with the advent of the paradigm of environmental development in the early 1980s, where organizations begin to move away from their narrow economic conception and make profound strategic adaptations in response to environmental pressures and social expectations (Robinson, 2000)

Inspired in part by a growing recognition of the need to transition from environmental management for more comprehensive management called sustainable, in the 1990s, a new change occurred (Jamali 2006). Pressures from other stakeholders in the business, so-called stakeholders - as shareholders, owners, partners, government agencies - influence companies demonstrating best practices in organizational management, compliance with laws and regulations and at the same time, reduce costs and impact on the environment (Bamber, Sharp & Castka, 2004).

This advancement and dissemination of concepts in organizations made them forced to serve beyond the traditional competitive advantages, other parameters to ensure satisfaction and customer loyalty (Karapetrovic, 2002).

These factors resulted in increased complexity of business management and the origin of new demands for transparency and corporate citizenship (Jamali, 2006).

This development took place to meet the expectations motivated from the 1960s, the development and introduction of management standards and standardization, which came to help companies meet these customer relations, supplier and society (Wang & Tsai, 2009; Santos, Mendes & Barbosa, 2011), resulting in the need for organizations to deploy and certify their environments in order to gain competitive advantages in the dispute and the markets in which they operate (Sohal & Zutshi, 2004).

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Although these normative standards undergo certifications from renowned international bodies, no guarantee that the company remains on track towards sustainability, given the fact that there are no regulatory standards to assess what level of sustainability that an organization is.

Commonly, when it comes to management standards and certifications for organizational environments, perceived to implementation of the quality management system, environmental management, management of health and safety at work and, more recently, social responsibility standards those who have a synergy with the pillars of sustainability, i.e. with the environmental, economic and social dimensions.

In essence, the normative standards are documents that define the most effective and efficient way to make a product or perform a task. These normative standards are written by a rigorous and formal process, involving extensive consultation with all relevant agencies, and outlines the organizational "best practices" and regulatory obligations to fulfill. When treated in the context of sustainability, standards of management systems have an extremely useful role in providing a roadmap for the implementation of sustainable organizational development in a growing number of areas (Baron, 2010).

On this point, Vasques (2007) stresses that the absence of a normative standard for sustainable development hinders the beginning of the actions of organizations because they do not get guidelines developed.

Given this, companies wishing to start deploying a sustainable organizational policy end up finding difficulties, since no access to information, is little scientific content by writing about it, is the high cost that the information has, when obtained from consulting firms.

Recently, with the publication of the updated normative standards of quality management, environmental management, management of health and safety and social responsibility versions, there has been a high degree of compatibility and similarity between these (Jorgensen & Simonsen, 2002; Jorgensen, Remmen & Mellado, 2006; Bernardo, Casadeus, Karapetrovic & Heras, 2009), which spawned the ambition and tendency to integrate them, the fact that, according to Jorgensen (2008), which would allow to create a common normative standard to promote management systems more sustainable.

Such integration of management standards is discussed through the concept of IMS, which seeks to integrate commonalities of various management systems and respect the individuality of each standard (Celik, 2009). This reasoning can be used as the basis of a model of internal measurement of sustainability, given that regulatory standards, as well as the dimensions have a strong synergy between themselves and particular characteristics that need to be respected.

To achieve sustainability and the concept of the triple bottom line, Tsai and Chou (2009) advocate the need for organizations to implement and certify their systems through regulatory management standards such as ISO 9000, ISO 14000, OHSAS 18000 and SA 8000.

However, while the integration of the dimensions of sustainability cannot be deduced, manage aspects of the triple bottom line remains a challenge (GRI, 2010). Further integrate dimensions mean embracing the ambiguity in dealing with an elusive and diverse range of themes and values (Jamali, 2006).

For Jorgensen (2008), the mechanism for organizations to become sustainable is the need to analyze, holistically, production processes and products developed in order to improve them on an operational level, in all its parts and throughout the chain, you will see the quality, the environment and the health and safety of employees as to make them sustainable mechanism.

With an IMS, Pojasek (2011) argues that the management of sustainability can be achieved through communication between existing systems. The proposed Jorgensen (2008) and Pojasek (2011) meets the objective contained in this chapter, where achieving sustainability concerns, first, the internal reality of the organization, then come public perceptions (Lueneburger & Goleman, 2010), i.e. the internal

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structure through integrated management systems can be a powerful mechanism for achieving organizational sustainability.

The definitions of the concept of IMS, processes and outcomes, according to Bernard et al. (2009), vary not only depending on the situation of the organization, but also because of the particularity of the studies. Karapetrovic, Casadesus and Heras (2010) complement these few studies, when they occur, are based on theoretical or empirical cases, contributing to the need for debate on the subject.

The theoretical conceptualization of IMS in the literature, according to Zeng, Shi and Lou (2007), are still restricted to a few jobs. Can be cited as studies: Beckmerhagen, Berg, Karapetrovic and Willborn (2003), Karapetrovič (2003), De Cicco (2004), Pojasek (2006), Arifin, Aiyub, Awang, Jahi and Iteng (2009) and Bernard et al. (2009).

The latter, Bernard et al. (2009) combining the definitions of various authors, summarizes the concept of IMS as the process of connecting various management systems of the organization into a single system to common resources and continually improve stakeholder satisfaction.

This integration of the management system is more than simply adding elements of standards in an already structured system (Fresner & Engelhardt, 2004), and cannot be set to put different systems in a single manual (Wilkinson & Dale, 1999).

The IMS shape "system of systems", each system maintains its individual identity (Wilkinson & Dale, 1999), aiming to use the synergies between these rules during the creation and implementation of a management system (Mackau, 2003).

Although studies leading to the formulation of the theory of IMS are being made, there is no consensus among authors about the theoretical definition of the subject. What exists is a systemic view on the need for a consolidated management, but still at an early stage, where we seek the integration of systems (Karapetrovic, 2010; Simon, Karapetrovic & Casadesus, 2012; Satolo, 2012; Satolo, Calarge e Cauchick, 2013).

This lack of consensus on the definition of IMS can be seen in the various terms used to characterize it. In the international literature, the terminology of IMS is treated as Integrated Management System (Mackau, 2003; Holdsworth, 2003; Bamber, Sharp, &Castka, 2004; Zeng, Shi & Lou, 2007; Arifin, et al., 2009; Bernardo et al., 2009; Bernardo et al., 2010; Santos, et al., 2011; Hamidi, Omidvari & Meftahi, 2012), Integrated Management Systems (Wilkinson & Dale, 1999; Karapetrovic, 2002; Beckmerhagen et al., 2003; Fresner & Engelhardt, 2004; Jorgensen et al., 2006; Salomene, 2008; Karapetrovic, Casadesus & Heras, 2010; SIMON et al., 2012) and as a Unified Management System (Jorgensen & Simonsen, 2002).

This variety of classifications, sorted by Hacking and Guthrie (2008) as an "alphabet soup" of acronyms and terms, currently generates a confusing picture about the topic.

In this chapter, the term will be adopted Integrated Management System (IMS), it will be dealt with the integration of various systems into a single management system.

This integration of various management systems is treated in the literature linking up quality, environment, and health and safety at work (Wilkinson & Dale, 1999) and, more recently, social responsibility (Jorgensen et al., 2006).

Thus, it becomes necessary to understand the structure and evolution of the standards for IMS, which is the subject of the next section. It caveat, however, that this is a brief explanation of such rules, not being objective in this section or further explain any points for standards, but important for the purpose of this chapter points.

Basic normative standards and the Integrated Management System (IMS) to reach organizational Sustainability

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As shown in the previous section and illustrated in Figure 2, in an IMS are integrated basically four normative standards: quality [ISO 9000 (ISO, 2008a)]; environment [ISO 14001 (ISO, 2008b)]; occupational health and safety [OHSAS 18001 (BSI, 2008)], and social responsibility [ISO 26000 (ISO, 2010)].

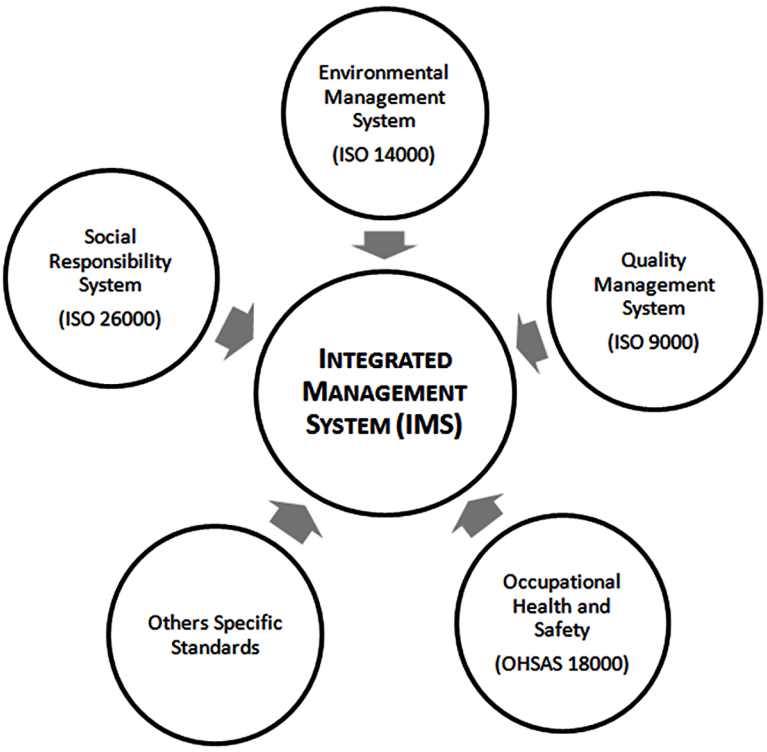
Other normative standards may select IMS organization. Are cited as examples specific standards for industries such as food [ISO 22000 (ISO, 2006)] aerospace [AS 9100 (SAE, 2004)], automotive[TS 16949 (ISO, 2002)], telecommunication [TL 9000 (ISO, 1998)], information systems [ISO 27001 (ISO, 2007a)], and supply chain management [ISO 28000 (ISO, 2007b)].

However, according to the author, these normative standards are rarely discussed in the context of IMS.

In order to clarify and facilitate the understanding of IMS, according to Wilkinson and Dale (1999), it is important to understand the history and structure relevant to IMS standards, because the need for clear definitions is always useful to establish good communication about a particular topic, especially when this is an emerging issue, as in this case.

In this chapter, the use of the concept of IMS features is restricted to the four management systems commonly employed by organizations (quality, environmental, occupational health and safety, and social responsibility) because they are central themes of the work and used as the basis for the proposal the measurement of organizational sustainability model.

Figure 2. Model of a IMS



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Quality Management System: ISO 9001

ISO 9001 describes a number of key elements to enable the design and implementation of the quality management system (Zeng, Shi & Lou, 2007).

It is considered one of the most successful and most deployed normative standards (Bayati & Taghavi, 2007), and the development of its first release occurred in 1987. Currently, the standard is presented in its fourth update, in force since December 2008, and which sought mainly increased compatibility with ISO 14000 families (Mollenkopf et al., 2010).

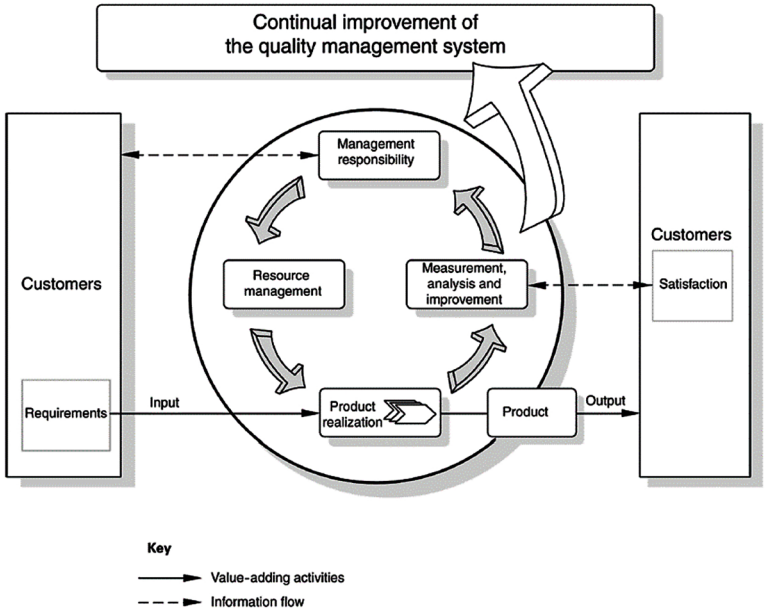
ISO 9001 consists of 18 requirements, namely: general requirements, documentation requirements; responsibility of management, planning, resource management, infrastructure, work environment, planning of product realization, customer-related processes, design and development; acquisition, product and service delivery, control of monitoring and measuring equipment, measurement, analysis and improvement, control of nonconforming product, analysis of data, and improving (ISO, 2008a).

The implementation of the requirements of the standard in the organization can occur in conjunction with the tool called PDCA cycle, and the elements involved shown in Figure 3.

To Naveh and Marcus (2005), the implementation of ISO 9001 requires that the company has an internal standard procedure, replicable routines and processes for product development, manufacturing, delivery, service and support.

The benefits associated with implementing ISO 9000 reported in the literature are diverse, being featured: definition of consumer focus, increase access to international markets, increase the level of employee engagement, maintaining the consistency of the business processes, ensuring the reduction loss of time, material and effort, implementation of continuous improvement. Its implementation, however, only confirms that the company has an effective quality management system, but does not guarantee

Figure 3. Model of a quality management system based on process (ISO, 2008a)



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the quality of products manufactured by the company, this warranty is through an actively managed and implemented by the culture of quality (Jorgensen, 2008; Terziovski & Power, 2007).

The acceptance and success of this standard are significant, verifying that, worldwide, by December 2012, more than 1.1 million companies are certified in 184 countries (ISO, 2013).

Environmental Management System: ISO 14001

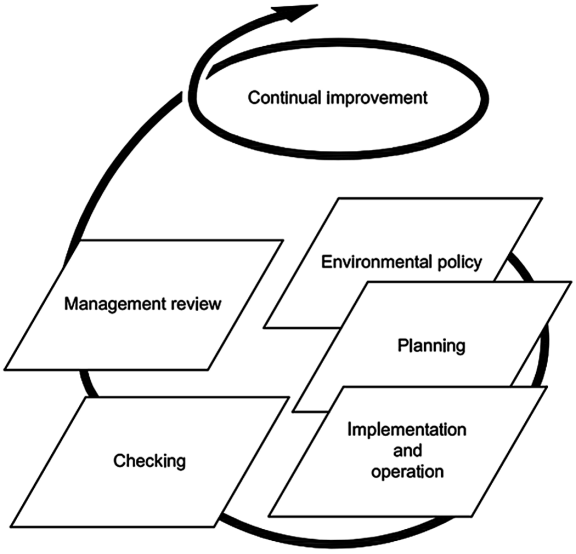
The objective of ISO 14001 is to create an environmental management system that allows the organization structuring mechanisms for continuous improvement in performance and reduction in resources consumed and, therefore, of environmental resources (Bernardo et al., 2009).

The ISO14000 series of standards, established in 1996, was reviewed in 2004 (Lagodimos, Chountalas & Chatzi, 2007) creating a higher level of similarity with the standards of ISO 9000 series (Karapetrovic & Casadesus, 2009).

The requirements covering the ISO 14001 comprises a total of 22, which are requirements of the environmental management system, general requirements, environmental policy, planning, environmental aspects, legal and other requirements, objectives and targets; management program (s) environmental, implementation and operation, structure and responsibility; training, awareness and competence, communication, environmental management system documentation, document control, operational control, emergency preparedness and response; checking and corrective action, monitoring and measurement, non- compliance and corrective and preventive actions; records; audit of the environmental management system, management review (ISO, 2008b).

The implementation of these requirements (shown in Figure 4), as well as ISO 9000, involves the PDCA cycle. According to Zutshi and Sohal (2004), during the deployment process, one should take into account five key elements: environmental policy, planning, implementation and operation, inspection and corrective action, and management review.

Figure 4. Elements of an environmental management system (ISO, 2008b)



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Oliveira and Serra (2010) list a number of associated with the deployment of an Environmental Management System, among these benefits: access to new markets, law-abiding management, regulatory incentives, risk reduction, access to more capital, the improvement of the production process, improvement of environmental performance improvement in the overall management of the company, improving the relationship with employees, improving public image, competitive advantage within specific segments, meeting the demands of customers, increased quality of life, achievement of clean operations (green), increasing the competitiveness of the product or service and public awareness.

There are approximately 285.000 companies in 167 countries worldwide ISO 14001 certified (ISO, 2013).

Occupational Health and Safety: OHSAS 18001

The Management System for Occupational Safety and Health is characterized by specifying procedures for organizations to manage their activities, products and services, in order to control and prevent circumstances that may result in accidents, injuries or occupational diseases.

This standard emerged in 1996 as BS 8800 - Guide to Occupational Health and Safety Management System Safety. In 1999, OHSAS 18001 (Occupational Health and Safety Assessment Series) was launched as the first specification of Health and Safety to submit character certificate (Zeng, Shi & Lou 2007), having passed in July 2007, for its first review.

Its creation was designed to allow a harmonious integration with the standards of quality management and environmental management. To do so, requires the preparation of a specific security plan to be updated on an annual basis, and is broad enough to include the entire organization.

This similarity can be seen by the 22 requirements that comprise the OHSAS 18001 standard, which include: general requirements planning; planning for hazard identification, risk assessment and risk control, legal and other requirements; occupational health and safety policy objectives; implementation and operation; resources, roles, responsibility, accountability and authority, competence training and awareness, communication, participation and consultation, documentation, document control, operational control, preparedness and emergency response, monitoring and performance measurement, evaluation of conformity; incident investigation, nonconformity, corrective and preventive actions; records and record management, internal audit, management review (BSI, 2008).

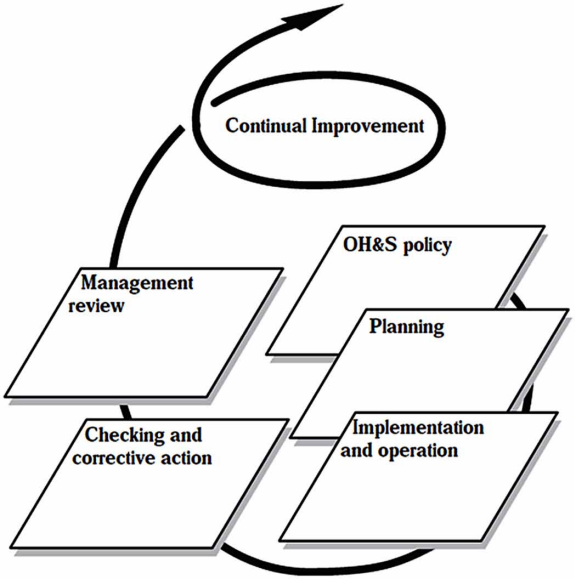
Representative elements of the implementation of OHSAS 18001 processes also use the concepts of PDCA cycle and are highlighted schematically in Figure 5.

Among the benefits associated with the implementation of OHSAS 18000 reported in the literature include: reducing the number of accidents through prevention and control of hazards in the workplace, reducing the risk of serious accidents occur, reducing material losses caused by accidents and downtime, reducing severance costs and insurance, cost reduction with the withdrawal of workers, the potential reduction in downtime and associated costs, demonstrating to stakeholders of corporate commitment to health and safety (Zeng, Tam &Tam, 2008; Duijm, Fievez, Gerbec, Hauptmanns & Konstandinidou, 2008; Vinodkumar &Bhasi, 2011).

Jorgensen et al. (2006) describe the ISO voted twice times for the development of a standard in their patterns, both being denied. However, in 2013, began working for the creation of the new ISO standard, ISO 45001, on occupational health and safety management system requirements is being produced by the Project Committee, ISO PC 283, with the intention of publication in October 2016. The standard

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Figure 5. Elements of a management system for occupational health and safety (BSI, 2008)



will be aligned with ISO 9001 (Quality Management) and ISO 14001 (Environmental Management), themselves which are undergoing revision and are due for publication in 2015.

According to the latest available survey, worldwide, approximately 55,000 companies are certified in 80 countries (BSI, 2011).

Social Responsibility: ISO 26000

ISO 26000 (ISO, 2010) standard was launched in 2010, resulting in a five-year trial involving 450 experts from 99 countries. His aim is to establish an international standard for organizational establishment of a Management System of Social Responsibility.

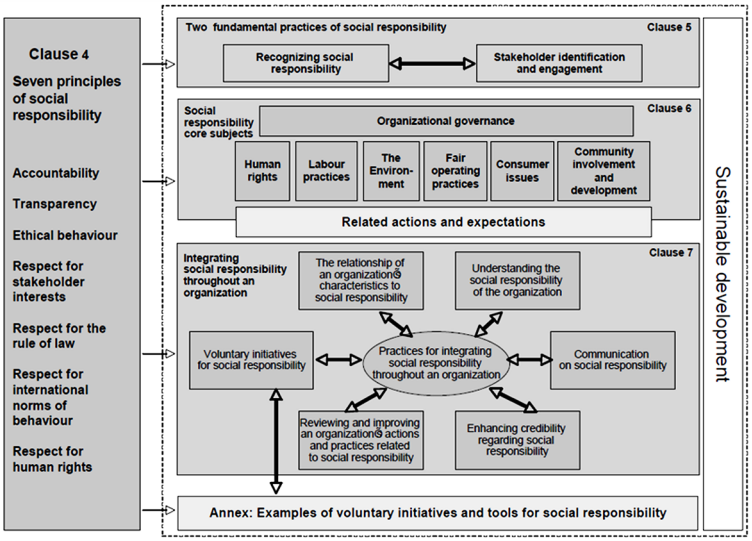
Its origin is based on SA8000, launched in October 1997, the Social Accountability 8000 (SA8000), which established the first global standard certification focused on corporate social responsibility. Created by CEPAA - Council on Economics Priorities Accreditation Agency, currently called the SAI - Social Accountability International - U.S. non-governmental body - the standard focuses on securing the rights of workers involved in production processes, promoting standardization in all sectors business (Willians, 2010).

The ISO 26000 aims to guide companies to adopt socially responsible practices. During its preparation, rose the possible parallels with the standards already established Quality Management and Environmental Management, consisting of eight requirements, highlighted in Figure 6: organizational governance, human rights, labor policies, environment, fair practices operation, consumer issues, community involvement and development (Castka & Balzarova, 2008; ISO, 2010).

According Pojasek (2011), ISO 26000 is not a management system such as ISO 9000 and ISO 14000, but a roadmap for organizations that want to establish a system of Social Responsibility. According to the author, the generation of a system of organizational management, like ISO 9000, should be supported in the specification ISO 26000, which guides the structuring of a system of social responsibility management based on PDCA cycle.

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Figure 6. Elements of the social responsibility norm (ISO, 2010)



As new rules, in order to guide organizations, is not yet scheduled for audits to obtain certifications (Castka & Balzarova, 2008; Pojasek, 2011). Similarly, point benefits are still limited to a few published studies, and further efforts need from researchers. Perera (2009) in one of these studies highlights benefits in terms of productivity gains, improved image and cost savings.

NORMATIVE STANDARDS FOR MANAGEMENT A INTEGRATED SYSTEM

Although this discussion on the creation of an integrated system governed by a single normative standard has become an obvious thread, currently, there is a worldwide accepted standard that covers an integration methodology (Bernardo, Casadesus, Karapetrovic & Heras, 2010).

Internationally, the ISO published in 2008 the book called The Integrated Use of Management System Standards, reporting and promotes a reference to sixteen experiences of implementing IMS (ISO, 2008c). This book, however, lacks a method for deployment and management of the system.

At the national level, different countries have developed their methods of integration, i.e., Australia and New Zealand - AS / NZS 4581: 1999 Denmark - DS 8001: 2005 Spain - UNE 66177: 2005 and the UK - PAS 99: 2012 (Bernardo, 2009; Bernardo et al., 2010.). These normative standards for deployment of IMS will be briefly discussed in the following subsections.

AS/NZS 4581: 1999

Was published AS / NZS 4581:1999 standard, developed by standardization bodies in New Zealand and Australia in 1999. According to Ferreira (2009), this normative standard addresses the integration of management systems guidelines for organizations with the purpose of business, government and community. The rules do not restrict its use only for quality management, environmental, safety and occupational health system and can be applied to all types of management systems.

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According to the author, establishes the rules common to all systems components to be integrated. To this end, comprises nine components for a management system, which: responsibility and leadership management, identification and needs analysis, policy and objectives, planning and implementation of the system, resource allocation, communication and information systems, management processes and activities, monitoring and measurement, critical analysis of the direction and improvement plans (Arifin, 2009). Figure 7 shows the model of IMS standard AS / NSZ 4581:1999.

UNE 66177: 2005

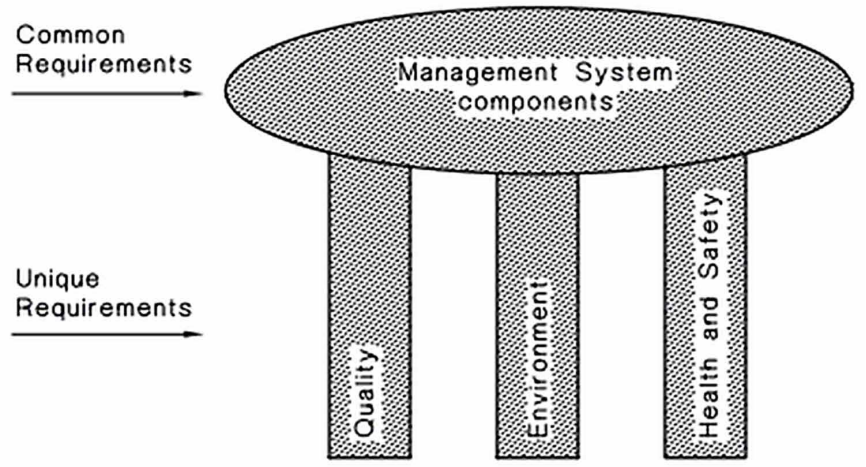
In 2005, Spain issued its normative standard IMS, called UNE 66177:2005 - Systems gestión Guide to integración la Gestión de los systems. The normative standard defines IMS as the set formed by the combination of organizational structure, responsibilities, procedures, processes and resources that are established for the integrated management systems (Barral, 2007; Guillén & Carmenates, 2009).

The steps for implementation of a IMS -based normative standard UNE 66177 (2005) and the study of Guillén and Carmenates (2009) are divided into four:

1. Design: creating the objective and subjective conditions to begin to define the system and obtain the commitment of all levels.
2. Planning: determines the status of the organization for the implementation of the current regulatory standards for the development and integration of existing systems, set the integration method and program of activities to implement and effectively manage the changes.
3. Monitoring and measurement: objective periodically evaluate and adjust the implementation plan and ensure the suitability, adequacy and effectiveness of the system since its implementation was performed.
4. Continuous Improvement: aims to identify opportunities for continuous improvement to help increase the performance of IMS, and the appropriate tools in each case.

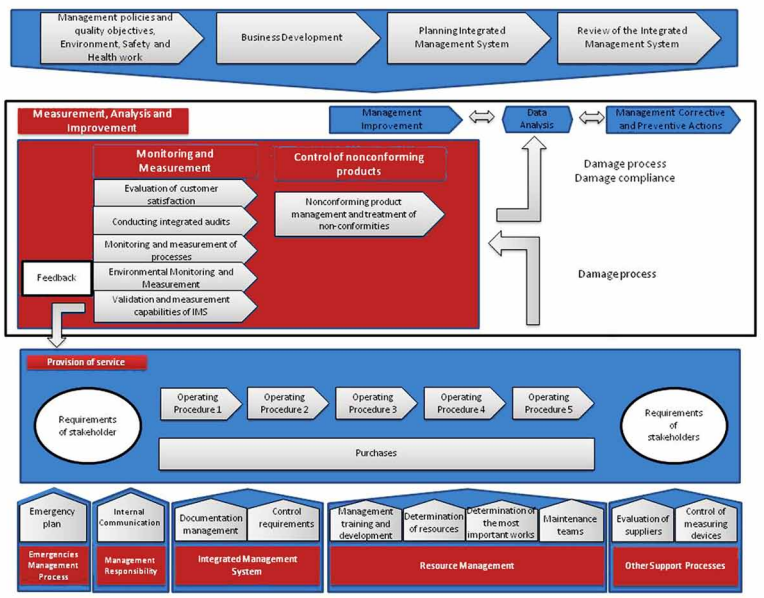
Figure 8 is proposed by UNE 66177 (AENOR, 2005) for the implementation of a IMS model.

Figure 7. IMS Model used in the standard AS / NZS 4581:1999 (Ferreira, 2009)



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Figure 8. Model proposed by UNE 66177 (AENOR, 2005) for the implementation of IMS



DS 8001: 2005

The normative standard Danish (Dansk Standard 8001, 2005) had started its production in 2003 from studies by a large working group under the motto'' an organization, a system "(Jorgensen, 2008). The standard describes the characteristics of a good management and common and individual elements that may involve a IMS (Rasmussen, 2007).

Figure 9 is proposed by DS 8001 (Dansk Standard, 2005) to implement a IMS model.

In the first level, the normative pattern possessed a strategic approach, with emphasis on corporate governance. In this step, we try to emphasize the importance of the management system, organizations demonstrating the starting point for business strategies. The organization has developed a mission, vision and strategy, and create corresponding goals and policies, meeting the demands of stakeholders (Rasmussen, 2007; Jorgensen, 2008).

At the second level, the normative standard describes the common elements in an IMS and also provides standard tools for such integration.

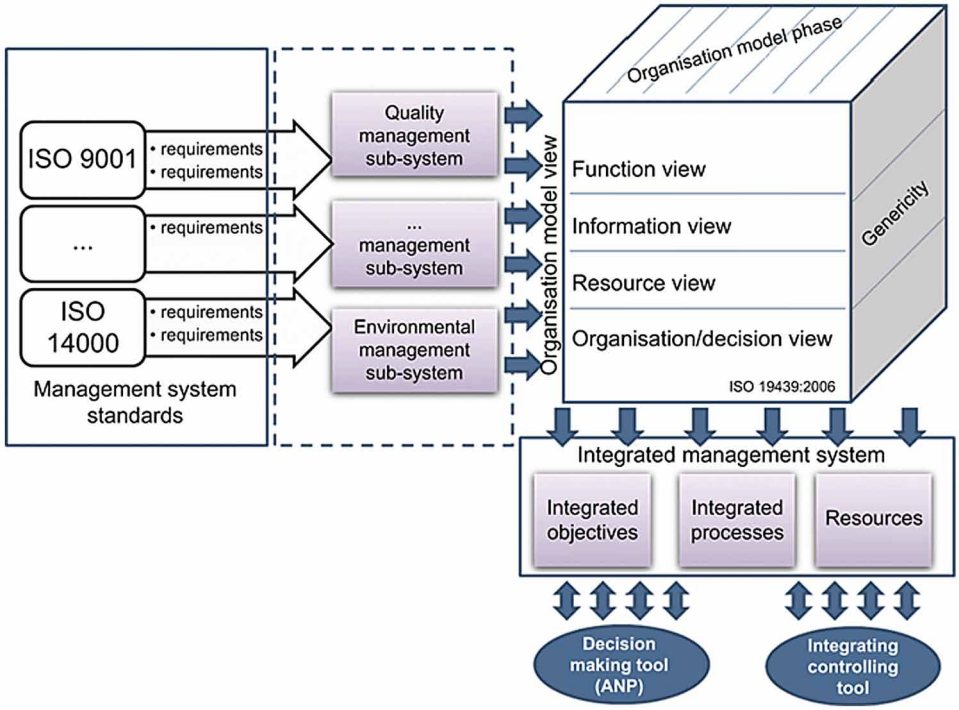
Finally, the third level of the normative standard, discusses the different management areas and describes how an organization can choose to integrate your IMS, employing several security management systems such as quality, environment, energy, occupational health and safety, food, social responsibility, risk management, among others (Rasmussen, 2007; Jorgensen, 2008).

PAS 99:2012

In 2006, the United Kingdom through the British Standards (BSI), based on the ISO Guide 72:2001, developed his legal standard to meet the common requirements of an IMS, called PAS 99 (Publicly Available Specification), and which underwent its first revision in 2012. This objective normative standard

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Figure 9. Model proposed by DS 8501 (2005) for the implementation of IMS



to be used as a model for the implementation of common standards or specifications of requirements management system in an integrated manner (Vasconcelos, 2011).

To Vasconcelos (2011), the PAS 99:2006 provides a simple model for organizations to integrate into a single structure all the standards and specifications of management systems that adopt. However, to properly deploy PAS 99:2006 does not guarantee the company than the other management systems comply with regulatory standards governing them, i.e., the joint implementation of the environmental management system and quality through PAS 99:2006 does not guarantee that it fully conforms to the required respectively by ISO 14001 and ISO 9001 standards. The structure created by the PAS 99:2006 is shown in Figure 10.

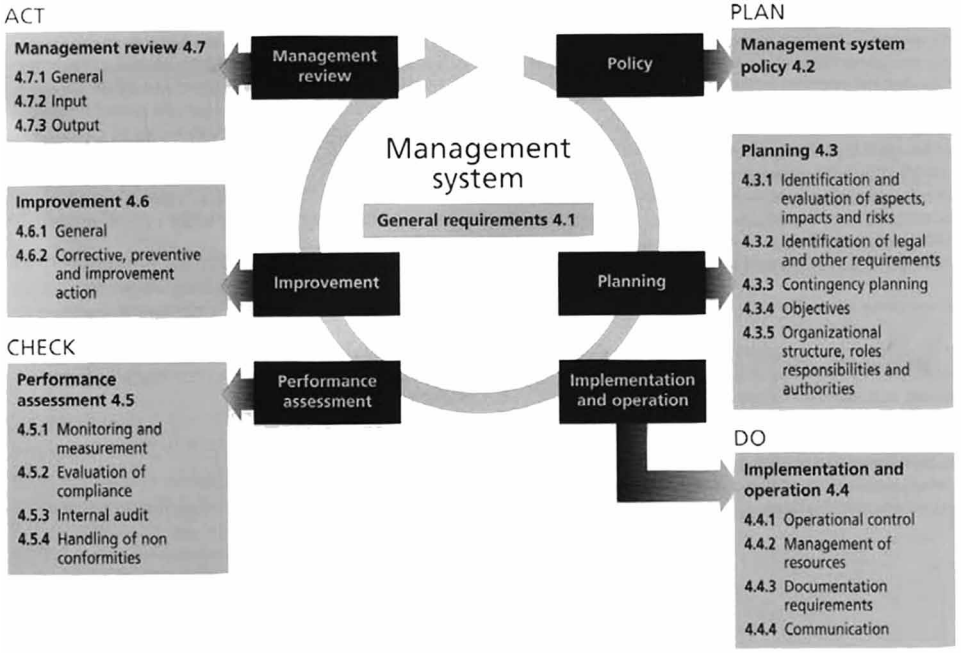
INTERRELATIONS BETWEEN THE REQUIREMENTS OF THE STANDARD PAS 99:2012 AND DIMENSIONS OF ORGANIZATIONAL SUSTAINABILITY

The design of an IMS is given for the use of synergies between the different normative standards and the elimination of redundancies within them.

In recent years, the revision of normative standards ISO 9001, ISO 14001, OHSAS 18001 and ISO 26000 increased the similarities between different patterns and made them more compatible. This improved the possibility of integrating the standards and supporting links between the necessary systems allowing target a sustainable management system (Karapetrovic, Casadesus & Heras, 2010; Bernardo

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Figure 10. Requirements to delineate the structure of the IMS (BSI, 2006)



et al, 2010). These standards form the integrated IMS and have high interaction with the dimensions of sustainability (triple bottom line).

The equivalence between the requirements of the normative standards ISO 9000, ISO14000 and ISO18000 is presented in Table 1, made from the proposed requirements for integration of management systems with the normative standard PAS 99.

Justifies the choice of the standard PAS 99 standard as the basis for establishing the inter-relationship with the sustainability, three important aspects: (i) this normative standard, although not universal, stands out for its further spread in relation to other models presented (ii) has as proposal for its creation, maintaining strong relationship to the normative ISO and OHSAS standards, and (iii) its implementation, as well as in other normative standards in its process uses the PDCA cycle, thus facilitating system management the high level of similarity.

It is observed from Table 1 the high level of synergy between the three normative standards. Verifies the existence of various sections / subsections that interrelate as well as items that are characteristic only a few patterns, highlighting the concept presented by several authors (Jamali, 2006; Celik, 2009; Bernardes et al., 2009; Pojasek, 2011) where the systems that make up an IMS feature common and particular points that need to be respected.

The establishment of the interrelationships between normative standards beyond demonstrates strong synergy, the possibility to carry out the implementation of the management system following the steps of the PDCA cycle, so this strongly defended by normative standards.

The PDCA cycle had its origin with Dr.W. Edwards Demings lectured in Japan in 1950. Deming, Father of total quality management has put forth the concept of Plan, Do, Check and Act cycle. The PDCA cycle was broadened to include strategies and methods to develop, test, and implement changes that would result in improvement. The PDCA-cycle is a never ending cycle designed to improve qual-

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Table 1. Equivalence between the elements of an IMS based on the requirements of the standard PAS

Requirements		Equivalence between the Normative Standards and PAS 99:2006	Requirement on			
Version 2006	Version 2012		ISO 9001	ISO 14001	OHSAS 18000	ISO 26000
4.1	4.3 4.4	General requirements	4.1.	4.1	4.1	5.1
4.2	5.2	Management system policy	5.3	4.2	4.2	5.2.1
4.3	6	Planning	5.4	4.3	4.3	3.3
4.3.1	4.1 6.1.1	Identification and evaluation of aspects, impacts and risks	4.2.2	4.4.4	4.5.1	3.5.2
4.3.2	4.2	Identification of legal and other requirements	7.2.1	4.3.1 4.3.2 4.4.6	4.3.2	5.2.1 5.2.2 5.2.3
4.3.3	6.1.2	Contingency planning	8.3	4.4.7	4.4.7	6.4.6.2. 6.5.3.2
4.3.4	6.2	Objectives	5.4.1	4.3.3	4.3.3	5.2.1
4.3.5	5.1 5.3	Organizational structure, roles, responsibilities and authorities	5.	4.4.1	4.4.1	6.2.1.1 6.2.1.2
4.4	8	Implementation and operation	7	4.4	4.4	-
				4.4.6	4.4.6	3.4.3
4.4.1	8.1	Operational control	4.2.3	4.4.5	4.4.5	5.2.1 5.2.2 5.2.3
			4.2.2	4.5.3	4.5.3	6.4
4.4.2	7.1	Management of resources	6	4.4.1	4.4.1	6.2
	7.2		6.2.2	4.4.2	4.4.2	6.4.7
4.4.3	7.5 7.5.1 7.5.2 7.5.3	Documentation requirements	4.2	4.4.4	4.4.4	7.3 7.4 7.5
4.4.4	4.2	Communication	7.2.3	4.4.3	4.4.3	6.2.2
	7.4		5.5.3	4.4.3	4.4.3	4.3
4.5	4.5	Performance assessment	8	4.5.1	4.5.1	6.2.3
4.5.1	9.1 9.1.1	Monitoring and measurement	8.2.3	4.5.1	4.5.1	6.5 6.4.6 6.4.7
4.5.2	9.1.2	Evaluation of compliance	8.2	4.5.1	4.5.2	6.4.6 6.4.7
4.5.3	9.2	Internal audit	8.2.2	4.5.3	4.5.4	-
4.5.4	10.1	Handling of nonconformities	8.3 8.5.2 8.5.3	4.5.2	4.5.2	6.7.6
4.6	10	Improvement	8	4.5	4.5	7.7
4.6.1	10.2	General	8.1	4.5.1	4.5.1	7.7.1
4.6.2	10.1	Corrective, preventive and improvement action	8.2.3	4.5.1	4.5.1	-
			8.2.4			
4.7	9.3	Management review	5.6	4.6	4.6	7.3
4.7.1	9.3	General	5.6.1.	4.6	4.6	7.3
4.7.2	9.3.1	Input	5.6.2.	4.6	4.6	7.3
4.7.3	9.3.2	Output	5.6.3	4.6	4.6	7.3

*Retired from Risk Tecnologia (2006)

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ity and efficiency. PDCA cycle approach to quality improvement helps on institute to focus on the goal and obtain the commitment of all the stakeholders to the accomplishment of the goal set (Singh, 2013).

Thus, the regulatory requirements presented in Table 2 can be grouped into six major areas, which are related to stage of the PDCA cycle. The six topics are: (i) policy management system; (ii) Planning, (iii) Implementation and operation; (iv) Performance assessment; (v) improvement and (vi) Management review. These relationships are shown in Figure 11 and described in Table 2.

Figure 11. Relationship between Normative Standards of IMS and PDCA Cycle steps

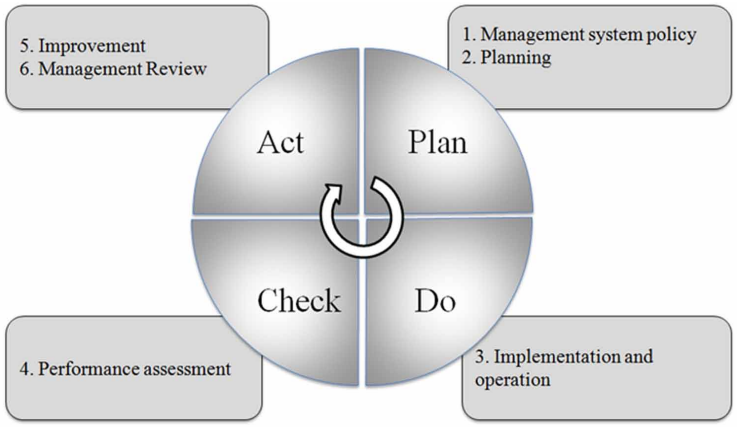


Table 2. Relationship between Normative Standards and Requirements of IMS and PDCA Cycle steps

PDCA Cycle Steps	Axes		Requirements	
Plan	1	Management system policy	1.1	Management system policy
	2	Planning	2.1	Identification and evaluation of aspects, impacts and risks
			2.2	Identification of legal and other requirements
			2.3	Contingency planning
			2.4	Objectives
			2.5	Organizational structure, roles, responsibilities and authorities
Do	3	Implementation and operation	3.1	Operational control
			3.2	Management of resources
			3.3	Documentation requirements
			3.4	Communication
Check	4	Performance assessment	4.1	Monitoring and measurement
			4.2	Evaluation of compliance
			4.3	Internal audit
			4.4	Handling of nonconformities
Act	5	Improvement	5.1	General
			5.2	Corrective, preventive and improvement action
	6	Management review	6.1	General
			6.2	Input
			6.3	Output

Source: Elaborated by the authors

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The implementation of IMS in this way now goes by meeting the requirements of PAS 99 standard, and that are directly related to the environmental, social and economic dimensions proposals for sustainable development, and these relationships below described.

PLAN

Axis 1. Management System Policy

Requirement 1.1. Management System Policy

It is understood that the policy of the management system of the organization should include in its mission / vision the social and environmental dimensions as well as the maintenance of its economic health, showing the internal and external stakeholders concern for the future of the organization and provide gains beyond the financial interests with ethical behavior and respect for their partners and the environment, envisioning long-term career plan to ensure more able and motivated human resources.

Axis 2. Planning

Requirement 2.1. Identification and Evaluation of Aspects, Impacts and Risks

The organization shall establish, implement and maintain procedures to identify areas of risk and impact of its activities, products and services within the defined scope of your management system. Should establish a set of procedures for social and environmental assessment to be followed and their interconnection with the economic evaluation of the project. These impacts and risks can be evaluated taking into account: the image of the organization, legal points, points financial, strategic points, operating points and outsourcing.

Requirement 2.2. Identification of Legal and Other Requirements

This requirement refers to the establishment, implementation and maintenance of procedures to determine the legal and other requirements related to its activities, products and services that are relevant to the scope of the management system requirements in order to take them into account in establishing, implementing and maintenance management system. It is important to understand the legal requirements in this (mainly environmental) regulation as a mechanism of competitive opportunity and not as a punishment mechanism. Identify which are the critical demands of society in relation to the business and likely predict which actions will be taken by relevant standards or policies and make investments for efficiency gains and provide significant competitive advantage. This will bring to the organization the opportunity to gain know-how coming from pioneering and reputation, which will reach it, the economic part of the organization.

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Requirement 2.3. Contingency Planning

The organization shall establish, document and maintain procedures to identify and respond to any unplanned event, emergency or potential disaster. This procedure should aim to prevent or mitigate the consequences of any such occurrences and consider the continuity of business operations. Are among these contingencies from product recall actions until disaster management such as fire, flood or environmental disasters. An unplanned, emergency or disaster event occurs without the knowledge of such organization possesses and, in most cases, is directly related to its stakeholders in its various representations, i.e., an employee who may be an accident within the organization or client that might get hurt due to failure in a product. Whatever the contingency, the company brings the need for economic planning initially to invest in improvements to prevent these events and also to face the need for repairs to society and to the internal and external environment due to its occurrence.

Requirement 2.4. Objectives

Shall be established by the organization objectives that take into account significant aspects, legal obligations, other requirements and its commitment to continuous improvement by implementing their policy, which must be measurable, relevant and realistic. It is important that the objectives of the management system envisage and to target improvements for employees and the environment, through continuous improvement of existing conditions in the workplace and improve its performance with respect to the amount of resources that are used to purchase raw materials and products finished in order to reduce them to short, medium and long term.

Requirement 2.5. Organizational Structure, Roles, Responsibility and Authority

The organization must indicate specific representatives of management who, irrespective of other responsibilities, shall have a function, defined responsibility and authority for ensuring that the management system is established, implemented and maintained, and also report to top management performance management system for critical analysis, including recommendations for improvement. Must representatives have a knowledge of standards / specifications adopted in the organization's management system so that they can contribute significantly in the continuous improvement of social, environmental and economic dimensions. The organization also allow other employees and direct channels stakeholders within the structure to provide feedback and assist in the improvement process.

DO

Axis 3. Implementation and operation

Requirement 3.1. Operational Control

The management system must be structured to ensure that operations are performed in specific conditions, in order to meet the policies and objectives of the organization as well as the legal requirements and other requirements. It is understood that, for the social dimension, the organization must ensure

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that the operations in your production system offer employees safety, to prevent unsafe working conditions. From the point of view of the environment, you must ensure that the amount of resources used to manufacture and purchase of supplies appropriate, avoiding waste. At this point, you can also waste be included not only in the manufacturing environment, which directly affects the economic dimension, which can be inserted aspects of losses from a logistical, administrative, quality and energy. All the losses that occur in the manufacturing environment result in financial losses and significantly impact the outcome of the organization. Meet and measure these operating losses is of significant importance for the future of the organization.

Requirement 3.2. Resource Management

The organization shall ensure that all people who work for it and on its behalf are competent on the basis of appropriate education, training, skills and experience to the tasks assigned to them. To occur, the organization shall determine, provide and maintain the infrastructure and resources needed to achieve their goals. Thus, the organization of social and environmental point of view, must constantly train employees (internal or outsourced) so that they know their role for the organization and to society, performing with seriousness and responsibility, their activities. For such points occur, it is for the organization to plan and provide resources for training, understanding that these are investments for the organization and help the non-occurrence of accidents and incidents that may result in financial losses. The organization must also demonstrate the resources available to its employees and the correct way to use them, so as to maintain their integrity. It is also important for the management and maintenance of the resources that the organization presents employees with the opportunity for professional growth through democratic and transparent criteria for career advancement and to combat discrimination of any kind.

Requirement 3.3. Documentation Requirements

The documentation of the management system must have the description of the scope of the system, including standards / specifications adopted management systems; statements of policies and objectives of the organization; system manual; documented procedures and record that is required by the management system and its component standards and documents as determined by the organization to be necessary to ensure the planning, operation and effective control of its processes. The organization makes this documentation is known to all employees, as well as what is their role and responsibility in the design, implementation and improvement of this document.

Requirement 3.4. Communication

The organization shall establish, implement and maintain effective arrangements for internal communication between the various levels and functions of the organization, and for receiving, recording and responding to relevant communications from interested parties. It is worth at this point to present to internal and external community reports performance against the goals of the management system and its past, present and future to improve the system performance in social, environmental and economic dimensions shares.

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CHECK

Axis 4. Performance Evaluation

Requirement 4.1. Monitoring and Measurement

The organization shall perform measurements and monitoring to determine the degree of compliance with the established goals. This should include the recording of information to monitor the performance of the relevant operational controls and to evaluate compliance with the organization's goals and the ability of the processes to achieve planned results. It is up to responsible management system perform the monitoring and measuring points defined in operational requirements and documentation control requirements, these actions should be proactive, to achieve the goals and plans, and reactive, responding to and reporting accidents and incidents. Such indicators should allow, where possible, the evaluation and measurement of economic gains and losses, we understand that this is part of the sustainability of the organization.

Requirement 4.2. Conformity Assessment

The organization shall conduct periodic evaluations of compliance with legal requirements, I understand, in this respect, that the organization must meet and review the scope of your system by removing, inserting or changing requirements from the update of the standards / specifications that make up your management system. This process should occur in partnership with the stakeholders of the organization by checking the economic, environmental and social impacts that the changes may bring, be they positive or negative.

Requirement 4.3. Internal Audit

The organization shall establish and maintain a program of regular audit of its management system as a mechanism of control and verification that all objectives outlined in its design are being met and understood by all, although within this process evaluation of social, environmental and economic organization. It also, at the end of the audit, the presentation of results and their comparison with previous audits in order to ensure continuous and clear process to everyone in the organization.

Requirement 4.4. Treatment of Non-Conformities

When identified noncompliance must corrected, and the actions taken to mitigate their impact. It is important to verify the origin of non-compliance. If this non-compliance is the result of the operation on the part of the employee failures, it is important to conduct further training to prevent recurrence, denoting this point the social dimension. In the environmental point of view, nonconformities generate material losses, creating the need to reprocess the part or not being able to dispose of your place its reuse. It should first be aware of these things and, if you need to rework or disposal, possess mechanisms that do not harm the environment or minimize expenses for his recovery. Nonconformities cause economic

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losses and measure the losses of materials and parts, as well as the need to rework the same or proper disposal of your expenses, it is of extreme necessity, and also a point of assessing organizational improvement towards the latter.

ACT

Axis 5. Improvement

Requirement 5.1. General

The organization shall continually improve the effectiveness of the management system through the use of policy, objectives, audit results, analysis of data on the performance evaluation, corrective and preventive actions and management review and should define and allocate responsibility and authority the improvement of the GIS.

Requirement 5.2. Corrective, Preventive and Improvement Action

The organization must know and be prepared to take corrective, preventive and improvement actions, listing and defining how the organization will act on nonconformities or potential nonconformities (including feedback from stakeholders), as well as registering and reviewing the effectiveness and the results of actions performed by establishing appropriate mechanisms for evaluation and measurement of economic gains and losses.

Axis 6. Critical analysis by the direction

Requirement 6.1. General

It is up to senior management critically to analyze the organization's management system at planned intervals, to ensure its continuing suitability, adequacy and effectiveness, making assessing opportunities for improvement and the need for changes in the management system, including policy and objectives. It is understood, therefore, that the senior management, this requirement should act primarily as an evaluation mechanism (regulation) on the actions undertaken and as a controller requirement management system and should actively participate in the interaction with stakeholders (stakeholders), bringing points of improvements listed by them, whether social, environmental or economic order.

Requirement 6.2. Inputs

The inputs relate to the set of information available to senior management for monitoring management system. For these data are critically analyzed by senior management, should the information set of social, environmental and economic order to understand, respecting its characteristics, the results of audits, feedback from stakeholders, the status of preventive actions and provide corrective follow-up actions

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from previous management reviews, changes in circumstances, including developments in legal and other requirements related to aspects of the organization and risk requirements, recommendations for improvement, data and information on the organization's performance and the results of the evaluation of compliance with legal and other requirements.

Requirement 6.3. Outputs

Outputs relate to the whole of any decisions and actions related to the management system. Top management must present actions of social, environmental and economic comprising respecting its characteristics, the quest for improving the efficiency of the management system, the improvement related to stakeholder requirements, and the need for resources order to enable system improvement management and its processes.

FUTURE RESEARCH DIRECTIONS

Research involving the topic of sustainability and the subject IMS are growing in the scientific literature on various aspects such as the development of models of management, economic evaluation models, the degree of adhesion.

However, few studies envision the relationship between these two topics (IMS and sustainability), this being a wide field of research.

The organizational management in a sustainable manner, respecting the environment and society, and given the economic primordium of its existence, causes business processes become complex and require further research.

Another aspect is the development of normative standards, which undergo constant updates that has brought closer to the dimensions of sustainability, but is that organizations are following these changes? Does the concept of sustainability is really understood? Do organizations have focused on becoming sustainable internally?

We observe, therefore, that the theme has gaps to be exploited, may be mentioned: (i) lack of consensus on the definition / concept of sustainability; (ii) various approaches to applying sustainability in the organizational environment; (iii) the low level of literature and research in the area; (iv) absence of a universally accepted evaluation model; (v) review existing models have problems with selection, prioritization and weighting of dimensions (Siena, 2008); (vi) concern the valuation models of sustainability to the organization with the external aspects, omitting regarding the evaluation of the internal aspects (Lueneburger & Goleman, 2010).

One of the reasons for these gaps, according to Siena (2008), is the difficulty in materializing the concept of sustainability, as the conceptual bases on the issues involved are not consolidated, there is no consensus on what to measure, how to measure and mainly about how to weigh and combine data.

In this context, according to Henderson (2011), to conduct studies that contribute to the evolution of the theme, so it is necessary to identify hypotheses that can be tested and support the development of new research.

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- What environmental, social and economic indicators are relevant to use?
- What are possible indicators to measure and report, and what obstacles exist to measure and report?
- How the indicators should be aggregated into a sustainability index based on a fairly simple model, but reliable, available resources in the real world?
- You can verify this index, to some extent, comparing the results of the index to the literature and own ambitions of the organization?
- What are the limitations and uncertainties of the conceptual structure of suggested content?
- What are the main opportunities and benefits of working with an aggregate index?

For this to occur in a relevant, comprehensive and consistent development model needs to have a methodological framework which involves answering questions, as pointed by Singh et al. (2009).

CONCLUSION

In this chapter, the concepts of organizational sustainability and IMS, in order to present their definitions and the main normative bases that characterize have been described.

Were also highlighted the initiatives of creating normative standards of validity for global management of an integrated organizational system. One key point is to demonstrate the synergy that exists between the IMS and the dimensions of sustainability.

It was found that the PAS 99:2006 model is presented as a normative standard most similar to ISO 9000, ISO 14000, ISO 26000 and OHSAS 18000 standards, having a methodology for implementing a IMS approaching these standards, employing the concept of PDCA for its management.

We notice, however, that evidence is necessary to establish a relationship between these patterns and normative dimensions of sustainability, demonstrating synergy.

This characterization of synergy between the IMS and sustainability enables organizations see through normative standards already known and reported in the literature, the possibility of improving their internal processes in order to achieve their actions to provide future survival without harming society, the maintaining the environment and economically alive.

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KEY TERMS AND DEFINITIONS

Integrated Management System: Represents the unification of various management systems into a single system, taking advantage of the many synergies between them, without ignoring the peculiarities of each.

Normative Standards: A document that contains a technical specification or other precise criteria designed to be used consistently as a rule, guideline, or definition.

Organizational Sustainability: Related to the concept of sustainability, advocating the care the social, environmental and economic dimensions, is mainly focused on the internal processes of the organization, understanding that it is necessary to first have internal sustainability for later view external actions.

PDCA Cycle: Created in the 1950s by Deming, is a systematic process for continuous improvement, accomplished through four steps: Plan, Do, Check and Act.

Requirements: Documented definition of a property or behaviors that a particular product or service must meet.

Sustainability: Concept of extensive discussion. His concept seeks to promote longevity through the attainment of economic profit, respecting the environment and society.

Sustainability Dimensions: Known as social, economic and environmental dimensions, the tripod represent the ideals of sustainability (triple bottom line).

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Chapter 22
Identifying the Contemporary Status of E-Service Sustainability Research

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ABSTRACT

Sustainable development is a world-wide major concern, required in every domain of life, including that of government. E-services are widely acknowledged for the contribution they make to e-government. The research question raised in this study is: What is the existing status of e-service sustainability research? The research method used is a literature study that adopts a concept-centric approach. Selected literature was then analyzed using the twin concepts of e-service sustainability itself and the enabler (secondary) effects of sustainable e-services. The Triple Bottom Line's model was used to further categorize the findings using economic, environmental, and social sustainability concepts. The results of the study revealed a lack of research into e-service sustainability. By way of contrast, it revealed 20 articles that cover the enabler effect. Existing research is related to economic and social dimensions, with the most common topic being related to user satisfaction.

INTRODUCTION

E-services are beneficial to citizens worldwide in many ways; indeed, they have been proven to be important enablers of successful e-government (Stamoulis et al., 2001). The number of e-services in use is increasing in both the developed and the developing world (DESA, 2012). In addition to the direct benefits of e-services, they can impact on other interdependent systems, such as economic, environmental and social systems. This is possible because e-services utilize pervasive computing devices, such as the Internet and other ICTs. To date, the e-service concept is relatively new and not well defined (Islam &

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Scupola, 2011). In its broadest sense it could cover almost any sort of digital application. E-services are of particular interest in the public sector because of their potential to increase efficiency as well as effectiveness (Haque & Pathrannarakul, 2013). In this paper we delimit our scope to focus only on e-services in the public sector. We limit our definition of e-services in the e-government domain to "the electronic delivery of government information, programs, and services often (but not exclusively) over the Internet" (Dawes, 2002).

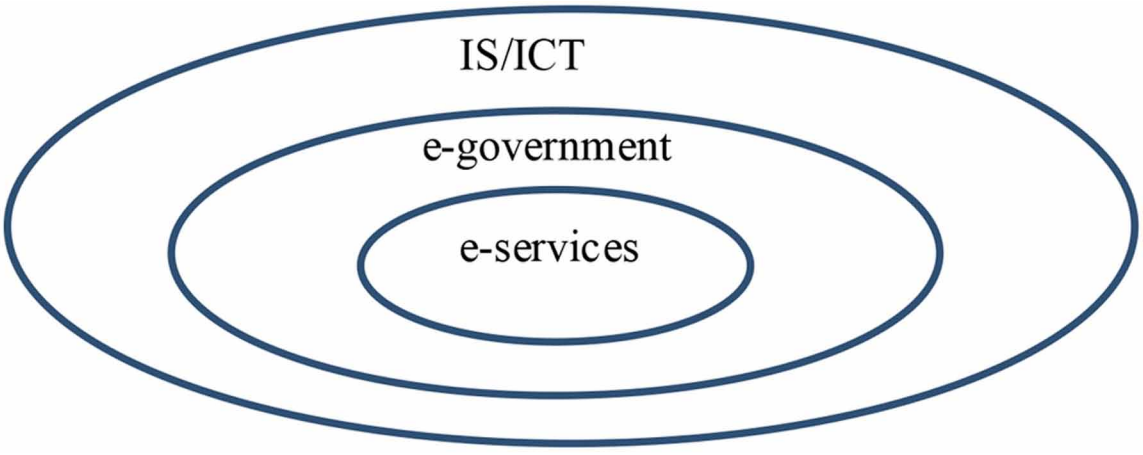
In this paper, we perceive e-services to be a subfield of e-government, which in turn is a subfield of the IS/ICT domain. This means that research into IS, ICT, and e-government in general is also relevant to the field of e-services and vice versa.

Researchers have pointed out the positive and negative impacts of ICTs on economic, social and environmental systems (Mitrea et al., 2010; Hilty et al., 2006). Sustainability, which is considered to be a positive impact, has become an increasingly important concern for political, social and economic reasons. Thus, the number of technology-related sustainability studies is increasing (Mitrea et al., 2010; Viet et al., 2011). This growing interest in the sustainability of e-government is indicated by a comparison of UN e-government surveys undertaken in 2010 and 2012: the number of instances of the term *sustainable* increased from zero to 41, respectively.

Sustainability largely emerged as a concern following the United Nations Conference on Human Environment (UNCHE) held in Stockholm, Sweden, in June 1972. The most recent UN conference, Rio+20, was held in Rio de Janeiro in June 2012. The message that came out of Rio+20 was one reason for selecting the e-government domain, and specifically research into e-service sustainability, as the subject of this paper. E-government in general, and e-services in particular, are both emerging fields; indeed, they are the focus of governments all over the world. Investigating the status of research into the sustainability of e-services will make it possible to direct future efforts within this field.

The research question raised in this study is: *What is the existing status of e-service sustainability research?* The boundaries of the study are limited to e-services in the e-government domain. E-services are one of the major components of e-government and sustainability is the requirement of all systems, irrespective of the domain to which they belong (UNCSD, 2012).

Figure 1. Relationship between the fields of e-services, e-government, and IS/ICT



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The main motivation factor for this study is to gain an awareness of the importance of sustainability and sustainable development in all sections of society for the better economic, social and environmental survival of humanity; indeed, this was one of the indirect messages of the Rio+20 conference (UNCSD, 2012). The contribution of the paper is its investigation into existing research on the sustainability of e-services. Such an investigation does not, as yet, exist.

It seems as if sustainability should be a major asset to public e-services, if one considers the potential benefits of digitizing manual services, such as income tax declaration, renewal of medical prescriptions and online voting. According to Axelsson, Melin and Lindgren (2013), the two major goals of public e-services are efficiency of government and benefits for citizens. In a world where all kinds of resources appear to be scarce, increasing the number of efficient public e-services seems to have the potential to meet the demands of a sustainable society.

To date, research has focused on two aspects of e-service sustainability (Mitrea et al., 2010): first, the sustainability of the e-services themselves and second, the sustainability enabler effects of e-services as a means to achieving something else. When we use the term *sustainability of e-services*, we refer to the design and implementation of e-services in terms of ecological, economic and social responsibility. This aspect, which can include information overload for users, security risks and the criminal use of Internet applications, is a neglected perspective of research in this area. Just because a service is transferred from manual to automatic doesn't mean that no resources are consumed or that risks disappear. As an illustrative example, one study found that the performance of two Google search operations consumes as much energy as boiling a kettle of water. A Google search produces 7 grams of CO2 while boiling a kettle of water produces 15 grams (BBC 2009). When we talk about *sustainability enabler effects*, we refer to e-services not as isolated phenomena but as being integrated within a context that involves people and other systems, both manual and automatic.

According to Bengtsson and Ågerfalk (2011) and Klischewski and Lessa (2012), sustainability research in IS and e-government respectively is in its infancy or is even ignored. The long-term success of some projects, such as those involving e-government, is dependent on its sustainability (Klischewski & Lessa, 2012). We believe, therefore, that sustainability research does actually exist. And since e-services are significant to e-government, they are a suitable point of departure.

The main motivation factor for this study is an awareness of the importance of sustainability and sustainable development in all sections of society for the better economic, social and environmental survival of humanity; this was one of the indirect messages of the Rio+20 conference (UNCSD, 2012)

The paper is organized as follows. Section 2 gives the theoretical background of the study, including a presentation of the Triple Bottom Line model. In section 3, we introduce the method of the literature study. In section 4, the results and analysis are presented. Finally, section 5 includes a discussion of the analysis, together with any conclusions and implications.

THEORETICAL BACKGROUND

Sustainable development has no single universally accepted definition; indeed, it has mostly been operationalized in accordance with the relevant context or discipline: for example, in frameworks utilized to carry out sustainability studies of natural resource management systems, such as the Pressure-State-Response (PSR) framework; the framework based on indicators for natural resource management evaluation (MESMIS, *Spanish acronym*) and the Quantitative Analysis of Land Use Systems (QUALUS)

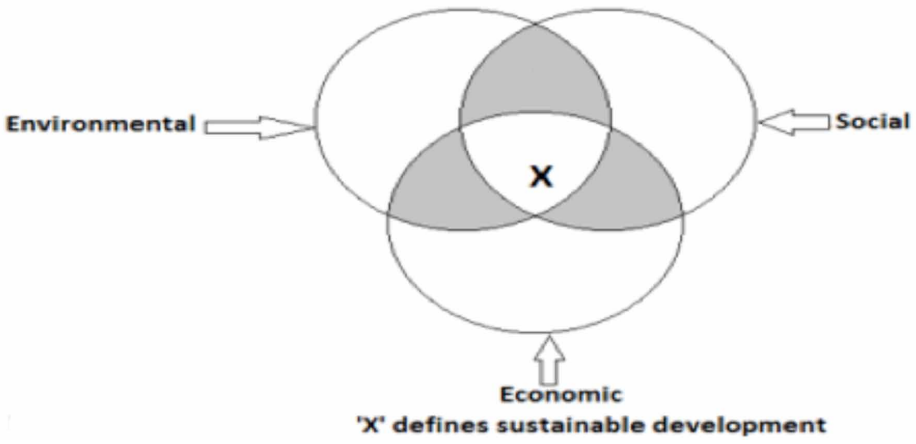
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framework (Ridaura, 2005). In this study, we have adopted the definition of sustainable development put forward by the Brundtland Commission of 1987, in which sustainable development was defined as 'the development that meets present needs without compromising the ability of future generations to meet their needs' (IISD 2012). This definition is general in nature and widely accepted; thus, it serves our purpose. In order to provide a more domain-related definition, we also used Kanungo's (2004) definition of sustainable investments as 'those whose benefits keep continuing into the future'.

Several theories and models have been used in sustainability research (Loukola & Kyllönen, 2005). Some models exist for the study of sustainability in different systems; for example, the three-legged sustainability stool, circles of sustainability and the GREENSOFT Model for studies of software. In general, two models of sustainability are referred to more often than others. Firstly, some models are based on the Triple Bottom Line (TBL) conception; for example, the three ring circus, three pillar model or Venn diagram, as shown in figure 2. The second is the Russian doll model or three nested frequencies, as shown in figure 3. The Russian doll model incorporates the environment as a pre-condition for the other two dimensions of sustainability. The pillar of sustainability or three ring circus model, on the other hand, defines sustainability as the intersection of three dimensions. Several studies of sustainability invoke the idea of sustainable development by using the three ring circus model (Levett, 1998). In this study, we used the three ring circus model that is based on the TBL conception because it incorporates all dimensions of sustainability equally, unlike the Russian doll model, which focuses on the environmental aspect. The three ring circus model is the one most often utilized for sustainability studies. According to Dao et al. (2011), it is used by 68% of the top 250 global companies on the Fortune 500.

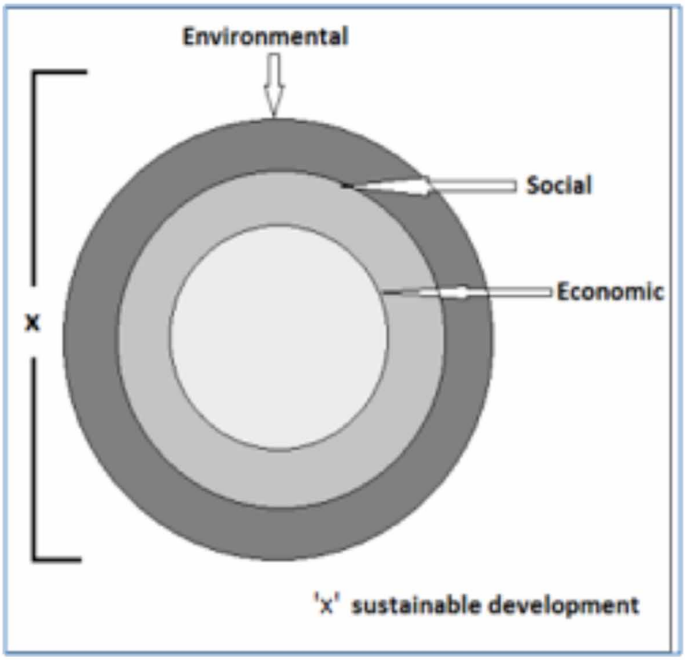
Like Viet et al. (2011) and Mitrea et al. (2010), we adopted the Triple Bottom Line's (TBL) model for our perspective on sustainability (Slaper & Hall, 2011). The Triple Bottom Line's model for sustainable development has also been referred to as the three pillar model and the three ring circus. We adopted the Triple Bottom Line's model in order to categorize the concepts; in turn, this enabled us to compare data. Whilst the Triple Bottom Line's model can be used to quantify the concepts, we only used it to categorize them. Data on the sustainability of e-services was categorized according to environmental, social and economic dimensions (Slaper & Hall, 2011). Figure 2 shows the Triple Bottom Line concept of sustainable development. In this model, the three dimensions of sustainability are interdependent. The

Figure 2. The triple bottom line's model



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Figure 3. The Russian doll model



overlapping (grey filled) areas in Figure 2 show the interdependence of the sustainability dimensions, while the intersection of all three dimensions gives 'X', which can be defined as sustainable development.

- **The Environmental Dimension:** An environmentally sustainable system must maintain a stable resource base, avoiding the overexploitation of renewable resource systems or environmental sink functions, and depleting nonrenewable resources only to the extent that investment is made in adequate substitutes. This includes the maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources (Harris, 2003, p. 1).
- **The Economic Dimension:** An economically sustainable system must be able to produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme sectoral imbalances, which damage agricultural or industrial production (Harris, 2003, p. 1).
- **Social Sustainability:** A socially sustainable system must achieve fairness in distribution and opportunity, adequate provision of social services, including health and education, gender equity, and political accountability and participation (Harris, 2003, p. 1).

According to the TBL concept, the sustainability aspects of e-services can be initialized. In the model, the three dimensions of sustainability can be related to e-services in much the same way as researchers relate them to other technologies, such as ICTs.

Table 1 shows research covered by the three TBL sustainability dimensions. The need for e-service sustainability is indicated by the number of examples of sustainable ICT cases discussed in scientific papers, as proposed by Mitrea et al. (2010). E-services utilize ICTs and other technologies according to

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Table 1. Focus of ICT research according to sustainability dimensions (Mitrea et al., 2010)

Economic Dimensions and Importance of ICT Development	Environmental Dimensions of ICT Development	Social/cultural Dimensions of ICT Development
Increase in productivity	Traffic reduction optimization	Support for community networks
Basic infrastructure for the digital economy and for the functioning of other sectors	Increased energy efficiency	Optimization of cooperation, participation and solidarity
Innovation basis outside the ICT field	Efficient information systems for environmental management	Support for new forms of political and civic participation and engagement
Controversial relationship between ICT and economic growth, dependent on the existence of the institutional setting that sustains the mutual reinforcement of the free market and ICT innovation	Environmentally-friendly production modes	Open source as appropriate
Potential and risks arising from the acceptance of 'appropriate technologies in developing countries'		Technology for global education
		Optimization of family-work life through teleworking
		New working time models/agendas
		Multimedia support for new forms of health care and education

the adopted TBL concept (Mitrea et al., 2010). Thus, it is acknowledged that ICTs have both positive and negative impacts on sustainable development (Hilty et al., 2006).

Starting with the negative *environmental impacts* of ICTs, it has been found that annual emissions amount to approximately 0.86 metric gigaton per year, which is equal to about 2 per cent of global carbon emissions. This percentage is expected to double by 2020, especially for technologies such as mobile telephones (Dunn, 2010). In the US, ICTs alone make up 2.5 per cent of carbon emissions and this share is expected to increase to 2.8 per cent by 2020 (GeSI, 2008). Thus, carbon emissions from ICTs are equal to or are greater than the total carbon emissions generated by the airline industry.

The negative *economic impacts* of ICTs can be exemplified by considering a recent study, which has shown that new high-tech technologies use gold and silver in the production processes that are valued at more than 21 billion US dollars. Currently, only 15 per cent of that figure can be recovered, with the remaining 85 per cent, amounting to $21 billion, lost as e-waste (GeSI, 2012a).

With regard to the negative *social impacts* of ICTs, it is relevant to consider a case mentioned in a referenced study, which described how the unregulated production of gold from e-waste led to the death of 100 children in Nigeria (Mobbs, 2010). Also documented are the huge quantities of e-waste that are imported by the developing world for various purposes (UNU-ISP, 2011).

In addition to the negative environmental, economic and social impacts exemplified above, there are, of course, the huge positive impacts of ICTs. These are probably perceived to be more significant than negative impacts, because the field is continuously growing. However, this study is mostly concerned with the existing state of knowledge of e-service sustainability, regardless of the type of impact.

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METHOD

This study used a literature and document review method that is based on the concept centric approach put forward by Webster and Watson (2002). The core idea of the concept centric approach is to organize the study from central concepts either deductively or inductively or both. We also adopted and considered concepts of analysis from Grönlund and Andersson (2006), who focused on the quality of e-government research. The criterion and categories of this study were adopted to evaluate research papers on e-service sustainability. Following the consideration of a study by Islam and Scupola (2011), a literature review was designed specifically for researching services. The study was organized as shown in Figure 4.

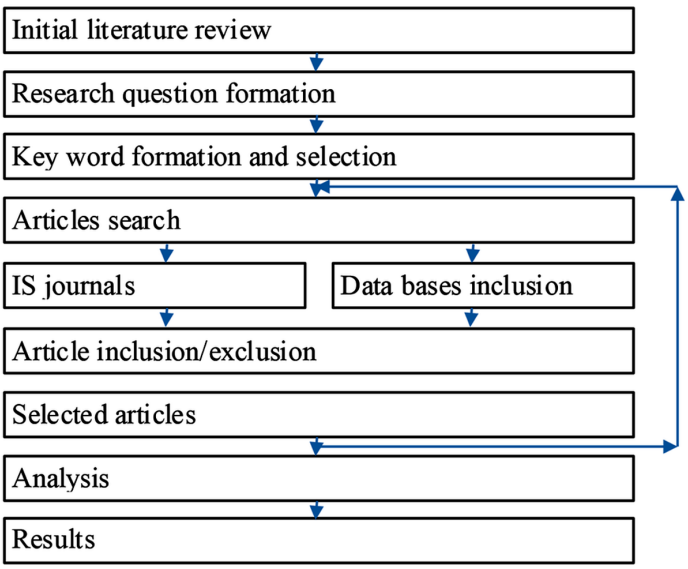
Initial Literature Review

An initial literature review was performed in advance of the formation of the research question. The goal of this pre-study was to identify current basic knowledge with regard to sustainability, and current and past efforts in sustainability practices related to ICT. The initial literature review included sustainability reports and articles. The outcome of the initial literature review provided explanations of required key terms and a knowledge background to formulate the research question. The initial study also provided a knowledge background to specify the domain and scope of the study.

Keywords and Search Process

The keyword formation process and selection was performed according to the requirements of the research question (Webster & Watson, 2002). We searched using combinations of *sustainable/ sustainability* and (singular and plural forms of) *e-service/eservice/electronic service* and *government/ egovernment/e-government/ICT*. These combinations were used in the search process using Google Scholar and Sum-

Figure 4. The research process



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mon, a search engine that includes several other search engines, such as ACM Digital Library, Scopus, ABI/Inform, IEEE Explore, LISTA and Web of Science. The search was limited to papers published between January 2000 and September 2012. The start of the period was chosen because the number of research papers that target e-services began to increase at that time.

The paper search process started with a search of renowned journals in the domain of Information Systems (Webster & Watson, 2002). In our case, we selected journals from an AIS senior scholars' basket of journals (Islam & Scupola, 2011): Management Information Systems Quarterly (MISQ), European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Internet Research(IR), Electronic Journal of Electronic Government (EJEG), Journal of Information Technology (JIT), Government Information Quarterly (GIQ), Journal of Strategic information systems (JSIS), Journal of Association for Information Systems (JAIS), and e-Services Journal (eSJ).

In the tables below, Keyword 2 (Kw2) is the most important search key. Nonetheless, we included three more searches in order to be able to make comparisons.

Table 2 shows the number of paper hits for the selected keywords against the journal names, respectively. For example, there were 160 paper hits for the keyword "sustainability e-services". In the result we included synonyms and homonyms that are made up of all possible combinations of words that are grouped together to form keywords.

The second source of the paper search are databases and scientific search engines. During this process, the following databases were accessed: Web of Science, Scopus, Summon, Inspec, IEEE *Xplore*, ERIC, Google Scholar, Scirus, SwePub and ACM Digital Library. Most of these databases are multidisciplinary, because of the nature of Information Systems (IS) papers (Webster & Watson 2002). In addition to the selected keywords, our search process also included synonyms and homonyms that are made up of all possible combinations of words that are grouped together to form keywords. Table 3 shows the names of the search engines and the number of paper hits for the keywords, respectively.

Table 2. Number of hits for AIS senior scholars' basket of journals, Jan 2000 – Sept 2012

Sr.no	Journal	Kw1	Kw2	Kw3	Kw4
1	MISQ	10	0	3	0
2	EJIS	0	0	2	19
3	ISJ	17	2	3	17
4	IR	15	15	4	3
5	EJEG	11	11	55	160
6	JIT	0	3	7	3
7	GIQ	77	67	39	83
8	JAIS	25	16	4	54
9	JSIS	56	46	10	8
10	eSJ	0	0	0	4
	Total	211	160	127	351
Kw1 = sustainability. Kw2 = sustainability e-services					
Kw3 = sustainability ICT. Kw4 government e-services					

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Table 3. Number of hits for selected databases, Jan 2000 - Sept 2012

Sr.no	Database/Search Engines	Kw1	Kw2	Kw3	Kw4
1	Web of Science	564	2	179	156
2	Scopus	2,545	4	13	351
3	Summon	929	0	1	42
4	Inspec	2,072	11	5	27
5	IEEEXplore	1,609	3	87	87
6	ERIC	2,759	0	28	6
7	ACM Digital Library	2,119	43	457	15
8	SwePub	1,901	0	43	66
9	Scirus	829,397	2	408	693
10	Google Scholar	729,000	1	139	554
	Total	1,572,895	66	1,360	1,997
Kw1 = sustainability. Kw2 = sustainability e-services.					
Kw3 = sustainability ICT. Kw4 government e-services.					

With regard to the 66 hits for Keyword 2 (Kw2), most of the papers (43) were accessed from the ACM digital library. Comparing the number of hits for keywords 1 (Kw1), 3 (Kw3) and 4 (Kw4) with those for Kw2 gives a glimpse into sustainability efforts in general, compared with e-service sustainability in particular. Kw2 has only 66 hits, compared with Kw1, which has 1,572,895 hits; the same trend can be observed by comparing the remaining keywords with Kw2.

Paper Inclusion and Exclusion Criteria

The outcome of the whole search process with Kw2 produced a total of 226 papers, i.e., 160 from Table 2 and 66 from Table 3, retrieved by keyword search only. These papers were initially analyzed by reading the title, abstract and keywords for inclusion or exclusion in the second analysis. After the first analysis, papers that contain information relating to e-service sustainability in their title, abstract or keywords were selected for further research; otherwise, they were excluded from the study. With regard to Table 2, all of the papers (351) were analyzed for inclusion or exclusion. However, as for Table 3, only papers that included hits of keyword Kw2 were analyzed. The outcome of this whole process was a total of 20 papers that include information related to e-services sustainability. These papers were then selected for conceptual analysis.

Data Analysis

The outcome of the process described above is a selection of papers that have been initially filtered to ensure they relate to e-service sustainability. Firstly, the selected articles were categorized according to the Triple Bottom Line (TBL) concept of sustainability, i.e., environmental, social and economic dimensions, as represented in Table 4 of the results section. Secondly, each of these papers was analyzed in order to classify them into one of two interrelated concepts of sustainability: *C1: sustainability of*

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Table 4. Categorization of e-service sustainability, Jan 2000-Sep 2012

Sustainability concept / Years	Papers relating to knowledge of e-service sustainability						
	C1			C2			
	Environ	Social	Economic	Environ	Social	Economic	Total
2000				1			1
2001						1	1
2002							
2003							
2004						1	1
2005					2	1	3
2006							
2007					3		3
2008					1	1	2
2009					2	1	3
2010					2	2	4
2011					1		1
2012						1	1
Total	0	0	0	1	11	8	20
Note. C1 = Sustainability of e-services themselves. C2 = e-services as enabler of sustainability							

e-services themselves and *C2: sustainability enabler effects of e-services*. The aforementioned processes were carried out through a detailed and systematic analysis of titles, keywords and abstracts. This process ended with a final selection of papers, as presented in Table 5. The selected papers were further analyzed using rigor and relevance criteria in order to identify the research trend and the maturity of the field. The criteria utilized for this analysis process was adopted from the study by Grönlund and Andersson (2006), which elicited the type of approach, type of method, publishing domain and research topic. The first two categories were used to find out the maturity of the field. The publishing domain states how much was published in journals and conference proceedings, respectively. The topic aspect reveals research trends and focus. Table 6 shows the result of this final step.

RESULTS AND ANALYSIS

The papers identified during the previous process were categorized into concepts using TBL sustainability dimensions - the major entities analyzed in the study - as units of analysis; see Table 4 (Webster & Watson, 2002). The sustainability dimensions were selected as concepts that can be compared over time; in our case between 2000 and 2012. In Table 4, two categories (C1 and C2), show the interrelated concepts of e-service sustainability. C1 represents the sustainability of the e-services themselves, whilst C2 represents the enabler effects of e-services.

Table 4 shows the number of papers that refer to e-service sustainability during the selected period of time. No papers were found which cover C1, whilst 20 papers were found which cover C2.

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Table 5. Authors and articles for C2

Economic	Costopoulou & Tambouris (2004) One-stop eServices for the forest sector. Ranerup (2005) Motives in the Design of Public E-services. The Example of Quasi-Markets for Education. Zhang et al. (2010) Interactions, Competition and Innovation in a Service-Oriented Internet: An Economic Model. Nath et al. (2001) Bankers' Perspectives on Internet Banking. Cellary (2008) Strategic Impact of e-Government on Economy and Society Tutorial and Workshop. Taipale (2012) The use of e-government services and the Internet: The role of socio-demographic, economic and geographical predictors. Skielse & Perjons (2009) Improving E-Government through Benefit Analysis and Value Modeling. Zdravkovic & Ilayperuma (2010) A Model-driven Approach for Designing E-Services Using Business Ontological Frameworks.
Environ-mental	Karatzas et al. (2000) Development of a hierarchical system for the teletransmission of environmental and energy data.
Social	Carter & Bélanger (2005) The utilization of e-government services: citizen trust, innovation and acceptance Factors. Seyal (2011) Customer Satisfaction with Internet Banking in Brunei Darussalam: Evaluating the Role of Demographic Factors. Hwang & Li (2009) Conquer Web 2.0 Motivational Challenges from Social Context Evolution. Jun (2009) Research on E-Service Quality, Customer Relational Benefits and Customer Satisfaction. Liao et al. (2007) Theory of planning behavior (TPB) and customer satisfaction in the continued use of e-service: An integrated model. Cyr et al. (2007) The role of social presence in establishing loyalty in e-Service environments. Sheibani et al. (2010) A Novel Approach to Satisfaction Framework for Social Issues via E-Services. Asgarkhani (2005) The Reality of e-Service in the Public Sector: A Local Government Perspective. Alter (2010) Integrating Sociotechnical and Technical Views of e-Services. Grundén (2008) Evaluation of eGovernment Implementation from a Social Perspective. Löfstedt (2007) Social Systems Design as a Vehicle Towards Local Public e-Services for and by Citizens.

Table 6. Categorization of papers after rigor and relevance analysis

TBL cat	TG	TT	D	P	TH	C/J (Domain)	Topic	Method
En1	X					J(IS)	Use of e-services	Experiment
Ec1		X				J(IS) (eSJ)	Impacts of e-services	Ethnography
Ec2	X					C(IEEE)	Benefit analysis and modeling	Grounded Theory
Ec3		X				J(IS)	Impacts of e-services	Product descript
Ec4		X				C	Impacts of e-services	Product descript
Ec5			X			C(IS)	Impacts of e-services	Case study
Ec6			X			J	Factors affecting use	Ethnography
Ec7	X					C(IEEE)	Benefit analysis and modeling	Experiment
Ec8	X					C(IEEE)	Benefit analysis and modeling	Case study
So1	X					J(IS)	Modeling and user satisfaction	Interpretive
So2			X			J(IS) (eSJ)	User satisfaction	Ethnography
So3	X					C(IEEE)	Social context evaluation	Case study
So4	X					C(IEEE)	Modeling and user satisfaction	Ethnography
So5	X					J	Modeling and user satisfaction	Interpretive
So6	X					J	Modeling and user loyalty	Interpretive
So7	X					C(IEEE)	Modeling and user satisfaction	Interpretive
So8					X	C(IEEE)	Factors for e-service adoption	Ethnography
So9					X	J(IS)	User participation in system design	Literature study
So10	X					J(IS) (eSJ)	Modeling and sociotechnical views	Grounded theory
So11			X			C	User satisfaction	Interpretive
Total	**11**	**3**	**4**		**2**	**10 C + 10J**		
=	**14**		**6**			**20**		

En = Environmental. Ec = Economic. So = Social. TG = Theory generating. TT = Theory testing.
D = Descriptive. P = Philosophical. TH = Theoretical. C = Conference. J = Journal.

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Table 5 shows the title, author name and year of publication for the 20 selected C2 papers categorized by the TBL dimensions. These 20 papers include one that is related to the environmental factor of e-services, 11 papers for the social dimension and eight related to the economic dimension of e-services. The papers were further analyzed for rigor and relevance according to the criteria and categories put forward by Grönlund and Andersson (2006).

Table 6 depicts the basis for the analysis process in terms of rigor and relevance. Column 1 shows the coded acronyms for papers that relate to the *TBL categories* of environmental, economic and social sustainability: En, Ec and So, respectively. Columns 2 to 6 show the research types as coded acronyms, TG, TT, D, P, TH, which refer to 'theory generation', 'theory testing', 'descriptive', 'philosophical' and 'theoretical', respectively (Grönlund & Andersson, 2006). Column 7 represents the *source of the paper*, either (J)ournal or (C)onference. This column also shows the papers' scientific domains in parentheses; for example '(IS)'. Column 8 shows the *research topics* and column 9 the *research methods* covered by the selected papers. Similar approaches to the analysis of a research field have been carried out by Alavi and Carlson (1992), and Islam and Scupola (2011).

Research types (columns 2 to 6) demonstrate the maturity of a field by identifying the type of research carried out. The analysis shows that, out of the 20 papers, 11 belong to the TG (Theory Generating) category. This number indicates a certain degree of immaturity of the research field, because it presupposes an absence of theories (Grönlund & Andersson, 2006). This claim is supported by the low number of theory-testing papers.

Source of paper (column 7) shows where the research was published. This can ultimately indicate if there is an established set of forums for the focused research. Out of the 20 papers, 10 were published in journals and 10 at conferences. Column 7 shows that the majority of conference papers relate to an IEEE conference, which is another indicator of research field maturity. Moreover, most of the papers from the journal category were published in IS journals, particularly the eSJ (e-Services Journal). The fact that a journal dedicated to e-service research has only published two papers that focus on sustainability indicates a low level of maturity.

Research topics (column 8) shows the topics that are focused on in each paper. The only paper that relates specifically to the environmental category explains the benefits of e-services in relation to the centralization of environmental reporting systems. Of the eight economic dimension papers, four focus on the impact of e-services, whilst the rest discuss models and the integration of models for the economic analysis of e-services. The modeling papers also discuss relational cost benefits connected with e-services. In total, 11 articles can be seen to relate to the social dimension, with six of them relating specifically to user satisfaction. In all, 8 papers are concerned with modelling. In the same way that theory generation and explorative approaches can be interpreted as a sign of an immature field, the number of modelling papers may also indicate the same level of immaturity (Alavi & Carlson, 1992).

Research methods (column 9) shows how the choice of methods is affected by whether theories, models and sets of concepts exist in the field of e-services sustainability. This can, in turn, indicate the maturity of the field. If the field is well established in terms of theories, models and sets of concepts, it is likely that more experimental than explorative approaches will be found. Explorative approaches such as grounded theory, ethnography and case studies are necessary to define a field in terms of theories, models and sets of concepts. Descriptive studies and surveys are more likely to be built on existing and accepted concepts and constructs. Experiments and tests ultimately need theories or models if they are to be executed. This way, the methods used can assess the maturity of a field (deBruin et al., 2005). Interpretive studies are most often inductive case studies (Walsham, 1994; Walsham, 2006), something

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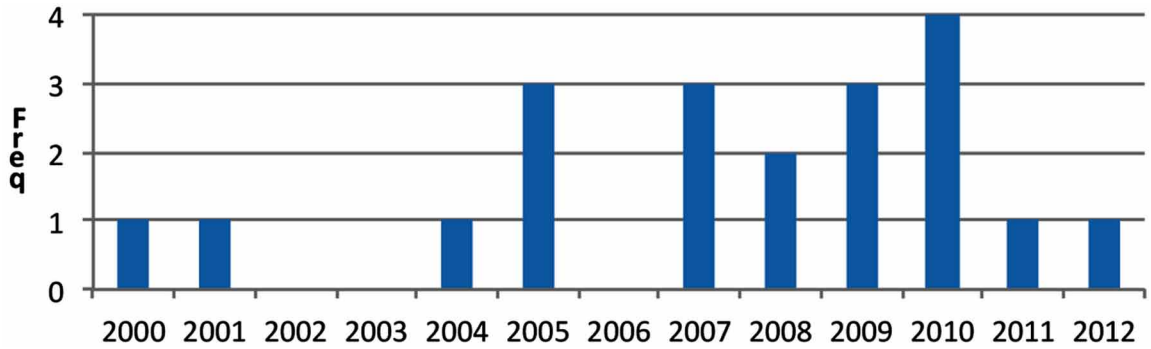
that supports the conclusion that interpretive studies are more common in a less mature field. Of the 20 papers, 17 were classified as more or less explorative.

An indicator of public e-service maturity is the number of papers published per year during the studied period. As shown in Figure 5, 15 of the 20 papers were written between 2005 and 2010. The fact that only two papers were published in 2011 and 2012 may be a coincidence; certainly, the overall frequency is too low to be the basis for trend analysis.

DISCUSSION AND CONCLUSION

The major finding of this study is that no research has been carried out with regard to the sustainability of e-services themselves. This finding is represented as variable C1 in the paper. Only a few research studies have sought to examine the sustainability enabler effects of e-services, as represented by variable C2 in this paper. These findings are in line with observations made by Bengtsson and Ågerfalk (2011) and by Klischewski and Lessi (2012). A literature review was carried out, which identified 20 selected papers relating to e-services sustainability. Thus, the frequency of research in the studied field can be seen to be rather modest. It should be noted that there is not a complete shortage of papers that analyze sustainability in the e-Government domain. However, we only included papers that explicitly analyze sustainability in e-services, either within the e-services themselves or as enablers. We also used all relevant kinds of conjugations of the terms "e-service" and "sustainability" in order to avoid missing relevant papers. Further on we have excluded papers that analyze sustainability and e-government in general, because their connection to e-services is implicit and does not provide any substantial contribution to the understanding of the sustainability of e-services. We also excluded papers in which e-services and sustainability are just mentioned but not analyzed. Finally, we excluded papers in which sustainability and e-government are discussed in terms of sustainable development. We consider sustainable development to be something that is not explicitly related to e-services. Sustainability is a homonym, which is used in many contexts and can have several meanings whereas the sustainability of the e-services themselves, is not explicitly studied yet. Another notable reason for the lack of research into e-services sustainability could be the conceptual vagueness or lack of clarity of the terms 'sustainable development' and 'sustainability'. As mentioned previously, whilst this study analyzed the sustainability of e-services, few papers relate to the sustainable development of e-services, i.e., where sustainable e-services are explained in

Figure 5. Papers per year



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terms of constancy. In addition, the term sustainability is sometimes utilized or presented as the meaning of constancy or fixed state of the system (ECLAC, 2001). However, presenting sustainability in this way can also lead to a certain vagueness in the research. The standard explanation given for 'sustainable development' and 'sustainability' is debatable. According to one quote, "sustainable development is the pathway to sustainability" (circular ecology, 2014). As mentioned previously, this study referred to the Brundtland definition for sustainable development and utilized the Triple Bottom Line model for the categorization of sustainability dimensions.

With regard to the dimensions of the Triple Bottom Line model, most papers relate to the social and economic dimensions. Only one paper was found which relates to the environment dimension. A maturity analysis was carried out, which shows that theory generating and testing are the most common research approaches to e-service sustainability. Most papers were published in high ranking conferences and journals. The lack of published papers shows that research on e-services sustainability is in its infancy.

An analysis of the topics covered by the papers shows that the one most commonly investigated was user satisfaction in the social dimension. In several studies and technology models, social aspects are considered to be important social issues. The environmental aspects of e-services are not yet on the scientific agenda, which we believe is a sign of immaturity.

The findings described above raise several questions that can be addressed by further research. For example, why is there an absence of papers related to the sustainability of e-services? At least two answers to such a question come to mind. It may be that contemporary researchers are not currently interested in explicit studies of e-service sustainability. On the other hand, they may be concerned about sustainability in the same way as this study, for example through a search for research papers. Thus, whilst research has focused on the separate dimensions it has not explicitly related them to sustainability. One can eventually explain or excuse the absence of sustainability research by relating to other IS fields. It is easy to notice that sustainability was not the first area to be researched within usability, systems development, or knowledge management. Consequently, there are also few studies on how e-service sustainability is researched. We found two, which is yet another sign of immaturity.

To elaborate further, e-services, which are a basic component of e-government, are widely accepted and utilized. Indeed, the use of e-services has increased year on year (DESA 2012). In this study, we selected e-services as a point of departure to investigate the sustainability of an important aspect of e-government. In addition to e-services, other dimensions and components of e-government could be considered relevant to sustainability evaluation or research. Currently, a situation exists in which there is an absence of studies on e-service sustainability. However, in this study we also investigated the existence of indirect sustainability research. By raising questions regarding sustainability indicators for e-services, we were able to broaden our research to include other sustainability aspects. For example, what are the indicator protocols and methodology sheets for e-services? This study could be extended to include further questions that address this issue. Sustainability indicators are considered to be basic requirements for sustainability evaluation (DESA, 2007), as are methodology sheets and indicator protocols (DESA, 2007).

A large number of studies have discussed the sustainability enabler effects of ICTs and other technologies. There is immense potential to save energy on a large scale through the use of ICTs. They can reduce carbon emissions and decrease greenhouse gases by up to 15 per cent. Furthermore, ICTs could help to save about 600 billion Euros ($946.5 billion) by 2020 (GeSI, 2012b). ICTs have multiple dimension impacts, including environmental, economic and social aspects. The potential for ICTs to be sustainable has been acknowledged not only by GeSI (2012b), but also by a number of other authors

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and organizations. For example, the most recent United Nations conference acknowledged the potential of ICTs for promoting sustainable development (UNCSD, 2012). Hence, the role played by ICTs, the Internet and other technologies with regard to sustainability enabler effects is widely acknowledged. Whilst some of this research might include e-services implicitly, there is a lack of explicit research about the sustainability of e-services.

The practical implications are directed to government officials. As first or second hand representatives of citizens, these officials need to consider the long-term effects of the implementation of e-services. Efficiency and effectiveness have been the major focus so far. Now is the time to explicitly include sustainability.

The scientific implication of this study is a call for more research into e-service sustainability. The importance of sustainable e-services is acknowledged as a requirement for a better future (UNCSD, 2012). The implication for researchers is that they need to focus on e-service sustainability in order to fill the existing gap. For practitioners, it is necessary to include sustainability as a mandatory requirement when developing public e-service applications.

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Chapter 23
Embedding Sustainability Learning:
Robustness in Changing Circumstances – Perspectives From a United Kingdom (UK) Higher Education Institution (HEI)

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ABSTRACT

In this chapter the authors argue the benefits of an "embedded strategy" for achieving a robust and sustainable Education for Sustainable Development (ESD) curriculum and outline some of the main approaches used at Kingston University (KU), London. The chapter includes feedback from students, academics, support staff and local employers engaged in these developments and highlights the main successes and the pitfalls encountered. Case studies exemplifying sustainability learning through a diversity of embedded approaches are presented and analysed. The authors' experience demonstrates that, although there is no "one size fits all" solution to ESD, sharing of experiences between sustainability professionals is vital to this agenda. The examples detailed in this chapter show that with careful design, active and multidisciplinary learning, sustainability understanding can be securely embedded in students' learning even where it is not the main programme objective.

INTRODUCTION

The United Nations (UN) decade of education for sustainable development (DESD), 2005-14, sought to move sustainability education from concept to practical reality for people worldwide. As such it was acknowledged that alongside environmental, social and economic understanding attention to 'context'

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was needed (UNESCO, 2005). It was suggested that sustainable development (SD) priorities and solutions would vary regionally; that differing political philosophies would engender different opportunities and approaches; and that differing social and cultural settings would similarly lead to a diversity of preferred policies and implementation priorities and practices. There would be no 'one size fits all' recipe or solution. It was also acknowledged that a multidisciplinary understanding was needed so that future world leaders, and those guiding regional and local policy, could appreciate the complexities of SD and promote leadership and good governance to meet the urgent challenges ahead *viz.,* avoidance of catastrophic climate change, or appropriate adaptation to changing climatic situations; maintenance of adequate good quality water supplies; sufficient food; energy security; avoidance of waste and pollution; maintenance of biodiversity; and promotion of good health; while at the same time promoting a fair and equal global society.

Since the start of the new millennium grass roots societal engagement with issues such as climate change and waste management has become commonplace in most developed economies and is widely acknowledged by governments worldwide. However, despite numerous global meetings and debates on *inter alia* curtailing carbon emissions, securing clean freshwater supplies for all, and providing adequate nutrition for all, only limited progress has been achieved. UN data show 11% of the global population (783 million people) still have no access to safe drinking water and 2.5 billion live without basic sanitation (UN-water, 2013). Indeed in the case of carbon emissions, overall these have continued to rise in the United Kingdom (UK) and European Union (EU) despite recent tough targets e.g. in the UK at least an 80% reduction in carbon budget compared with a 1990 baseline by 2050 (UKPGA, 2008). Though reductions in home-based emissions have been achieved, embedded emissions in imported goods have risen (Committee on Climate Change, 2013). Industry continues striving to find new fossil fuel sources investing far more in these polluting resources, such as the development of shale fracking, or expansion of nuclear power, than in major decarbonising alternatives. It could be argued that the underpinning reason for this poor achievement and limited vision is a failure of education. The current generation of world leaders has not been exposed to sustainability learning. As a consequence much rhetoric is expounded but the practical detail of the route forward, which requires a sound scientific and environmental base as well as social understanding and applicability, is missing. The level of public debate is also poor: nuclear versus renewables; wind versus solar; rather than a joined up integrated analysis based on sound scientific, social and economic information.

The key challenge is to rectify this; to develop sustainability education accessible to everyone. Yet, for example in the UK, changes mooted to the school curriculum suggest a retrenchment to an even less integrated science and arts curriculum (Wintour, 2013). Science education is less well funded than other core subjects, especially mathematics, and its teachers less rewarded. Disciplines, such as geography, agriculture and nutrition are seen as of secondary importance and the historical understanding of failures to appreciate new science (e.g. Galileo's problems) or the human search to understand our place in the world through religious traditions are given lesser status. The fundamental and challenging need to understand how all things link is not accorded a high priority; key sustainability skills such as critical thinking and change management likewise assume a lesser role to more traditional subject learning. Yet this is the real world over which our ill-prepared political leaders and financiers must govern. Our futures lie in a changing world environment with complex inter-linkages. In practice the currently proposed UK curriculum changes will make addressing sustainability issues in a pragmatic and practical manner more difficult and apparently of marginal importance, for example addressing climate change as a scientific matter with scant attention to social and economic relevance. This is indeed a concern.

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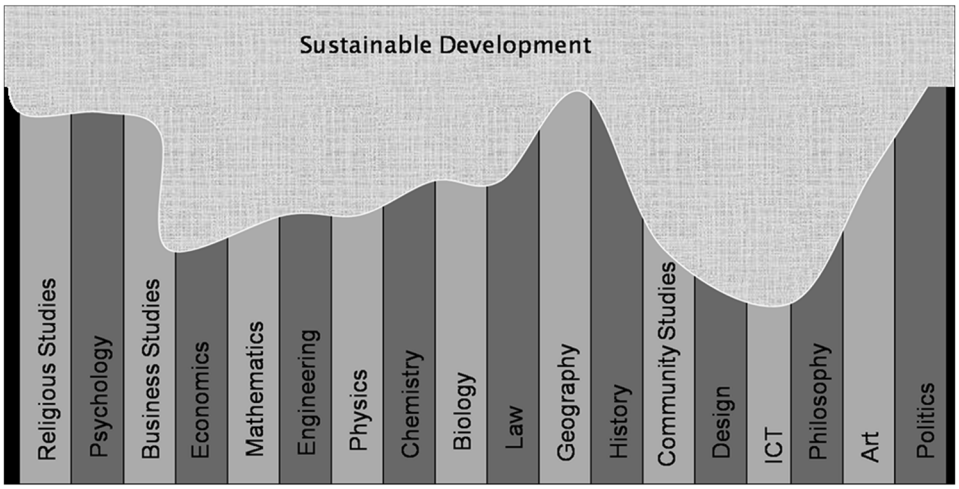
Higher education (HE) is similarly challenged. One major difficulty for the sector is inconsistent government standpoints with regard to sustainability and, for example, energy strategy. This in turn restricts investment and entrepreneurial activity and limits the graduate job market. The demand for graduate opportunities and courses devoted to SD thus is also restricted. This is especially so in the current UK context where new full cost fee levels for home students are causing prospective students and their families to question more closely the value of HE. Degrees in sustainability rarely lead to wealth, but even when this is not a key driver, job security is important and again policy fluctuations can make employment in this sector seem insecure. This was demonstrated recently in the UK when changes to the feed-in tariff for solar-generated electricity were substantially reduced causing financial difficulties for embryonic 'renewables companies' and their employees. The future of dedicated sustainability degrees, and related technical qualifications is similarly jeopardised. Vice chancellors and college principals seek courses that generate high student recruitment since this secures institutional financial futures. Families, too, seek the best long term opportunities for students. Counselling to prospective university students tends to reinforce this circumspection, partly due to teachers' professional unfamiliarity with sustainability degrees which are mainly new and postdate their qualifications, and partly reflecting these external pressures. These factors together mean that embedded sustainability teaching accessible from diverse main degree pathways is a potentially more fruitful and guaranteed approach for influencing future graduate citizens and potential society leaders than dedicated degree pathways especially at undergraduate levels.

As well as these essentially external drivers, a range of internal considerations have also militated against development of dedicated sustainability pathways. Undoubtedly research assessment pressures have meant academic staff have little time for the development or incorporation of new materials or indeed re-thinking pedagogic approaches. Many still see sustainability as intruding into their subject curriculum space (Dawe et al., 2003) not appreciating that change in pedagogic approach could deliver the same core disciplinary information but enriched in a multidisciplinary framework. This is where the assistance of dedicated sustainability staff can help achieve the transformational steps to sustainability understanding. Role-playing, practical campus learning, and town-gown links are just some examples of pedagogic shift that has facilitated this transformation at Kingston University (KU).

Many UK universities have embarked on curriculum restructuring aimed at freeing staff research time. Typically this means reducing the number of modules or units at each degree stage, though giving each more content and credit value, thus reducing administrative burdens and assessment pressures. When fewer modules are taken per stage, dedicated space for sustainability may not be available but an embedded strategy using more innovative and, in disciplinary terms, integrated teaching approaches can ensure students still became familiar with sustainability concepts, and at depth. This also fits with the apparent desire of UK students that sustainability be included across their courses rather than taught in separate specialist modules on the topics delivered, as discovered through recent work by the UK National Union of Students (NUS) in conjunction with the Higher Education Academy (HEA) (Bone & Agombar, 2011). Less easy to overcome is the faculty 'silos' mentality that can arise when major funding is devolved from the centre generating inter-faculty competition for students and associated income. This can create barriers that militate against inter-disciplinary programmes linking sciences, technology, design, business and humanities, linkages that are fundamental to sustainability understanding (Figure 1). Again dedicated sustainability staff can help resolve these difficulties, as can campus facilities which – if suitably designed and managed – can subliminally educate students in sustainability behaviour.

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Figure 1. Sustainability – 'need to know': a schematic representation of multidisciplinary learning underpinning sustainability action (Adapted from Taylor and Toogood (now Barron), 2010)
This schematic representation is developed from ideas presented by Prof Marie Harder, Brighton University, in a guest lecture on waste management as part of the KU Sustainability Hub 2009-10 research seminar series.



The external and internal pressures highlighted above have challenged dedicated curriculum developments for education for sustainable development (ESD) in all but a minority of institutions. It could be argued the more relevant priority is to develop sustainability educational tools that are universally accessible no matter how rich or poor, or how sustainability aware an institution may be. Our experience shows even small bottom-up changes can facilitate new sustainability learning across diverse disciplines but that the support of a focal 'Sustainability Hub' or, in the early stages, an active steering group will considerably speed and aid progress (Taylor, 2013).

In this paper we argue the benefits of an 'embedded strategy' to achieving a robust and sustainable ESD curriculum and outline some of the main approaches used at KU. We include feedback from students, academics, support staff and local employers engaged in these developments and highlight the main successes and the pitfalls encountered. We present and analyse case studies exemplifying sustainability learning through a diversity of embedded approaches including:

- Changing the environment in which students learn through campus developments for sustainability, including student engagement in changes
- Engaging the university community through fun events and debates linking to wider regional, national and international issues, activities and professional practices
- Linking the university to its town and region and co-development of sustainability practice including practical sustainability learning with local practitioners
- Fieldwork and practical developments supporting learning for ESD at local, national and international scales and demonstrating the importance of context in particular through international engagement
- Role-playing, mind maps, swap-shops, 'news' reports; activities for ESD as a means of engaging students with the complexities of real world sustainability.

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These approaches typically build from students' daily experience and arguably demonstrate to them how small actions for sustainability can facilitate high level changes. They also help them to develop more sophisticated and deeper cross disciplinary analytical skills including understanding of diverse professional viewpoints. We show how well-designed facilitated, rather than didactic, learning can motivate students' understanding and practice of sustainability and assist them in acquiring the multidisciplinary skills needed to understand, evaluate and manage, the complexities of SD. We discuss some of the barriers and pitfalls to this process as well as the benefits as exemplified by student response, e.g. uptake in independent research dissertations (Eames et al., 2013) and subsequent employment.

ORGANISATION BACKGROUND

KU is a medium-sized UK academic institution located in south-west London. It is a mainly urban, multi-site, post-1992, university. Building on its former polytechnic roots it has strengths in subjects of direct professional relevance such as engineering and applied sciences, art and design, architecture and planning, and business, education and healthcare sciences. It also has strong traditions in earth and environmental sciences and an expanding curriculum in the humanities including politics, drama, media and film studies. As of December 2012 Kingston has: four main campuses; ten additional substantive residential and administrative sites; five Faculties; 23,105 students, including 4,035 non-UK students from 150 countries; and 2,916 permanent staff.

Sustainability activity within the University originated with individuals from across the institution working as an unofficial group (The Steering Group for Sustainability (SGS)), campaigning and working towards change. From 2009 the Sustainability Hub linking all strands of sustainability has been formally embedded in the University's structure in one central department; sustainability is therefore no longer a project, it has become an acknowledged core activity.

SETTING THE STAGE

Campus Learning: Subliminal and Active

University and college campuses give immediate opportunities for student learning about sustainability. These can include activities specifically linked to curricula and formal learning; active volunteering; and learning encouraged through sustainability-linked campus management practices such as good waste management, offering and prioritising sustainable foods in canteens, energy efficiency initiatives such as automatic lighting, and grey water recycling (Figure 2). These are all issues which impinge on the everyday experiences of staff and students and are thus readily transferred into the wider community locally and, as students return home, nationally and internationally. Campus good practice, since it reaches all students irrespective of their main subject of study, has great potential to influence future lifestyles and sustainability behaviour.

Many universities in the UK have instigated student 'end of year' donation schemes for those leaving university residences. This especially benefits overseas students who may have nowhere to store belongings through the summer vacation period and who previously had little option other than to discard materials which, prior to these initiatives, typically went to landfill. By organising collection schemes

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Figure 2. Example poster from an energy awareness campaign (introduced in 2010-11 and repeated in 2011-12)

This poster is one of a series aimed at encouraging more responsible electricity consumption. It also links to more targeted campaigns such as 'Student Switch-off', a NUS run campaign focusing on encouraging efficient electricity use in the residential halls through education and prize rewards and introduction of publicly-displayed energy performance certificates as required by the EU's Energy Performance of Buildings Directive (EPBD, 2003).



for reusable items such as, shoes, textiles, kitchen utensils, duvets, electronics and diverting these from landfill obvious environmental benefits are achieved. At the same time local charities benefit from the donated goods and, as has happened at Kingston, key items such as files and kitchen equipment can be temporarily stored and sold at discount prices to incoming new students. This generates funds towards running the following year's collection making the scheme, at least partially, self-sustaining. It also raises sustainability awareness amongst staff and students, and shows incoming students the university has 'green' credentials while benefiting them by providing the opportunity to purchase essential items more cheaply. Outgoing students learn the lessons of re-use and recycling. At the same time the institution's local reputation and engagement is enhanced and, at Kingston, this learning extended to university leaders as the scheme attracted local and national awards, e.g. Green Gown[1] award (Smith, 2009). Since the first pioneering 'man with a van' scheme launched in 2005, the scheme has expanded to include waste from summer conference services and has annually diverted on average 6 tonnes of waste from landfill helping the Royal Borough of Kingston upon Thames (RBK) to meet its landfill targets within Greater London. At the same time excellent links with charitable organisations, ranging from Oxfam to the British Heart Foundation to small local charities such as Katz Castle, have been forged. In a curious example of 'upcycling', Katz Castle transformed old duvets into handcrafted cat and dog beds. In 2011, Katz Castle charity director said, "It's great to have a regular supply of duvets and last year I raised over £5000 from the sale of the pet beds I made out of them".

This is a noteworthy innovation since laundering old duvets is expensive and makes their routine re-use difficult. Helping students reduce their 'end of year waste' and dispose of it responsibly has become a routine integral part of waste management for Kingston's facilities management company, KUSCO. The scheme has evolved, becoming more streamlined and professional each year. For example, campus

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bins are now available for routine year-round disposal and charity collection of unwanted textiles and other reusable items. This avoids storage problems for students, for University Facilities Managers, and for the charities; it also better integrates recycling and re-use into routine daily activity.

Managing the campus offers numerous opportunities for sustainability learning; rainwater collection schemes, renewable energy projects, installation of insulating and biodiversity-promoting green roofs are obvious big winners. Much will depend on local circumstances and smaller scale opportunities should not be overlooked since these may be readily achievable without requiring major works and expense. While photovoltaics will be educational, and give a 'feel good factor', smaller projects may give more immediate opportunities to innovate and understand constraints as well as aspirations. KU is fortunate in having a diverse range of habitats for biodiversity monitoring and engagement activities. Since the majority of the campuses are based in an urban area this has surprised many people and recent activities have helped to dispel the myth that urban areas have 'no biodiversity interest' nor potential contribution to make. Initiatives have ranged from the creation of a woodland walk (through a small remnant ancient woodland) on one campus complete with signage and outdoor classroom opportunities for local schools; to pond restoration and creation on two campuses, again including learning opportunities for local school children; to 'bioblitzing' the sports field and surroundings and creating 'food gardens' for staff and students to share at the two largest campuses. Installation of campus beehives, linking to nationwide initiatives to promote pollinating insects, has proved particularly engaging to administrative staff, who also participate in general wildlife monitoring, e.g. reporting bird and bat sightings. One innovative scheme has involved courtyard 'greening' at the most urban campus. This was triggered by an open competition supported by the University's Estates department, Sustainability Hub and Landscape Interface Studio (Sustainability Hub, 2012) with student designers challenged to transform a barren concrete space into a pleasant outdoor facility with educational interest, and working to a fixed budget. Picking an outright winner proved difficult so the designers of the top two entries were asked to collaborate and merge the best elements of their designs into a new scheme for implementation. Thus a 'pharmacy garden' linked to a potential revolving art exhibition and relaxation space was created (Figure 3). The associated formal and informal learning is clearly substantial not just for the competition participants and winners but also for those voting and evaluating the schemes; those subsequently enjoying the new space; and those who can now study and monitor the development of the area. Building on this, the University has launched an annual Sustainability Fund offering up to £1000 for staff and student ideas to improve the environmental impact of its estate. In 2012-13 the Fund has supported the creation of a pond dipping platform at Kingston Hill Campus to improve teacher training and promote outdoor learning.

A similar, larger scale courtyard development at Manchester Metropolitan University was reported in the recent, 2013, People and Planet green league evaluation (Bawden, 2013). Here, members of the university's Urban Garden Society have transformed an inner courtyard and former eyesore into an interactive garden for staff and students. Herbs, edible flowers, fruit trees, salad crops and vegetables can all be found in raised beds with wooden benches. All plants are labelled and wheel chair access is possible. In both these projects multidisciplinary learning and benefits are evident as well as a transformation of estates management approaches on urban sites.

The enthusiasm engendered by these developments reflects a growing understanding of the importance of providing opportunities for student input and co-development of sustainable solutions pertinent to their own university campus environment involving all members of a university community (Agombar, 2013). For students the skills gained extend beyond subject knowledge and incorporate the wider skills

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Figure 3. Campus Courtyard development
The judging exhibition, all student design ideas displayed for staff and students to vote on their favourites [Authors' photograph, 2012]
The new courtyard garden the final student design courtyard space [Authors' photograph, 2013]



of collaborative working; for staff from all areas of the university the collaborative developments build involvement and may gently persuade them towards adoption of more sustainable lifestyles.

Another campus initiative currently under development at KU involves working with the UK Environment Agency (EA) on an urban campus riverbank site to de-engineer the river channel and create new meanders making a more pleasant open space for students and staff; more diverse wildlife habitats; and improved water regulation. This funded project links with ongoing work, regularly required and undertaken by staff and student volunteers led by the biodiversity and landscape officer, to eliminate invasive Himalayan balsam (*Impatiens glandulifera*) (Figure 4). It also links to formal curriculum activities monitoring river quality and riverine access undertaken by geography, environmental and biological science and landscape students and to overarching EA proposals for improving London's rivers. Observations (by Taylor) during student curriculum work monitoring similar changes introduced on a comparable south bank tributary of the River Thames in southeast London, the River Quaggy, revealed significant wildlife, water quality and social benefits. Thus a local grass roots volunteer sustainability initiative has now linked to regional sustainability objectives. At the same time this work has extended active formal learning opportunities across diverse disciplines, while also improving the external environment quality and opportunities for relaxation to the benefit of all members of the university community.

Numerous opportunities in the formal curriculum can spring from these initiatives through practical scientific monitoring; designing new areas; and analysing staff and student responses and engagement.

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Figure 4. 'Balsam bash' in the River Hogsmill [Authors Photograph, 2010]
Himalayan balsam is an invasive species introduced into the UK. It grows rapidly and may shade and outcompete native plants. Regular removal and control is needed to maintain native flora and habitat diversity and in a riverine situation promoting native species will help to maintain good ground cover in winter when the balsam dies back. This will help to stabilise the river bank. Himalayan balsam is easily removed by hand making its removal a suitable task for volunteer events. However, until all the seed sources are eliminated further upstream this management is required annually as the riverbank is reseeded with the balsam each year. The photo shows volunteers at work on the vegetated riverbank opposite one university campus.



One scheme linked undergraduate learning for environmental management systems with small campus development projects. Support staff from estates, facilities management, learning resources and catering identified proposed projects for which they needed further data e.g. lighting in learning resources centre (LRC) areas, and food waste management schemes. Working with the academic module leader and facilitated by sustainability staff, project briefs were developed. As part of their formal assessment students worked in small groups to collect relevant data; physical, social, and environmental, and then reported recommendations by oral presentation and 'professional report' to the 'commissioning' staff member as well as academic assessors. This was highly motivating for students and generated new insights for staff forging beneficial links and understanding between academics and diverse support staff. Everyone benefitted from feeling involved; they felt valued; students especially were motivated by this 'real world' learning opportunity, the chance to make a difference to their university. Campus management and wider support staff valued the opportunity to contribute to student learning and demonstrate the practical constraints on their roles. They welcomed the chance to input their expertise. They also appreciated the opportunity to gain data from small research projects, commissioned and designed in liaison with their student group; data they often needed to support new developments but were short of time to collect (Taylor et al., 2012). The scheme built on earlier volunteer work pioneered through town-gown links and extended into the formal postgraduate curriculum linking students with external employers.

In one example students, using lux meters, monitored light levels throughout the day and night in the LRC at the main university campus. Their data supported the business case for design improvements to space layout, benefitting future users, and saving energy. The KU energy manager (2011) said of the

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student assessment of lighting and energy consumption in the LRC, "I didn't have figures in terms of light levels etc to back things up before and these aspects are important". Comments from the student participants in the project (2011) included, "Locating and processing real data was the most valuable part of the assignment" and "It's invaluable to be using real case studies for assignments".

Other groups have, for example, analysed waste management in students' halls of residence and at university sport and recreational facilities; evaluated canteen waste and its composting potential; explored the potential for local food sourcing; and evaluated biodiversity projects. The residential hall manager involved in the student survey of waste management and environmental performance (2011) felt that "It's always useful to have fresh eyes look upon ongoing issues .... The final report is useful as a basis from which to start gathering more detailed information. More improvements can be made with more information at our disposal". The students working on the same waste evaluation of a residential hall (2011) said "Having to pull back and think through every little step helped make our final product more thorough and complete," "There was a certain protocol and language that had to be used that seemed to differentiate it from other coursework assignments" and "It revealed the true obstacles to improving and monitoring environmental performance".

CASE DESCRIPTION: LINKING TO 'BIG ISSUES'

Guest Debates and Talks

As part of the wider educative process, the university's volunteer Steering Group for Sustainability (SGS), the precursor to the established Sustainability Hub (Taylor, 2013), in conjunction with the local administrative authority (RBK) and its annual Festival of Ideas programme pioneered thematic town-gown debates relating to key environmental and sustainability questions. Topics included, e.g. climate change (and carbon rationing), urban biodiversity, food quality, Fairtrade, sustainable housing (Table 1) with the intention of engaging students, staff and the wider local public in topical and socially important debates. Invited celebrity experts debated with local guest speakers and university staff with the event chaired by an SGS member thus drawing in a very mixed audience and promoting lively open debates around introductory position statements from the debate panel. This promoted a more active audience engagement than the standard 'expert talk followed by audience questions' approach. Events sometimes continued long after the scheduled slot in local pubs and coffee houses. These events paved the way for wider town-gown collaborations and created further opportunities for students. Academic staff responsible

Table 1. Some examples of topics used in Town Gown debates at Kingston University, UK

Debating Climate Change: What Can You Do?
Go-Wild: Biodiversity in Your Back Garden and Beyond
Sustainable Homes and Cities: Can You Make a Difference?
Dinner's Dirty Secrets: Is It Ethical to Eat?
21st Century – A Global Water Crisis?
Fairtrade in a Changing World
Can We Teach Happiness?

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for some degree programmes also challenged students to review the events as part of their coursework assessments. Feedback showed that students welcomed the interaction with local people and the feeling that their contributions were valued. In a related exercise posters made by students exploring SD themes, as coursework assessments from diverse modules and degree programmes, were displayed in an opening social session ahead of the main debates. This advertised the university's educative work to the general public and brought useful critical feedback for students and positive good will which staff later built on through student placement opportunities, and real world learning opportunities, within the local community. Importantly, these events were fun for all participants and thus engaged people and encouraged their sustainability learning and continued participation in developing good practice for sustainability.

Linking with International Partners

Collaborations across international boundaries add another dimension to embedding sustainability into curricula. The ability for sustainability professionals to share best practice and the routes they have taken to solve problems provides the opportunity for resources to be pooled and progress made more quickly on a larger scale as effort does not have to be duplicated. Direct sharing of curricula has also occurred with students from Oldenburg, Germany, visiting Kingston and joining UK students in sustainability related fieldtrips around London for the past three years and reciprocal participation by Kingston postgraduate taught masters students in fieldwork exploring sustainable water management in northern Germany. Similarly students from Kingston and the Universities of Cádiz and Almería, Spain have collaborated on investigative fieldwork in Spain exploring issues for regional SD. The shared experiences promote better understanding of cultural context and in the Almerían link facilitated interviews with local residents on issues of water pricing and waste management and tourism development. Students also jointly explored issues of agricultural production and social development in the extensive 'plasticultura' areas on the Campo de Dalías, Almería, in southern Spain.

This sharing of expertise also can usefully extend into campus operations issues. Immersing students in a sustainable environment during their studies is a vital element of embedding sustainability learning into the HE system. The sustainability experience of KU has been sought by a range of universities including Bilbao University, Spain; Grand Valley State University, USA; King Fahd University, Saudi Arabia; the Catholic University of Lille, France; and Kyoto University, Japan, engendering conversations useful to both parties.

Through the Dorich House Group of European Universities[2], institutional level research links have been made between eight Universities from the UK, France (2), Germany, Spain, Turkey, Lithuania and Sweden. Eames et al. (2013) presented an initial comparison of Biology, Environmental Sciences and Surveying course programmes between Oldenburg University, Germany and KU which revealed many of the complexities that would need to be resolved to enable fuller measurements and comparisons to be made. The availability of data and variations in the aspects of each discipline generally taught in each country were two of the areas identified where more work could be usefully done to assist in quantifying sustainability coverage in curricula on an international scale. More comprehensive attempts to measure sustainability coverage in KU's curricula have also been conducted (Dawe et al., 2003; Eames, 2012). This focus on researching a methodology for measuring sustainability coverage is gaining momentum in the UK due to national initiatives such as the People and Planet Green League but also more inherently by the need to be able to measure in order to improve and manage progress.

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National Initiatives

The People and Planet Green League has been a powerful motivator for UK universities to become more sustainable in their operations. Universities are required to submit evidence as to their current situation including their carbon emissions, water use, recycling rates, procurement policies, and engagement with staff and students on sustainability. Since 2011 the League has also required evidence of Universities working to include sustainability in their curricula. With a revision of the whole methodology occurring for the 2014 League it is likely that curriculum will gain a larger prominence in the criteria, increasing the incentive for Universities to invest time, effort and financial support to this agenda.

Another national scheme having a beneficial impact on students' ability to learn about sustainability while at university is 'Green Impact' run by the UK NUS. Though primarily this scheme is focussed on engaging with staff and encouraging them to change their workplace behaviours to be more sustainable, an integral part of the scheme involves recruiting students as volunteers to audit the participating departments' efforts. The student volunteers are trained in auditing, gaining employability skills, which they then utilise in a professional capacity to assess their assigned staff team. Student volunteers can also choose to get involved in the scheme on a longer-term basis supporting an allocated staff team in their efforts to redesign their office processes to be more sustainable. Feedback from the students involved has revealed the benefits that they have gained from the scheme and also showed that their interest was particularly captured by the opportunity to investigate in more detail the university staff experience and to positively impact on their institution.

A currently ongoing national initiative, which is likely to have a profound effect on sustainability in HE curricula, is the production of new Quality Assurance Association (QAA) guidelines on how sustainability could be covered by universities in their courses. The QAA in the UK is responsible for safeguarding quality and standards in universities and colleges to ensure that students across the country have the best possible learning experience and that degrees from different institutions remain comparable. It publishes and consults with institutions to improve the UK Quality Code which "is used to assure the standards and quality of higher education in the United Kingdom" (QAA, 2012. p. 2). The development of these guidelines has been chosen to align with the recent guidelines on employability (QAA, 2010). 'Guidelines' were selected instead of the 'requirements' that the QAA has in place for other elements of the Quality Code due to the complexities of the issues and the work that still needs to be done to make the aim of complete sustainability coverage in curriculum a reality. The guidelines have not yet been released but have already raised interest throughout the UK HE sector and so it is hoped that they will assist in creating positive momentum for further change.

Professional practice institutes and other accreditation bodies have an extremely valuable role to play in embedding sustainability into a wide range of HE curricula. By applying requirements to teach sustainability into accreditation processes and assessment systems these bodies can, more effectively than many other methods, enforce change in curriculum to prepare students with the skills and knowledge that graduates in their fields will need. The Royal Institute of Chartered Surveyors (RICS) and the Engineering Council's UK Standard for Professional Engineering Competence (UK-SPEC) are just two of the bodies which require sustainability to be a part of the curriculum in order for a course to carry their accreditation. For business schools the Academy for Business in Society (EABIS) is a global network of leading business schools, companies and thought leadership institutions, committed to mainstreaming sustainable business enterprise in business research, policy research, management education, executive learning and development. Membership requires that a business school demonstrate its commitment to

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sustainability before the resources of the global network are made available to the staff and students of the school.

One particular case study showing where a national initiative has had an immediate and profoundly beneficial impact on KU students through their curriculum has been that of the Isle of Man TT (tourist trophy) Zero race "for motorcycles (two wheeled) to be powered without the use of carbon based fuels and have zero toxic/noxious emissions." (TT Zero, 2010. p. 27). Since the inaugural race in 2010 students in the School of Mechanical and Automotive Engineering have designed and entered an electrically powered motorbike into this competition. The bike was placed 5th in 2010, 3rd in 2011, and 4th in 2013 (with technical issues meaning that the bike did not finish the course in 2012). This opportunity for Kingston students to design a vehicle using cutting edge technology to take part in an internationally recognised race has taught them sustainable design skills as well as the additional invaluable experience of the industry enhancing their employability. It has also encouraged them to think more widely about issues of sustainable transport and personal mobility and design-related wider issues such as battery disposal or opportunities for re-use (Taylor, 2013; King, 2007).

Regional Issues

Organisations and collaborations at a regional level also play a key role in the development of sustainability inclusion in HE curricula. At a London level one such organisation is the London Regional Centre for Expertise (RCE) in ESD, one of a series of such centres set up in response to a call from the United Nations University (UNU) to work towards the aims of the UN DESD. This network of institutions facilitates the sharing of expertise across London by holding annual conferences and sending representatives to the UNU RCE international conferences so that knowledge can also be spread at that scale.

Regional political boundaries also provide opportunities for both curriculum development and campus greening. The London Mayor's Low Carbon Prize competition has run in both 2102 and 2013 and is now set to be an annual event in the capital's HEIs' calendars. With Mayoral backing ensuring a high level of publicity and attracting corporate sponsorship of a development fund, this competition to find ideas from London's students to lower carbon emissions in the UK's capital is set to continue to capture students' imaginations. The winning idea (or ideas) receive(s) a share of the £20,000 development fund and support to take their low carbon idea to market and in 2012 shortlisted applicants could also apply for internships with the sponsoring company, Siemens. Moving into its third year this competition will form a recurring curriculum coursework opportunity with real world implications, as well as the possibility of students creating a business out of their idea if they are lucky enough to win. In 2013 an event for academics interested in the Prize was hosted by London City Hall providing a forum for collaborations and networking that is likely to be built on in subsequent years.

CURRENT CHALLENGES FACING THE ORGANISATION

Town and Gown Together: Shared Sustainability Learning

The relationship between a university and its surrounding community is often a tenuous one. The university is frequently viewed as an inaccessible institution that is more concerned about constructing new buildings, expanding its student intake and pre-occupied with its own, sometimes seemingly obscure,

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research. Fortunately this perception is beginning to change as increasingly our institutions are becoming more engaged in their communities, through volunteering schemes and the provision of university facilities for local events. But is this enough? Recent changes to fee structures in the UK have meant that many students now look to study locally and live at home to reduce their outgoings, increasing the necessity for universities to forge quality community links to attract students and stay competitive in financially uncertain times.

While some universities have been engaged with community-level activities for decades, the depth of engagement and true two-way learning has been limited. Often temporary and superficial, these relationships frequently convey the belief that communities benefit more from the interactions than the institution. If they are to be successful, universities must transcend their often paternalistic role by developing synergistic partnerships in which full involvement of the community is ensured and collaborative learning processes are the norm. Social issues can only be addressed through the collective and innovative efforts of multiple stakeholders, a need which will only increase as we face up to problems such as increasing social isolation, peak oil and climate change. Two examples of community-linked education developed at Kingston are introduced here.

A first year module entitled 'Sustainability in Practice' ensures student engagement with community groups who are implementing sustainability principles in the local environment. Students are taken out of the classroom to visit sites such as Kingston Permaculture Reserve at Knollmead, a 20 year old permaculture forest garden. They get to hear how the community group went about creating such a space and the challenges they have to overcome; they learn permaculture principles and then put them into practice by getting involved practically onsite. The impact of such firsthand experiences should not be underestimated. By redefining where learning can take place and with whom, we break down not only the university/community barrier but also the professional/personal artificial barrier universities indirectly advocate. All aspects of sustainability problems and our selves are interrelated. Practice is not undertaken with one part and personal life another and students are exposed to this through offsite, community learning opportunities.

To date Kingston has run these site visits with students from a mix of academic courses and year groups simultaneously, mainly with sustainable development and design students, facilitating interdisciplinary peer-to-peer learning as well as the benefits of learning with community experts. As we tend to view things not as they truly are but in the context of our own personal preconceived notions and prejudices - the more viewpoints and interactions we can expose our students to, the more we can help develop reflective learners ready to deal with 21st century challenges. As one student put it "It was the first time in my three years at the university that someone had talked about the big picture of our environmental challenges; the whole experience enabled me to start to join up the dots." (Rachel Burgess, Sustainable Development student, 2011).

Community members can have a holistic joined-up perspective that breaks down academic silos. Academics are selected, on the whole, to focus on generating original specialised knowledge. This is part of what students need, but more than this they need orientation and the opportunity to gain a broad perspective in preparation for life in changing times. There is great value in exposing students to people whose thoughts are not boxed in by conventional roles that belong to a given time and place such as the framing of particular academic disciplines.

Students appreciate the experience too. The local group often finds that students return in their own time to continue their learning from the community.

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We've enjoyed the visits of students to Knollmead in recent years. They have a ready understanding of what we're trying to do and why - they can see the value of proactive community responses, and are curious about the approaches we're taking. We benefit by getting good questions, and the stimulus to organise our thoughts. We also benefit, in some cases, by recruiting volunteers who seek to contribute to active local solutions to sustainability challenges (John Fellowes, Knollmead Permaculture Group, 2013)

Thus the whole community, in its widest sense benefits and genuine shared learning can be fostered through such experiences.

Another innovative example of such work comes from KU and St. George's, University of London. 'Heritage2Health' (H2H) is a coordinated approach to shared learning and understanding between health, social care, the creative industries, and the heritage and countryside sectors. It seeks to bring these rich and diverse sectors together to develop shared solutions to empowering and improving wellbeing and participation of vulnerable groups. Established in 2005, H2H supports access to heritage sites for people with any disability or health issue, including mental health or learning disability, as well as carers and people who identify themselves as socially isolated, by the facilitation of challenge days at heritage sites (Nash & Aitchinson, 2009).

This unique and informal volunteering programme sees stakeholders of all ages and abilities, (social care, design and arts students, with community members and heritage professionals) come together to plan and host challenge events at local heritage sites. The challenge events are devised solely by participants and can vary from physical challenges (such as walking long distances or over previously perceived difficult terrain), to creative (such as using art or drama to explore and connect to historic sites) or intellectual challenges (such as fact finding missions). All participants undergo a social and emotional challenge as they learn to engage with new people in unfamiliar surroundings. And just like the 'Sustainability in Practice' trips off campus, the experience dissolves traditional barriers to learning and boundaries between people, encouraging participants to question pre-conceived notions of roles, identities, limitations and disabilities. By removing students from their normal clinical environment and showing that everyone has something to learn and teach they are able to transcend professional restrictions and broaden their perspective.

H2H challenge days are real shared learning journeys. The act of working in small teams, as equal partners through planning and delivery, ensures no one person is seen as teacher and supports the development of a shared identity, communal purpose, and facilitates social bonding as well as establishing trust; boosting individual confidence, well-being and sense of self-worth, and creating social capital locally. The events also offer a very rare cross-generational learning experience for students and an improved understanding for the heritage sector of visitor needs. The emphases on autonomy, potential, mutual respect and co-operation are not only integral to community participation approaches for health care professionals (NICE, 2008) but vital if we are to develop professionals able to co-create sustainable, inclusive communities.

Inter-professional learning is also vital to achieve this end and one that H2H does particularly well. Students from a range of disciplines and from their first year of professional training are encouraged to participate, ensuring inter-professional learning is experienced at an early stage and seen as a professional norm. It facilitates students to do far more than understand other professional roles. By working according to the principles of ignoring traditional identities and encouraging full participation, H2H helps in "generating genuine interdependence and allowing equal contribution by all group members"

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(O'Halloran et al., 2006, p. 18), which can act to equalise perceived differences in professional status and develop well-rounded professionals, who are able to work collaboratively.

Such a rich and innovative scheme has the potential to be duplicated elsewhere, supporting the accumulation of clinical hours for student nurses, and enriching voluntary opportunities within the heritage sector, by the establishment of specific H2H buddy volunteers. There is scope too to widen the opportunity of engagement to other subject areas such as film students to document challenge days. A scheme like this gives hope that a community-led curriculum is not only desirable but possible for mainstream adoption. By exploring opportunities for collaborative learning with our local communities it is hoped that we can challenge traditional beliefs in the hierarchy of knowledge; move away from the adopted instrumental approach to HE and expand our notion of quality to capture HEs potential transformational role for society.

ESD Within the Formal Curriculum

Within the formal university curriculum a diversity of approaches has been applied across a wide range of disciplines. An emergent theme is 'real world sustainability' moving beyond the theoretical debates to application. Courses ranging from accountancy, law and business through, environmental sciences and geography to engineering, design and built environmental subjects such as architecture, planning and surveying have all promoted active sustainability learning. Skills-linked approaches have been used with students at all levels. Sustainability professionals need to be able to analyse and interpret new situations within a SD framework. To achieve this they need not only good scientific understanding and analytical skills but they must also be perceptive listeners, close observers and excellent communicators. They must be able to engage people in the process of change; and able to debate, challenge and frame new policies. Sustainability professionals need multidisciplinary backgrounds to equip them to search for, interpret and link disparate relevant information. Beyond that they must win the 'hearts and minds' debate. These are major challenges not just for students to acquire these attributes but for staff too in terms of designing curricula and learning and assessment tasks which promote these skills. As already noted, inter- or multi-disciplinarity, especially mixing subjects traditionally taught by different faculties is not always popular with faculty managers. Their concerns lie with cost efficiencies and operational economies. Protecting particular faculty positions and incomes may bring conflicting priorities and loyalties. Space management restrictions can also militate against more innovative teaching and learning activities such as role-playing and informal group work approaches which are particularly beneficial to sustainability learning (Wainwright, 2013). 'Bums on seats', maximising recruitment and thereby income, can seem key and thus selling the story externally is also important. As discussed above, externally sustainability education is often poorly understood and may not be highly valued. However, our experience suggests that with careful design, active, multidisciplinary learning that fosters sustainability understanding can be securely embedded in curricula even where it is not the main programme objective.

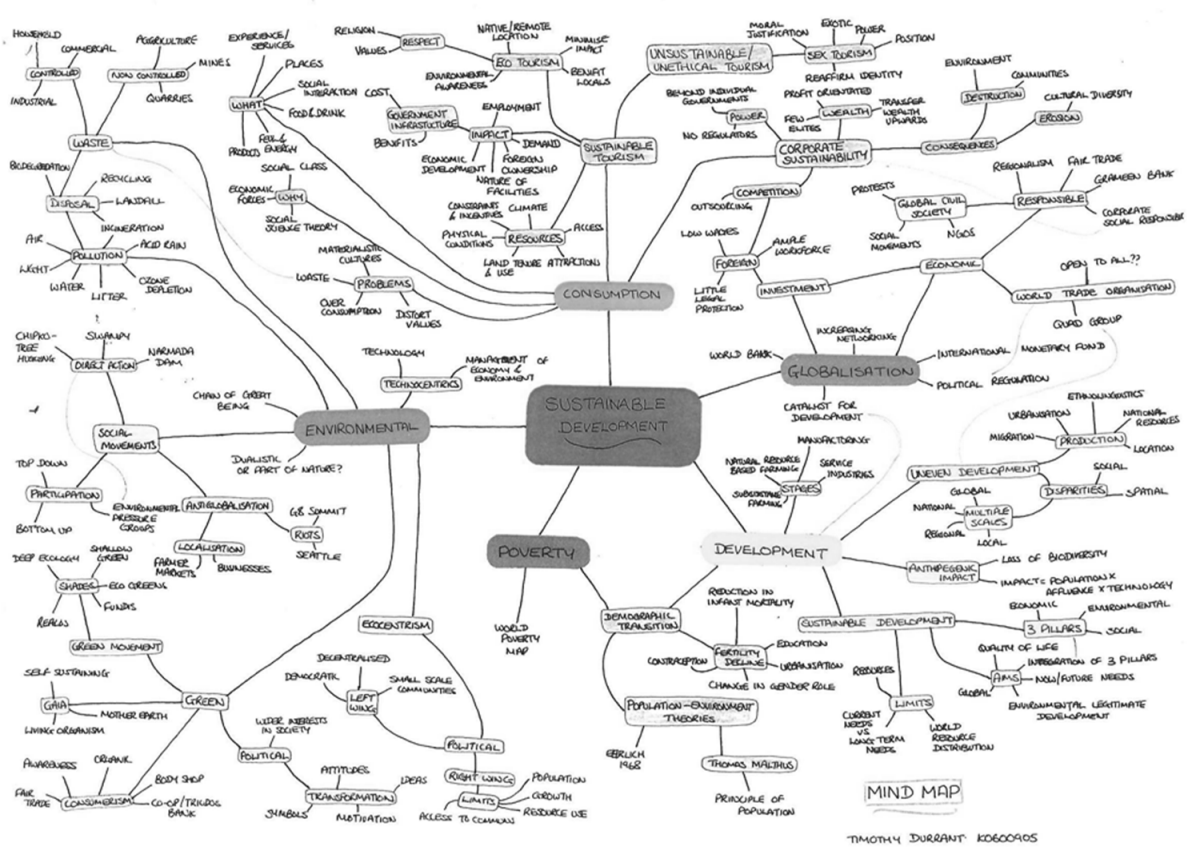
Pedagogic approaches are key. The challenge is to find teaching and learning strategies that are active and participatory; that can be used in diverse main discipline frameworks and which challenge students to think beyond their immediate main discipline focus. One such example was piloted in a first year undergraduate module in Human Geography, which is taken by students across the Earth and Environmental Sciences and by some Social Science students. Classes are large, with up to 200 students making lectures a main vehicle for dissemination of core material. Support activities and assessments, however, are designed to generate enthusiasm and individual initiative. In one assessment example each

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student is asked to produce a 'mind map' of SD for which she or he draws on core curriculum material and supplementary personal research on development studies, environmentalism, resource management, cultural diversity and so forth which is introduced via the main lecture programme and supplemented by tutorial discussions of recommended reading. The task is individual and innovative; it is about student's personal perception; it requires the student to organise his or her thoughts in a way not previously expected. It also opens students' minds to the extended and tangled web of knowledge and skills needed to support SD initiatives worldwide (Figure 5). Above all it engages them in a way no essay would ever achieve. The task is fun and the emerging diversity of 'sustainability maps' highlights clearly that no one solution fits a given context, let alone has universal applicability.

Similarly fieldwork and practical developments supporting learning for ESD at local, national and in international settings demonstrate the importance of context; cultural, environmental and social, in influencing pathways to equitable and sustainable futures. Too often field studies are so focused on a particular task in hand, *e.g.* landscape evolution or understanding markets, that wider cultural matters essential to understanding developmental behaviour are overlooked. At Kingston in final year degree fieldwork Environmental and Geographical students are challenged to integrate this picture through a graduated series of tasks ranging from pre-work researching the area to be visited; to on-site visits; to reflective post-fieldwork analysis. Before visiting, students research their destination working in small

Figure 5. An example student sustainability mind map



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groups focusing on key themes such as political context, historical change, religion and culture, agriculture, water resources, climate, mineral resources etc. They prepare a background report and present their key findings in an opening seminar on arrival when they also receive local feedback. Then through visits and informal interviews and personal research students build a picture of the current situation. Commonly this changes their pre-visit perceptions of the destination. Their understanding of other peoples' constraints and realities is extended and they gain a deep insight into the problems of SD. The importance of international travel and exchanges for informing policy formulation becomes clear. They then write a reflective report on SD priorities for the immediate, 5 year and 10 year futures of the region explored. The learning curve is steep; the enormity of real world complexities becomes evident; the practical constraints of cultural background and politics as they interweave with historical contexts, contemporary economics and geographic opportunities, become apparent. As one perceptive environmental science student commented in 2010, "poor governance is the key factor restricting this country's development". In other words, it is not the abundance or lack of resources that is the problem but the need for citizen involvement and an engaged government to create an equitable and secure society which is key. In another variant of this programme students produce a video 'news' report on their destination similarly identifying and prioritising development priorities supported through illustrative diary material and interviews. Many students cite this as the highlight of their degree experience.

Of course students cannot always be travelling to learn; it is too time consuming, expensive, difficult for those with family responsibilities, and some might argue the carbon footprint is too large. Role-playing can also contribute to in-depth multidisciplinary learning and in the environmental curricula at Kingston it is used at all levels from initial undergraduate to postgraduate taught masters students. While for year one students, roles may be explained through briefing notes, final year and masters students are challenged to independently research their roles and then write a fully referenced position paper supporting their role perspective. A staff member chairs the 'public enquiry' game and a colleague acts as a note taker and independent second assessor. In the role-play debate each student presents his or her role's assumed viewpoint (based on the student's personal research) and together they debate the issue. Initial assessment relates to both the position paper and the succinctness of argument in the debate. For some courses, this activity has been taken a stage further. Where classes are larger several role-play games are devised. Each student participates in one game, as described, but each also observes all other games and then, for one of their choice, writes a judicial review paper. Thus in a large group each student participates in a game as a role-player and also reviews a different game as a reflective 'judge'. Deep learning is promoted in terms of the written position paper and judicial review or stake holder analysis; robust debating skills are also demanded such that the overall exercise thereby tests a wide range of pertinent sustainability professional abilities. Preparatory workshops encourage peer-to-peer interaction and debate with staff, and the role-play activities encourage and reward independent research and enable engagement with very current topics which need insight and resolution. Topics have included: energy security in the UK; food security; responses to sea level change in a small island developing state; and land-use development conflicts such as a national park or mineral extraction and rights of indigenous peoples. This approach is readily transferable between disciplines and study topics; works well with multidisciplinary as well as single discipline groups; and extends and deepens student understanding of SD in a wide range of contexts.

The common factor in these examples is active participatory learning which has fostered interdisciplinary understanding and engagement and in the course of Kingston's university-wide recent curriculum redesign from 15 credit modules to 30 credit modules these pedagogic developments have been retained.

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They are cherished by both students and staff since they are fun, active ways to learn and teach. They stimulate students to become more engaged with their learning and thereby they often achieve more highly; they promote a staff-student dialogue that also encourages staff development. Furthermore the presence, since 2010, of a dedicated Sustainability Hub has raised campus-wide awareness of the need for this material and sustainability learning and secured its acknowledgement in the new 'Led by Learning' university framework (Kingston University, 2012). The Hub presence ensures a watchful eye on progress across the faculties; and provides an extra resource to assist with change and development.

Real world learning activity with external employers has been fostered in a range of degree programmes; it brings several added advantages to all participants. Historically, many degree programmes have routinely included a work placement year. Furthermore, it is commonly observed that participants return from this work experience better-focused and more self-disciplined such that when both three year and optional four year with sandwich versions of the same formal degree curriculum are available there is circumstantial evidence (informally from course directors and placement tutors) that students opting for the placement experience achieve more highly in their final year programme than their second year performance would predict. A variety of factors though can make placement years, when optional, seem unattractive to undergraduates. These include perceived unjust fee payments, particularly in the new, UK, full cost structures; unwillingness to relocate to take up a placement year; impracticability of relocation in the context of family commitments; separation from friendship groups; the preference for graduating as soon as possible given a difficult employment market; and the limited availability of full year paid placement opportunities. These factors prompted some innovative re-thinking among academic staff to offer the benefits of real world learning experience to undergraduates and also postgraduates who had selected programmes that they expected would enhance their sustainability-related employability or career progression. The following discussion highlights two short-term work experience links specifically designed, in conjunction with host employers, to enhance sustainability learning *viz.,* Sustainability at Work, a mini placement (originally offered as a freestanding undergraduate module now available as an embedded fieldwork alternative) and coursework linked sustainability auditing of local businesses primarily available to postgraduate students.

The module, Sustainability at Work was originally designed for the degree in Sustainable Development launched in 2005. It is a final year module that could be taken in various ways alongside the main formal curriculum; it does not require the student to take a year out from formal study on placement; nor to relocate. The work is with local employers who volunteer their time to supervise the student and in return receive a research report on an issue of concern for the success of their business. Essential elements for the students include research and evaluation of the host employer business in terms of its sustainability policy in relation to its sector and to overarching UK government, EU or global policy, as applicable; work on a small research project that the employer needs in order to develop the sustainability credentials of the business; and work shadowing the sustainability professional, or other employee, charged with overseeing environmental and sustainability policy. Students are supported by university-based tutorials; by sharing experience through seminar and poster presentations; and by a designated mentor in the work place. The work sits alongside the students other curriculum activities. The scheme has proved particularly successful with students and employers; it has even led to initial short term paid employment on graduation. Participant numbers were initially low but have increased more than five-fold since the module was launched. The key limitation is convincing potential employers of the scheme's rewards in relation to the time they must contribute initially to induct the student into their business.

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Student feedback from the inaugural edition of the module in 2009 included, "I also wanted to give some feedback about the Sustainability at Work module. I enjoyed it so much. I can say that it was the best module of all." The staff contact for the student working in the estates department (2009) said, "During her time with us, [.....] showed a high level of initiative and efficient work ethic giving strong support especially helping to run the University's new Eco-champions scheme".

The initial pioneering editions of this module were facilitated by Sustainability Hub staff taking the burden from faculty colleagues and thereby also overcoming the inevitable faculty managerial and potential employer resistance (perceived hassle) to such a scheme. They beneficially could search out employer collaborations building on links established through the town-gown engagement activities. The module makes an alternative vehicle for application of sustainability skills and gaining new insights for those who cannot undertake extended overseas travel. That the programme has now been wholly taken over by faculty staff and incorporated into the routine curriculum testifies, not just to its success with students and their learning, but also to the beneficial presence of a core of Sustainability Hub staff who could undertake the initial pump-priming activities.

Similarly work initially pioneered by sustainability staff working in collaboration with the RBK's Environmental and Sustainability department and the University Volunteer Service has now been incorporated into faculty-led teaching of environmental undergraduate and taught postgraduate masters students. Previously in this chapter we have outlined how formal curriculum activities in environmental management systems can be linked with small campus development projects. This work developed from a major series of innovative links initially involving students as volunteers but is now incorporated in the routine undergraduate and postgraduate curricula. These award winning developments attracted support funding from the UK HEA to evaluate and further develop the programme (Taylor et al*.,* 2012). Positive Environment Kingston (PEK) (Corrigan, 2007) was the initial scheme jointly developed by the University's Sustainability Team, Volunteer Service and the Environmental and Sustainability department of the RBK. From the Borough's perspective the scheme aimed to improve the sustainability performance of small businesses and charities within the Borough and, through guidance on best practice, help to reduce the Borough's ecological footprint. In the original scheme volunteer students, from any academic discipline, were trained as environmental mentors for local SMEs (small and medium enterprises), small charitable organisations, schools, sports clubs, etc. to assist them in producing an Environmental Action Plan. In return for free training, volunteers mentored a partner organisation identified by the Borough as needing help. Success saw the partner business or charity produce an environmental or sustainability plan and the student volunteer was awarded a formal certificate of competence and participation. The scheme was subsequently adapted for use in the formal curriculum of undergraduate and postgraduate students working on environmental and sustainability auditing. Typically taught masters students worked with the external host employers and second year undergraduates with the in-house hosts. The work forms part of an academic module with the key assessment elements being an individual report on Environmental Impact Assessment but with the other major elements being the team audit presentation and report. Reports are made available to host employers who are invited to attend the team presentations. Indeed it is part of their responsibility to participate in this feedback session; in return they receive a free audit.

In depth analysis of academic staff, student participants and host employers shows these learning activities have generated multiple benefits.

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- *'Employers'* (the businesses, charities, etc) benefit in terms of a free audit; exposure to sustainability ideas; and a chance to contribute to curriculum development.
- *Students* benefit in terms of practical professional experience which can enhance curricula vitae (CVs) and improve employability and also through the contacts made to develop further work-experience opportunities (and even immediate employment).
- *University staff* benefit in that employer links inform curriculum development and create contacts for research and consultancy opportunities (Taylor et al*.,* 2012).

Wider benefits have also accrued in terms of town-gown goodwill; in-house capacity building for sustainability understanding; and the 'feel good factor' of making a difference. In reporting similar business-linked learning with students at Southampton University, Kemp (2008) also noted these wider benefits. Luna and Maxey (2013) similarly found active participatory learning emerged as a key characteristic of sustainability education during their research linked to development of the Green Academy.

Students in the Kingston 2010-11 cohorts were asked to give questionnaire and group discussion feedback on the scheme. Staff also evaluated their performance in terms of achievement in the team audits, report and presentation and in the related individual essay-style work undertaken. Many students feared they were disadvantaged by weaker group members but detailed analysis of both undergraduate and postgraduate results did not support this point. In practice the highest scoring element for both cohorts was the group oral presentation. The motivational aspect of the real world learning was especially evident with 90% postgraduates saying they would elect to take the module if it were optional rather than an obligatory core and 74% undergraduates rating the module as one of their most preferred. For this group, modules including fieldwork also rated highly reinforcing the view that students like and respond well to active participatory learning and for most undergraduates their greater enthusiasm for such modules was mirrored by higher achievement (Taylor et al., 2012).

Students were also very aware of the wider skills benefits the audit work required (see Table 2). They cited planning and patience as significant skills learned alongside diplomacy and time management; they liked the chance to work in real world conditions and learn about putting policy into practice; and they enjoyed feeding back their opinions to their host employers.

SOLUTIONS AND RECOMMENDATIONS

Reflections on Sustainability Learning

At the turn of the new millennium Kofi Annan, UN secretary general, in an address delivered during a 2001 visit to Bangladesh, suggested that, **"**Our biggest challenge in this new century is to take an idea that seems abstract - sustainable development - and turn it... into a reality for all the world's people."

A decade earlier university leaders had recognised the important role of education and universities in achieving sustainable futures saying, "Universities educate most of the people who develop and manage society's institutions. For this reason universities bear profound responsibilities to increase the awareness, knowledge, technologies, and tools to create an environmentally sustainable future" (Association of University Leaders for a Sustainable Future, 1990).

But how are we doing? Is sustainability learning reaching all people? And beyond that are we giving new graduates the skills and practical expertise to apply sustainability principles in new and emerging

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contexts? Have we responded and progressed; what evidence do we have; how do we measure progress in sustainability education? Sara Parkin writing the foreword to The Sustainable University: Progress and Prospects suggests we have made little progress. She points out that

Despite many decades of documenting the consequences of environmental degradation (and with most evidence supplied by universities) our civilisation has not learnt how to stop their damaging activities, nor how to plan for peaceful resilience in a time of rapid change (Parkin, in Sterling, et al., 2013, p xviii).

Parkin goes on to say that it is not nature or the environment that needs to change but us, a truth that she claims needs to dawn more widely. She identifies three core principles of human behaviour change:

- Understanding the need for change
- Acquiring the necessary knowledge and skills that make behaviour change possible
- Operating a recognition and reward system that reinforces the right behaviour

Parkin claims we are stuck somewhere between the first and second principle. The key question is whether universities are supplying the intellectual leadership to shift societal change forward and move us away from potential self-destruction and into a sustainable future. We need to give as much attention

Table 2. Sampled student feedback on their audit experiences (29/31 students responded MSc; 29/30 BSc) (Adapted from Taylor et al., 2012)

Degree route	Comment
A Postgraduates	
Sustainability, Environment and Change	You dig deep and find other things to consider
Sustainability for Built Environment Practice	Gave an opportunity to work with others who have different expertise
Sustainable Environmental Development with Management Studies	Site evaluation - interaction with workers. Gives a more clear idea about current and actual environmental management
Environmental and Earth Resources Management	The learning process and the realistic approach- also the report write up and planning
Sustainable Environmental Development with Management Studies	It's an opportunity to put in practice knowledge and experience
Environmental and Earth Resources Management	Interviews highlighted the power of verbal communication
B Undergraduates	
Environmental Science (EU direct entrant)	You start from zero and then you realise at the end how much you developed your knowledge about it
Environmental Science	Learning how to be professional, systematic planning
Sustainable Development	Experience writing questionnaires and performing interviews
Sustainable Development	The practical assessment - learning the real work of EIA and audit
Sustainable Development	Importance of being thorough and good communication skills, learning the importance of many aspects and their influence on the process - eye for detail, team cooperation, staff communication
Environmental Management	The presentations - it's sort of an exciting challenge
Environmental Studies (joint honours- BA)	Made me more aware of obstacles facing audit professionals (although many could have been alleviated and may have been created by being a student)

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to affecting this shift as we have given to investigating the nature of the environment itself. This is central to sustainability, as distinct from environmental, education.

Researchers worldwide have identified some common barriers to moving sustainability education forward as summarised in Table 3 (*inter alia* Dawe et al., 2005, Velaquez et al., 2005; Granados Sanchez et al., 2012). Discussions at the inaugural workshops for the Green Academy (Luna & Maxey, 2013) showed that these barriers still persist. Finding a way forward remains a significant challenge.

Sterling (2013) argues that deeper problems persist and underpin the very slow progress in sustainability education which is still primarily seen as an 'interesting extra' rather than the core necessity identified by Parkin, Annan, and other influential sustainability advocates e.g. Porritt, Gore. Sterling sees two other problem areas relating to the *modus operandi* of HE. One reflects the growing need for universities to compete for students and to be measured in terms of student satisfaction and students' (and employers') perceptions of course relevance and desirable content. Universities feel the need to respond to 'customer satisfaction'. These issues have taken prominence over more idealistic values such as critical discourse, cultural enrichment, societal leadership and responsible citizenship. This situation, in turn, deters sharing (Luna & Maxey, 2013). A second key problem Sterling argues reflects the western intellectual legacy, in particular the dominance of reductionist study approaches. Issues such as those raised by Hardin's seminal work on the 'Tragedy of the Commons' (Hardin, 1968) and the duality of Arts and Science as articulated by Snow (1964) continue to militate against valuing multidisciplinary expertise. While the biggest problems facing society e.g. energy, water and food security require both scientific and socio-cultural understanding the degree programme opportunities for such education remain restricted. We continue to value more the single discipline expert in politics, law, physics and chemistry and give less esteem to those who integrate multidisciplinary understanding. Parkin (2013) is also slightly dismissive of the single dedicated sustainability module approach; Bioregional (a UK sustainability research charity) is a little critical of the dedicated degree programme (personal communication, 2010). Though these are good initiatives, the key issue is to reach everyone. This is where embedded ESD has so much to offer.

But how to monitor and measure success? This is a highly difficult challenge and one the UK academic sustainability community is keen to address. People and Planet annually publishes a UK universities 'green league' but sustainability in curricula currently gets limited reward in their evaluation system. Others have tried to enumerate ESD in the curriculum through module counts (Dawe et al., 2003; Eames, 2012) or through uptake in dissertation topics (Eames et al., 2013: Carrera et al., 2007). Counting modules and courses has limited value. Though this beneficially tells us what opportunities to learn are being offered; it does not tell us the extent of learner engagement and beyond that behaviour change whether in the limited academic sphere or more widely in subsequent career activities and lifestyle choices. Similarly

Table 3. Perceived barriers to sustainability learning in the formal curriculum (Adapted from Sterling, 2013 p.13)

Policy studies Institute et al., 2008 Report to HEFCE	**Dawe et al., 2005 Research for the UK HEA**
• Lack of interest in sustainable development • Silo or mono-disciplinary thinking and institutional organisation which militates against cross – departmental activity that is essential for education in sustainable development • Lack of incentives or priority to engage in ESD	• Curriculum too crowded, no spare space for sustainability • Perceived irrelevance of sustainability • Limited staff awareness or/and expertise • Limited institutional commitment • Limited commitment from external stakeholders • Too demanding and difficult

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counting graduates in relevant careers in part misses the point; it is changed lifestyles and contributions in changing company behaviour and decision making, the invisible metrics, which also matter. A survey of Kingston alumni conducted as part of an as yet unpublished masters thesis (Radanovic, 2012) asked whether alumni had been able to introduce 'green'/sustainability principles into their job/workplace in any of the jobs they had previously held. The sample size was 379 alumni; 269 responded to this question. The results showed that 19% had made a change in a current or previous workplace and 37% had made a change 'to some extent'. The initiatives undertaken ranged from waste and travel improvements, to green days at a school, to procedures being put in place to ensure sustainability is considered in the design phase of construction projects. The analysis of whether alumni were 'green' or not was extended to include different 'shades of green' adapted slightly from the definitions used by Crowley (1999). Fifty nine percent of respondents could be classified as currently having a 'green job' with students who had learnt about sustainability during their course being more likely to have a 'deep green' job than those who had not (following Crowley (1999), a job was defined as deep green if its process was not polluting, if its product was environmentally friendly or if the job role contributed to sustainability or social justice). Nuances within these data do require further analysis but indicate that it is possible to measure the impact that a HE curriculum can have on graduates into their careers.

The dissertation metrics likewise do suggest some real engagement since typically topics for students' final year degree projects are self-selected. This hypothesis was investigated as part of the work done by Eames et al. (2013). The theory behind this testing assumed that where final year research project topics are chosen by the students they are likely to reflect an area of the subject matter taught during their course either that they found particularly interesting or that they wish to pursue in their future careers. By analysing keywords in dissertation titles for sustainability content it would therefore be possible to measure the effectiveness of the curriculum content in inspiring students on the topic of sustainability. Where data on self-selected titles was available this method was successful in quantifying the student take up of sustainability related projects. However our scoping study showed that often these data are not stored unless individual lecturers collect the information making year by year comparisons impossible unless systems are put in place to allow this. Similarly growth of sustainability research and funding for example the British Ecological Society's promotion of work on ecosystem services and the UK Engineering and Physical Sciences Research Council's (EPSRC) and Natural Environment Research Council (NERC) support for work on e.g. carbon capture, renewable energy, ecosystems services and poverty alleviation, all testify to awareness of the need to engage high level research in matters of SD. These major research programmes should in turn expand sustainability educational opportunities as well as producing the intended targeted benefits.

In our discussions on ESD we have included student participant feedback. It shows that problem-based learning and practical action learning engages students and triggers changed perceptions and behaviour. Emerging research also suggests this is the most appropriate vehicle for ESD, but there are difficulties. Some commonly cited barriers remain e.g. time to develop a changed approach; difficulty of application with large groups; and problems of informal learning space which often arise when small groups from within a larger class cohort need to meet.

Problem-based learning and its potential to be used more widely to facilitate education for sustainability has been the subject of a recently completed collaborative three-year project between Keele University, the University of Manchester and Staffordshire University funded by the HEA's National Teaching Fellowship Scheme (Tomkinson & Hutt, 2012). Traditional problem-based learning requires small groups of students to be facilitated in person, usually twice a week, to identify the learning they

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will have to undertake in order to solve or at least begin to address the problem presented (Barrows, 1996). The hybrid problem-based learning approaches used in the case study examples such as those presented by Tomkinson and Hutt (2012), Tomkinson (2011) and Dobson and Tomkinson (2013), instead have trialled the use of online networks for groups to discuss ideas and use outcome-based rather than process-based assessments to reduce face-to-face facilitation time and remove the potential complication caused by needing to find spaces to meet. The University of Manchester has in this way managed to run a module with hybrid problem-based learning for 100 students (Dobson & Tomkinson, 2013). By its nature problem-based learning is ideally suited to teaching sustainability as the skills that we would wish our students to leave HE with focus around the need for them to be able to assess situations and find sustainable solutions to the problems they may face in their future careers and wider lives. Problem-based learning focuses on students solving 'wicked' problems (Rittel & Webber, 1973) which have no clear end, no definitive formulation, have consequences to every solution but no accepted right or wrong answer, and have causes with no unique explanation. These are exactly the types of situations our current students will have to face when they graduate and learning to solve them in a sustainable way adds to the value of this pedagogy.

Facilitation is, however, still beneficial for pump-priming new initiatives. The Kingston work-based audits were greatly aided by start-up support from a Sustainability Team member. Contacts with host employers built on previous Sustainability Hub and SGS initiatives such as town-gown debates, and Fairtrade collaborations. This saved the academic staff member involved much time and consolidated employer contributions and engagement into the learning process. Additional work during the HEA-supported period allowed employment of an assistant to monitor the whole process gaining participant feedback and establishing guidelines and expectations for all parties; students, university academics and host employers. Devising a simple tool kit for participation smoothed the way for future collaborations and emphasised the importance of each party's role. For example research showed that employers were reluctant to give time to attend the students' assessed feedback seminars thereby missing out on engaging with their fellow employers in a shared exploration of their business perspectives on sustainability. It also revealed that part of this reluctance was nervousness, fear of being exposed as ignorant of sustainability requirements and best practice and not just among their peers. They assumed university staff were 'experts' and would be judgemental whereas in practice they were very much co-learners. Shared learning opportunities were thereby being lost and since the sustainability journey is largely new and innovative these sharing opportunities are important. The extra conversations possible during the HEA-supported phase helped to overcome these barriers and to identify a more suitable time and location (in the town centre) for host employer attendance.

Shared learning is a major potential benefit of collaborative approaches. New ideas will emerge when academic staff themselves engage not as leaders but as co-learners with their students and other participants. This point was articulated in the H2H case study. Non-hierarchical teaching often partners problem-based learning and emerges as a key strategy for ESD. Given appropriate physical learning spaces, as outlined by Wainright (2013) reporting on the new medical building at Limerick, student-led learning though discussion with tutors as facilitators can prove effective for all. The C-SCAIPE[3] informal learning space at Kingston very much reinforces this view.

The development of a Green Academy (GA) in the UK is a new initiative to create a support network for universities seeking to make sustainability more central to their operations and curricula. Participating universities and colleges must assemble, as a minimum requirement, a core team including a member of their executive, an academic champion, and a student representative with additional members (up to five

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or six team total) drawn from estates, finance, human resources, the careers office, or staff from other support services, as most appropriate to the institution. Thus the teams represent the whole university or college community. By working together to prepare for, and subsequently participate in, a residential workshop they start to overcome the within-institutional barriers to sustainability and to develop shared a vision for sustainability and ESD at their institution and to devise and prioritise implementation programmes. Meeting with teams from other universities at the residential workshop further enriches the process and the teams are supported by 'critical friends', drawn from universities already engaging with this sustainability journey. This support between participating institutions, and also with critical friends, continues after the focal workshop. In depth analysis and feedback on the inaugural, 2011, GA process has revealed the many positive benefits felt by participants, and a few snags (Luna & Maxey, 2013; Kemp et al., 2012). In particular, the inter-institutional support helps to overcome barriers and sharing ideas accelerates the introduction and spread of ESD as well as further campus operational improvements. Importantly it publicly integrates and consolidates top-level engagement which helps to safeguard ESD in periods of institutional structural change.

However, it is widely acknowledged that the spread of high quality ESD needs to accelerate more rapidly than the current GA structure allows. Eight Higher Education Institution (HEI) teams participated in the first GA; adding another eight annually would reach just 40 of the UK's 165 HEIs in 5 years (Luna and Maxey, 2013). A more rapid penetration of these ideas throughout the sector is needed. Possibilities include running two academies annually and/or extending the pool of critical friends such that regional academies could supplement national events. This would, though, imply major co-operative links between local HEIs which often find themselves competing for students and in some cases badge their distinctiveness to being 'more green' than their local rivals. There remain some very real barriers to overcome.

Nevertheless the development of the GA marks a significant step forward and suggests a framework and mutually beneficial process for potential change away from the competitive protection of innovations to the benefits of sharing. The network for bottom-up engagement and co-developments between academics, students and support staff endorsed by senior management that a GA approach could potentially generate may in the longer term generate more enduring grass roots developments than top-down directives. Certainly it will beneficially complement them. Bottom-up engagement and regional sustainability networks are more likely to win 'hearts and minds' and thus more likely to endure even when an institution's other main foci change; thus they may be (and have been so far at KU) the better vehicle for accelerating ESD and associated sustainability improvements in institutional operations.

As Sara Parkin also observed:

Ultimately (though) the test of success has to be how a university (or any other institution) contributes to building natural human and social capital, how ubiquitous that contribution is across the institution (meaning not just the energy managers job or the odd module) and how seriously the university uses its power to influence others. (Parkin, in Sterling et al., 2013, p xix).

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ENDNOTES

1. Green Gown Awards are a national scheme in the UK, though since 2012 with an international extension. It is administered by the Environmental Association of University and Colleges (EAUC) in collaboration with diverse partners and sponsors representing sustainability professionals and higher education. For further information see http://eauc.org.uk/green_gown_awards
2. The Dorich House Group of Universities is a collaboration established through Kingston-led discussions. It takes its name from an historic building bequeathed to Kingston by the artist and sculptor, Dora Gordine and her husband Richard Hare. Dorich House is now used by the university as a small conference facility and exhibitions space and also houses a small museum collection.
3. C-SCAIPE is the Centre for Sustainable Communities Achieved though Integrated Professional Education. It was established as a Centre of Excellence for Teaching and Learning (CETL), one of a series of subject centres funded by the Higher Education Funding Council for England (HEFCE) under a five year programme from 2005. C-SCAIPE now continues as a research centre but the learning space and associated debating chamber are a popular university resource for informal student study and the area is also commonly used for town-gown events and seminars, with priority use given to sustainability-themed activities.

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Chapter 24
'Net' Social Change:
Grassroots Empowerment for Sustainable Development

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ABSTRACT

The notion of empowerment broadly refers to the ability of actors to fulfil their missions. However, assessing Information and Communication Technology (ICT) specific contributions to this remains an exigent task in the context of grassroots organizations. The objective of this chapter is to analyse the differences in levels of empowerment between ICT adopters and non-adopters Grassroots Environmental Organizations (GEOs) in Perth, Western Australia. The chapter draws on organizational empowerment theory and proposes an evaluation framework to assess ICT-mediated empowerment for sustainable development. Utilizing a survey of GEOs and interviews with leaders, the chapter unravels the contributions of ICTs in enabling these grassroots actors. The chapter ends with the discussion on the need for overcoming digital divide and recommends strategic support for GEOs that are either not able to or not willing to keep up with the emerging trend of ICTs.

INTRODUCTION

Grassroots sustainable development initiatives have been considered to be more effective at the regional scale because regions are large enough for federal and state authorities to deal with, yet small enough for community based actors and local governments to participate in the decision-making process (Dore & Woodhill, 1999; Lawrence, 2005). The basic premise of the notion of sustainable development is that centralized and fragmented emphasis on economic-growth at the expense of social and/or environmental costs is eventually detrimental to the overall societal well-being. The very essence of this notion has inspired various grassroots actors to mobilize themselves to bring about social change to reverse the trend of escalating environmental degradation around the world. For instance, Australia has been dependent on thousands of Grassroots Environmental Organizations (GEOs) across the country in order to safeguard local environment. This is done through activities that range from conserving threatened

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biodiversity to restoring degraded habitats in the regions like Perth, capital city of Western Australia, where two-thirds of native ecosystems have been lost in the past 150 years (Davis & Froend, 1999; Stenhouse, 2004; Dhakal, 2014a).

On the one hand, GEOs operate in challenging circumstances because of the lack of a) availability or access to adequate funds and volunteers, b) capacity to forge partnerships with other actors, and c) certainty over long-term viability to accomplish organizational missions (Simpson & Clifton, 2010; Tennent & Lockie, 2013; Dhakal, 2015). On the other hand, despite being under-resourced and volunteer-dependent, GEOs are often considered reliable partners by governmental and non-governmental organizations in terms of bringing about social change for sustainable development (Smith, 2000; Anheier, 2005). Consequently, the role that Information and Communications Technologies (ICTs), for example, the Internet and Internet based tools play is important in enabling GEOs' driven environmental stewardship initiatives. In recent years, this role has been increasingly acknowledged around the world (Kutner, 2000; Burt & Taylor, 2003; Horton, 2004; Hawken, 2007; Dhakal, 2011). It is in this context that an important question of 'To what extent do ICTs enable grassroots actors to become significantly empowered?' is critical. This question forms the basis of discussion in this chapter.

The theoretical conjecture that links ICT-mediated empowerment and GEOs proposes that empowered grassroots actors are better equipped to undertake sustainable development initiatives. However, the ways to ascertain empowerment levels, be it those mediated by ICTs or not, remain methodologically difficult. This complexity is partly brought about by the multiple descriptions and dimensions associated with the notion of empowerment. The possibility and practicability of evaluating empowerment may thus become confusing or even controversial. It thus goes without saying that without reliable measurement attempts, the properties and the significance of empowerment will remain obscure. Rappaport (1984) had argued that:

We must not reify empowerment in the measurement of the end product, or the process, or in a particular intervention or means by which it comes about. That is, the way it is measured is not the thing in itself. Nevertheless, each measurement, intervention, and description in a particular context adds to our understanding of the construct (Rappaport, 1984, p. 4).

In line with this debate on the reification of empowerment this chapter demonstrates that an attempt to assess empowerment can unravel useful insights. Such an assessment can also help to ascertain if indeed empowered GEOs are in a better position to attain sustainable development objectives and can inform policy interventions. The chapter begins by adopting working definitions of relevant key terms before discussing the main thesis of this chapter as well as the challenges that may be encountered in the process of measuring empowerment levels of GEOs.

GRASSROOTS ENVIRONMENTAL ORGANIZATIONS (GEOs)

GEOs are not-for-profit and non-governmental organizations. By nature, they are identified as a part of the "charities", "civil society", "community sector", "voluntary sector" or "third sector" (Lyons, 2001). Based on the description of Australian Taxation Office [ATO], formal or informal organizations that operate at the grassroots to care for the environment (ATO, 2000, p. 49) are referred to as GEOs for the purpose of this chapter. GEOs across the country have been at the forefront of social change for

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sustainable development since the early 1990s. As a result, landmark sustainable development policies and funding mechanisms such as the National Landcare Program and the Natural Heritage Trust have extensively relied on GEOs in order to implement on-ground environmental initiatives (Dhakal, 2014a). The role of GEOs is often facilitated by the notion and practice of voluntarism. Essentially, community members volunteer their resources like time and skills towards resolving sustainable development challenges (Dhakal, 2015). These community efforts have helped GEOs to make significant contributions particularly in the Perth region where the remnant nature is continually under threat from unsustainable development. However, like many other grassroots organizations, GEOs generally operate in difficult circumstances where they have to compete for limited availability of essential resources such as funding and volunteers (Dhakal, 2012). This is the reason why Head (2009) argued that sustainable development strategies in Australia over the years have not only tapped into the interests of GEOs but also shifted responsibilities to them without providing adequate support to enable their capabilities. It is argued in this chapter that one of the strategies that can capacitate GEOs is the usage of the ICTs.

INFORMATION AND COMMUNICATIONS TECHNOLOGIES (ICTs) AND THE DIGITAL DIVIDE

In its strategy to promote digital literacy in Asia and the Pacific, the United Nations Educational, Scientific and Cultural Organization [UNESCO] described ICTs as:

Any device and application used to access, manage, integrate, evaluate, create and communicate information and knowledge, including but not limited to radio, television, cellular phones, computer hardware and software, network hardware and software, satellite systems, peripherals, connections to the Internet, etc. Therefore, digital technologies are included in this definition together with services and applications used for communication and information processing functions associated with these devices (UNESCO, 2008, p. 11).

This chapter identifies various types of ICTs in enhancing the capabilities of GEOs to attain sustainable development objectives. A specific preference is given to the use of the Internet as well as Internet based tools such as email, website, and social media for the purpose of analysing strategies and levels of GEOs' empowerment. Nonetheless, it also recognizes that the trend of ICT uptake amongst smaller grassroots organizations has been generally slow because of barriers such as costs, skills and access (Roessler, 2004). These disparities in access to and the uptake of ICT are often referred to as the digital divide. This type of divide is a symbol of perceived disadvantage of actors that either are unable or do not choose to make use of ICTs (Cullen, 2001). While the evolution of the term digital divide has been discussed at length elsewhere (Servon, 2002; Gunkel, 2003; van Dijk, 2003), Warschauer (2003) suggests that the notion is not simply about a binary divide of 'haves' versus 'have nots', where a single overriding factor is seen to determine or bridge such a divide. He argues that ICTs do not exist as external variables to be injected from the outside in order to bring about social change; rather they are intertwined in a complex manner in organizational systems and processes within a society. Thus, ICTs should be understood as tools that can foster empowerment if used strategically to bring about social change necessary for the achievement of sustainable development. Several studies around the world have highlighted the benefits of ICT uptake for grassroots actors (Burt & Taylor, 2001; Burt & Taylor, 2003,

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Weare et al., 2005; Hackler & Saxton, 2007; Kavanaugh et al., 2007; Dhakal, 2009). It is, therefore, imperative for the purpose of this chapter to unravel factors that cause the digital divide in the context of GEOs' sustainable development aspirations.

'Net' Social Change and GEOs' Responses

ICT for social change continues to be a theme for debates around sustainable development. Millions of GEOs across the globe, for example, are reported to have made significant impact through the use of ICTs (Hawken, 2007). However, the adoption rate and use differ from country to country. In Australia, ICT uptake dates back to 1990 and the GEOs were one of the first third sector organizations to experiment with the Internet uptake (Dhakal, 2011). The Australian National Landcare Program worked together with the University of Melbourne to address a gap in GEOs' communication channels in the early 1990s (Hawkins et al., 1992). Similarly, another electronic network called 'CoastNet' was developed by the Australian Department of Environment, Sports and Territories (DEST) in the mid-1990s aimed at enabling GEOs to exchange information with other organizations involved in the planning and management of coastal environment (Dhakal, 2010a). While both networks were aimed at empowering GEOs by providing Internet-based forums, they ultimately failed because of barriers such as cost, time and the workload involved in accessing online services during that era (Minter, 1995; Curnow, 1996). Since then, only few studies have examined the uptake of ICTs amongst grassroots organizations in general (Denison et al., 2003; Barraket, 2005, Burgess & Bingley, 2007; Dhakal, 2011). While the information on the trend of ICT adoption amongst grassroots organizations in Australia has been relatively unknown (Denison & Johanson, 2007), the evaluation of the role ICTs play in empowering environmental specific grassroots organizations i.e. GEOs has been typically overlooked (Dhakal, 2010a; Johanson et al., 2013). Nonetheless, studying the implications of ICTs on societal actors is unlikely to yield fruitful insights from technological deterministic stance (McIver, 2003) which views ICT as a 'must have' tool for 'every' grassroots actors. Kole (2001) also argues that it is equally important for ICTs-society nexus studies to develop a conceptual framework that recognizes the mutual relationships between technologies and society for a specific purpose. It is in this context, the notion of empowerment and a framework for ICT-mediated empowerment is deliberated next.

A FRAMEWORK FOR EVALUATING ICT-MEDIATED EMPOWERMENT

The notion of empowerment means different things to different people. Page and Czuba (1995) argued that the term has often been used without actually understanding of its real meaning leading to the current theoretical underdevelopment and empirical misinterpretations of it (Segal et al., 1995). Nonetheless, empowerment concept encapsulates the capability of actors to make choices in order to gain mastery over individual or organizational affairs (Rappaport, 1984; Perkins & Zimmerman, 1995). In simplistic terms, empowerment concerns various ways societal actors with less power can be enabled to take charge to gain control over their business. Since power is conceptualized as a multidimensional social phenomenon, empowerment too is a multi-level construct with different meanings, processes and outcomes both at the individual and organizational levels (Kasmel & Tanggaard, 2011). Individual empowerment emphasizes the psychological elements of person's attributes including intrapersonal, interactional and behavioural components (Zimmerman et al., 1992). Organizational empowerment, on

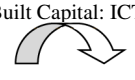
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the other hand, focuses on the structure and practices of organizational functioning and its attributes at three different levels of intra-organizational, inter-organizational, and extra-organizational components (Peterson & Zimmerman, 2004).

In terms of intra-organizational component, empowerment represents the state of viability facilitated by mechanisms that ensures that necessary resources are available in order to fulfil organizational missions (Griffith et al., 2008). This view is consistent with the resource mobilization theory which proposes that the optimum use of existing organizational resources e.g. financial and human capital is vital for the longevity of collective action (McCarthy & Zald, 2001). Secondly, inter-organizational component suggests that undertaking joint actions through partnership arrangement ends up with institutionalizing processes that seek mutual and beneficial organizational ties (Mohan & Stokke, 2000). This proposition is in line with resource dependence theory which assumes that the availability of essential resources to fulfil organizational missions is scarce and for this reason, organizations are inclined to establish external relationships in order to secure the essential resources they need (Pfeffer & Salancik, 1978). The third extra-organizational component demonstrates the influence of organizations on social issues through activities that often have implications, for example, sustainable development, beyond organizations themselves such as, policy level changes or environmental progress (Titeca, 2008). This view is consistent with community organizing theory which manifests empowerment as social power possessed by organizations (Speer & Hughey, 1995). This chapter draws on the conceptual foundation of Peterson and Zimmerman (2004) and proposes a framework for evaluating ICT-mediated empowerment of GEOs based on processes as well as outcomes specific indicators.

As depicted in Table 1, the framework for assessing ICT-mediated empowerment utilises five forms of capital or resource as indicators of empowerment processes, namely; built, financial, human, natural, and social. Flora et al. (2004) view capital as a resource or asset that can be used, invested or exchanged in order to create new resources or assets. Built capital refers to material infrastructure and manmade equipment such as highways and ICTs gadgets like computers. Financial capital refers to money or wealth that facilitates productivity e.g. funds to pursue organizational mission while human capital refers to knowledge and skills that are either inherited or acquired through education or training. Natural capital encompasses a spectrum of natural assets in the natural environment that provides benefits through ecosystem e.g. remnant ecosystems. Finally, social capital refers to the social connections that enable organizations to act collectively e.g. relationships with stakeholders (Putnam, 2000; Roseland, 2000; Goodwin, 2003; Moore et al., 2006; Voora & Venema, 2008; Dhakal, 2014b). The basic tenet of incorporating different types of capital in the evaluation framework is to gain holistic understanding of the resources-based view of organizational empowerment.

Table 1. A framework for evaluating ICT-mediated empowerment of GEOs

Tiers of Empowerment	Processes Indicators	Catalyst	Outcome Indicators
Intra-organizational	Acquisition of: Financial capital Human capital	Built Capital: ICTs 	Organizational viability
Inter-organizational	Maintenance of: Social capital		Partnership arrangement
Extra-organizational	Protection of: Natural capital		Policy influence

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In addition, the proposed framework outlines three outcome specific indicators of empowerment, namely; viability (inter-organizational), partnership (inter-organizational) and influence (extra-organizational). First, Fowler (2000) emphasized the regenerative ability as necessary for organizations to keep going and adapt to the changing external environment. In this regard, it is important for GEOs not only to utilize currently available resources wisely but also to have the ability to secure crucial sources in difficult circumstances. Second, Curtis et al. (2002) reiterated that it is unrealistic to expect grassroots organizations e.g. watershed groups in the US and Australia to remain functional without substantial cooperation and coordination with other intermediary organizations. It is this partnership arrangement that can foster joint grassroots level sustainable development initiatives. Third, it has been documented that GEOs that have been particularly successful in Australia are those that are able to exert power or influence at the policy level and improve grassroots environmental outcomes (Webb & Cary, 2005). Consequently, power – the capacity of one actor to get another actor to do what it would otherwise would not have done (Ackerman & Eden, 2011) – is of particular significance for the empowerment perspective because as Bourdieu (1986) argued, the capability of actors to exert influence depends on whether they are empowered or not.

METHODS

The chapter proposes that there are opportunities for meaningful understanding of ICT-mediated empowerment for sustainable development, and consequently, the central question that this paper asks is: 'to what extent does ICT enable GEOs to become significantly empowered?' This chapter draws on data collected for a PhD research entitled 'strengthening environmental stewardship in Perth, Western Australia: An investigation of linkages between organizational social capital and information and communication technologies in environmental community organizations' (Dhakal, 2010a). The research relied on a survey of 81 GEOs, fourteen (14) interviews with leaders carried out between 2008 and 2010. The updated analysis of online presence of GEOs, the content analysis of their organizational online presence, and four (4) additional consultations with leaders were carried out between 2011 and 2014. The survey research captured the trend of ICT uptake amongst GEOs in terms of access to the Internet, point of access and the status of adoption of ICTs, such as email, websites, and blogs. Post PhD consultations primarily focused on the utilization of social media into organizational activities.

In order to capture the empowerment processes, the research specifically relied on capitals and capabilities framework (Bebbington, 1999) and respondents were asked to indicate strength/weakness of their organization's capabilities by choosing from five statements:

1. Accomplish its environmental objectives i.e. safeguard natural capital,
2. Adopt and utilize information & communication technologies (ICT) i.e. exploit built capital,
3. Attract and retain volunteers i.e. garner human capital,
4. Maintain relationship with relevant stakeholders i.e. harness social capital, and
5. Raise adequate funds to support its activities i.e. secure financial capital.

The opinions were rated according to the Likert scale; very weak (0), weak (1), neither weak nor strong (2), strong (3), and, very strong (4). In order to capture empowerment outcomes, survey respondents were asked to report on:

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1. The likelihood of the organizations to keep going as an indicator of organizational viability;
2. Current partnership arrangements, and if yes, two of the most important partner organizations; and
3. Organizational stage to gauge influence on environmental policy.

Respondents were asked to identify organizational stage in relation to environmental objectives as:

1. Recently set,
2. Accomplished some objectives and active,
3. Did not accomplish any and inactive,
4. Accomplished some but inactive, and
5. Others i.e. currently restructuring, and open ended responses.

Survey and interview data were organised, processed, and analysed using two software tools: SPSS and Excel. In order to protect the privacy of the respondents and the organizations interview excerpts are presented using each respondent's designation and organizational ID without specifically naming individuals or GEOs.

FINDINGS

Survey Response

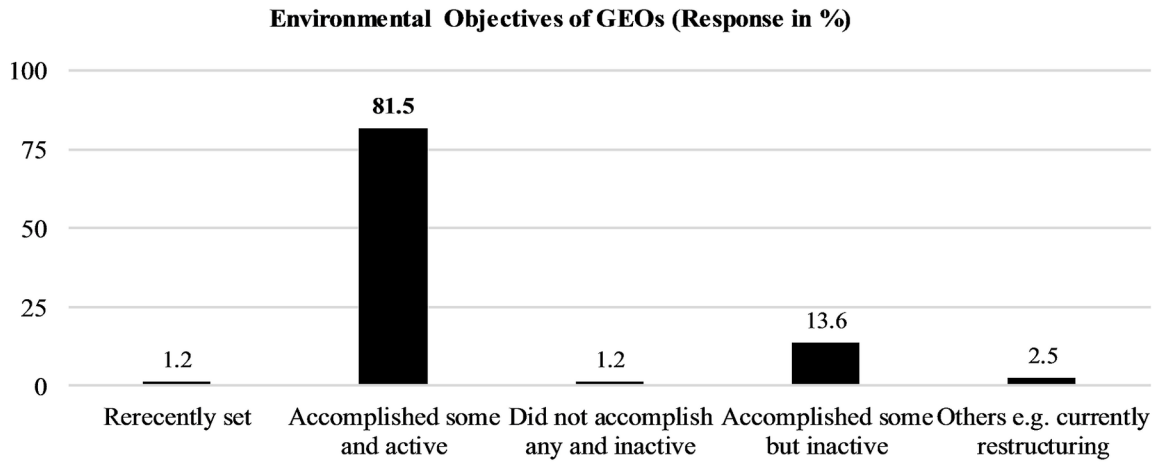
A total of 116 GEOs was identified from the regional natural resources management (NRM) directory and requested to participate in the survey. In order to improve response rate of the mail-based survey, the Tailored Design Method (TDM) was utilized to design and disseminate the survey instrument (Dillman, 2000). 83 GEOs responded, of which 81 (70%) were complete and usable. The overall response rate was well above a desirable rate of 50% for the non-profit organizations survey (Hager et al., 2003).

GEOs' Profile

Three of the most common activities reported by responding organizations were: protection and/or restoration of ecosystems (86%), environmental education/awareness (82%) and conservation and/or preservation of biodiversity. The mean number of activities reported by GEOs stood at 3.64 (median of 4). The average age of responding GEOs was 14.2 years. Nearly two-thirds (65%) of responding leaders were females and the majority (84%) were aged between 41 and 70 years of age. A total of 2,907 volunteers were affiliated with the 81 responding organizations. On average the GEOs had 37.1 (median 15) volunteers. The survey responses indicated that governmental support (local, state and federal) and private sector grants were the main sources of funding. The average number of funding sources stood at 2.44 (median of 3) per organization. Nearly 70% of GEOs indicated that they were positive about their future prospect. In addition, nearly 68% of GEOs also reported of having partnership arrangement with at least one other organization. In terms of organizational stage, as Figure 1 depicts, an overwhelming majority (81.5%) of GEOs indicated that they had accomplished some environmental objectives and were currently active.

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Figure 1. Organizational stage of responding GEOs



ICT Uptake and Digital Divide

The majority of GEOs (88%) who responded had Internet access and used email. However, this revelation is disappointing when compared to the 2002 survey which found that nearly 90% of community organizations in Australia had access to the Internet, nearly a decade earlier than the current study (Denison, 2003). While the lack of Internet access and email usage amongst 12% of GEOs in the Perth region is clearly an indicator of the digital divide, there are other multi-layered reasons as to why some organizations do not utilize email. For instance, the coordinator of GEO#36 indicated that most of the organizational interactions happened face-to-face and there was no need to use ICTs. Some leaders of GEOs that have adopted ICTs also believed that it was necessary to try to reduce the number of emails and the length of e-mails in order to avoid ICT based interactions as being 'noise', and responding to email/website/social media requests on a 24/7 basis. This could lead to burn-out of volunteers who have multiple roles and commitments. In addition, the coordinator of GEO#38 pointed out the reluctance of volunteers to trust emails because of forwarded unwanted emails and risks associated with spam. These accounts suggest that there is a sense of resistance towards ICT uptake due to the lack of perceived benefits associated with ICT use in the context of smaller grassroots organizations. More importantly, issues such as actual need, age, information overload ('noise'), and trust on ICT appeared to be the root causes of digital divide.

Less than one-tenth (7%) of organizations posted blogs and nearly 14% used social media. A recent community sector report on ICTs uptake (ACOSS, 2013) noted that nearly one quarter of community organizations in Australia did not use any form of social media and only 4% posted blogs. Once again, this fact highlights the extent of digital divide amongst GEOs. While the rate of blogging in GEOs is slightly higher than the national trend, social media use is clearly well below the national average. Other contemporary reports also reveal that smaller grassroots organizations are still in danger from being left out of the information highway because they are struggling to access and effectively utilize available ICT opportunities (The NOUS Group, 2010; Notara, 2011). For instance, the convenor of GEO#58 indicated that most of the volunteers associated with her organizations were over the age of 65 and were particularly inept and not fond of using social media. The organization only recently began to utilize

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social networking sites in order to attract younger volunteers in the local community. These findings are consistent with the observations of Merkel et al. (2007) that the complex and evolving nature of ICTs can be barriers for organizations that are not necessarily tech-savvy.

More than one-third (41%) of GEOs have websites. However, this is not really encouraging when compared to the 2002 survey which indicated over 61% of community organizations across Australia had websites (Denison, 2003). Qualitative observations in part help explain the under-utilisation of websites by GEOs. For example, GEO#80's executive director remarked that the organization had been able to establish an online presence only through sponsorship and grant support and that on-going maintenance/technical support is quite expensive. Interview with a leader of GEO#66 (female over 70) indicated that the organizations' website was designed by kin of affiliated volunteers. However, the website has not been updated in regular intervals because of the lack of necessary skills/time to do so. These results are consistent with the observations of gender divide and time shortage for grassroots organizations to effectively use ICTs; that is, older female in Australia are particularly vulnerable to being left out of the rapidly evolving social media landscape (ABS, 2007; Dhakal, 2010b; Palmer, 2011) and voluntary organizations in Canada are spending as much as six hours a week on maintaining their websites (Leverus, 2003).

ICT-Mediated Empowerment

In order to explore the ICT-mediated empowerment processes, Spearman Rho (nonparametric) correlation test was carried out amongst various forms of capabilities of GEOs. According to the guidelines of Cohen (1988), correlation coefficients (rs) ≥ 0.5 is considered strong, (rs) $\leq 0.49 \geq 0.3$ is considered moderate and (rs) $\leq 0.29 \geq 0.10$ is considered weak. As depicted in Table 2, correlation tests detected moderate associations between ICTs and financial and social capital ($p \geq 0.01$).

It is clear from the correlation test that two of the most important factors for the ability to make the most out of ICTs were the ability to maintain relationships with relevant stakeholders and raise adequate funds. However, the correlation test also indicated the lesser significance of ICTs for GEOs' capability to address environmental issues in the Perth region. This association is not surprising, as less than one-third of responding organizations had websites, while less than one-tenth posted blogs.

In order to explore ICT-mediated empowerment outcomes, two-by-two cross-tabulations between websites (yes and no)/social media (yes and no) and dichotomised responses (yes and no) on viability, partnership, and organizational stage (Table 3) were used. Percentages across the columns help interpret the association between two categories because they provide an estimate of effect (Peat et al., 2008). The cross-tabulation revealed in Table 3 shows several significant differences between adopters and

Table 2. Spearman Rho correlation

GEOs' Capability To	ICT	HUM	FUN	SOC	ENV
Adopt and utilise ICTs (ICT)	1.00				
Attract and retain volunteers (HUM)	.269*	1.00			
Raise adequate funding (FUN)	.414**	.559**	1.00		
Maintain relationship with stakeholders (SOC)	.300**	.662**	.522**	1.00	
Accomplish environmental objectives (ENV)	.261*	.503**	.413**	.564**	1.00

* Significant at 0.05 probability level, ** Significant at 0.01 probability level.

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Table 3. ICT uptake and three tiers of organizational empowerment

Empowerment Tiers		GEOs Have Website?			GEOs Use Social Media?		
		No	Yes	Total	No	Yes	Total
Intra-Organizational (Viability Likelihood)	No	17	7	24 (29.6%)	24	0	24 (29.6%)
	Yes	23	34	57 (70.4%)	46	11	57 (70.4%)
	Total	40	41	81 (100%)	70	11	81 (100%)
		*x^2 (n=81): 6.278, df =1, p= 0.012**			*x^2 (n=81): 5.359, df =1, p= 0.021**		
Inter-Organizational (Partnership Engagement)	No	13	5	18 (22.2%)	18	0	18 (22.2%)
	Yes	27	36	63 (77.8%)	52	11	63 (77.8%)
	Total	40	41	81 (100%)	70	11	81 (100%)
		*x^2 (n=81): 4.830, df =1, p= 0.028**			*x^2 (n=81): 3.637, df =1, p= 0.057**		
Extra-Organizational (Accomplished Some Objectives and Active)	No	12	3	15 (18.5%)	15	0	15 (18.5%)
	Yes	28	38	66 (81.5%)	55	11	11 (81.5%)
	Total	40	41	81 (100%)	70	11	81 (100%)
		*x^2 (n=81): 6.904, df =1, p= 0.009**			*x^2 (n=81): 2.893, df =1, p= 0.089***		

* Significant at 0.05 probability level, ** Significant at 0.1 probability level.

non-adopters of ICTs. A significantly greater percentage of GEOs that have websites and use social media were more likely to be viable, engaged in partnership arrangement and had made significant environmental contributions.

While it is necessary to be cautious in establishing the causal relationships between variables based on the statistical associations alone (Cohen & Lea, 2004), such links between ICTs uptake and empowerment do have plausible explanations. Firstly, the correlations between ICTs adoption and financial and social resources suggest that some GEOs might be using social media as an additional avenue to attract acquires necessary resources locally. For instance, GEO#58 has particularly utilised social media in order to recruit volunteers for larger community events as well as to advertise garage-sale or other fund-raising activities. Conversely, it might also be the case that the uptake of ICTs has benefitted GEOs that are already enabled to a certain extent, rather than serving the needs of organizations that need to be empowered. Secondly, it can be speculated that organizations that are likely to be viable are more interested in establishing partnership arrangements and utilizing ICTs to build and maintain organizational relationships than those with a negative outlook. For example, five of the GEOs that responded to the survey had partnership arrangements with an environmental network in the region. These organizations not only receive technical assistance on matters like grant application and management plan preparations but also host their websites through the network's website. This finding reveals the significance of the role bridging or intermediary organizations (Brown, 1991; Dreier, 1996) play in the ICT-mediated empowerment of smaller grassroots organizations. Thirdly, GEOs that are likely to influence policies and environmental outcomes have clearly utilized ICTs to further their cause. For instance, GEO#81 has used website as a tool to increase awareness about the significance of local wetlands currently under threat because of the proposed highway construction over the wetlands. The organization is also making use of social media to harness community members to file an online petition directly to the WA Premier

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to campaign against the proposed highway from being built and help spread the news about protest rallies. ICTs in this case clearly provided additional means for the organization to influence sustainable development agenda at the extra-organizational level.

LIMITATIONS

As with any empirical research, there are limitations in this investigation. Firstly, although leadership qualities or their qualitative personalities as well as their past affiliations or associations in a community at the broader scale can influence the level of empowerment (Wood et al., 2008), this paper did not explore the attributes of leadership. It is in this context, the analysis of the ICT-mediated empowerment can be extended in the future by incorporating leadership attributes. Secondly, this chapter examined organizations that are currently active in the Perth region. Several defunct organizations that responded but did not participate in the survey indicated that some leaders who are solely interested in environmental outcomes but not in the processes that nurtures empowerment pathways – led to organizational dissolution (Dhakal, 2010a). This observation is consistent with the findings of Carr (2002) who pointed out that the depletion of stakeholder relationships have led to the disbanding of some of the GEOs in WA. Further research on the association between ICT-mediated organizational empowerment (or a lack thereof) and the dissolution of some GEOs would be worthy of investigation; not only to strengthen the case for fostering empowerment processes, but also to find ways to prevent empowerment processes as well as environmental outcomes from getting eroded.

DISCUSSIONS AND CONCLUSION

This chapter explored the extent to which ICTs enable the empowerment of GEOs in the Perth region of Western Australia. One of the main contributions of this chapter is the development of an organizational empowerment framework recognizing that the mutual relations between GEOs and ICTs can be harnessed for broader sustainable development agenda.

The three tiered conceptualization of an organizational empowerment provided a useful theoretical framework for evaluating the ways ICT-utilization enhanced the capacity of GEOs to accomplish their goals. The qualitative and quantitative findings indicated associations between the uptake of ICTs and the acquisition of financial and social resources by GEOs. A significantly greater percentage of GEOs that have websites and use social media had positive association with the indicators of intra, inter and extra organizational empowerment. In line with Bourdieu's (1986) argument, it has been demonstrated in this study that the capability to exert power depends, in the first place, on whether people are empowered or not. These findings further demonstrate that the utilization of ICTs can strengthen GEOs to carry out sustainable development initiatives and overcome resources-scarcities.

However, the associations between ICTs and empowerment are often reciprocal as it is not only possible for ICTs uptake to affect empowerment processes and outcomes but also vice versa. As Kraut et al. (1998) suggested, it is important to take this two-way relationship into consideration because even if empirical evidence were to convincingly connect ICT uptake with empowerment, it would not neces-

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sarily confirm the causal direction of the relationship. More importantly, the findings presented in this chapter do not always suggest that GEOs that are non-adopters are inferior to those who are adopters; instead organizations that have adopted ICTs might simply have additional means with which they can be empowered. This interpretation is consistent with the 'networked society' stance (Castells, 2000) which associates the lack of ICT utilization with missed opportunities (Floridi, 2001; Hacker et al., 2009; Dhakal et al., 2013).

What the state of ICTs uptake amongst GEOs in the Perth region highlights is the fact that the majority of responding organizations neither have websites nor use social media. It is likely the case that the general lack of enthusiasm for ICT uptake is an indication of a greater predominance of importance placed upon face-to-face interactions more than the digital divide itself (Kavanaugh et al., 2007). In other words, low ICT uptake may not necessarily be perceived as binary understanding of the digital divide but in terms of preferred mode of communications and the scope of organizational activities. Nevertheless, these findings clearly point to the need to address the digital divide in the broader context of social inequalities, if ICT-mediated empowerment is to be achieved, even in developed countries like Australia. Mainly because diffusion and appropriate utilization of ICTs present immense opportunities for sustainable development, whereas their absence is likely to accentuate the already existing divide (Sciadas, 2005). In this regard, ICT-mediated empowerment strategies might benefit by taking into consideration the underpinnings of theory of Diffusion of Innovations (Rogers, 1995) which suggests that organizations with more social, financial and human resources will generally be the first ones to adopt new technologies.

FUTURE TRENDS

It is apparent that not every GEO has the need to rely on ICTs to become empowered. However, as ICTs become increasingly ubiquitous in an organizational context, GEOs that are either unable to or unwilling to adopt ICT can be further disadvantaged because of lessening opportunities to engage in sustainable development initiatives. GEOs can adopt various mechanisms in order to be empowered in multiple ways and this short chapter does not aim to underestimate the complexities of empowerment (or the lack of it) by equating it with the uptake of ICT. In the case of GEOs in the Perth region, however, the uptake of ICTs stands out as a distinctive factor associated with enhanced empowerment, both processes and outcomes. This finding resonates with the observation that ICTs have become an essential ingredient of successful environmentally-oriented grassroots actors that often have to 'do more with less' (Neto, 2008). On the flip side, some of these organizations were willingly or unwillingly and/or overlooking or under-exploiting the potential of ICTs in general. This observation is consistent with the low utilization of ICTs amongst similar organizations elsewhere in Australia (Johanson et al., 2013). Since GEOs with a higher uptake of ICTs were in a better position to be empowered, future efforts (both governmental and non-governmental) to build ICT capacity of these organizations may benefit from involving intermediary organizations as well as making use of an organizational empowerment framework developed in this chapter to develop, monitor and evaluate ICT interventions in the Perth region and beyond.

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KEY TERMS AND DEFINITIONS

Digital Divide: A symbol of perceived disadvantage of actors that either are unable or do not choose to make use of information and communication technologies.

Extra-Organizational Empowerment: The influence of organizational activities on economic, environmental or social issues with implications beyond organizations.

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Grassroots Environmental Organizations: Formal or informal not-for-profit and non-governmental organizations that operate at the grassroots to care for the local environment.

Information and Communication Technologies: Internet as well as Internet based tools such as email, website, and social media.

Inter-Organizational Empowerment: The capacity to undertake joint actions with other organizations that results in mutual benefits.

Intra-Organizational Empowerment: The state of viability facilitated by mechanisms within organizations that ensures necessary resources are available in order to fulfil missions.

Organizational Empowerment: The ability to fulfil organizational missions based on the structure and practices of organizational functioning and its attributes.

Sustainable Development: Holistic societal aspirations on economic progress as well as social and environmental justice.

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Section 3
Tools and Technologies

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Chapter 25
Renewable Energy Sources: Comparison of Their Use and Respective Policies on a Global Scale

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ABSTRACT

Sustainability concerns resulting from the consumption of natural resources, life-threatening levels of pollution, global warming, climate change and the ever-increasing worldwide energy use have brought renewable energy sources to forefront. Given the possibility of depletion of fossil fuels in the near future, the utilization of clean and renewable energy sources have become inevitable. Consequently, governments and global organizations adopted respective regulations to ensure the production and use of renewable energy and promote the respective new investments. In the light of these developments, the aim of this study is to conduct a detailed review and evaluation on the current literature and global energy statistics. The respective projects, binding regulations, incentives, and pricing mechanisms have also been studied to analyze and compare the renewable energy policies adopted worldwide. Ultimately, the goal is to make certain suggestions and lay out possible solutions regarding global energy problems.

INTRODUCTION

Renewables excluding large hydro accounted for 9.1% of world electricity generation in 2014, up from 8.5% in 2013 with a corresponding increase of 17% in global investment ($270.2 billion invested in 2014 in renewable power and fuels excluding large hydro-electric projects) (Frankfurt School-UNEP Centre/ BNEF, 2015). The reason behind this is the concern for sustainability resulting from factors including but not limited to the depletion of natural resources, life-threatening levels of pollution, global warm-

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ing, climate change and the ever-increasing worldwide energy consumption (Komor & Bazilian, 2005; Apergis & Payne, 2010). The effective utilization of renewable energy is critical across the world, where 1.3 billion people still do not have access to modern sources of energy (WEF, 2013). Societies have much to gain from the effective use of renewable energy with certain issues to consider while making this happen (see Table 1).

In order to make use of these advantages stated in Table 1 and to address the critical issues, countries have developed government policies and adopted respective regulations to ensure the production and use of renewable energy and promote the respective new investments. This has been realized both individually and also as a part of global organizations and networks such as the Organisation for Economic Co-operation and Development (OECD), European Union (EU), United Nations (UN) and International Energy Agency (IEA) (Arioglu Akan et al., 2014).

The government policies on renewable energy constitute a "highly complex policy subsystem that lies at the intersection between environmental policy, economic policy, and energy policy" (Yi & Feiock, 2014). Within this perspective, a detailed review and evaluation have been conducted in this study on the current literature, projects, binding regulations, incentives, and pricing mechanisms together with the respective energy statistics to analyze and compare the renewable energy policies adopted worldwide. It has ultimately been aimed to make certain suggestions and lay out possible solutions regarding renewable energy based on the relationships between the current policies and use throughout the world. To this end, the third part of the study provides the broad definitions on the main concepts discussed in this study. A comparative analysis of renewable energy use (both on a general basis and also by source) throughout the world has been given in the fourth part. The fifth part summarizes the global renewable energy policies adopted worldwide. In this part, the policies of the OECD, the EU and some countries

Table 1. Advantages and disadvantages of renewable energy

Advantages	Disadvantages
Provides low operating and maintaining costs	High up-front investment
Provides long life period	Entails long-term planning
Service cost is low	Entails long-term agreements
Reliable source	Entails multidisciplinary involvement
Induces technology development	Could involve resettlement
Fosters regional development	Entails new legal codes
Provides efficient energy production and safety	Excessive competition
Generates revenue and tax	
Creates new employment opportunities	
Protects environment and saves environmental protection costs	
Enhances living conditions	
It is waste-free	
Improves air quality	
Preserves ecosystems	
Helps slow down climate change	

Gökmen & Temiz, 2015.

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selected with respect to certain renewable energy indicators have been included. A general view on the 2050 worldwide renewable energy goals is provided in the sixth section. This is followed by solutions and recommendations drawn from the study and certain future research directions. Finally, in the conclusions part, an executive summary can be found.

BACKGROUND

The Renewable Energy Working Party of the IEA defines renewable energy as follows:

Renewable Energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, biofuels, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources. (IEA, 2013a)

In line with the above definition, renewable energy sources can be classified under the following categories (IEA, 2013a):

- Hydroelectricity,
- Geothermal,
- Solar,
- Tide/Wave/Ocean,
- Wind,
- Solid biofuels, biogases, liquid biofuels,
- Renewable municipal waste.

Below are more detailed explanations on the above-listed sources of renewable energy provided by the IEA (2014a):

- **Hydroelectricity:** Refers to potential and kinetic energy of water converted into electricity in hydroelectric plants.
- **Geothermal:** Energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. It is used for electricity generation, heat production for sale to third parties or directly as heat in its primary form.
- **Solar:** Solar radiation exploited for electricity generation and hot water production. Passive solar energy for direct heating, cooling or lighting of dwellings or other buildings is not included. Solar photovoltaic is solar radiation exploited for electricity generation by photovoltaic cells. Solar thermal is solar radiation exploited for hot water production by flat plate collectors (mainly of the thermosyphone type) for domestic hot water or seasonal heating of swimming pools and electricity generation by solar thermal-electric plants.
- **Tide/Wave/Ocean:** Mechanical energy derived from tidal movement, wave motion or ocean current and exploited for electricity generation.
- **Wind:** Kinetic energy of wind exploited for electricity generation by wind turbines.

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- **Solid Biofuels:** Covers organic, non-fossil material of biological origin, which may be used as fuel for heat and electricity production. These include primary solid biofuels (fuelwood, wood residues and by-products; wood pellets; black liquor; bagasse; animal waste; other vegetal materials and residuals) and charcoal.
- **Biogases:** Gases composed principally of methane and carbon dioxide produced by anaerobic fermentation of biomass, or by thermal processes. They include landfill gas, sewage sludge gas, other biogases from anaerobic digestion and biogases from thermal processes.
- **Liquid Biofuels:** Includes fuels and bioadditives such as biogasoline, biodiesel, and other liquid biofuels.
- **Renewable Municipal Waste:** Consists of the biodegradable part of municipal waste products that are combusted directly to produce heat and/or electricity. It comprises waste produced by the residential, commercial and public services sectors that is collected by local authorities for disposal in a central location, including biodegradable hospital waste.

COMPARATIVE ANALYSIS OF THE RENEWABLE ENERGY USE THROUHOUT THE WORLD

This part of the study provides a brief analysis on the comparison of renewable energy use in Africa, Non-OECD Americas, Asia, China, Non-OECD Europe and Eurasia, Middle East, OECD and World Total[1]. The purpose is to lay out the current situation of renewable energy use on a general basis and also by source. To this end, Table 2 presents the overall renewable energy share in total primary energy supply (TPES) in addition to the individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste. The figures are the averages of the respective data corresponding to the years between 2008 and 2012, which have been gathered from IEA yearly "Renewables Information" reports (2010-2014 Editions). Figure 1 depicts the worldwide renewable energy shares in TPES between 2008 and 2012, and the five-year average individual shares of the above-mentioned sources can be viewed in Figure 2. The geographical coverage provided in Table 2, Figure 1, and Figure 2 and throughout the current section is as reported by the IEA and constitutes the following:

Table 2. Five-year (2008-2012) average share of renewable energy in TPES (general and by source)

Region	Renewables in TPES (%)	Hydro (%)	Geothermal, Solar, Wind, and Wave (%)	Biofuel and Renewable Waste (%)
Africa	49.3	1.3	0.2	47.7
Non-OECD Americas	30.2	10.1	0.6	19.5
Asia	26.2	1.5	1.8	22.9
China	11.4	2.4	0.6	8.3
Non-OECD Europe and Eurasia	3.7	2.2	0.1	1.4
Middle East	0.5	0.2	0.1	0.1
OECD	7.8	2.2	1.2	4.4
World	13.0	2.3	0.9	9.8

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Figure 1. Worldwide renewable energy shares in TPES (2008-2012)

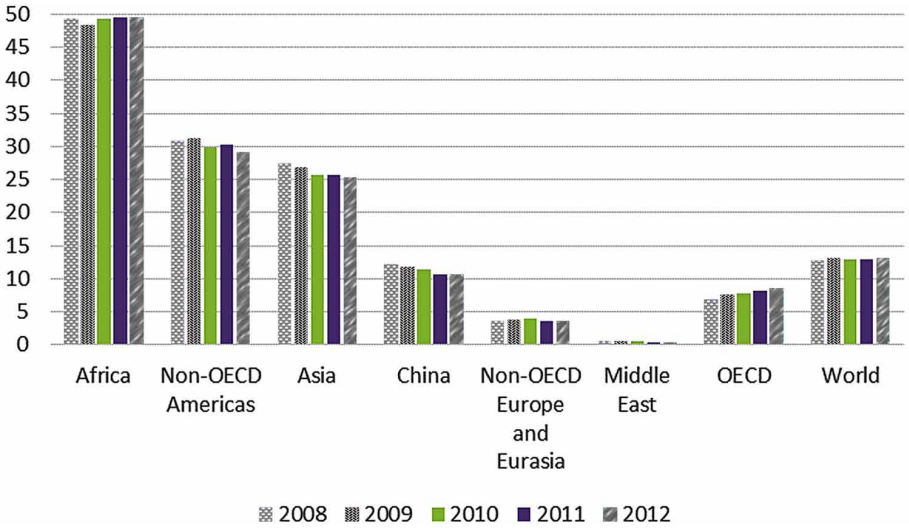
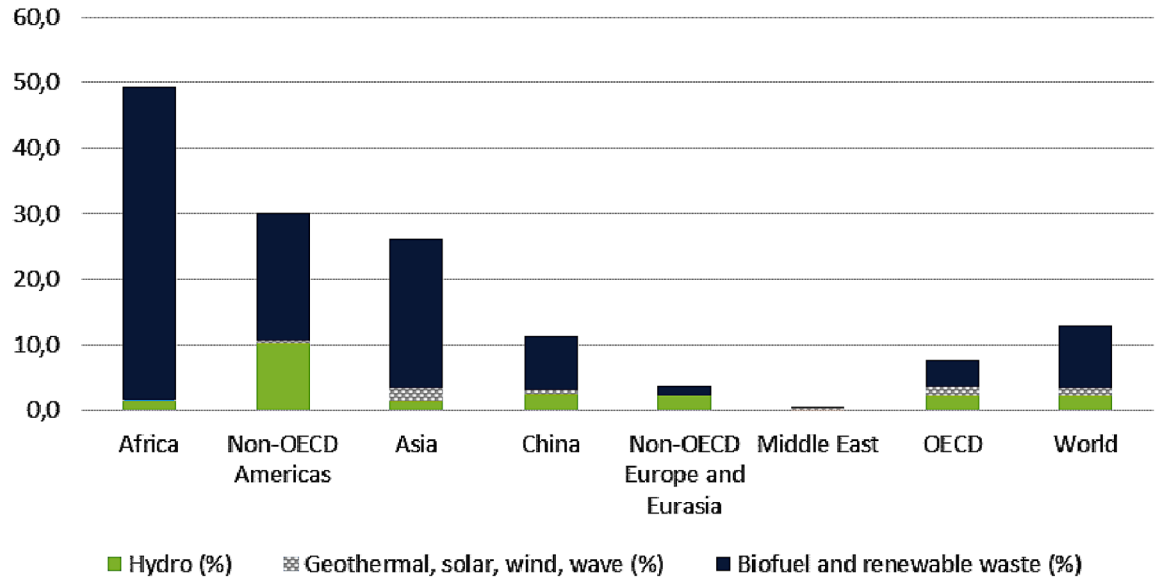


Figure 2. Worldwide renewable energy use (five-year averages for years 2008-2012 by source)



- **Africa:** Includes Algeria; Angola; Benin; Botswana; Cameroon; Congo; Democratic Republic of Congo; Côte d'Ivoire; Egypt; Eritrea; Ethiopia; Gabon; Ghana; Kenya; Libya; Mauritius; Morocco; Mozambique; Namibia (from 1991); Nigeria; Senegal; South Africa; Sudan[2]; United Republic of Tanzania; Togo; Tunisia; Zambia; Zimbabwe and Other Africa. *Other Africa* includes Burkina Faso; Burundi; Cape Verde; Central African Republic; Chad; Comoros; Djibouti; Equatorial Guinea; Gambia; Guinea; Guinea-Bissau; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Namibia (until 1990); Niger; Reunion; Rwanda; Sao Tome and Principe; Seychelles; Sierra Leone; Somalia; Swaziland; Uganda and Western Sahara.

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- **Non-OECD Americas:** Includes Argentina; Bolivia; Brazil; Colombia; Costa Rica; Cuba; Dominican Republic; Ecuador; El Salvador; Guatemala; Haiti; Honduras; Jamaica; Netherlands Antilles; Nicaragua; Panama; Paraguay; Peru; Trinidad and Tobago; Uruguay; Venezuela and Other Non-OECD Americas. *Other Non-OECD Americas* includes Antigua and Barbuda; Aruba; Bahamas; Barbados; Belize; Bermuda; British Virgin Islands; Cayman Islands; Dominica; Falkland Islands (Malvinas); French Guyana; Grenada; Guadeloupe; Guyana; Martinique; Montserrat; Puerto Rico (for natural gas and electricity); St. Kitts and Nevis; Saint Lucia; Saint Pierre et Miquelon; St. Vincent and the Grenadines; Suriname; and Turks and Caicos Islands.
- **Asia:** Includes Bangladesh; Brunei Darussalam; Cambodia; India; Indonesia; DPR of Korea; Malaysia; Mongolia; Myanmar; Nepal; Pakistan; Philippines; Singapore; Sri Lanka; Chinese Taipei; Thailand; Viet Nam and Other Asia. *Other Asia* includes Afghanistan; Bhutan; Cambodia (until 1994); Cook Islands; East Timor; Fiji; French Polynesia; Kiribati; Laos; Macao, China; Maldives; New Caledonia; Palau (from 1994); Papua New Guinea; Samoa; Solomon Islands; Tonga and Vanuatu.
- **China:** Includes the People's Republic of China and Hong Kong, China.
- **Non-OECD Europe and Eurasia[3]:** Includes Albania; Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Cyprus[4]; Former Yugoslav Republic of Macedonia (FYROM); Georgia; Gibraltar; Kazakhstan; Kosovo[5]; Kyrgyzstan; Latvia; Lithuania; Malta; Republic of Moldova; Montenegro[5]; Romania; Russian Federation; Serbia[5]; Tajikistan; Turkmenistan; Ukraine and Uzbekistan.
- **Middle East:** Includes Bahrain; Islamic Republic of Iran; Iraq; Jordan; Kuwait; Lebanon; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; United Arab Emirates and Yemen.
- **OECD Total:** Comprises Australia; Austria; Belgium; Canada; Chile; the Czech Republic; Denmark; Estonia[6]; Finland, France; Germany; Greece; Hungary; Iceland; Ireland; Israel[7]; Italy; Japan; Korea; Luxembourg; Mexico; the Netherlands; New Zealand; Norway; Poland; Portugal; the Slovak Republic; Slovenia[6]; Spain; Sweden; Switzerland; Turkey; the United Kingdom and the United States.

The analysis of Table 2 and Figure 1 reveals the following results:

- The percentage of renewable energy use in Africa has reached up to 50%, which is significantly above the world average. This is due to the fact that mostly organic non-fossil fuels are used in African countries.
- The Middle East, which is the center of fossil fuels, is expectedly where renewable energy has the lowest share.
- As for the OECD countries, the renewable energy use is close to the world average with a slight increase throughout the years subject to study.
- China has also caught up with the world average in terms of renewable energy use.
- Non-OECD Americas and Asia are the second and third, respectively, both well above the world average. Non-OECD Europe and Eurasia is fairly below the OECD and World averages.
- While Africa, Non-OECD Americas, Non-OECD Europe and Eurasia, Middle East and the World shows a steady behavior with regard to renewable energy share in TPES, a slight decrease has been observed in Asia and China starting from 2009.

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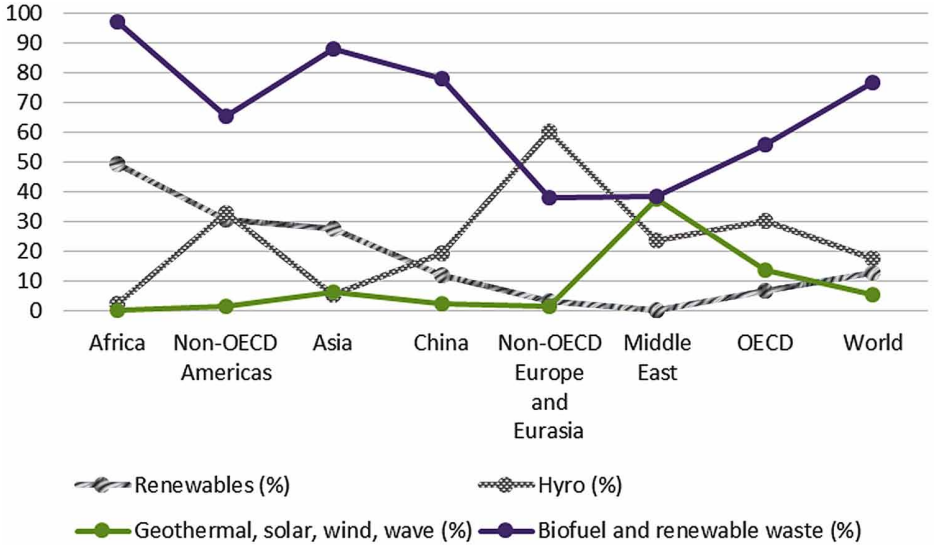
The analysis of the individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste in Table 2 and Figure 2 indicates the following:

- Except for Non-OECD Europe and Eurasia and the Middle East, biofuels and renewable wastes constitute the highest percentage of renewables throughout the world. This is especially significant for Africa, Asia and the World Total.
- The relative utilization percentage of hydro is the highest in Non-OECD Europe and Eurasia followed by the Middle East, Non-OECD Americas, OECD and China, respectively.
- As for geothermal, solar, wind and wave energies combined, the most significant utilization (as a percentage of the TPES) is observed in the Middle East followed by OECD average.
- The most uniform distribution of the individual shares is in OECD where the total 7.8% of renewables is divided as 2.2%, 1.2% and 4.4% among hydro, geothermal/solar/wind/wave and biofuel/renewable waste, respectively.

The distribution of the individual shares (expressed as percentages of total renewables) over time have also been studied, between 2008 and 2012 (see Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7), with the following results:

- It has been observed that, for biofuels and renewable wastes, the geographical groupings can be listed as Africa, Asia, World Total, China, Non-OECD Americas, OECD Total, Non-OECD Europe and Eurasia and the Middle East, in decreasing order. This ordering is different for the year 2008 only, where the percentage of biofuels and renewable wastes in renewables is higher in the Middle East compared to Non-OECD Europe and Eurasia.
- The investigation of the share of geothermal, solar, wind and wave energies combined in total renewables reveals that the Middle East, which was the first in this category in 2008, 2009 and

Figure 3. Worldwide renewable energy use in 2008



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Figure 4. Worldwide renewable energy use in 2009

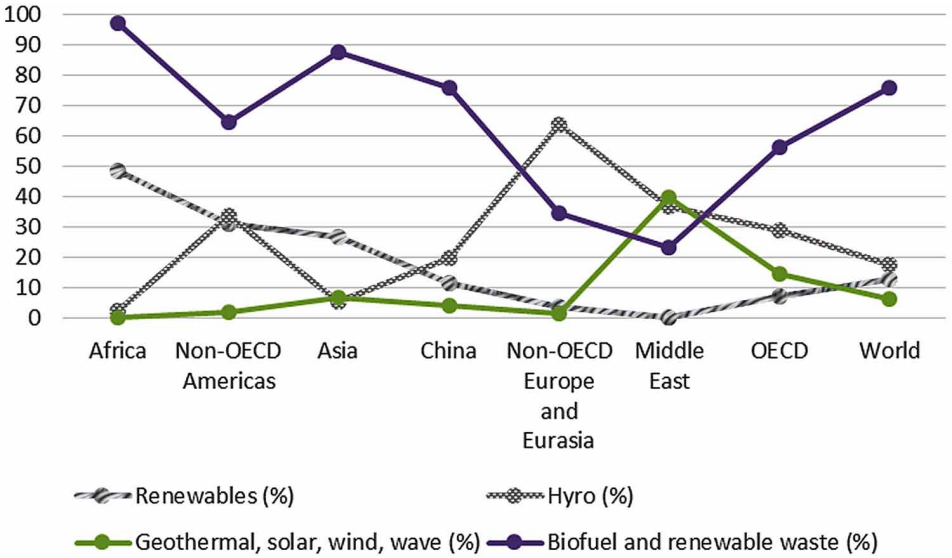
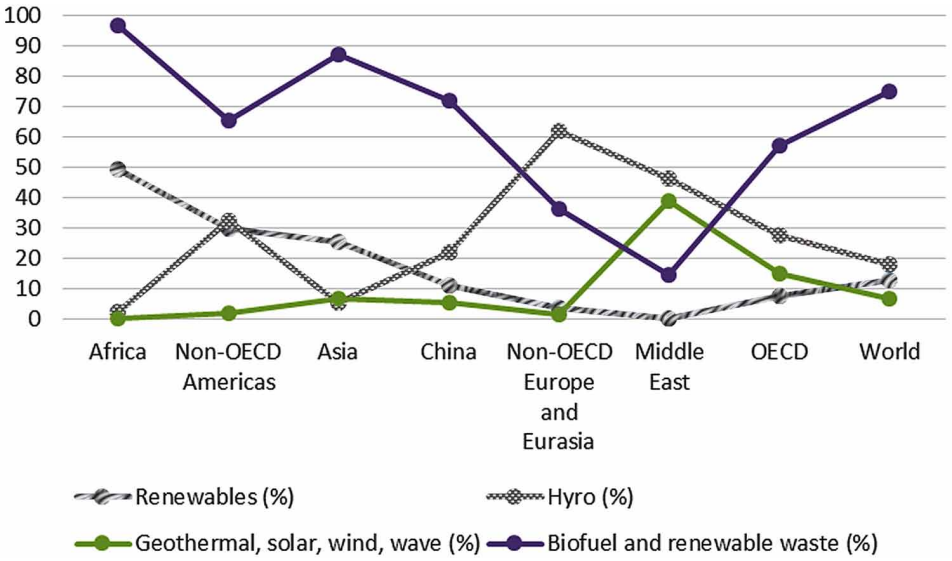


Figure 5. Worldwide renewable energy use in 2010



2010, has been replaced by OECD Total in years 2011 and 2012. The reason for this change is that starting from 2010, hydro constitutes a higher percentage in total renewables than geothermal, solar, wind and wave energies combined.

- In terms of the share of hydro in total renewables, Non-OECD Europe and Eurasia has the highest percentage until 2011. In 2011 and 2012, it has been replaced by the Middle East.
- When the geographical groupings are investigated within themselves throughout the years subject to study, it can be concluded that there has been no changes in the distribution of the individual

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Figure 6. Worldwide renewable energy use in 2011

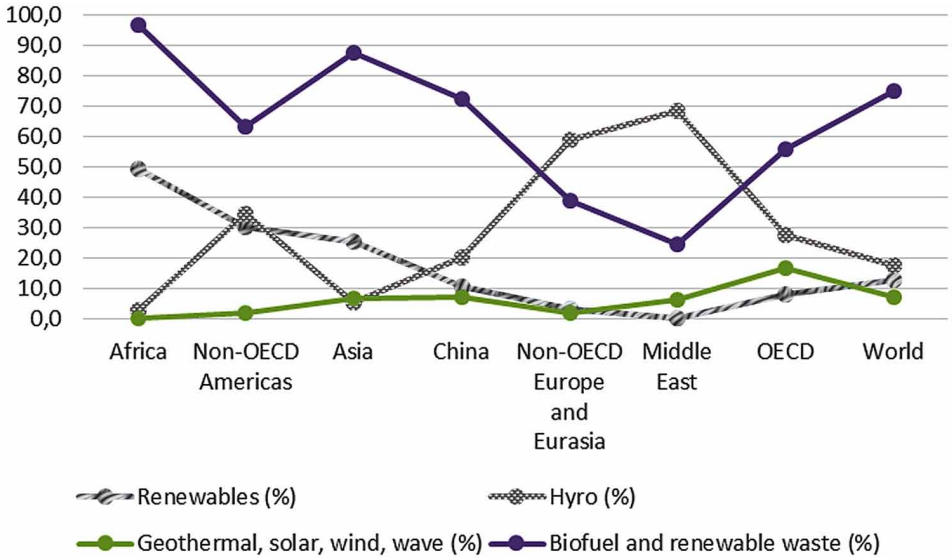
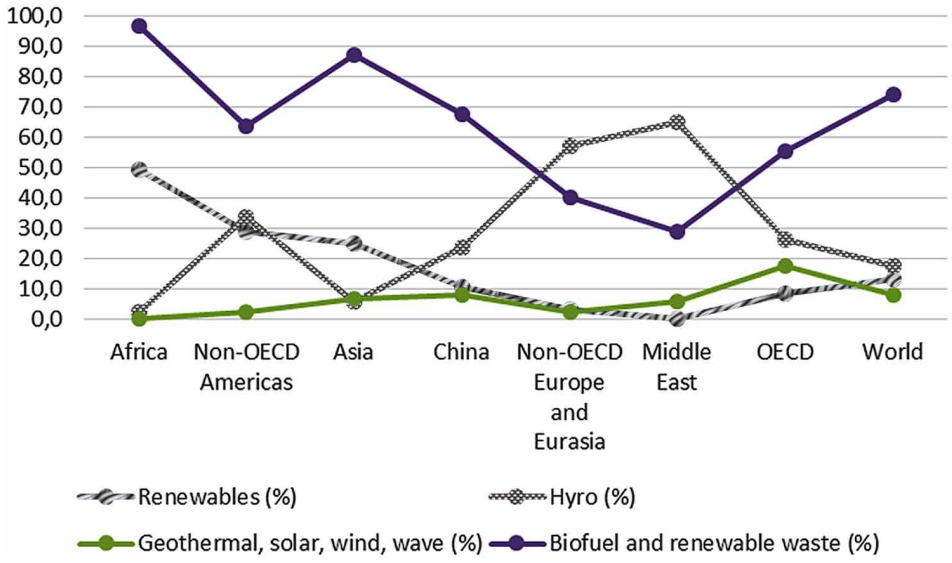


Figure 7. Worldwide renewable energy use in 2012



renewable sources. The only exception is the Middle East, where in 2008, biofuel/renewable waste and geothermal/solar/wind/wave had almost equal shares with hydro having a lower percentage, this situation changed in favor of hydro starting from 2010. In the current case, hydro has the highest share followed by biofuel/renewable waste and geothermal/solar/wind/wave, respectively.

In order to conduct a comparative analysis of renewable energy use on a country basis, the indicators provided in the 2014 dated Global Status Report of Renewable Energy Policy Network (REN21, 2014)

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have been used (see also Selam et al., 2014). Table 3 depicts the top five countries in terms of annual investment, net capacity additions and production in 2013. The top five countries in terms of total capacity or generation as of end-2013 can be viewed in Table 4. A simple rating methodology has been devised to position the countries with respect to the indicators presented in Table 4. In addition to these indicators, *Investment in Renewable Power* and *Fuels and Share of Gross Domestic Product (GDP) (USD)* rankings from Table 3 have also been included. Thus, a total of 17 indicators have been used (see Table 7 in the Appendix). The methodology is such that if a country is in the first position, it gets 5 points from the corresponding indicator. If it is in the second, third, fourth and fifth positions, the scores are 4, 3, 2 and 1, respectively. If it is not listed in the ranking of a certain indicator, the corresponding score is 0. The scores, totals and averages (in descending order) can be viewed in Table 8 in the Appendix. The top 5 countries with respect to this ranking scheme have been listed as China, United States, Germany, Brazil and Spain with average scores of 2.76, 2.35, 1.71, 0.82 and 0.82, respectively.

RENEWABLE ENERGY POLICIES AROUND THE WORLD

General Renewable Energy Policies of the OECD

OECD has been established in 1961 with the aim of "promoting policies that will improve the economic and social well-being of people around the world" (OECD, 2014). Currently, there are 34 member countries spanning the globe, from North and South America to Europe and the Asia-Pasific region (OECD, 2014).

In 2010, 18% of the world population lived in the OECD with 74% of the GDP being created in its 34 member countries. The TPES of the OECD in 2010 represented about 44% of global energy supply,

Table 3. Top five countries in terms of annual investment/net capacity additions/production in 2013

Indicators	Rank				
	1	2	3	4	5
Investment in renewable power and fuels	China	United States	Japan	United Kingdom	Germany
Share of GDP (USD) invested[1]	Uruguay	Mauritus	Costa Rica	South Africa	Nicaragua
Geothermal power capacity	New Zealand	Turkey	United States	Kenya	Philippines
Hydropower capacity	China	Turkey	Brazil	Vietnam	India
Solar PV capacity	China	Japan	United States	Germany	United Kingdom
Concentrating solar thermal power (CSP) capacity	United States	Spain	United Arab Emirates	India	China
Wind power capacity	China	Germany	United Kingdom	India	Canada
Solar water heating capacity[2]	China	Turkey	India	Brazil	Germany
Biodiesel production	United States	Germany	Brazil	Argentina	France
Fuel ethanol production	United States	Brazil	China	Canada	France

REN21, 2014.

[1]Countries considered include those covered by BNEF; GDP is for 2012 and from the World Bank. The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydropower projects of between 1 and 50 MW; all solar power projects with those less than 1 MW estimated separately and referred to as small-scale projects or distributed capacity; all ocean energy projects; and all biofuel projects with an annual capacity of 1 million litres or more.

[2]Solar water collector (heating) rankings are for 2012, and are based on capacity of water (glazed or unglazed) collectors only; however, including air collectors would not affect order.

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Table 4. Top five countries in terms of total capacity or generation[5] as of end-2013

Indicators	Rank				
	1	2	3	4	5
Renewable power (incl. hydro)	China	United States	Brazil	Canada	Germany
Renewable power (not incl. hydro)	China	United States	Germany	Spain/Italy	India
Renewable power capacity per capita (not incl. hydro)[1]	Denmark	Germany	Portugal	Spain/Sweden	Austria
Biopower generation	United States	Germany	China	Brazil	India
Geothermal power	United States	Philippines	Indonesia	Mexico	Italy
Hydropower[2]	China	Brazil	United States	Canada	Russia
Hydropower generation[2]	China	Brazil	Canada	United States	Russia
CSP	Spain	United States	United Arab Emirates	India	Algeria
Solar PV	Germany	China	Italy	Japan	United States
Solar PV capacity per capita	Germany	Italy	Belgium	Greece	Czech Republic
Wind power	China	United States	Germany	Spain	India
Wind power capacity per capita	Denmark	Sweden	Spain	Portugal	Ireland
HEAT					
Solar water heating[3]	China	United States	Germany	Turkey	Brazil
Solar water heating capacity per capita[3]	Cyprus	Austria	Israel	Barbados	Greece
Geothermal heat[4]	China	Turkey	Iceland	Japan	Italy

REN21, 2014.

[1]Per capita renewable power capacity ranking considers only those countries that place among the top 20 worldwide for total installed renewable power capacity, not including hydropower.

[2]Country rankings for hydropower capacity and generation differ because some countries rely on hydropower for baseload supply whereas others use it more to follow the electric load and match peaks in demand.

[3]Solar water collector (heating) rankings are for 2012, and are based on capacity of water (glazed or unglazed) collectors only; however, including air collectors would not affect order.

[4]Not including heat pumps. Rankings are based on a mix of 2010 data and more recent statistics for some countries.

[5]Capacity, otherwise noted.

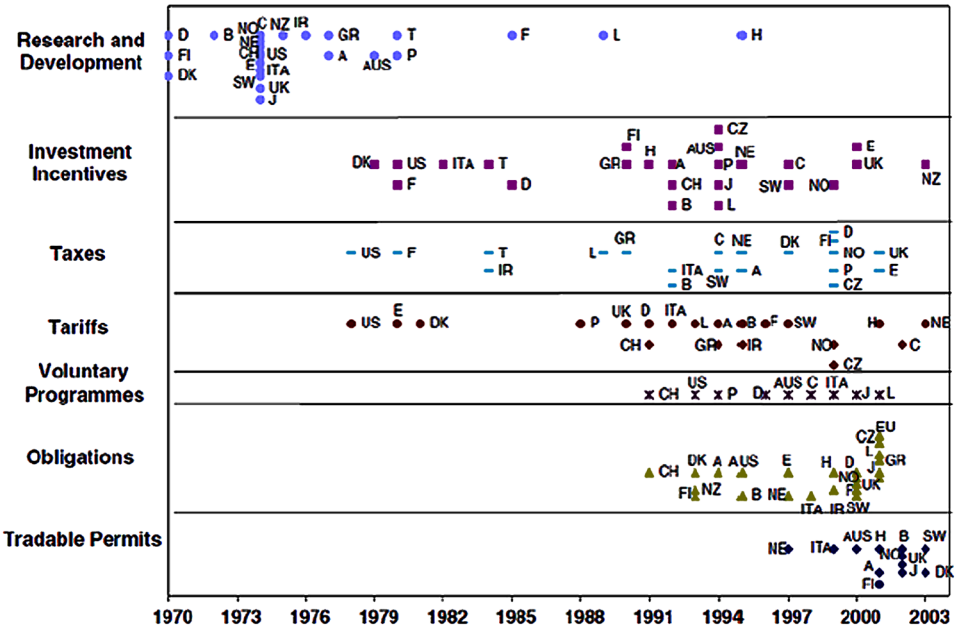
while the total energy production constituted 30% of the global energy production (IEA, 2012a). Bigerna et al. (2014) address three main pillars of the energy and environmental policy for sustainability as investments in renewable energy sources, increases in energy efficiency and promotion of energy savings behaviors. The OECD countries have adopted certain energy efficiency policies such that each government made its own decision regarding the measures to be taken and their implementation (Saidel and Alves, 2003). These measures fall under the following basic categories (Saidel and Alves, 2003):

- Restrictive regulations,
- Information to the public,
- Creation of market asymmetries,
- Funding/loans programs,
- State capital/private capital partnerships,

The evolution of the renewable energy policies in OECD countries can be viewed in Figure 8.

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Figure 8. Patterns of policy adoption in selected OECD countries (Nicolli and Vona, 2012)



General Renewable Energy Policies of the EU

Environmental concerns, supply security and competitiveness considerably affected the EU policies especially those related to the renewable energy sector, resulting in an effective renewable energy policy since 1997 (EWEA, 2011). The Renewable Energy Directive 2009/28/EC set forth a European framework for the promotion of renewable energy by 2020 through mandatory national renewable energy targets (EC, 2013a). Thus, the current policy of the EU for 2020 aims at 20% substitution of fossil fuels by renewable energy resources that include biomass and waste, hydro, geothermal, solar, and wind power (Krozer, 2013). The other targets for 2020 are greenhouse gas emission reductions of 20% relative to emissions in 1990 and 20% savings in energy consumption compared to projections (EC, 2013b). Consequently, 19.9% of the absolute European energy generation in the EU27 in 2009 was produced by renewables, with hydro-power taking the lead (11.6%), followed by wind (4.2%) (Fouquet, 2013).

Each member of the EU has decided on its own strategies to meet the above-stated energy targets and published these in Renewable Energy Action Plans (NREAP) between July 2010 and January 2011 as required by the EU (Directive 2009/28/EC) (Kitzing et al., 2012). The most common renewable energy sources (RES) support strategies implemented in the EU can be listed as the following (Kitzing et al., 2012):

- Feed-in tariffs; guaranteed prices,
- Feed-in premiums; production premiums,
- Tender schemes,
- Quota obligations with tradable green certificates,
- Investment grants,

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- Fiscal measures (tax incentives, etc.),
- Financing support (loans, etc.).

Recently, there have been efforts regarding an integrated policy framework for the period up to 2030 with the following targets (EC, 2014):

- Reducing EU domestic greenhouse gas emissions by 40% below the 1990 level and by 2030.
- Increasing the share of renewable energy to at least 27% of the EU's energy consumption by 2030.
- Realizing 30% energy savings.
- Establishing a market stability reserve at the beginning of the next ETS (Emissions Trading System) trading period in 2021.
- Developing a set of key indicators to assess progress over time and provide a factual basis for policy action as needed.
- Establishing a new governance framework based on national plans for competitive, secure and sustainable energy.

Renewable Energy Policies of Some Selected Countries

In this section, the renewable energy policies of China, United States, Germany, Brazil, Spain, Turkey and India are briefly introduced. The first five of these countries have been listed at the top with respect to certain renewable energy performance indicators (see the Appendix). Turkey has been included because it is a developing country with significant renewable energy sources. As for India, it has also been included because a wide array of renewable energy policies has been adopted, even more than some countries in the top five. The renewable energy support policies of the first fifteen countries in the ranking have been depicted in Table 5.

China

China is world's largest energy user, accounting for one fifth of all global energy consumption with an expected increase by 60% by 2030 (IRENA, 2014). Energy conservation, efficiency in energy utilization and emission reduction have become the main foci in China's energy policy. As a result, it has become a global leader in renewable energy, installing more new renewable energy capacity than all of Europe and the rest of the Asia Pacific region in 2013 alone (IRENA, 2014). Some of the steps taken to achieve these can be summarized as the following (China's Energy Policy, 2012):

- Various energy-saving renovations are implemented.
- Efforts have been made to support new and renewable energy developments.
- Improvements have been made in civil energy use conditions (energy service level, access to natural gas and electricity, combined heat and power projects etc.).
- Environmental protection has been increased.

The country's energy consumption per-capita is low and decreasing every year. The energy consumption for every 10 000 yuan of GDP decreased by 20.7% from 2006 to 2011 (China's Energy Policy, 2012). China aims to increase the use of non-fossil fuels by developing new and renewable energy

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Table 5. Renewable energy support policies for 15 selected countries

Country	Renewable Energy Targets	Regulatory Policies and Targets							Fiscal Incentives and Public Financing				
		Feed-In Tariff/ Premium Payment	Electric Utility Quota Obligation/ Renewable Portfolio Standard (RPS)	Net Metering	Tradable Renewable Energy Certificate (REC)	Tendering	Heat Obligation/ Mandate	Biofuels Obligation/ Mandate	Capital Subsidy or Rebate	Investment or Production Tax Credits	Reductions in Sales, Energy, CO_2, Value-Added Tax (VAT), or Other Taxes	Energy Production Payment	Public Investment, Loans, or Grants
China	R	R	○			○	○	○	○	○	○	○	○
United States	R*	R*	R*	R*	●	R	●	R	○	X	○	○	R
Germany	○	R					○	○	○	○	○		○
Brazil	○			○		R	●	R		○	R		R
Spain[1]	○			○	○			○	○	○		○	
Italy	○	R	○	○	○	R	○	○	○	○	○		○
Denmark	○	○		○	○	○		○	○	○	○		R
Canada	●	R*	●	●		○		○	○	○	○		○
Japan	○	○	○	○	○	○			○				○
Sweden	○		○		○			○	○	○	○		○
Turkey	○	R						○	○				○
Austria	○	○			○			○	○	○			○
Cyprus	○	○		N		○		○	R				
India	R	○	○	N*	○	R	●	R	R	○		R	○
Portugal	R	R	○			○	○	○	X	X	○		X

REN21, 2014.

● Existing national

○ Existing sub-national

N new

R revised

X removed/ Expired

* Sub-national

[1]Spain removed FIT support for new projects in 2012. Incentives for projects that had previously qualified for FIT support continue to be revised.

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sources by the end of the 12th Five-Year Plan. It is the leading renewable energy producer in the world with the world's richest hydropower resources, and currently less than 30% of its resources have been utilized (China's Energy Policy, 2012; Liu, 2013). These resources can help China to achieve the goal of increasing the non-fossil energy consumption share to 15% by 2020. Chinese government wants to provide hydropower development by using local resources and local employment. This country is also the fastest growing wind power market in the world (Hanna, 2010). Thus, the goal is to encourage research and development (R&D) studies in wind-power equipment production, improve the standards and control in the sector, optimize the wind power production and develop offshore wind farms. Other significant aspects of China's renewable energy policies involve the following (China's Energy Policy, 2012; Meisen & Hawkins, 2014):

- Promote and encourage the development and utilization of its rich solar energy resources with the construction of power stations, solar power generation projects, efforts to generalize solar heating, cooling, water heaters and industrial applications of solar energy.
- Make nuclear power plants safer and more efficient especially after the Fukushima Daiichi nuclear disaster in 2011.
- Benefit from the biomass potential in rural areas.

It is also stated in the REmap 2030 analysis of China (IRENA, 2014) that significant potential exists for renewable energy in end-use sectors. Industry can achieve a 10% renewable energy share, and the building sector can transform its fuel mix to two-thirds renewables. Solar thermal heat and electrification pose a significant potential so does modern biomass for process heating and space/water heating.

United States

The US, which accommodates 4.5% of the world population and consumes 19.2% of the world's energy (second largest after China), is one of the richest countries in terms of renewable energy portfolio (Aslani & Wong, 2014). Being criticized for the significant variation in renewable energy policy designs among states, the US underwent major developments in the energy policy arena over the course of the last few years, diverging from fossil fuels towards a sustainable and coherent energy system with greater energy independence (IEA, 2014b; Park, 2015). Some of these renewable energy policies include but are not limited to subsidies for wind, solar, and geothermal producers; biomass grants; increasing the amount of biofuel that must be mixed with gasoline; making geothermal energy more competitive with fossil fuels in generating electricity; tax reductions; loan guarantees and renewable portfolio standard in each state (Aslani and Wong, 2014).

The most significant developments in the policy arena can be listed as the following (IEA, 2014b):

- The enactment of the American Recovery and Reinvestment Act (ARRA) (2009), through which the Department of Energy (DOE) invested more than USD 31 billion in energy infrastructure, clean energy projects and energy efficiency.
- The President's Blueprint for a Secure Energy Future (2011), which set forth a clear agenda for the medium-term direction of federal energy policy based on doubling of electricity generation from wind, solar and geothermal sources by 2020, halving net oil imports by the end of the decade, doubling energy productivity by 2030 and providing international leadership in clean energy.

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- The "All-of-the-above" strategy (2012), which aimed at support for economic growth and job creation, enhanced energy security, and deployment of low-carbon energy technologies, through a series of defined policy actions.

Despite the above-mentioned developments and the RPS adopted by many states, there are still certain unsolved issues on the national level regarding how the goal of doubling renewable energy production from wind, geothermal and solar sources by 2020 compared to 2012 will be reached (IEA, 2014b). Certain remarks and suggestions concerning the renewable energy policies of the US have been made, some of which can be listed as the following (Osmani et al., 2013; IEA, 2014b; IRENA, 2015; Park, 2015):

- Effective, coordinated and diversified national policies should be developed to reduce the uncertainties to maintain investor confidence in secure electricity infrastructure (including transmission, distribution, smart grids, renewable energy integration and climate resilience).
- The end-use sectors of transport, industry and buildings, which pose a significant potential for renewable energy technologies, should more effectively be included in policy-making.
- A consistent, predictable and long-term policy support should be employed to create market certainty.
- Policies are particularly needed to attract investments in grid transmission and biomass logistics.
- The external costs of using fossil fuels (e.g. human healthcare costs, the effect of greenhouse gas emissions and climate change etc.) on the US macro economy should better be reflected in the overall systems. The environmental costs should be included in the retail price of electricity.
- Fossil fuel or nuclear-based electricity should not financially be supported to the extent that will undermine the immediate effects of renewable energy policies, especially financial incentives. The shale drilling permission that has recently been taken into effect may also slow down the utilization of renewable energy technologies.
- The fluctuations and uncertainties in tax incentives should be reduced, and the subsidies for electricity generation should be distributed equitably. Moreover, a national FIT and RPS should be implemented.

Germany

Germany initiated the development of renewable energy technology for electricity over two decades ago (Hartwig et al., 2014). In 1991, the German government passed the Electricity Feed In Law (Stromeinspeisungsgesetz or StromEinspG), which later evolved into the Renewable Energy Act (Erneuerbare Energien Gesetz) (came into effect in 2000), to promote the feed-in of energy produced by renewable energy technologies into the grid for electricity suppliers (Hartwig et al., 2014). With the Renewable Energy Act, the entire regulatory framework for renewable energy technologies was revised and differentiated tariffs were adopted for each form of renewable energy (Hartwig et al., 2014). As a result of these efforts of the German government to become one of the most energy efficient and environmentally sound economies in the world without compromising the country's affordable energy prices and economic growth, renewable energy use underwent dramatic changes (IEA, 2013b; IEA, 2013c). The share of renewable energy in final energy consumption in Germany increased from around 4% in 2000 to more than 12%, and its share in gross electricity consumption enhanced from around 6% in 2000 to over 25% by 2013 (Blazejcak et al., 2014). In 2000, hydropower constituted the largest part of renew-

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able generation (60%) followed by wind power (26%) and biomass (13%); whereas in 2013, wind power took the lead (35%), followed by biomass (31%), solar PV (20%) and hydropower (14%) (Blazejcak et al., 2014). On the overall, the share of renewables in the primary energy demand of Germany increased from 1.3% in 1990 to 11.7% in 2013 (Scholz et al., 2014).

The most significant steps that the policy makers have taken are the Energy Concept (Energiewende) (2010) and its energy reforms (2011) (IEA, 2013b; IEA, 2013c). The Energy Concept, which was built on the success of previous policies (especially the Integrated Energy and Climate Programme of 2007), set forth the principles of a long-term, integrated energy pathway to take the country to 2050, placing renewable energy at the center of future supply (IEA, 2013c). Germany's energy goals include the following (IEA, 2013b):

- Reduction in greenhouse gas emissions by 40% by 2020 and by at least 80% by 2050.
- Decrease in primary energy consumption by 20% by 2020 and by 50% by 2050 (base year 2008).
- Increase in the proportion of energy consumption covered by renewables is to rise to 30% by 2030 and to 60% by 2050.

An important issue that has affected Germany's attitude towards renewable energy use is the Fukushima Daiichi nuclear accident in March 2011 (IEA, 2013c; Hartwig et al., 2014). A key feature of the Energy Concept was a proposal to extend the operating lifetime of the German nuclear power fleet by an average of 12 years, therefore postponing the nuclear power phase-out agreed by the former government (IEA 2013c). However, after the Fukushima nuclear disaster, the German Government intensified their efforts towards nuclear phase-out by 2022 starting with the immediate closure of the eight oldest plants (Hartwig et al., 2014; IEA, 2013c). This decision resulted in the adoption of a second package of measures, which completed the Energy concept, to support renewable energy and grid expansion, promote energy efficiency, fund the reforms and reverse the previous decisions to extend the lifetime of the nuclear plants (IEA, 2013c).

In order to follow the developments concerning the use of clean energy, Energy of the Future, a long-term and fact-based monitoring process, was designed to inform the public comprehensively about the restructuring of the energy system, to promote public participation and to increase acceptance of the reforms (IEA, 2013b). It included an annual monitoring report (the first being submitted in December 2012) to outline the general facts and status and a more detailed progress report (to be submitted every three years starting from 2014) to evaluate the future challenges and needs (IEA, 2013b).

Although Germany is one of the leading countries in terms of renewable energy policies, there are still certain issues that need to be addressed. These can be listed as the following (IEA, 2013b; IEA, 2013c; Pregger et al., 2013):

- Continue to increase funding for research, development and deployment (RD&D) to ensure that energy technology innovation will meet the challenges set out in the Energy Concept.
- Further strengthen the function of the co-ordination platform to effectively involve all stakeholders.
- Continue to assess its RD&D challenges and to adjust its RD&D portfolio as national energy policy priorities change.
- Continue efforts in energy education and training to meet future demands for researchers and engineers.

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- Improve energy statistics where needed because incomplete data on international energy prices and energy consumption in the household, transport and trade sectors can only provide a restricted view.
- The German Renewable Energy Sources Act (EEG) must be preserved in principle for the transformation of the electricity supply. Feed-in tariffs should be kept up-to-date to support technological innovations that reduce costs.
- Introduce non-budgetary subsidy instruments for the expansion of renewables in the heat sector to especially include the existing stock of older buildings.
- Set incentives and specifications in the transportation sector for the further substantial reduction of fuel consumptions of motor cars and utility vehicles. (The further development of electric vehicles and of the public battery-charging infrastructure is needed.)

Turkey

In the last decade, there has been a significant shift in the world toward emerging markets and consequently energy demand; in that, while the developed world used two thirds of world oil in 2000, by 2011 this was split about evenly between developed and developing countries (WEF, 2013). This shift is estimated to continue with virtually all growth from here on being expected in emerging market nations (WEF, 2013), and thus, the energy consumption and production in developing countries have become much more critical. Turkey is one of these developing countries with a substantial amount and wide range of renewable energy sources, and it is located in an advantageous geographical position that enables their effective utilization (Baris & Kucukali, 2012; Benli, 2013; Yuksel & Kaygusuz, 2011). However, because of the rapid increase in the energy consumption (Ozturk et al., 2009) and the inefficient use of resources, Turkey remains to be an energy importing country with more than half of its energy being met externally (Kaya, 2006; Yuksel & Kaygusuz, 2011; Benli, 2013).

The energy consumption in Turkey is constantly increasing due to the economic developments, population growth, increasing urbanization and industrialization (Ozturk et al., 2009; Kotcioğlu, 2011), and thus, it is in a position to import over 70% of its primary energy supply (with oil and natural gas having the biggest shares) (Kaya & Çanka Kılıç, 2012). On the other hand, the primary energy production is increasing and the most significant developments are observed in hydropower, geothermal, solar energy and coal production (Yüksel & Arman, 2014). Despite these developments, the share of renewable energy in electricity generation was only 17.4% by the end of 2008 (Yuksel, 2013). The renewable energy potential in Turkey (hydropower, solar, biomass and wind power) is sufficient to meet the accelerated demand (Kotcioğlu, 2011), but it has not been efficiently utilized, leaving the country with an urgent need for effective energy policies. Ozturk et al. (2009) summarize Turkey's general energy policy as follows:

- Meeting long-term demand using public, private, and foreign capital.
- Accelerating privatization activities in the energy sector.
- Taking into consideration supply costs of energy imports.
- Meeting demand as much as possible through indigenous resources.
- Diversifying energy supplies and avoiding dependence on a single source or country.
- Adding new and renewable sources (geothermal heat, solar, wind, etc.) as soon as possible to the energy supply system.

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- Ensuring sufficient, reliable and economic energy supplies on time.
- Ensuring energy security of supply.
- Implementing measures for energy efficiency.
- Planning energy R&D activities to meet requirements.
- Minimizing losses in energy production, transmission, distribution and consumption.
- Protecting the environment and public health in the production of energy.

The above-stated principles are also covered in the Strategy Plan 2010-2014, where the following targets are set for 2023-the 100th anniversary of Turkish Republic (the Vision 2023 Programme) (Kabakci & Tanugur, 2010):

- To be able to make complete use of potential of indigenous coal and hydraulic resources.
- To make maximum use of renewable resources.
- To incorporate nuclear energy into electricity generation within the period until 2020.
- To secure rapid and continuous improvement in energy efficiency in a way that parallels EU countries.

In order to make maximum use of renewable resources as stated in the Strategic Plan, all the potential renewable energy types should be utilized. Renewable energy supply in Turkey is mostly hydropower and biomass, but air pollution concerns and deforestation have resulted in a decrease in the biomass use, changing the composition of the renewable energy supply in favor of wind energy (Kotcioğlu, 2011; Toklu, 2013). There is a significant potential for wind power development in Turkey (Kotcioğlu, 2011), which should effectively be utilized in the near future due to the fact that between 22.5TWh and 4 5.0TWh of electricity must be generated from renewable energy sources other than hydropower in the next decade to fill the demand gap (Melikoglu, 2013). It is estimated that this gap can be diminished by wind and solar energy if the investments are carried out as planned and the goals in Vision 2023 agenda can be achieved (Melikoglu, 2013). In its report on Turkish Renewable Energy Policies, International Energy Agency (IEA) has made certain recommendations, which should be taken into consideration to address the above-stated issues. These are (IEA, 2009):

- Continue efforts to ensure a predictable and transparent support framework to attract investments, while creating technology-specific incentives that will decrease over time.
- Design the feed-in tariff to be as flexible and predictable as possible and assess the options to introduce further flexibility in support mechanisms, such as premium on wholesale price.
- Continue efforts to ensure smooth integration of new renewable electricity capacity into the grid.
- Continue efforts to remove non-economic barriers to renewable energy development.
- Consider stronger policy support for the wider use of solar and geothermal heat and biofuels for transport in a sustainable and cost-effective way.
- Increase the focus on the energy efficiency in energy policy making and implementation and monitor the effectiveness of the chosen policies and measures, both in terms of costs and emissions reductions (Kaygusuz & Sari, 2011).
- Expand the partnerships with the private sector through increased use of collaboration for energy R&D.

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India

India has the world's fifth-largest electricity generation capacity, which currently stands at 243 GW with a highly diverse power sector, varying from commercial sources like coal, natural gas, hydro, oil and nuclear as well as unconventional sources of energy like solar, wind, bio-gas and agriculture (Novonous, 2014). Nonetheless, the country is facing an emerging supply-demand imbalance situation with the increases in total electricity demand, resulting from industrialization, urbanization, population growth and economic growth (MNRE, 2011; Novonous, 2014). To be able to provide adequate electricity to its population, India needs to more than double its current installed capacity to over 300 GW by 2017, and the demand for oil in 2015 is expected to be 41% higher than in 2007 and almost 150% higher in 2030 (NREL, 2010). There is also a rising concern over climate change (Novonous, 2014). The country currently emits approximately 4% of global greenhouse gas emissions, while its per capita emissions are only one-quarter of the global average and less than one-tenth of those of most developed nations (NREL, 2010). The government has committed to reducing the emissions intensity of its economy to 20%-25% below 2005 levels by 2020 and not exceeding the per capita greenhouse gas emissions of industrialized nations (NREL, 2010). These have made the use of renewable energy inevitable in India, and establishing a sustainable energy base has gained significance since early 1970s (MNRE, 2011).

India has substantial renewable energy sources, including a large land mass that receives among the highest solar irradiation in the world, a long coastline and high wind velocities that provide many opportunities for both land-based and offshore wind farms, significant annual production of biomass, and numerous rivers and waterways that have potential for hydropower (NREL, 2010). Although the total renewable energy potential from various sources in India is 249,188 MW, renewable energy including large hydro constitutes for only 28.8% of overall installed capacity, and the country has been able to achieve only 12.95% of its renewable energy potential as of March 31st, 2014 (Novonous, 2014). The government has set ambitious targets for renewable energy — a doubling of existing renewable energy capacity to 55,000 MW by 2017 (Shrimali et al., 2014). In 1992, the Government of India established the Ministry of New and Renewable Energy (MNRE), the world's first ministry committed to renewable energy, with the aim of expanding contributions of renewable energy in all of India's end-use sectors and undertaking the respective policy and planning activities (NREL, 2010). Moreover, in order to expand the use of renewable energy, certain policies and instruments have been introduced, some of which can be listed as the following (NREL, 2010):

- Electricity Act 2003, which mandates that each State Electricity Regulatory Commission (SERC) establish minimum renewable power purchases; allows for the Central Electricity Regulatory Commission (CERC) to set a preferential tariff for electricity generated from renewable energy technologies; provides open access of the transmission and distribution system to licensed renewable power generators.
- National Electricity Policy 2005, which allows SERCs to establish preferential tariffs for electricity generated from renewable sources.
- National Tariff Policy 2006, which mandates that each SERC specify a renewable purchase obligation (RPO) with distribution companies in a time-bound manner with purchases to be made through a competitive bidding process.

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- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) 2005, which supports extension of electricity to all rural and below poverty line households through a 90% subsidy of capital equipment costs for renewable and non-renewable energy systems.
- Eleventh Plan 2007–2012, which establishes a target that 10% of power generating capacity shall be from renewable sources by 2012 (a goal that has already been reached) and supports phasing out of investment-related subsidies in favor of performance-measured incentives.
- National Action Plan on Climate Change (NAPCC) 2008, which aims to promote development goals while addressing greenhouse gases mitigation and climate change adaptation through eight specific missions (including solar energy, energy efficiency, water, sustainable habitat, and related topics).
- Clean Development Mechanism (CDM) of the Kyoto Protocol, which supports the development of renewable energy projects.

Certain recommendations have been made for policy makers concerning more effective utilization and expansion of renewable energy. These can be viewed in Table 6.

Table 6. Renewable energy policy recommendations for India by source

Renewable Energy Source	Recommendations
Wind	• Improve short-term wind forecasting • Adequate Grid Connectivity • Solve institutional inefficiencies • Establish long-term markets for off-shore wind power • Provide flexible financing options to new players
Solar	• Implementation of Domestic Content Regulation (DCR) • Imposition of Anti Dumping Duties to shield local industry from cheap import from China etc. • Proper Enforcement of Solar RPOs • Provide access to low cost funds • Timely Release of Subsidies • Support in accessing/developing new technologies
Small Hydropower	• Speedy implementation of policies by states • R&D activity for provide accurate hydrological and site data • Speedy clearances for small hydro power projects • Provide access to low cost funds • Timely release of Subsidies • Support in accessing/developing new technologies
Biomass/Bagasse Cogeneration	• Creation of biomass/bagasse cogeneration related policies by all states • Setting up of fuel depots • Regularization of feedstock prices and availability • Provide access to low cost funds to new players • Timely release of subsidies • Support in accessing/developing new technologies
Waste	• Creation of Waste to Energy related policies by all states • Setting up of fuel supply chain • Provide access to low cost funds to new players • Support in accessing/developing new technologies • Increase public awareness towards Waste to Energy • Increase FDI in this sector

Novonous, 2014.

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DISCUSSIONS

The aim of this section is to elaborate on the relationship between the renewable energy performance of the studied countries with the renewable energy policies and investments, primarily based on the analysis carried out up to this point. The most significant issue that needs to be addressed is that the countries with the highest renewable energy performance have extensively adopted either both (e.g. China, United States) or one of (e.g. Germany) the two main groups of renewable energy support policies, namely regulatory policies and targets and fiscal incentives and public financing (see Table 5). The most commonly used policies in the first group are renewable energy targets, biofuels obligation/mandate, feed-in tariff/premium payment and tendering, respectively. As for the fiscal incentives and public financing, the most frequently observed forms are capital subsidy or rebate; public investment, loans, or grants; and investment or production tax credits, respectively. Among all, renewable energy targets and capital subsidies or rebates are the most broadly used support policies.

Another significant outcome observed in Table 5 is the variety of the renewable energy support policies adopted in India. All of the policy types have been utilized in this country except for reductions, in sales, energy, CO_2, and VAT, and although, it is in the 14th place in the country listing, in terms of the adopted policies, it shares the 2nd place with Italy after the US. This is to indicate that the enactment of the respective laws and regulations does not necessarily lead absolute results. Germany is another example to support this fact because although it is right after the US in the performance list, the variety of the renewable energy policies are far less than those adopted in the US. What makes Germany so successful in the renewable energy arena aside from the fact that it is one of the first countries to have realized the necessity of renewable energy is that there is a fact-based monitoring process, namely the Energy of the Future. This system not only makes sure that the energy reforms are being realized but it promotes public participation and acceptance.

The final issue that needs to be pointed out is necessity of the respective investments. Environmental investments have always been subject to skepticism because their returns cannot be observed in the short-run. However, it can be stated that the top-performing countries are past this issue because global investment in renewable power and fuels (excluding large hydro-electric projects) was $270.2 billion in 2014, nearly 17% higher than the previous year (Frankfurt School-UNEP Centre/BNEF, 2015). The biggest renewable energy investments in 2014 were realized in major economies – with China far out in front at $83.3 billion, the US at the second place with $38.3 billion, and Japan in the third place with $35.7 billion. India was up 14% compared to 2013 at $7.4 billion, and Brazil 93% higher, at $7.6 billion (Frankfurt School-UNEP Centre/BNEF, 2015). The other significant fact is that substantial renewable energy investments have been made in developing countries in 2014, wherein a total of $131.3 billion has been invested, 36% higher than the 2013 figures. On the other hand, the corresponding number is $138.9 billion for developing countries, which is only 3% higher than the previous year. Indonesia, Chile, Mexico, Kenya, South Africa and Turkey were the countries, which made significantly high investments (Frankfurt School-UNEP Centre/BNEF, 2015). Hence, it can clearly be stated that there is a strong relationship between renewable energy investments and how well countries perform in this arena and that developing countries are eager to catch the top-performers in a short amount of time.

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CONCLUSION AND FUTURE RESEARCH

The possibility of depletion of fossil fuels in the near future and rising concerns for sustainability have urged countries to consider renewable energy as an alternative energy source. Consequently, governments and global organizations have adopted respective regulations to ensure the production and use of renewable energy and promote the respective new investments. In the light of these developments, this study has been conducted to lay out the current situation of renewable energy use and policies around the world with the ultimate goal of making certain suggestions and pointing out possible solutions in this area. To this end, first, a comparative statistical analysis has been carried out using the geographical coverage OECD has provided. Thus, the countries have been studied under eight groups, namely Africa, Non-OECD Americas, Asia, China, Non-OECD Europe and Eurasia, Middle East, OECD and World Total. Certain descriptive statistics have been provided for this geographical coverage on the share of renewable energy in TPES; individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste; and the distribution of the individual shares (expressed as percentages of total renewables) between 2008 and 2012. The data used in this analysis have been gathered from the IEA yearly "Renewables Information" reports (2010-2014 Editions). Following the statistical analysis on the renewable energy use, countries have been listed according to their renewable energy performance using a simple ranking methodology, using 17 of the indicators and the data provided by REN21. Then, the overall renewable energy policies of the EU and OECD and those of certain selected countries have been investigated. The selected countries include the top three renewable energy performers with respect to the ranking carried out, which are China, US and Germany in addition to Turkey and Spain. Turkey has been analyzed in terms of renewable energy policies because it is a developing country with a substantial amount and wide range of renewable energy sources but is still importing over 70% of its primary energy supply. As for India, it has the fifth-largest electricity generation capacity in the world with substantial sources of renewable energy and a broad range of renewable energy policies. Following the individual analyses of policies, their relationship with renewable energy performance has been elaborated. Renewable energy investments have also been studied in the discussions section. The most significant results of the study can briefly be summarized as the following:

- Except for Non-OECD Europe and Eurasia and the Middle East, biofuels and renewable wastes constitute the highest percentage of renewables throughout the world. This is especially significant for Africa, Asia and the World Total.
- The investigation of the geographical groupings in terms of the distribution of individual renewable sources between 2008 and 2012, a steady behavior has been observed except for the Middle East, where the shares of individual renewable energy sources have undergone significant changes through the respective years.
- According to the renewable energy performance ranking, the top five countries have been determined as China, US, Germany, Brazil and Spain.
- The countries with the highest renewable energy performance have extensively adopted regulatory policies and targets and/or fiscal incentives and public financing.
- Renewable energy targets and capital subsidies or rebates are the most broadly used support policies.

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- It has been observed that the key to renewable energy performance is not only adopting the respective policies but to monitor their effective use. This promotes public participation and acceptance as well, which are significant for any sustainability action.
- Substantial energy investments have been made in 2014 in both developing and developed countries. This is important because it points out to the fact that the usual skepticism concerning the necessity of environmental investments has been overcome on a global scale.

This study has certain limitations in that a more extensive analysis has to be carried out on the individual renewable energy performance of the world countries. This poses as the most promising area of future research. Data mining techniques can be used to analyze the renewable energy performance based on indicators that include but are not limited to those used in this study. Moreover, formal quantitative analysis techniques should be used to investigate how renewable energy performance is affected by the respective policies and investments. In relation to investments, quantitative models on cost-benefit analysis are also needed. Another issue is the significant shift in the world toward emerging markets. Developing countries have become just as or even more critical (because this shift is estimated to continue) actors in terms of renewable energy use and investments. Thus, their current and future roles should be studied in detail. One final remark is the necessity of joint actions taken in renewable energy use and policies. An example of this is the recent cooperation between China and the US, setting a target for decreasing carbon emissions. In conclusion, it can be stated that renewable energy is wide open for future research not only in terms of technological developments but also concerning its use and respective policies.

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KEY TERMS AND DEFINITIONS

Capital Subsidy: A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater).

Feed-in Premium: A type of feed-in policy, where producers of electricity from renewable sources sell electricity at market prices, and a premium is added to the market price to compensate for higher costs and thus to mitigate financial risks of renewables production.

Feed-in Tariff: The basic form of feed-in policies, where a minimum price (tariff) per unit (normally kWh or MWh) is guaranteed over a stated fixed-term period when electricity can be sold and fed into the electricity network, normally with priority or guaranteed grid access and dispatch.

Fiscal Incentive: An economic incentive that provides individuals, households, or companies with a reduction in their contribution to the public treasury via income or other taxes, or with direct payments from the public treasury in the form of rebates or grants.

Investment Tax Credit: A taxation measure that allows investments in renewable energy to be fully or partially deducted from the tax obligations or income of a project developer, industry, building owner, etc.

Mandate/Obligation: A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum, and often gradually increasing, target for renewable energy, such as a percentage of total supply or a stated amount of capacity.

Net Metering: A regulated arrangement in which utility customers who have installed their own generating systems pay only for the net electricity delivered from the utility (total consumption minus on-site self-generation).

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Production Tax Credit: A taxation measure that provides the investor or owner of a qualifying property or facility with an annual tax credit based on the amount of renewable energy (electricity, heat, or biofuel) generated by that facility.

Renewable Energy Certificate (REC): A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat).

Renewable Energy Target: An official commitment, plan, or goal set by a government (at the local, state, national, or regional level) to achieve a certain amount of renewable energy by a future date.

Renewable Portfolio Standard (RPS): An obligation placed by a government on a utility company, group of companies, or consumers to provide or use a predetermined minimum renewable share of installed capacity, or of electricity or heat generated or sold.[8]

ENDNOTES

1 World Marine and Aviation Bunkers have not been included in the analysis because of the lack of data.

2 Because only aggregated data were available until 2012, the data for Sudan also include South Sudan.

3 *In the Renewables Information (2010 Edition)*, the data for the year 2008 have been provided for Non-OECD Europe and Former Soviet Union separately. Starting from the 2011 Edition (2009 data), these have been combined under Non-OECD Europe and Eurasia except for Estonia and Slovenia. Estonia and Slovenia, which were included in Former Soviet Union and Non-OECD Europe, respectively, in the 2008 data, were both included in OECD Europe starting from the 2009 data.

4 Footnote by Turkey: *The information … with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue"*. Footnote by all the European Union Member States of the OECD and the European Union: *The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information … relates to the area under the effective control of the Government of the Republic of Cyprus.*

5 Data for Serbia include Montenegro until 2004 and Kosovo until 1999.

6 Estonia and Slovenia are included starting in 1990. Prior to 1990, data for Estonia are included in Former Soviet Union and data for Slovenia in Former Yugoslavia in the publication *Energy Statistics of Non-OECD Countries*.

7 The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

8 The definitions have been taken from IEA *Renewables Information 2014* Report.

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APPENDIX

Table 7. Renewable energy indicators used in country ranking

Indicator	Explanation
1	Renewable power (incl. hydro)
2	Renewable power (not incl. hydro)
3	Renewable power capacity per capita (not incl. hydro)
4	Biopower generation
5	Geothermal power
6	Hydropower
7	Hydropower generation
8	CSP
9	Solar PV
10	Solar PV capacity per capita
11	Wind power
12	Wind power capacity per capita
13	Solar water heating
14	Solar water heating capacity per capita
15	Geothermal heat
16	Investment in renewable power and fuels
17	Share of GDP (USD) invested

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Table 8. Renewable energy indicator scores, totals and averages on a country basis

Countries	Indicator[1] Scores																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total	Average
China	5	5	0	3	0	5	5	0	4	0	5	0	5	0	5	5	0	47	2,76
United States	4	4	0	5	5	3	2	4	1	0	4	0	4	0	0	4	0	40	2,35
Germany	1	3	4	4	0	0	0	0	5	5	3	0	3	0	0	1	0	29	1,71
Brazil	3	0	0	2	0	4	4	0	0	0	0	0	1	0	0	0	0	14	0,82
Spain	0	2	2	0	0	0	0	5	0	0	2	3	0	0	0	0	0	14	0,82
Italy	0	2	0	0	1	0	0	0	3	4	0	0	0	0	1	0	0	11	0,65
Denmark	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	10	0,59
Canada	2	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	7	0,41
Japan	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	3	0	7	0,41
Sweden	0	0	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0	6	0,35
Turkey	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	0	6	0,35
Austria	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	5	0,29
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	0,29
India	0	1	0	1	0	0	0	2	0	0	1	0	0	0	0	0	0	5	0,29
Portugal	0	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5	0,29
Uruguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0,29
Mauritus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0,24
Philippines	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4	0,24
Belgium	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0,18
Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0,18
Greece	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	3	0,18
Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0,18
Indonesia	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0,18
Israel	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0,18
United Arab Emirates	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	0,18
Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0,12
Mexico	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0,12
Russia	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0,12
South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0,12
United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0,12
Algeria	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0,06
Czech Republic	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0,06
Ireland	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0,06
Nicaragua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0,06

[1]The list of the indicators can be viewed inTable 7.

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Chapter 26
How to Manage Sustainability: A Framework for Corporate Sustainability Tools

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ABSTRACT

Sustainability has increasingly become a critical issue for wellbeing of human life and maintaining sustainability is responsibility of many parties such as individuals, corporations or governments. When taking its social, economical, or environmental impacts into consideration, maybe the most important player in that arena is organizations and in order to take the necessary actions about sustainability, first of all a common understanding of the topic is needed. For this reason, in this chapter it is aimed to create awareness about sustainability issue and commonly used tools for management of it. In this context, definition of sustainability and four corporate sustainability management tools (Environmental Management System - EMS, Sustainable Value Stream Mapping - Sus-VSM, Total Quality Environmental Management - TQEM and Sustainable Balanced Score Card - SBSC) have been explained.

INTRODUCTION

Sustainability is a new paradigm which came into prominence in the near past and since it is critical for the Universe, maintaining the necessary conditions for sustainability - from a single individual to businesses - is the responsibility of every entity in the World. Then the question is this; why is sustainability so much important today? Especially after the industrialization, in centuries, CO_2 levels in the atmosphere has been increasing and causing temperatures to rise, oceans to acidify, ice caps to melt (Watson, 2012:viii). Therefore, unless necessary actions are taken, the only inheritance to our next generations will be unfortunately a ruined ecology and all of us know what this means for life.

More generally the term “sustainability” means to endure. The term is used in different areas such as sustainable city, sustainable food, sustainable agriculture etc. (Young & Dhanda, 2013:3). Although it is used in different areas, sustainability is related with the quality of life and long lasting resources. Also from the point of environmental science, the term is used for the quality of not being harmful to

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environment or depleting natural resources, and thereby supporting long-term ecological balance (www.dictionary.com).

In today's highly industrialized world, one of the most critical actors in sustainability issue is obviously businesses. For this reason, corporate sustainability takes the attention of many scholars. Corporate sustainability incorporates a societal three dimensional goal of sustainability for corporations, governments and civil society. And these three dimensions comprised of economic, environmental and social facets (Wilson, 2003:1). This is also called as Triple Bottom Line (TBL) and for corporate sustainability; companies need to measure their impacts not only on the bottom line (profits), but also on the community and the environment as well. (Young and Dhanda, 2013:3).

Since globally people desire to live in a more humane, caring, equitable environment with prosperity, attention of scholars and the number of sustainability researches are increasing every day (Ikediashi, Ogunlana & Ujene, 2014:305). Parallel to this global tendency, colleges and institutions are opening sustainability courses in order to increase the awareness about the topic (Sisaye, 2013:224). With these developments, businesses are facing some pressures internally and externally about their responsibilities in social and environmental issues (Winter & Knemeyer, 2013:23) and as a result of this, a movement towards a sustainable environment is emerging.

In order to manage sustainability, organizations need to control their operations and link this with their strategies. Therefore, mechanisms to achieve sustainability have critical importance. For this aim organizations can use some tools to manage corporate sustainability. In this context, commonly used sustainability tools can be mainly classified under the four headings as environmental management system (EMS), total quality environmental management (TQEM), sustainable value stream mapping (Sus-VSM) and sustainability balanced score card (SBSC) (Young & Dhanda, 2013:3). In order to apply these tools based on their needs, businesses need to know the necessary basic knowledge about corporate sustainability tools. Therefore, mainly the basic knowledge about sustainability and commonly used tools for managing corporate sustainability has been presented in this chapter.

More specifically, readers of this chapter will;

- Get basic knowledge about definition and history of sustainability
- Learn different usages of the term in different areas
- Learn about sustainable development and triple bottom line
- Get awareness about importance of the topic
- Dive into topic with a corporation view point and
- Learn commonly used corporate sustainability management tools.

BACKGROUND

Although the term sustainability has a long history, it has been getting more and more importance and attention from many scholars and business people for approximately past a few years (Chowdhury, 2013:603). Some of the main reasons of this increasing awareness about sustainability are increased research and investigation on environmental problems caused by climate changes in recent years and several calls on international platforms for consciousness about the topic (Ikediashi, Ogunlana & Ujene, 2014:305). Actually origins of sustainability can be traced back to centuries ago (Jones et.al., 2013:90),

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but at that time the term wasn't mentioned with its today's naming and it was explained in the context of another issues such as environmentalism, economic theory, scarce resources etc.

One of the most important milestones of sustainability history has been the United Nation's Conference on Human Environment (UNCHE) held in Stockholm in 1972 (Balbinot & Borim-De-Souza, 2012:159). In this conference, the attention has been taken to the need of a common understanding and principles guiding and inspiring people worldwide for preservation and enhancement of human environment (Mebratu 1998:502). Another important movement has occurred in the year of 1980. At that time World Conservation Strategy formulated by joint effort of The World Wildlife Fund (WWF), UNEPR and International Union for the Conservation of Nature (IUCN) has been launched internationally. This was a starting point for the introduction of sustainable development (Balbinot & Borim-De-Souza, 2012:159). However, as a term in real sense, the most widely used definition of sustainable development has been introduced by The World Commission on Environment and Development (WCED) in 1987. The Commission also called as Brundtland Commission issued a report entitled "our common future" and in this report sustainable development has been defined as "using resources to meet the needs of the present without compromising the ability of future generations to meet their own needs." (Winter & Knemeyer, 2013:23). It has been a large scope definition (Westelius, Westelius & Brytting, 2013:162) and since it can be interpreted from many different aspects, the definition of Brundtland Commission has been accepted widely (Mebratu, 1998:502). After WCED Report, In 1992 Rio Conference (Earth Summit) also known as UN Conference on Environment and Development (UNCED) has been held (Mebratu, 1998:502) and in this conference attention has been taken to the issue of the need for urgent national actions for sustainable development (Hamelin & Nwankwo, 2013:261). Especially after WCED to today, sustainability and sustainable development issue has gained momentum in worldwide and it has also taken a great academic attention. Recently (2015), United Nation's global summit for the adoption of post-2015 development agenda and sustainable development goals has been held in New York with the participation of relevant stakeholders including parliaments, businesses and civil society organizations. On the summit, 17 sustainable development goals and related 169 targets which will stimulate actions in critically important areas for humanity and the planet have been agreed upon and a Universal call has been made for actions supporting the transformation into a better World (UN post-2015 Agenda, September 2015; https://sustainabledevelopment.un.org).

With increased interest in the topic, many different definitions of sustainability have been proposed by different scholars and therefore there is no one generally accepted definition (Hockerts, 2001:1; Ratiu & Anderson, 2014:162; Joseph, 2013:441). The term is most commonly used as equivalent of the terms such as "long term", "durable" (Ehnert, 2006:3) or "environmentally sensitive" and also as stated earlier, it has been applied to different areas such as construction (Yates, 2013:281), human resource management (Ardichvili, 2012:876), strategic management (Hulgen & Mirze, 2004:30) or supply chain management (Winter & Knemeyer, 2013:19). For example, sustainable construction is related with maintaining a healthy built environment and this can be achieved by efficiency in resource consumption, using recyclable materials, eliminating toxics and a quality focus (Yates, 2013:283). Similarly, sustainable supply chain management is related with the topics such as green purchasing, purchasing ethics, remanufacturing, safety management or carbon footprints and is mainly an extension of sustainability to whole supply chain (Winter & Knemeyer, 2013:19). On the other hand, sustainability strategic management is associated with long lasting competitive advantage (Hulgen & Mirze, 2004:30) whereas sustainable human resource management is related with human resources practices which support sustainable development (Becker, 2011 cited in Ardichvili 2012:875-876).

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Although most of the time sustainability and sustainable development has been used interchangeably, there are scholars who take sustainable development as a broader concept than sustainability. Also based on another view, sustainability is an ending point of sustainable development process (Jones et.al., 2013:90). Whether it is an end point or a process, sustainability is related with operational drivers of profitability and their relationships to people and environment we all live in (Winter & Knemeyer 2013:19). In that vein, in a definition sustainability was associated with exploitation of natural resources without harmful effects (Ikediashi, Ogunlana & Ujene, 2014:305). Besides, in another definition made by Environmental Protection Agency (EPA), social, economic and environmental aspects were mentioned, the harmony and balance between these three aspects were stressed (Chowdhury, 2013:603). As it can also be interpreted from the definition of WCED (WCED Report, 1987) sustainable development is not only an environmental conservation, more comprehensively it is also related with quality of life (Joseph, 2013:442) and with mindful human activities for this aim (Yates 2013:283). In this chapter also, the term sustainability is used as broader as and interchangeably with sustainable development.

In order to achieve sustainable development, there are three pillars that should be taken into consideration (Chowdhury, 2013:603). These are economic, social and environmental aspects of sustainability and are also called as triple bottom line (TBL/3BL) (Dos Santos, Svensson & Padin, 2013:104). TBL is related with environmental, social or economic value added (or otherwise harmful effects on these aspects) and also there are different namings about these aspects such as profits, planet, people (3P) or economics, environment and equity (3E) in the literature. Although there are nuances between these classifications, their contents are consistent (Winter & Knemeyer 2013:22) and the common idea is that there should be a balanced attention to all these three elements (Ardichvili, 2012:875).

As proposed by Docherty et.al. (2008), sustainability can be investigated in three levels as individual, organizational and societal (p.10). For sustainability to occur, each level has its own responsibilities and has to work in harmony for this common aim. From the point of organizations, the important question is; "what is the role of business when striving towards sustainable development?" (Bieker, 2002:5). Sustainability efforts are generally based on managing impacts on Earth's life, eco-systems, its stakeholders (Dos Santos, Svensson & Padin, 2013:104) and for sustainable development; necessary systems and services that are economically, environmentally and socially sustainable are needed to be built in organizations (Chowdhury, 2013:603). Corporate sustainability management has to focus on innovation, stakeholders' requirements and also on efficiency as well as on effectiveness of business processes (Baumgartner, 2014:260). Therefore, a system approach is needed for the management of corporate sustainability (Azapagic, 2003:304).

When it comes to three pillars of sustainability, economic aspect is defined as "the degree to which an organization actively and constructively deploys its resources to support the socio-economic well-being of its surrounding community" (Jones et.al., 2013:90) and it is also related with being a successful and competitive organization in terms of efficient use of resources and achievement of profitability (Winter & Knemeyer 2013:24). Although this dimension of sustainability is the most focused issue, other dimensions of sustainability are also needed to be considered. Environmental aspect is related with taking into consideration environmental effects of business operations and taking necessary actions for preservation of natural resources (Ikediashi, Ogunlana & Ujene, 2014:305). On the other hand, social aspect (as stated by Katsoulakos & Kotsoulakos) is related with "the impact of products or operations on human rights, labor, health, safety, regional development and other community concerns" (Ikediashi, Ogunlana & Ujene, 2014:305). As well as being economic units, businesses are social entities and in

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order to achieve sustainable development, they should also align their operations by considering impacts on social environment.

Besides being a responsibility, sustainability management provides some advantages to organizations. Researches have showed that corporate value is positively related with successful implementation of social and environmental strategy. Also, an improved sustainability performance may increase employee satisfaction and productivity, lower costs and improve image and reputation of the company. In this way, these organizations become demanded by customers, shareholders, employees and communities around them (Epstein & Wisner, 2001:9-10).

As it is seen from aforementioned explanations, organizations have responsibilities for sustainability and sustainability management also creates many advantages for them. Therefore, organizations need to create some mechanisms to manage corporate sustainability. In this context, there are some commonly used tools to achieve corporate sustainability and these corporate sustainability tools will be explained in detail in the next section.

SUSTAINABILITY MANAGEMENT TOOLS

Increasing global interest on sustainable development has resulted in growing needs of managing sustainable operations in organizations. Therefore, organizations have adopted some management tools to achieve a better performance on sustainable development issue. In this context, four commonly used sustainability tools - environmental management system (EMS), Total Quality Environmental Management (TQEM), Sustainable Value Stream Mapping (Sus-VSM), Sustainability Balanced Scorecard (SBSC) - have been explained in the subsequent sections.

Environmental Management System (EMS)

In recent years, industrial globalization has taken place and this has created important effects on environment (Gonzales, Sarkis & Adenso-Diaz, 2008: 1034) and as a result, increasing need of protecting the environment from industrial pollution has made maintaining sustainable operations an inevitable goal rather than an option for organizations (Alberti et.al, 2010:4455). Therefore, more and more organizations have become to search new ways in order to overcome environmental sustainability issue (Zutshi & Sohal, 2004:336) and they have tried to adopt and embodied green solutions into their business operations (Gonzales, Sarkis & Adenso-Diaz, 2008:1022). One example of a widely used tool among organizations for maintaining sustainable development is the Environmental Management System (EMS) (Szekely & Strebel, 2013:470). Environmental Management System (EMS) is a set of rational methodologies for the management of all activities regarding environmental aspects (Alberti et.al, 2010:4455). It requires considering environmental issues (Darnall & Edwards, 2006:303) and incorporates with a philosophy behind it. EMSs can be formal or informal which can also be classified as certified or non-certified. Although EMS can be applied as a non-certified management system, there are also some voluntary certification schemes such as EMAS (Eco-management and Audit Scheme) and ISO 14001 for providing an opportunity to organizations for improving their environmental performance (Iraldo, Testa & Frey, 2009:1444). While certified EMS provides a framework for stages of EMS implementation, non-certified EMS has more flexibility in execution (Darnall & Edwards, 2006:303). However, regardless of the fact that it is certified or non-certified, EMS needs a systematic approach and commitment throughout the

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organization to implement (Iraldo, Testa & Frey, 2009:1444). Organizations adopting an EMS, develop an environmental policy, make planning in order to reduce their harmful effects on the environment, set objectives accordingly, make the necessary controlling and take corrective actions in a systematic manner in order to evaluate and manage their effects on natural environment (Darnall & Edwards, 2006:30). Deming's continuous improvement model (PDCA, Plan - Do - Check - Act Cycle) provides a base for implementation of environmental management system (Darnall & Edwards, 2006:302). Here it can be said that planning has a critical role in EMS process. But, in order to implement such a system, first of all organization should realize the need for it. Therefore, awareness of an EMS need can be thought as a pre-stage of environmental management system implementation process (Kirkland and Thompson, 1999:131). This need can arise from different reasons which can also be thought as driving forces of EMS implementation. It can be a social driver such as expectations of public, a financial driver such as concern of credit ratings or an organizational sensitivity towards natural environment (Zutshi & Sohal, 2004:337). When it comes to adoption process, it can be classified under five main stages as environmental policy, planning, implementation and operation, checking and management review (ISO:14001:2004). Environmental policy stage is related with commitment to the system. In this stage, organization states its values, viewpoint and philosophy about continual environmental performance. In planning stage, organization determines goals based on its environmental policy. In the implementation stage, in order to achieve these environmental goals, organization works on the necessary management structure (Darnall & Edwards, 2006:303). In this context, many operational issues are held such as allocation of resources, training of workers etc. (Iraldo, Testa & Frey, 2009:1445). After implementation, it is important to control activities. If there is something which is incompatible with goals, the necessary actions should be taken. Therefore, in the fourth stage, monitoring and correction plays a critical role. In the final stage (management review), based on continuing environmental operations, organization may revise its goals and policies (Darnall & Edwards, 2006:303). In this way the process goes on and on as a continuous environmental improvement. Ricoh group which is an office automation equipments company can be given as an example of environmental management system. The group does business worldwide (Japan, Americas, Europe/Middle East/Africa and Asia/Pacific/China) and reduces its environmental impact on a global scale (Nakagawa, 2001:499). For management of environmental impact, Ricoh uses PDCA (Plan-Do-Check-Act) cycle. In that vein, the company starts the process by preparing an environmental action plan (plan). Since selection of key areas are important in preparing such a plan, areas with high importance both for stakeholders and Ricoh itself are determined with materiality matrix and based on the selected key areas, the necessary improvements are executed (do). Ricoh knows that controlling has a critical role for the success of this process. Top management supports it and with an internal control system, developmental areas are identified (check). In that way continuous improvement is ensured (Act) (Ricoh Group Sustainability Report, 2014).

Although adoption of an environmental management system is costly, it has many advantages as well. It creates public trust toward organization. It prevents harmful effects of organization on natural environment by reducing waste and provides economic or non-economic other advantages (such as good company image, increasing resource efficiency). However, it shouldn't be forgotten that a successful implementation requires time, investment and patience (Alberti et.al, 2010:4463,4465). Therefore, being aware of this fact and acting accordingly is important for a successful implementation process.

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Total Quality Environmental Management (TQEM)

Another sustainability management tool for businesses is Total Quality Environmental Management (TQEM). TQEM concept has been promoted as an extension of Total Quality Management by a group of leading businesses which constitutes GEMI (Global Environmental Management Initiative) (Hanna and Newman, 1995:44). GEMI which includes companies such as Procter and Gamble, AT&T and IBM have stressed the integration of TQM methods with environmental management practices. There are parallels between TQM and TQEM, and it is argued that TQM principles /quality improvement approaches can be applied to Total Quality Environmental Management (Chandrashekar, Dougless & Avery, 1999:1).

In general, the term "quality" is related with understanding, meeting or even exceeding customer needs and based on these needs, designing products/services which satisfy customers. (Hanna and Newman, 1995:43). On the other hand, total quality management is related with ensuring quality throughout the organization and continuously improving business processes to maintain this. From top to bottom in the hierarchy, everyone's participation and a supporting culture are needed for a successful total quality management (Madu, 1998:3). The same idea is also valid for total quality environmental management. In today, environmental concerns of businesses are also among needs/expectations of customers and in order to satisfy these customers, businesses need to improve their processes towards a better environmental performance.

Like emergence of total quality management with increasing quality expectations of customers in 1950s, environmental management has also emerged with awareness of environmental issues and green movement in 1990s (Hanna & Newman, 1995:41). TQM has aimed creating a culture in which all waste is eliminated, zero defects achieved, a system approach is applied and customer expectations are met with continuous improvement. Therefore, TQM reflects a management philosophy and uses lots of techniques for quality improvement such as Pareto diagrams, control charts or cause & effect (fishbone) diagrams with the idea of doing the right thing at the first time. Similarly, Total Quality Environmental Management (TQEM) involves with taking a holistic environmental responsibility in all business operations (Sammalisto, 2001:47) and it is based on continuous improvement (Del Brio et.al, 2001:495). It has been defined as "an economically driven, system wide and integrated approach to the reduction and elimination of all waste streams associated with the design, manufacture, use and/or disposal of products or materials." (Curkovic, Sroufe & Landeros, 2008:94). Therefore, TQEM is a proactive way of environmental management and it is more than compliance to environmental regulations (Griffiths & Petrick, 2001:1575).

TQEM emphasizes four basic principles as customer orientation, continuous improvement, doing the job right at the first time and a system approach to work (Chandrashekar, Dougless & Avery, 1999:1; Sammalisto, 2001:48). But prior to all these principles, maybe the most important thing which is also embedded with other principles can be said to be top management. Management is the key for TQEM to work and high levels of management commitment and support are needed for implementation of all these principles (Sammalisto, 2001:49). For the success of TQEM, there should be a link between environmental practices and corporate strategy and this link can be formed by programs supported and led by top management (Curkovic, Sroufe & Landeros, 2008:96). Once management forms this link, then other principles can be applied accordingly. As listed above, one of the most important principles in TQEM is *customer orientation* (Sammalisto, 2001:48). In traditional view of marketing, customer orientation is defined in terms of meeting the customer expectations of product/service performance, quality, price and value. In today, environmental performance of businesses has also become an ex-

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pectation of customers (Chandrashekar, Dougless & Avery, 1999:2) and therefore satisfying customer needs now includes providing product/services which does not harm the environment (Sammalisto, 2001:48). Here, it should also be noted that besides customers, other stakeholders' satisfaction (such as shareholders', regulatory agencies' and the community's) are also among the factors that should be taken into consideration for customer orientation principle of businesses while applying TQEM (Affisco, 1998:390). Other principle of TQEM is *continuous improvement*. Continuous improvement is important both for customer satisfaction and business development (Sammalisto, 2001:49). It is related with continuously searching for better ways of environmental management. In this context, business processes are regularly controlled, changes are observed and necessary actions are taken for development (Sammalisto, 2001:48). For environmental continuous improvement, businesses utilize similar quality improvement techniques as of TQM. Pareto analysis, cause-and-effect diagrams, flow diagrams can be listed as examples of these techniques (May & Flannery, 1995:29). Although these techniques are useful, involvement of all employees is also needed for continuous improvement. For this reason, empowerment and teamwork are also important (Sammalisto, 2001:48,49). Another important principle for TQEM is *doing the job right at the first time*. This principle is related with prevention and therefore requires regular control of processes. Here the main idea is not detecting defects but taking the necessary actions to reduce or minimize waste before occurrence. The cost of failure (whether it is internal or external) is most of the time higher than prevention costs. Therefore, TQEM requires designing and planning the system accordingly (Curkovic, Sroufe & Landeros, 2008:98,99). As well as principles of customer orientation, continuous improvement and doing the job right at the first time, one another critical principle of TQEM is the *system approach*. As it is stated before, TQEM needs a holistic viewpoint and this holism can only be achieved through the system approach (May & Flannery, 1995:29). In order to increase environmental performance, an organization wide effort is needed and environmental thinking should be incorporated into every aspect of business operations (Jayathirtha, 2001:245). There should be a clear direction and all internal processes should be designed accordingly. Rather than focusing on one point, the big picture should be seen. Therefore, system approach is critical for a successful TQEM and it provides integration between all these principles.

Eastman Kodak Company, which is a world leader in the development, manufacture and marketing of both conventional and electronic imaging technology, is one of the companies using TQEM successfully. Based on the TQM principles, the company has prepared a TQEM matrix with seven categories (leadership, information & analysis, strategic planning, human resources, quality assurance of environmental performance, environmental results and customer/stakeholder satisfaction) and assigned weights to these categories. For these categories, TQEM objectives have been set and it was ensured that the matrix system has been understood and accepted by all participant departments. This made it an organization wide process. Although at first there were confusion and resistance, in a short time it turned into commitment to the system. In time, TQEM scores of each category has increased dramatically and also environmental performance of the company has improved (Lave, Conway-Schempf & Horvath, 1997).

Total Quality Environmental Management aims reducing waste, designing products with minimal environmental effect, creating environmental awareness among employees and within community (Jayathirtha, 2001:246), and in this way increasing environmental performance of businesses. With green movement and the increasing concern for environment, environmental excellence has started to be seen as an important source of competitive advantage (Hanna and Newman, 1995:38). Most environmental issues are related with internal processes and making improvements result in lower costs and reduce environmental impact (Chandrashekar, Dougless & Avery, 1999:1). Many businesses using TQEM are

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producing higher quality, environment friendly products with environmentally sound processes and as a result, improving their productivity (Hanna & Newman, 1995:49). Although returns can take time, environmental programs pay for themselves (Chandrashekar, Dougless & Avery, 1999:1) and therefore in the long run create advantages for businesses. However, in order to benefit from these advantages, management and employees should believe in TQEM and exert effort accordingly. TQEM is a holistic environmental management tool and needs structural, cultural changes enabling employees to take on greater responsibilities in solving problems. Therefore it will not work if applied just for compliance to environmental regulations (Griffiths & Petrick, 2001:1576). Mistrust or suspicion towards TQEM are main obstacles that should be overcame by businesses (Chandrashekar, Dougless & Avery, 1999:12) and as it should be in other corporate sustainability tools, management should be patient about its returns in also TQEM.

Sustainable Value Stream Mapping (Sus-VSM)

Another sustainability management tool is sustainable value stream mapping (Sus-VSM) and this tool of sustainability is based on the conventional value stream mapping tool which is used in lean manufacturing (Thorsen, 2005:2). Lean manufacturing is a systematic approach which aims determining and eliminating all wastes for improving customer value (Seth, Seth & Goel, 2008:532) and it has derived mostly from Toyota Production System (TPS) during 1990s (Faulkner, Templeton, Gullett & Badurdeen, 2012:815). Toyota Production System aims reducing the time spent between an order placed and delivery made by eliminating wastes (Norton & Fearne, 2009:3). According to this system these wastes (which are not contribute to the value of the product) are called as "muda" and listed as follows (Ohno 2010:62);

1. Waste of over production.
2. Waste of time on hand (waiting).
3. Waste of transportation.
4. Waste of processing itself.
5. Waste of stock on hand (Inventory).
6. Waste of movement.
7. Waste of making defective products.

All these wastes are unnecessary and non-value adding, therefore it creates additional cost and lowers productivity (Norton & Fearne, 2009:4). According to the lean paradigm which has been proposed by Womack and Jones, in order to eliminate waste, investigation of the value stream is important and a value stream is defined as "all the actions currently required to bring a product through the main flows essential to every product:

1. The production flow from raw materials to the customers, and
2. The design flow from concept to launch" (Rother & Shook, 2009:1).

In a value stream there are three kinds of activities. These activities can be value adding activities (e.g.sub-assembly of parts), non-value adding but unavoidable activities (e.g. walking long distances to pick up parts) and non-value adding activities which are avoidable (e.g. waiting time). In order to increase customer value, these avoidable non-value adding activities should be removed from the process

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(Womack & Jones, 2003:20; Seth et.al.,2008:538). For this reason, conventional value stream mapping (VSM) is a widely used tool in lean manufacturing to determine wastes which will be eliminated by continuous improvement (Faulkner & Badurdeen, 2014:16). Value stream mapping visualizes the wastes in a manufacturing system and provides an insight for future improvements (Brown, Amundson & Badurdeen, 2014:164). In order to do that, VSM draws a product's (or a product family's) manufacturing life-cycle that identifies each phase throughout the production process and by taking all production phases into consideration, it provides a holistic view (Lovelle, 2001:28). The value stream map is a pencil & paper tool, and composed of simple symbols and stream lines (Li, Cao & Pan, 2012:1105). Therefore, it provides a simple communication of information and shows sources of wastes (Brown et.al, 2014:165). However, it can draw the value stream either on factory level or as an extended VSM, on whole supply chain level (Torres & Gati, 2009:1690) and in the second situation (if it is an extended VSM), additional information is needed to be obtained from outside parties.

As it is used for lean manufacturing, value stream mapping is a potential tool to be used also for sustainable manufacturing. In recent years, sustainable manufacturing has gained more importance and the lean manufacturing practices have increasingly being used for sustainable production (Faulkner & Badurdeen, 2014:8). The United States Department of Commerce (US DOC) defines sustainable manufacturing as "the creation of manufactured products which use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound" (Faulkner et.al.,2012:815). As it is seen from the definition, sustainable manufacturing includes economical, environmental and societal aspects. On the other hand, lean manufacturing targets only economical waste (mostly based on time, e.g. lead time, cycle time). Therefore, sustainable manufacturing needs a more holistic view which captures all supply chain. Since conventional value stream mapping does not have environmental and societal metrics, there has been a need for an improved VSM which includes additional metrics (Faulkner & Badurdeen, 2014:9). For this reason, attempts for an improved VSM which uses additional metrics (namely environmental and societal) have emerged (Sparks & Badurdeen, 2014:1). But these early attempts of sustainable value stream mapping have been mostly based on environmental metrics (Faulkner & Badurdeen, 2014:8). In this context, US Environmental Protection Agency (EPA) has developed a lean and environmental toolkit (Faulkner et.al.,2012:815) and has defined environmental wastes as "any unnecessary use of resources, or substance released to the air, water or land that could harm human health or the environment". In this lean and environmental toolkit, water usage has been added as an environmental metric (Li et.al., 2012:1103) and in this way, lean implementation and environmental performance has been integrated (Norton & Fearne, 2009:8). EPA has also developed another toolkit. This lean and energy toolkit has been designed to track energy consumption and efficiency. Although these two toolkits are useful, neither of them has taken societal metrics into consideration (Sparks & Badurdeen, 2014:2). After EPA's toolkits, an environmental value stream mapping (E-VSM) tool has been developed by Torres and Gati (Torres & Gati, 2009:1689). In E-VSM, water usage metrics have been used in the form of different ways of water lost. Therefore, this tool has been provided a more detailed investigation and it has been an extended version of EPA's lean and environment toolkit (Sparks & Badurdeen, 2014:2). But still societal metrics were not taken into consideration. Later, Simon and Mason have developed the sustainable value stream mapping tool (SVSM). In this tool, in addition to value added time, greenhouse gasses and CO_2 emissions have been investigated. Still there was no societal metrics considered but here it was assumed that used metrics are indirectly related with societal issues (Faulkner et.al.,2012:816). On the other hand, Norton and Fearne have extended SVSM by adding additional metrics developed by Norton and created

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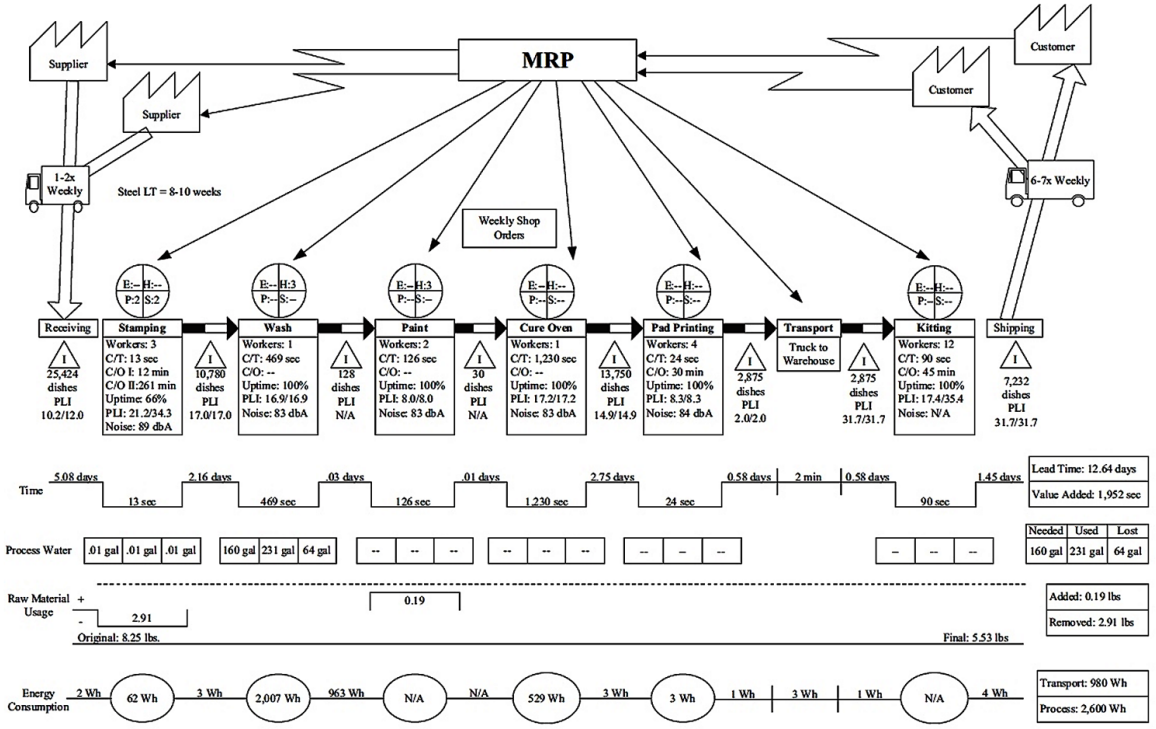
sustainable value chain mapping (SVCM) tool. For metrics selection, UK Department for Environment, Food and Rural Affairs (DEFRA) has recommended some basic environmental performance indicators (EPIs) as waste, GHG emissions and water use. Other EPIs were also suggested to be selected with the recommendation of relevant industry or trade organizations (Norton & Fearne, 2009:11-12). There was still a need for comprehensive evaluation of multiple metrics including societal aspects. Based on this need, University of Kentucky (UK) project team has worked with National Institute of Standards and Technology (NIST) and developed more than 50 metrics. Later on, by using some of these metrics developed, a comprehensive sustainable value stream mapping tool (Sus-VSM) has been proposed by Faulkner et.al. (Faulkner et.al., 2012:816,817). In Sus-VSM, in addition to standard VSM metric of time waste, environmental and societal metrics have also been used (Brown et.al, 2014:166-168).

Table 1. Sus-VSM metrics and descriptions

	Sus-VSM Metrics
Economic	Time Waste
Environmental	• Raw Material Usage • Energy Consumption • Process Water Consumption
Societal	• Physical Work (Job Hazards) • Work Environment (Ergonomics)

Brown et.al, 2014:166-168.

Figure 1. An example of Sus-VSM for satellite dish production line
Faulkner & Badurdeen, 2014:16.



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As different from previous works, Sus-VSM tool has been designed to evaluate all aspects (economic, environmental, societal) of sustainability (Faulkner et.al., 2012:822) and in this way it has provided a more detailed evaluation (Brown et.al, 2014:166).

Sustainable value stream mapping starts with a current situation investigation. In this step, the *current state map* is prepared. Value stream is evaluated according to selected metrics and wastes are identified. After preparation of current state map and identification of wastes, in the next step a *future state map* is drawn. Future state map shows the desired design of new value stream. And finally, an *implementation plan* is prepared for applying necessary improvements (Rother & Shook, 2009:7). Since this tool needs information and material flows to be drawn, in order to get the necessary information it should be conducted in a cross-functional team setting (Lovelle, 2001:30). Although Sus-VSM is a useful tool, for complex situations (e.g. high variety of production), it is important to determine scope of analysis before starting the process (Brown et.al, 2014:165). There may be one product line, a product family line or whole supply chain to be investigated. In each option, metrics selection should also be aligned accordingly (Sparks & Badurdeen, 2014:4). In order to make a more dynamic analysis and digital visualization, Sus-VSM can also be used in integration with other tools such as discrete event simulation (DES) (Paju et.al.,2010:3411). Whether it is used as a pencil and paper tool or with a simulator, Sus-VSM provides a valuable roadmap to maintain sustainability.

Sustainable Balanced Scorecard (SBSC)

Another sustainability management tool is the one which is called Sustainable Balanced Scorecard (SBSC) and this tool is based on the traditional Balanced Scorecard (BSC) (Bieker, 2003:17). Balanced Scorecard (BSC) has been developed in the early 1900s by Harvard professor R. Kaplan and D. Norton as a new tool for performance management (Bieker, 2002:2) and this tool is different from traditional controlling mechanisms of organizations. Controlling in management has a critical role and performance measurement is mostly made by looking at financial performance indicators. However, financial measures may be insufficient and therefore organizations need different perspectives which support financial results. In that vein, BSC is the one which is proposed for this reason. The BSC is based on the idea that the efficient use of investment capital is no longer the only determinant for competitive advantage, and increasingly soft factors such as intellectual capital, knowledge creation or excellent customer orientation became more important (Figge et.al.:2002:270). Therefore, Balanced Scorecard takes also the intangible assets into consideration and helps organizations to manage demands of relevant stakeholders (Bieker, 2002:7). In this context, in BSC there are four perspectives as financial perspective, customer perspective, internal processes perspective and lastly innovation and learning perspective (Kaplan & Norton, 1992:72).

1. **The Financial Perspective:** Focuses on the shareholders' interests and shows whether the company's strategy, implementation and operations are contributing to bottom-line. But as different from traditional management instruments, it stresses drivers for future profitability.
2. **The Customer Perspective:** Focuses on measures that indicate how the company is creating customer value through its strategy and actions. Customers' concerns tend to fall into four categories as time, quality, performance & service, cost and this perspective makes it possible to get the internal processes, services and products into line with the necessities of current and future markets.

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3. **The Internal Processes Perspective:** Measures how well a company performs on key internal dimensions. For this perspective, first of all the company's core competencies and the critical technologies needed to ensure continued market leadership are identified and measured.
4. **The Innovation and Learning Perspective:** Measures how well the company is preparing to meet the challenges of the future through leveraging its organizational and human assets. Human resources is thought as an underlying strategic factor of success and via this perspective it is linked to organization's strategy (Bieker, 2003:19, Epstein & Wisner, 2001:2, Kaplan & Norton, 1992:73-77).

These perspectives are not thought as isolated and therefore they are in cause and effect relationships with each other. Also they are measured by indicators (as leading and lagging) and objectives in operational levels are linked to corporate strategy.

1. **Leading Indicators:** Reflect the future strategic goals and
2. **Lagging Indicators:** Reflect the results to depict the effectiveness and efficiency of measures in the past (Bieker, 2003:18).

And also in order to form the necessary cause and effect relationships, these indicators are thought as a continuum or linked with each other (Epstein & Wisner, 2001:2). Therefore by means of BSC, performance measurement of corporate strategies can be made in terms of these four perspectives (Möller & Schaltegger, 2005:74).

Balanced Scorecard helps companies to accomplish critical management processes and it can be used as a strategic management tool (Sidiropoulos et.al, 2004:29). In this context, it helps translation of vision into action, communication of this vision with all organizational levels and linking it with short-term goals, integration of business and financial plans, and also helps strategic learning with feedback (Kaplan & Norton, 1996:75-77).

Sustainability balanced scorecard (SBSC) also works in the same manner. Conceptually sustainability management with BSC tries to address the problem of corporate contributions to sustainability in an integrative way. This time, characteristics of BSC are used for three pillars of sustainability (economic, environmental, social) and sustainability related indicators are linked with sustainability strategies (Figge et.al.:2002:272). Setting up a sustainability balanced scorecard starts with corporate vision and mission (Bieker, 2003:23). Since this is a top down approach, here it should be noted that the link between objectives and strategy can be formed providing that currently there is a strategy about the issue (Bieker, 2002:3). Therefore, in order to set up a SBSC, first of all sustainability should be addressed in vision and mission of the organization. In the second step, in line with that vision and mission, corporate sustainability strategies are determined and communicated with all hierarchical levels in the organization. After strategy clarification, sustainability objectives are identified based on the corporate sustainability strategies. In the following steps, casual relationships are determined and objectives are integrated into the SBSC perspectives and by defining indicators, targets and measures, SBSC is integrated into the core management system (Bieker, 2003:23). Before setting up a SBSC, scope should be made clear. Organization may apply it on a department, on a specific strategic business unit (SBU) or on the entire organization (Figge et.al.:2002:277) and also indicators can be organization specific. Based on the determined perspectives, sustainability balanced scorecard can be designed in different ways. It can be formed by integrating sustainability indicators under each of four perspectives or as one other choice it can be formed by adding a fifth perspective (sustainability perspective) to the traditional balanced

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scorecard. In order to increase the acceptance of enhancements, integration of sustainability metrics into the four perspectives can be preferred (Möller & Schaltegger, 2005:76). On the other hand, if resource allocation to social and environmental responsibilities is relatively large, then the second way can be seen as more appropriate. Sustainability balanced scorecard of Bristol-Myers Squibb (BMS) which is a multinational pharmaceutical company can be given as an example of the former design. In preparation of the SBSC, the company has prepared sustainability measures for each of the four perspectives (i.e. good citizenship metrics for customer perspective or energy use metric for internal business processes perspective) and formed the necessary links. In this way, BMS management has tied those specified performance metrics to corporate and business unit strategy to provide for an effective implementation of their concerns for social and environmental issues (Epstein & Wisner, 2001:5). As one another example (the latter design), Volkswagen's sustainability balanced scorecard can be given. Volkswagen (VW) has prepared a SBSC for its research department and used a fifth perspective which is called 'society'. Since sustainability management needs to take into consideration all stakeholders, society has been critical for the company. VW also formed the necessary cause and effect relationships and prepared its strategy map (Bieker, 2003:30). As it can be seen from all these examples, choice of the scope, metrics and type of SBSC depends on the organizations' needs and therefore it is mostly organization specific.

Sustainable balanced scorecard provides a strong tool for an integrated corporate sustainability management (Figge et.al.:2002:283). With this tool, companies get the opportunity to translate sustainability visions and strategies into action (Bieker, 2003:30) and also a balance of economic, social and environmental issues can be achieved (Möller & Schaltegger, 2005:75). By using SBSC, senior managers reposition their organization toward improved corporate responsibility and also this positively affects the organization's image and reputation (Epstein & Wisner, 2001:10). However, it may not be so easy all the time to implement this sustainability management tool and there may be some obstacles. This is because; it is a complex and highly micro political process requiring patience, power and persistence. But, if cultural issues are taken into consideration and employees are involved in the process, a successful implementation may take place (Bieker, 2003:30).

As it can be seen from all these explanations above, these four sustainability management tools have some similarities and differences, and while choosing the appropriate one, taking these similarities and differences into account may be helpful. First of all, these four tools are all top-down approaches. Therefore they need management support for implementation. However, in TQEM, an organization wide participation is much more important compared to other three sustainability management tools. Culture is a main obstacle for all change related issues and therefore it is the same for the implementation of these four sustainability management tools. Besides, while EMS, TQEM and Sus-VSM mostly involve in operational levels of sustainability, SBSC provides a more comprehensive tool which carries sustainability to a strategic level. Although there are similarities and differences among them, each of these tools provides valuable contributions for the management of sustainability.

CONCLUSION

Corporate sustainability is a critical concept which is getting more and more important. In today's highly industrialized business arena, harmful effects of corporations to the environment and society cannot be ignored. Organizations are operating in relationship with their stakeholders and for long lasting survival; they need to take into consideration their effects on all related parties. Sustainability has

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three pillars as economic, social and environmental aspects. All of these three pillars which are also called as triple bottom line (TBL/3BL) should be taken into consideration for sustainability. Economic aspect is related with the efficient use of resources and achieving profitability. Social aspect is related with considering social impacts of business operations on community (e.g. human rights, labor, health etc.) and environmental aspect is related with conservation of natural resources and taking the necessary actions to protect environment.

Scholars' and businesses' increasing attention to the importance of sustainability has resulted in increasing efforts for management of this issue. For several reasons (company image, social responsibility, humanism and environmentalism etc.) companies have generated and implemented different corporate sustainability tools. Use of these tools is dependent on the choice of the business and they are not mutually exclusive. Some of these corporate sustainability tools can be listed as Environmental Management System (EMS), Total Quality Environmental Management (TQEM), Sustainable Value Stream Mapping (Sus-VSM) and Sustainable Balanced Scorecard (SBSC). Environmental management system is mostly based on compliance and it uses Deming's PDCA cycle for the management of sustainability. It can be formal or informal and also it can be classified as certified or non-certified. Implementation of an environmental management system (EMS) starts with the awareness of a need for this. As well as awareness, the necessary policy, planning, implementation, controlling and improvement activities are also key for the success. This tool provides a systematic approach to organizations for better environmental performance but since it focuses on environmental issues, serves as a partial system of sustainability management. As another sustainability management tool, total quality environmental management (TQEM) utilizes total quality management techniques and by using these techniques it provides continuous sustainability improvement for organizations. Pareto diagrams, control charts, cause and effect diagrams are all among tools which are used for TQEM. Total quality environmental management emphasizes four basic principles as customer orientation, continuous improvement, doing the job right at the first time and a system approach. TQEM is a holistic environmental management tool and like total quality management does, TQEM which aims achieving sustainability also includes a cultural side in itself. Another corporate sustainability tool which is called sustainable value stream mapping (Sus-VSM) is related with sustainable manufacturing. This tool is based on the conventional value stream mapping and provides opportunity for identifying and eliminating wastes in terms of sustainability (by using economic, environmental and societal metrics). When it comes to the preparation, the process is comprised of three stages. At first stage of the process, a current state map is prepared. This step is followed by preparation of future state map and in the final step, an implementation plan is prepared to apply improvements. Sustainable value stream mapping tool also provides a roadmap for management of sustainability.

So far, as it can be seen from these explanations, all these tools are mainly related with operational level of sustainability. However, for a successful sustainability management; these efforts should be linked to corporate strategy. By linking the sustainability with strategy, both the issue will gain more importance and it will be possible to measure sustainability performance. For this reason, a fourth corporate sustainability management tool which is called sustainability balanced scorecard (SBSC) is important for sustainability management of corporations. Sustainable balanced scorecard is mainly based on the conventional balanced scorecard proposed by Kaplan and Norton. Conventional balanced scorecard provides performance measurement opportunity based on four different perspectives (financial, customer, internal business, innovation and learning). The idea behind this tool is the fact that financial performance measures are not sufficient anymore and the factors which affect financial results should also be taken into consideration for a healthy performance measurement. Sustainable balanced scorecard

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adds a sustainable perspective for measuring sustainability performance. This tool can be designed differently as with an integrated or with a separate sustainability aspect. Whether it is integrated or separate perspective, in both cases this tool forms the necessary link between sustainability related strategies and sustainability operations. In this way, it translates the strategy into action.

As stated before, organizations may choose one or more of these tools for management of sustainability. But here, the important point is that for a successful corporate sustainability all three aspects (economic, societal, environmental) should be taken into consideration. Therefore, when deciding the appropriate tool, this issue should also be considered by organizations carefully. Sometimes implementation process may last for a long time and may be costly. Therefore, they need a systematic approach and patience. However, although there may be difficulties in implementation, these tools provide support and improvement for sustainability performance of corporations.

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KEY TERMS AND DEFINITIONS

Balanced Scorecard: A comprehensive organizational performance measurement tool which is prepared mainly based on the four basic perspectives of financial, customer, internal business, innovation and learning.

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Environmental Management System: A corporate sustainability management tool which is applied based on Deming's PDCA cycle with the aim of eliminating environmental impact and improving sustainability performance of organization.

Sustainability Balanced Scorecard: A corporate sustainability performance measurement tool which is mainly based on traditional balanced scorecard and links sustainability goals with organization's strategy.

Sustainability Management: Concerns and efforts for eliminating hazardous impacts and making continuous improvements on economic, environmental and societal issues in order to ensure and maintain quality of life.

Sustainable Value Stream Mapping: A corporate sustainability management tool in which the value stream of a product line, product family line or whole supply chain is drawn and evaluated according to some metrics (economical, environmental and societal metrics) in order to make improvements in sustainability performance of organization.

Total Quality Environmental Management: A corporate sustainability management tool which is applied based on total quality management principles and techniques in order to improve sustainability performance of organization.

Total Quality Management: A contemporary management thought aiming doing the things right at the first time and achieving excellence in quality.

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Chapter 27
Grid Stabilization Effect of Combined Electricity Generation From Wind and Photovoltaic Systems in Murcia, Spain

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ABSTRACT

In this chapter, a model that calculates the impact on the grid of the simultaneous injection of electricity both from photovoltaic and wind sources is presented. The best locations for wind and photovoltaic technologies within Región de Murcia, southeast Spain, have been selected from a GIS database and evaluated and classified using a fuzzy version of the multicriteria decision method called Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). After the classification, the best locations are selected for each technology. Then, the impact on the grid arising from the injection of power generated in wind of photovoltaic systems installed at these specific locations and that are connected to the grid has been calculated in a power range of several kWp, including random steps of up to 50kW. The results show that stable grid parameters are obtained within 500ms in all cases, even when this relatively large power surge (or variation) is considered.

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INTRODUCTION

Nowadays, industrial and urban development are mostly driven by fossil fuels thus creating important environmental problems, being green-house-gases (GHG) emissions the best known. Alternative resources in power generation are being developed with the aim of meeting the increasing demand of energy but at the same time reducing the GHG emissions: renewable energy technology is the best choice for this purpose. Within the broad range of renewable options, wind and photovoltaic technology have been the most rapidly growing technologies worldwide. The electricity generation mix of any country in the world is increasingly incorporating a larger contribution of renewable energy supply (International Energy Agency, 2012; European Commission, 2013; Red Eléctrica Española, 2013). The electricity grid of such countries needs to match in real time the supply and demand of electricity, i.e. the electricity injected to the grid at a given time has to be the same as the electricity consumed by the users at the same time (European Commission, 2013). This is a challenge when renewable sources represent a large share of the electricity mix, and the road toward sustainability will require management of different intermittent sources probably with a storage back-up (International Energy Agency, 2012). This matching is usually guaranteed by the grid manager, which has the authority to allow or block the electricity input to the grid from different suppliers, and usually prioritizes generation from renewable sources. It has been alleged that a large amount of renewable electricity supply could become unmanageable because it depends strongly on uncontrollable environmental parameters such as wind speed or irradiance, which may vary strongly with geographical location or time (during same day or seasonal variations) (Prescott, 2004). Nevertheless, contrary to these allegations, a larger input of renewable energy, in particular from wind and photovoltaic sources in a given geographical region of large enough size can have a stabilizing effect to the grid (Chu, 2012), even for PV-only integration (Lund, 2006; Marcos, 2012). In order to benefit from this complementarity, a careful selection of the best location for installing the energy system is required.

The search and selection of optimal locations to install renewable energy facilities, requires not only to have an advisory group able to assess and analyze alternatives, but also to apply a set of tools and methods to facilitate the decision making process (Pohekar & Ramachandran, 2004). The problem of selecting the optimum location for renewable energy facilities is a complex problem because it needs to handle a great variety of criteria of different nature and origin, as well as to evaluate, in most cases, a large number of alternatives. For this purpose, Multicriteria Decision Methods (MCDM) (Roy, 1968; Saaty, 1980; Hwang & Yoon, 1980) are the main methods to tackle this type of problems (Al-Yahyai, Charabi, Gastli, & Al-Badi, 2012) by combining them, on the one hand with Geographical Information Systems (GIS) (Janke, 2010; Van-Haaren & Fthenakis, 2011) that will be used as support database to our problem, and on the other hand, with Soft Computing (Zadeh, 1994) tools applied to the own decision methodologies which gives them the uncertainty modeling and vagueness typical of the data used in this type of problems.

Once the first step of selection of the optimum location is accomplished, it is necessary to monitor the environmental parameters (or access to databases) which provide a measure of the potential renewable energy resource is required. From this data, simple models to calculate the electricity output provided by the technology of choice can be easily implemented, thus completing the required amount of information before taking any decision about the final installation of the energy systems, which usually involves a large economic investment.

For the particular case study proposed in this chapter, a combination of multicriteria decision methods with GIS as support database and Soft Computing, specifically the Fuzzy Logic (Zadeh, 1965) and

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simple analytical modelling implemented in MatLab-Simulink will be applied for searching optimal locations to implant wind and photovoltaic solar farms in Murcia and evaluate the impact on the stability of the grid provided a few of this systems are connected to the grid. The first step is therefore to select the optimum locations, then the required input parameters for the modeling will be gathered and finally the simulated output of the impact on the grid will be calculated and presented.

BACKGROUND

In engineering projects related to renewable energy facilities, as in any engineering project in general, decision making is an essential intellectual activity that needs to be carried out before any investment is done. Within the broad field of decision making support tools, appropriate methodologies must build and developed in the scientific area in which the question arises to be solved (San Cristobal, 2011). Although various decision support methods were developed in the 90s (Huang, Poh, & Ang, 1995; Georgopoulou, Lalas, & Papagiannakis, 1997), it was not until the beginning of the 2000s when studies in the field of renewable energy and multicriteria decision methods (MCDM) were extended as a result of the implementation of an enabling legislative framework. The PROMETHEE II method was used to investigate and evaluate the exploitation of geothermal energy sources in an island of Greece (Haralambopoulos & Polatidis, 2003), where different multicriteria decision methods were analyzed and evaluated (PROMETHEE, ELECTRE, AHP, MAUT, etc.) with the purpose of conducting an energy planning project (Pohekar & Ramachandran, 2004). Different technologies of solar thermal concentrators were evaluated using the PROMETHEE method (Cavallaro, 2009). The Fuzzy AHP method was used to select the most reliable projects using hybrid systems combining solar and wind power technology (Chen, 2010) or also across the combination of fuzzy variants of TOPSIS and AHP methods has been possible to evaluate different technologies of manufacturing solar photovoltaic cells (Garcia-Cascales, Lamata, & Sánchez-Lozano, 2012).

This brief summary demonstrates the advantage of using MCDM in the renewable energy field. Furthermore, in a problem as the one analyzed in this chapter, additional variables may hinder the execution and expansion of any energy facility (available surface, proximity to populated areas, distance to grid, etc…); the problem must be oriented to the optimization of the future facility taking into consideration this broad set of parameters, most of them linked to a particular geographical location. It is therefore important to consider Geographical Information System (GIS) tools for the correct gathering, analysis and visual presentation of the data and results of the calculation (Uyan, 2013). The success of the combination of GIS and MCDM systems is based upon the complementarity of both kinds of computational tools: GIS offers the decision maker the possibility to gather, store, manipulate and visualize in a direct manner any geographical information set, which in combination with the MCDM allows the user to organize and evaluate the different options presented before them (Malczewski, 1999). Since the first studies, the combination of GIS with MCDM have been used in a large number of analyses involving territorial planning such as urban layouts and infrastructure distribution (Joerin, Thériault, & Musy, 2001; Chang, Parvathinathan, & Breeden, 2008; Sadeghi-Niaraki, Varshosaz, Kim, & Jung, 2011; Coutinho-Rodriguez, Simao, & Henggeler-Antunez, 2011); but also applications with a special focus on renewable energies (Voivontas, Assimacopoulos, & Mourelatos, 1998; Baban & Parry, 2001; Amador & Domínguez, 2005), such as the studies in Georgia (USA) related to the evaluation of tidal energy by combination of GIS and MCDM (Defne, Haas, & Fritz, 2011). Oman, Charabi and Gastli (2011) analyzed the opportunity

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to install photovoltaic plants by a combination of GIS and fuzzy MCDM (OWA method). In an Italian region, GIS and AHP methodology was used to evaluate the convenience of installing a biomass facility (Zubaryeva, Zaccarelli, Del Giudice, & Zurlini, 2012). In order to evaluate the best location for photovoltaic solar plants in South Spain, GIS have been used in combination with the AHP method (Arán-Carrión, Espín-Estrella, Aznar-Dols, Zamorano-Toro, Rodríguez, & Ramos-Ridao, 2008) or with both AHP and TOPSIS (Sánchez-Lozano, Teruel-Solano, Soto-Elvira, & García-Cascales, 2013).

The Distributed Generation (DG) of electric energy has become part of the current electric power system; it consists of generating electrical power near the consumption area, breaking with the traditional concept, in which generation and consumption areas are far away from each other (Peças-Lopes, Hatziargyriou, Mutale, Djapic, & Jenkins, 2007; Ackermann, 2007; Ackermann, Andersson, & Söder, 2001) The future of power supply system could be composed by a great quantity of low voltage small grids interconnected through the distribution and transportation systems. On the other hand, energy and ecological issues such as the oil crisis, climate change and the high power supply demand around the world have increased the need of new energy alternatives. In this context a new scenario is arising in which very small energy sources make up a new supply system at local level: the Microgrid, which are small-scale supply networks with combined heat and power energy sources used to feed electrical loads and supply heat demand for a small community such as a suburban town, or an academic or public community such as a university or college, a commercial area, an industrial site, a set of stores or a municipal region; this approach usually employs Microsources or small generators which may be renewable or non-renewable Distributed Energy Sources (DER's) which inject power into the local grid at low voltage (Tan, Hassan, Majid, & Abdul Rahman, 2013).

The use of this kind of power supply sources would not only guarantee its quality and reliability, but also a more efficient use of natural resources. Likewise, the amount of DG sources directly connected to the distribution network will be increased actively. The profits associated to the Microgrid concept are clear. On the one hand, an improvement of the efficiency in energy transportation (reduction of energy losses) is achieved, when it is brought near the generation and consumption points. On the other hand, the electricity generation with low or null emissions of CO_2 and SO_2 to the atmosphere is possible, achieving a more responsible use of the available natural resources. And last but not least important merit of Microgrids comes from the inherent redundancy of generation systems, a fact that predicts that future power systems will be more robust and safer from eventual faults in the electrical supply system.

In the last years, different Microgrid management structures have been proposed. In them, various aspects have been outlined, but few works address the problem in all its extension. Most recent research projects show the technical difficulty of controlling the operation of Microgrid, because they are complex systems in which several subsystems interact: energy sources, power electronic converters, energy storage systems, loads and the grid (Hadjidemetriou, Kyriakides, & Blaabjerg, 2013). The implications for the control of the Microgrid derived from the transition between both operation modes will be considered. Important contributions are expected about the control of power electronic converters operating in Microgrids, as well as about the power system management.

The technical challenges associated with the operation and control of Microgrids are immense. Effective energy management within Microgrids is a key to achieve vital efficiency benefits by optimizing production and consumption of heat, gas and electricity (Foote, Burt, Wasiak, Mienski, Pawelek, Gburczyk, & Thoma, 2008). The coordinated control of a large number of distributed sources, possibly with conflicting requirements and limited communication is a very challenging problem imposing the adoption of distributed intelligence techniques. Furthermore, the management of instantaneous active

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and reactive power balances, power flow and network voltage profiles imposes unique challenges in the context of Microgrids.

Traditionally, power grids are supplied by sources having rotating masses and these are regarded as essential for the inherent stability of the systems. In contrast, Microgrids are dominated by inverter interfaced distributed sources that are inertia-less, but do offer the possibility of a more flexible operation. A further particular problem of Microgrids is the relatively high resistance of the low voltage networks. The amount of voltage drop on any RL circuit is approximately obtained by PR+QX, P and Q being the active and reactive power flow, R and X the resistance and reactance of the circuit. In general, high voltage of medium voltage networks, R is much lower than X, so that the injection of reactive power critically affects voltage drops. Active and reactive power effects are reasonably decoupled and this is the basis of several analytical techniques, like the fast decoupled load flow. In underground low voltage networks on the other hand, R is much higher, it can be three times higher or at least equal to X. This results in strong coupling of real and reactive power, and hence the control of voltage and frequency can no longer be considered separately.

Besides being complex and dynamic systems, power grids are sensitive systems that are affected by various eventualities which can range from operating errors to the connection and disconnection of loads. This fact demonstrates the need for continuous network monitoring to ensure correct operation of the power converter, and shows that there is an interactive relationship between the power converter and the network, so that may have an active role in provide the voltage and frequency to the system. For this reason, many international grid codes have been in force during the last few years in order to regulate the behavior of photovoltaic and wind energy systems in both regular steady-state and abnormal transient conditions.

The signals describing the grid status are essential at all times when the network is interconnected with renewable energy sources, since doing so the boundary conditions is established within which the signal must remain the voltage and often when photovoltaic cells and wind generators are connected to the network. Thus the information obtained in the process of network monitoring, updated at all times, must have accurate information of network status, and an adaptive process by which signals internal references are generated by the algorithm control of the power converter connected to the network are carried network variables, and these in turn led to the line variables. In order to identify quickly and accurately its work, synchronization algorithms must meet response requirements accurately and time, so that when the power converter is connected to the network so both work at unison. At present there are a variety of timing algorithms. However, among the most prominent are the PLL, dq-SOGI, Double and Multiple-SOGI.

Finally, we summarise in a few points the main advantages of using a Microgrid approach for the reliable supply of energy with a strong input from renewable sources. In addition to several advantages provided by conventional power systems, the following technical, economic and environmental benefits have led to gradual development and integration of DG systems:

1. Due to rapid load growth, the need for augmentation of conventional generation brings about a continuous depletion of fossil fuel reserve. Therefore, most of the countries are looking for non-conventional/renewable energy resources as an alternative.
2. Reduction of environmental pollution and global warming acts as a key factor in preferring renewable resources over fossil fuels. As part of the Kyoto Protocol, the EU, the UK and many other countries are planning to cut down greenhouse gas (carbon and nitrogenous by-products) emis-

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sions in order to counter climate change and global warming. Therefore, they are working on new energy generation and utilization policies to support proper utilization of these energy sources. It is expected that exploitation of DERs would help to generate ecofriendly clean power with much lesser environmental impact.

3. DG provides better scope for setting up co-generation, trigeneration or CHP plants for utilizing the waste heat for industrial/domestic/commercial applications. This increases the overall energy efficiency of the plant and also reduces thermal pollution of the environment.
4. Due to lower energy density and dependence on geographical conditions of a region, DERs are generally modular units of small capacity. These are geographically widespread and usually located close to loads. This is required for technical and economic viability of the plants. For example, CHP plants must be placed very close to their heat loads, as transporting waste heat over long distances is not economical. This makes it easier to find sites for them and helps to lower construction time and capital investment. Physical proximity of load and source also reduces the transmission and distribution (T&D) losses. Since power is generated at low voltage (LV), it is possible to connect a DER separately to the utility distribution network or they may be interconnected in the form of Microgrids. The Microgrid can again be connected to the utility as a separate semi-autonomous entity.
5. Stand-alone and grid-connected operations of DERs help in generation augmentation, thereby improving overall power quality and reliability. Moreover, a deregulated environment and open access to the distribution network also provide greater opportunities for DG integration. In some countries, the fuel diversity offered by DG is considered valuable, while in some developing countries, the shortage of power is so acute that any form of generation is encouraged to meet the load demand.

Within this approach of production and transmission of electricity, a new renewable energy market can be developed; despite representing only 2% of global energy consumption in 2013, it has received a strong investment increase, for example up to 1470 billion according to the International Energy Agency (IEA 2012), and therefore solar photovoltaic installed capacity has grown by 100 GW, and wind by 283 GW in 2013 worlwide, thus demonstrating that they could become a clear replacement for fossil and nuclear at medium term.

In this regard the European Union (EU) outlines 3 main objectives to follow (European Commission, 2013):

- Reduce the emission of green-house gases (GHG) by 20% by 2020.
- Improved energy efficiency by 20% by 2020.
- Increasing diversification of renewable energy production and exchange among their sources in order to achieve optimal performance.

So under the new vision system generation and transmission of electric power system has experienced in recent years a large number of sources of DG connections to the distribution network at Medium Voltage (MV), which have been able to be carried out by the recent technical advances in the DGs and meet specific characteristics that enable connection to distribution networks Low Voltage (LV) (Veeranna, 2012; Guo, 2013; L'AAbbate, Fulli, & Starr, 2007; Peças Lopes, Madureira, & Moreira, 2013).

In this chapter, a GIS methodology will be used as a first step to create a database of locations available to host photovoltaic plants and wind facilities. In a second stage, those locations will be evaluated

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using a fuzzy TOPSIS method, for which the weights of the criteria to be used had been previously obtained using a fuzzy AHP method. Back to GIS, the average temperature, irradiance and wind speed for the selected locations will be gathered and used in the final stage in which the impact of connecting the facilities to the local grid is evaluated. These final results will also provide additional information to a decision maker, and therefore can also be considered as a part of the multi-criteria decision method, although at this stage of the study there is no feedback of these results to the fuzzy AHP methodology used in the previous stage.

SOFT COMPUTING AND STANDARD MODELLING FOR THE SIMULATION OF RENEWABLE POWER GENERATION

The methodology of the study is based on a combination of soft computing tools used for the selection of the optimum locations for wind and photovoltaic systems and conventional modelling (based on Matlab-Simulink) which is used to calculate the impact on the grid from the injection of power from these systems; this impact is obtained from real-time simulation of control electronics and a statistical analysis of voltage, current and phase injected to the grid. The starting point for this kind of studies is the selection of the best geographical locations to install the renewable energy systems under consideration (in this case, wind and photovoltaic). For this purpose, the use computational tools such as Geographical Information Systems (GIS) are required. In order to evaluate the best location a large amount of variables and criteria need to be analyzed and evaluated and therefore Multi-criteria Decision Methods (MCDM) are required; usually these variable and criteria can be very different from each other, including their qualitative or quantitative nature, with different degrees of definition, including uncertainty, which makes compulsory the use of techniques of Soft Computing and in particular fuzzy logic. In a second stage, conventional simulation tools are used to calculate the impact on a local Microgrid of the electricity injection from a few selected sources. The impact is statistically evaluated using the voltage and frequency of the grid during a certain time span.

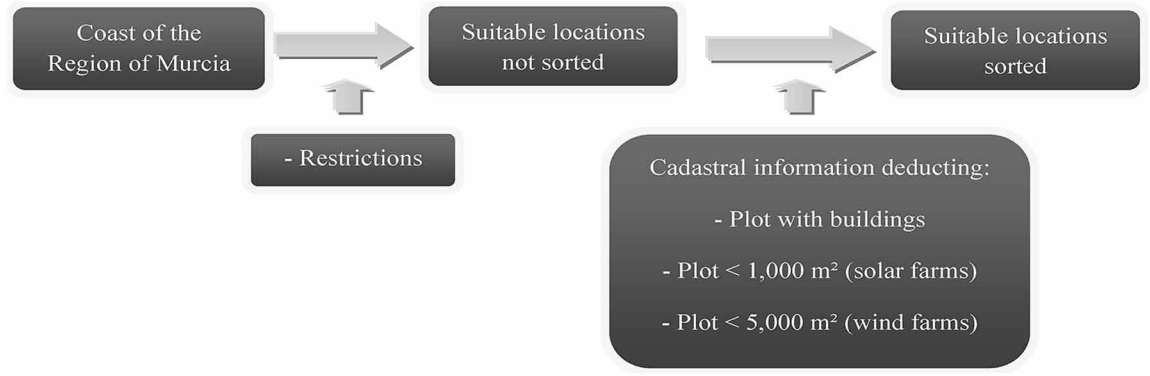
1. GIS System Data Gathering and Evaluation of Optimum Locations for Photovoltaic and Wind Technologies

Geographical information systems (GIS) are computing tools which allow to present the real world through georeferenced information, this information is expressed quantitatively as a set of numbers which can be visually represented as different thematic layers and can be superimposed creating specific representations of a given geographical area (specific surface).

The GIS software used in this chapter is gvSIG (www.gvSIG.org), this tool enables the incorporation of different layers of the same geographical area, each layer containing specific information which can also include legislative regulations regarding restrictions to the installation of photovoltaic or wind facilities (for example to avoid specific environmental impacts on protected areas). The restricted areas will be excluded from the final layers that in the next step will be analyzed and evaluated; a further restrictive processing is applied using information from administrative registrars which makes impossible the construction of the planned facility (for example because there exist a previous building in the same location), finally, only areas which provides a minimum of $1000m^2$ for photovoltaic facilities or $5000m^2$ for wind facilities have been considered (see Figure 1 for a description of the area selection procedure).

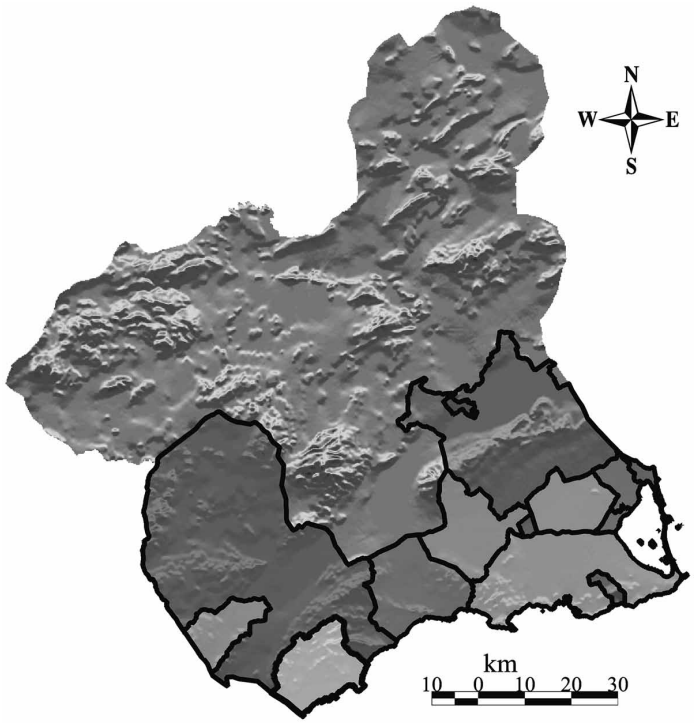
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Figure 1. Process scheme



Search for feasible locations. Restrictions and criteria. Coastal areas within Región de Murcia (Southeast Spain) are the geographical area under consideration in this study. The total area is composed of 13 municipalities, comprising a total of 4,456.59km^2. From the administrative office (Consejería de Obras Públicas y Ordenación del Territorio) a GIS layer was obtained which contained the whole area (Figure 2). The restrictions defined in Table 1 were applied to this initial layer; the restrictions comprise areas in which legislative regulation or geographical characteristics (watercourses, roads, etc.) make impossible the construction of the facilities, all these restrictions can be described using GIS layers that can be worked out using the gvSIG software, which allows us to "extract" the different restrictive layer from

Figure 2. Coast of the Region of Murcia



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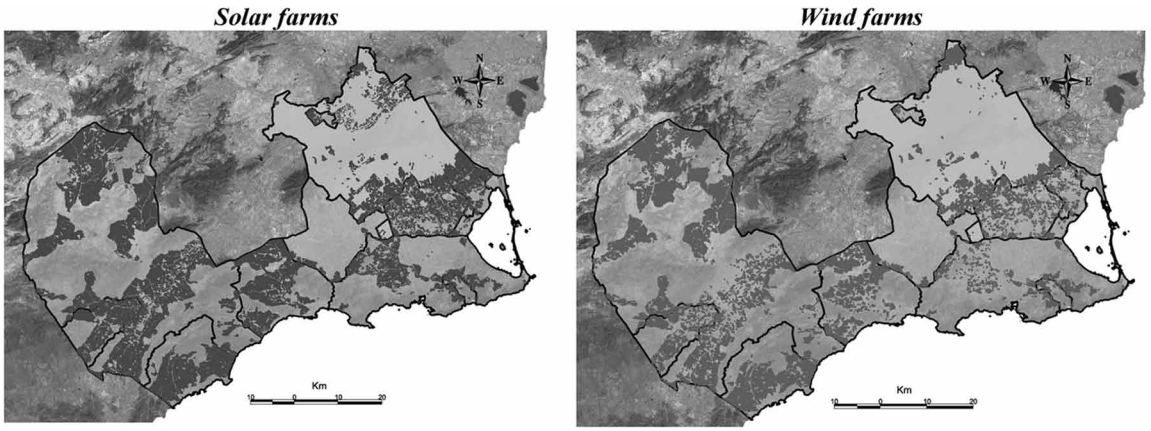
Table 1. Legal Restrictions for implant solar farms

N.	Denomination of the Restrictions
1	Urban, protected and undeveloped lands
2	Areas of high landscape value, water infrastructure, military zones and cattle trails
3	Watercourses and streams
4	Archaeological, paleontological sites and cultural heritage
5	Roads and railroad network
6	Community interest sites (LICs)
7	Areas of special protection for birds (ZEPAs)
8	Mediterranean coast and mountains

the original layer and apply the additional size criteria mentioned above (1000m^2 and 5000m^2 minimum size for PV and wind respectively), thus providing a final GIS representation including all relevant information linked to a particular geographical location and allowing a quick and visual representation of the information (Figure 3)

This stage provides an extensive database with contains all relevant data for a particular location. From bibliographic references the best criteria and its hierarchical organization that needs to be used in order to define the optimum location for a PV or wind facility is obtained as shown in Figures 4 and 5 respectively (Janke, 2010; Gastli & Charabi, 2010; Jo & Otanicar, 2011; Al-Yahyai, Charabi, Gastli, & Al-Badi, 2012). These criteria are introduced as GIS layers in gvSIG thus providing a large database containing 66,845 alternatives (viable locations) for photovoltaic plants and 33,290 alternatives for wind facilities. Each alternative is defined by its cartographic information (coordinates, municipality, administrative plot and subplot) and by a value which is assigned to each of the criteria described in Figures 4 and 5.

Figure 3. Suitable locations in the coast of Murcia



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Figure 4. Hierarchy of criteria in solar farms

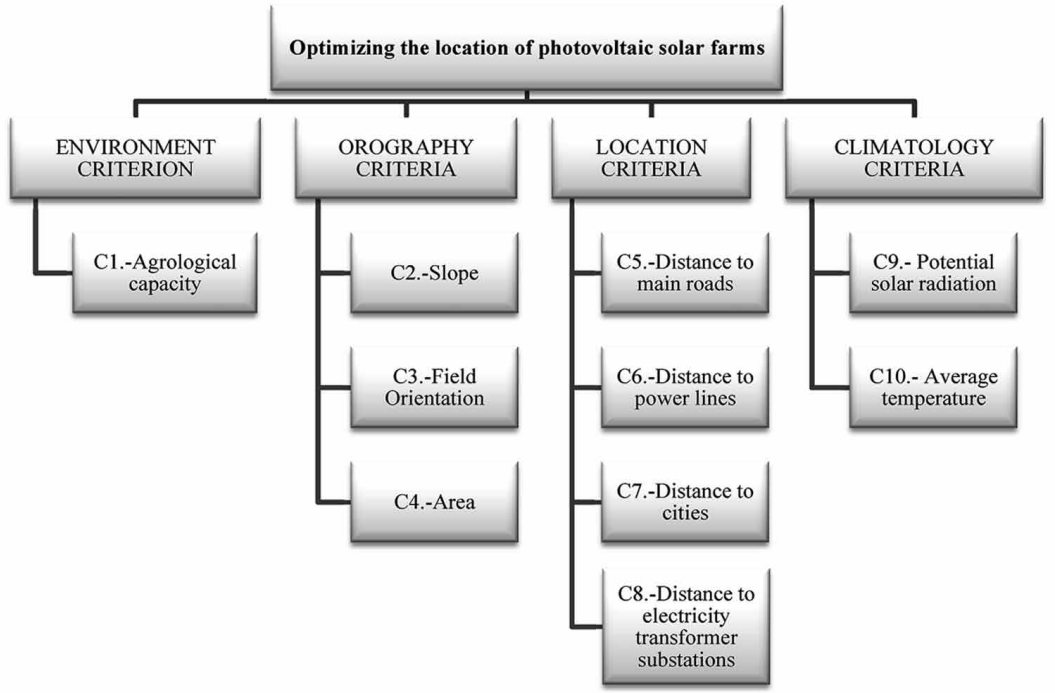
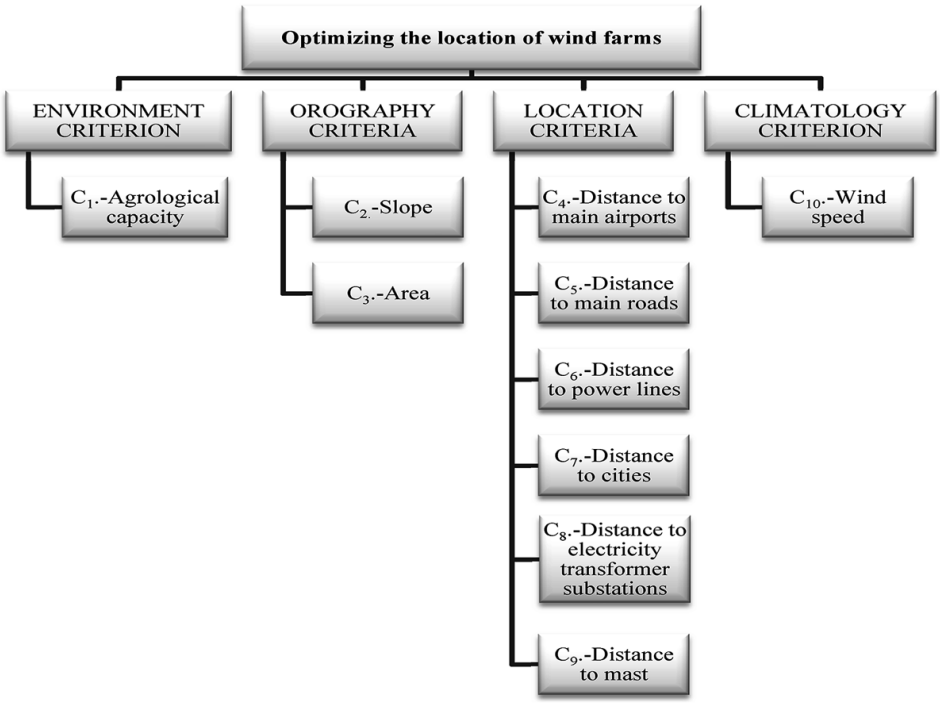


Figure 5. Hierarchy of criteria in wind farms



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1.1. Multicriteria Decision Making

Using the gvSIG software two decision matrixes are created (one for each technology: PV and wind) which are composed by a given number of alternatives (the viable locations) as a function of ten criteria that may influence the decision maker. This is therefore a multicriteria decision making problem (MCDM) (Chen & Hwang, 1992; Hwang & Yoon, 1981; Keeney & Raiffa, 1976; Luce & Raiffa, 1957), where it is sought to choose the best alternative A_i, $i=1,2,\ldots,n$ with $n\geq 2$ when considering the criteria C_j, $j=1,2,\ldots,m$ with $m\geq 2$ and experts E_k, $k=1,2,\ldots,r$ with $r\geq 2$; it is considered that n, r and m are finites. In order to solve this particular problem, the fuzzy version of the TOPSIS method will be used to evaluate the alternatives (Hwang & Yoon, 1981) and the AHP methodology will be used to determine the weight of each criteria (Saaty, 1980).

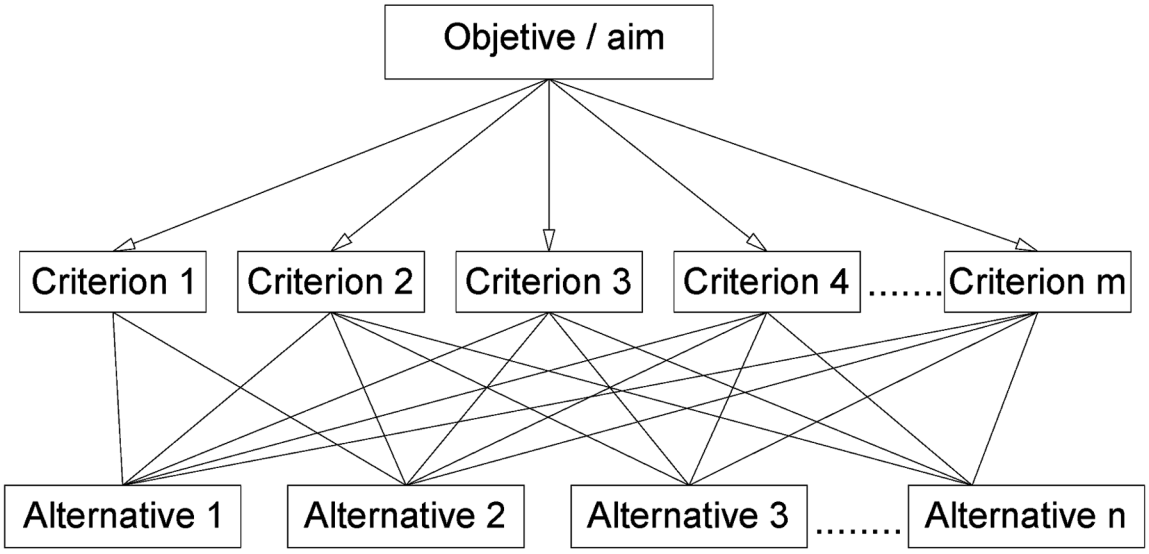
1.1.1. The AHP Method

The AHP method was proposed by Saaty in 1980 and it is based on the idea that a decision making problem with multiple criteria can be solved by the ranking of the proposed problems i.e. it consists of an alternative selection method based on a number of criteria which are often in conflict.

The main feature of the AHP method is that the decision problem is modeled using a hierarchy whose apex is the main objective of the problem, and the possible alternatives to evaluate are situated at the base, the intermediate levels correspond to the criteria/subcriteria based on which a decision is made (Figure 6.).

At each level of the hierarchy, comparisons are carried out between pairs of elements of that level, based on the importance or contribution of each element of the upper level to which they are linked. The target in the case under study is the optimal location of sites for solar photovoltaic and wind farms, and specifically in determining the weight or coefficient of importance of the intermediate levels of the hierarchy i.e., the criteria that influence the decision (Figures 4, 5). For this purpose the collaboration

Figure 6. AHP Hierarchy process



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of a group of experts was required, the method used to obtain the information is a pseudo-delphi, in which the actors do not interact; since the criteria comprise data of different nature (quantitative and qualitative), the information from the experts was defined using linguistic labels (Delgado, Verdegay, & Vila, 1992), being the triangular fuzzy numbers the option chosen to represent the information (Herrera, Alonso, Chiclana, & Herrera-Viedma, 2009; Klir, 1995; Zadeh, 1965; Zadeh, 1975).

The weights of the criteria will be determined by pair-wise comparison among criteria. As a result of the data collection process defined in (Sánchez-Lozano, Teruel-Solano, Soto-Elvira, & García-Cascales, 2013; Sánchez-Lozano, García-Cascales, Lamata, & Sierra, 2013), a total of (*n-1*) comparisons will be required. The labels used and their meanings are shown in table 2.

The weight of the criteria used to evaluate each of the alternatives was obtained by fuzzy AHP methodology for both PV and wind facilities as shown in Table 3.

Table 2. Scale of valuation in the pair-wise comparison process (Saaty, 1980)

Labels	Verbal Judgments of Preferences Between Criterion i and Criterion j	Triangular Fuzzy Scale and Reciprocals
(II)	Ci and Cj are equally important	(1, 1, 1) /(1,1,1)
(M+I)	Ci is slightly more/less important than Cj	(2, 3, 4)/(1/4,1/3,1/2)
(+I)	Ci is strongly more/less important than Cj	(4, 5, 6)/ (1/6,1/5,1/4)
(Mu+I)	Ci is very strongly more/less important than Cj	(6, 7, 8)/ (1/8,1/7,1/6)
(Ex+I)	Ci is extremely more/less important than Cj	(8, 9, 9)/ (1/9,1/9,1/8)

Table 3. Weight of criteria for location of solar and wind farms

Criteria	Criteria Weights (Triangular Fuzzy Numbers)					
	Location of Wind Farms			Location of Solar Farms		
	Fuzzy Weight			Fuzzy Weight		
C_1	0.048	0.051	0.060	0.038	0.041	0.049
C_2	0.054	0.066	0.081	0.046	0.058	0.072
C_3	0.048	0.051	0.060	0.042	0.051	0.062
C_4	0.048	0.051	0.060	0.114	0.127	0.141
C_5	0.054	0.066	0.081	0.042	0.049	0.059
C_6	0.054	0.066	0.081	0.124	0.144	0.177
C_7	0.054	0.066	0.081	0.172	0.185	0.193
C_8	0.054	0.066	0.081	0.145	0.168	0.187
C_9	0.048	0.051	0.060	0.109	0.119	0.129
C_{10}	0.429	0.463	0.483	0.044	0.053	0.067

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1.1.2. The TOPSIS Method

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) by Hwang and Yoon (1981), combines the use of the ideal solution, the anti-ideal solution or a mixture of both solutions (Figure 7).

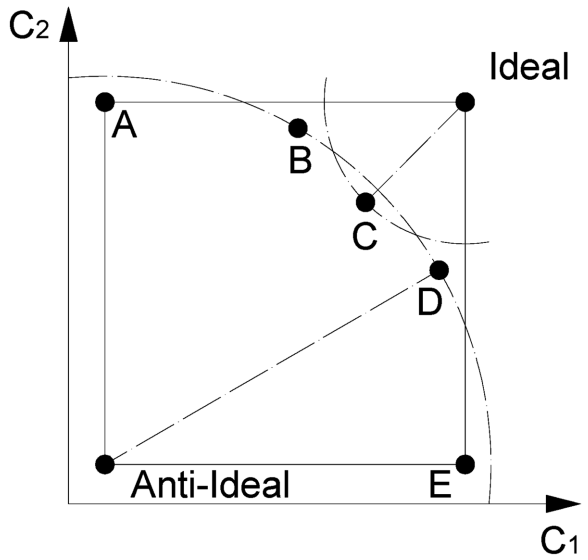
The algorithm is presented in Figure 8.

Since the criteria are defined by triangular fuzzy numbers, the TOPSIS method should be able to deal with this kind of information, furthermore, in the final layer, the best alternatives are sorted decreasingly according to a fuzzy number $\overline{R_i}$. For sorting the $\overline{R_i}$, they are first defuzzified using the following procedure (García-Cascales, & Lamata, 2007):

$$I_{1/3,1/2}\left(A_i\right) = \frac{1}{3}\left(\frac{a+4b+c}{2}\right) \tag{1}$$

The defuzzified $\overline{R_i}$ values play the role of a score that allows the decision maker to rank the alternatives. Once the defuzzification process has been carried out during the application of the decision making, each of the alternatives will get a score, named "R coefficient" which allows the decision maker to evaluate the different alternatives. 66,845 alternatives were evaluated for the PV facilities and 33,290 for the wind facilities using the fuzzy TOPSIS methodology which provides an *R* coefficient for each of the alternatives. All the obtained values were classified within four sets of results as a function of its reliability to be used as a location for a PV or wind facility; this grouping enables an easy visual representation using a color code: blue-excellent, green-very good, yellow-good and red-poor (Figures 9 and 10).

Figure 7. Ideal vs non-ideal alternatives (Cables, Garcia-Cascales, & Lamata, 2012)



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Figure 8. TOPSIS algorithm

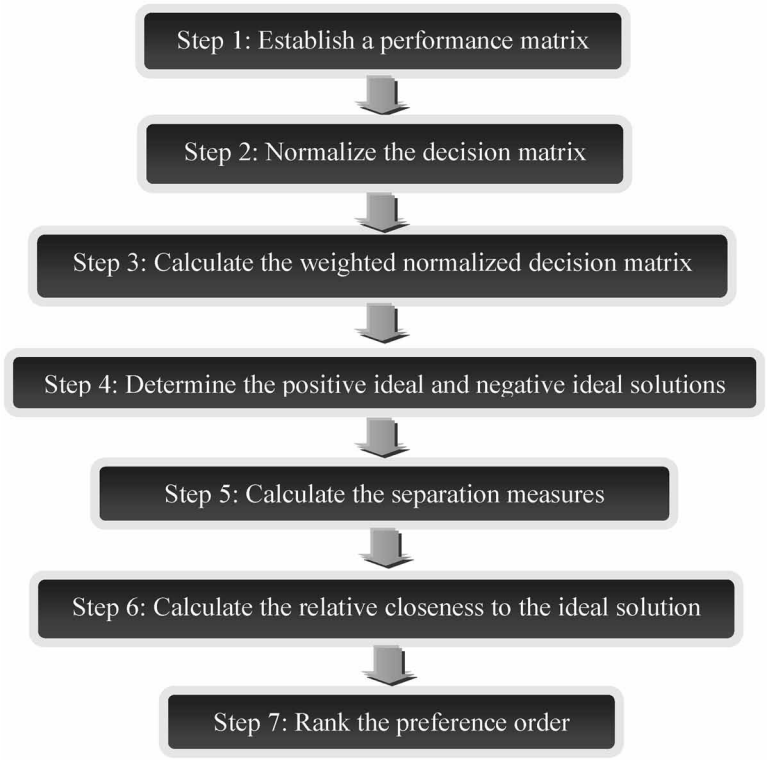
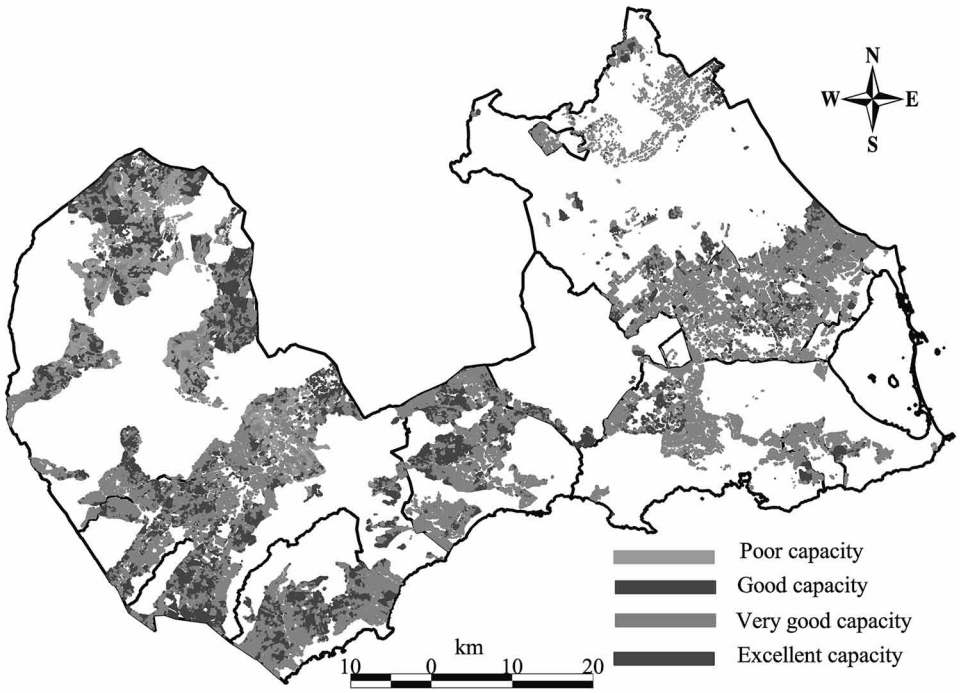
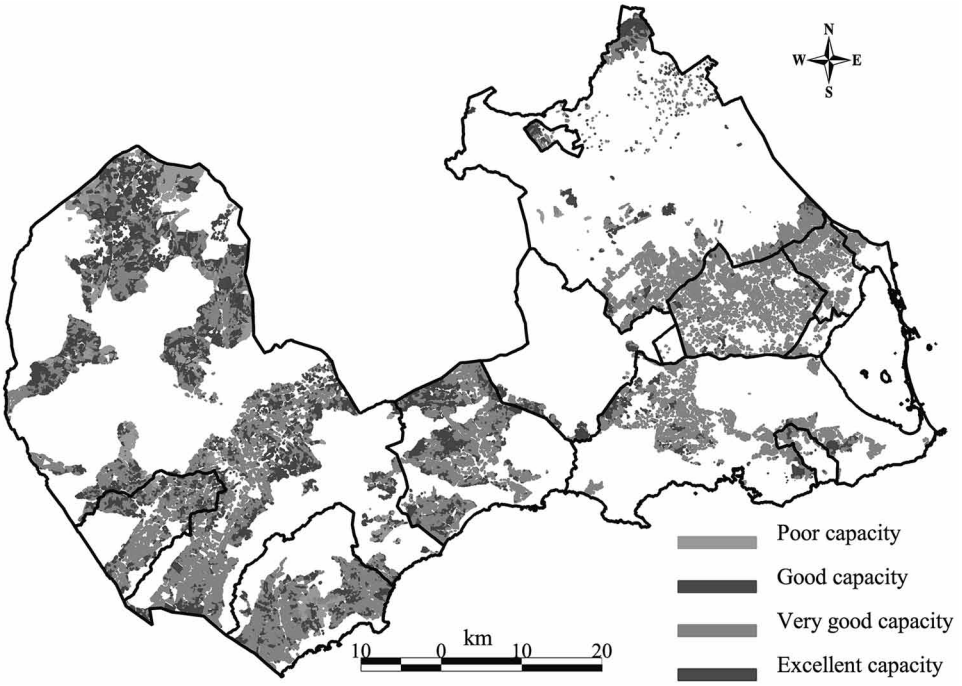


Figure 9. Map of the capacity to accommodate solar farms on the coast of the Region of Murcia



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Figure 10. Map of the capacity to accommodate wind farms on the coast of the Region of Murcia



From the overall classification of the more suitable locations for photovoltaic and wind facilities in the coastal areas of Region of Murcia, the best three locations for each of them are selected for the collection of environmental parameters that will be required for the simulation of the electricity production in such locations (and its impact on grid stability). The best PV locations are presented in Figure 11 and the best wind locations are presented in Figure 12.

2. Modeling the Generated Output from Wind and PV Systems

The methodology applied in the second part of this study is based on the simulation of expected power output from a network of solar photovoltaic and wind systems which are interconnected via controlled three-phase inverters and therefore constitute a Microgrid. The input data for the simulation will be real environmental parameters for the locations selected in section 1. The stability of the Microgrid will be evaluated in terms of frequency and voltage deviations as well as the number of generated harmonics. Al models will be implemented using Matlab-Simulink software.

In particular, the model of the plant consists on several blocks (see Figure 13): a) a block for generators or sources of energy, in this case, solar photovoltaic modules and wind turbines; environmental parameters are required to feed the block input tags. Photovoltaic and wind generators are both linked to a resistor and a pair of capacitors forming the generator circuit which comprises Resistor, Inductance and Capacitance (RIC); b) the bridge block which implements a universal three-phase power converter that consists of up to six power switches connected in a bridge configuration; different types of power switch and converter configuration can be implemented such as Source Voltage Inverter (VSI), IGBT-inverter, etc; the inverter is Pulse-Width Modulated (PWM) to produce a three-phase 50 Hz sinusoidal

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Figure 11. Three top-ranked locations for solar farms on the coast of the Region of Murcia

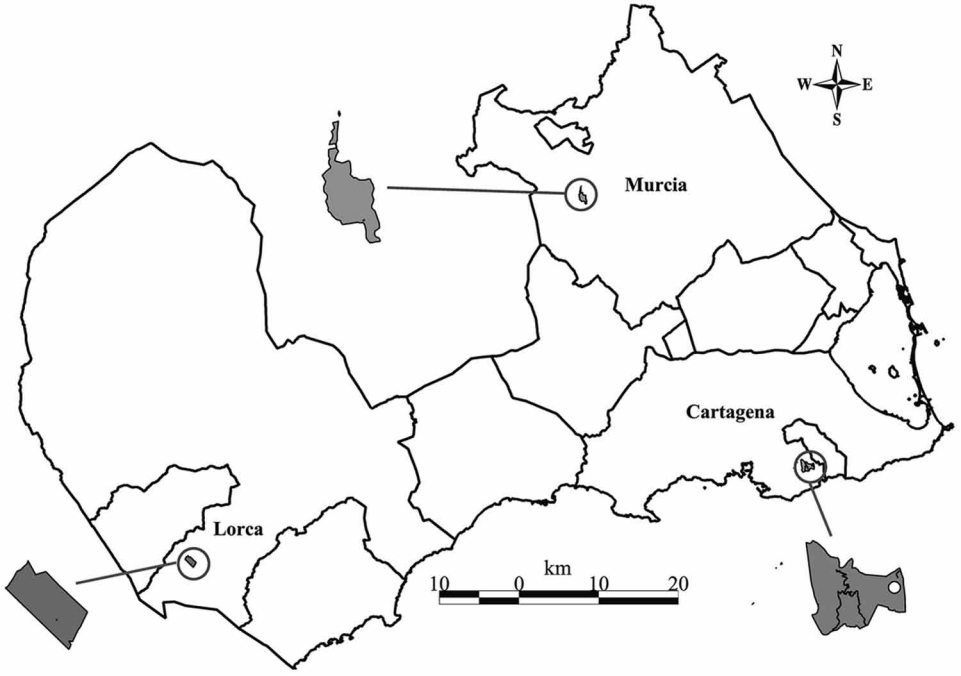
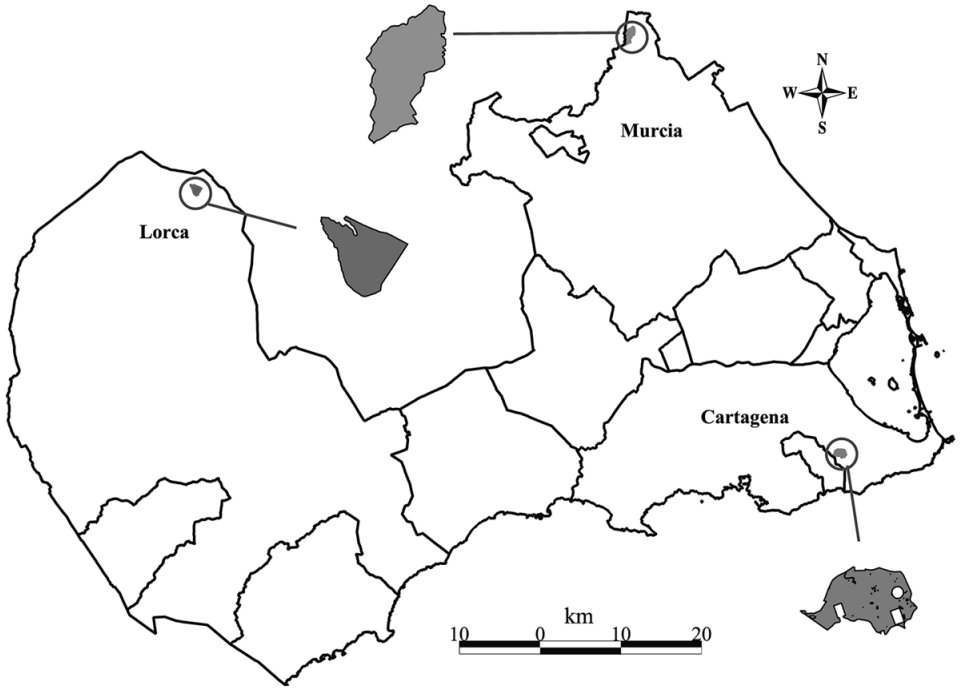
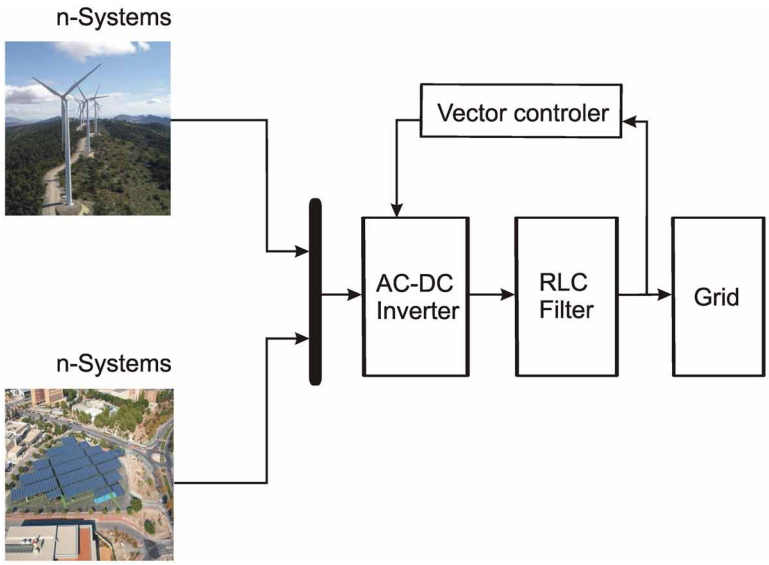


Figure 12. Three top-ranked locations for wind farms on the coast of the Region of Murcia



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Figure 13. Block diagram of the simulation stage which calculates the impact of N systems (PV or Wind) on the grid. It is illustrated with a picture of a PV system at University of Murcia and a Wind park in Yecla (Murcia). The environmental parameters are introduced as an input for the calculation of the renewable power injected to the grid through the different control blocks described in the text and schematically represented in the figure as a MatLab object oriented code



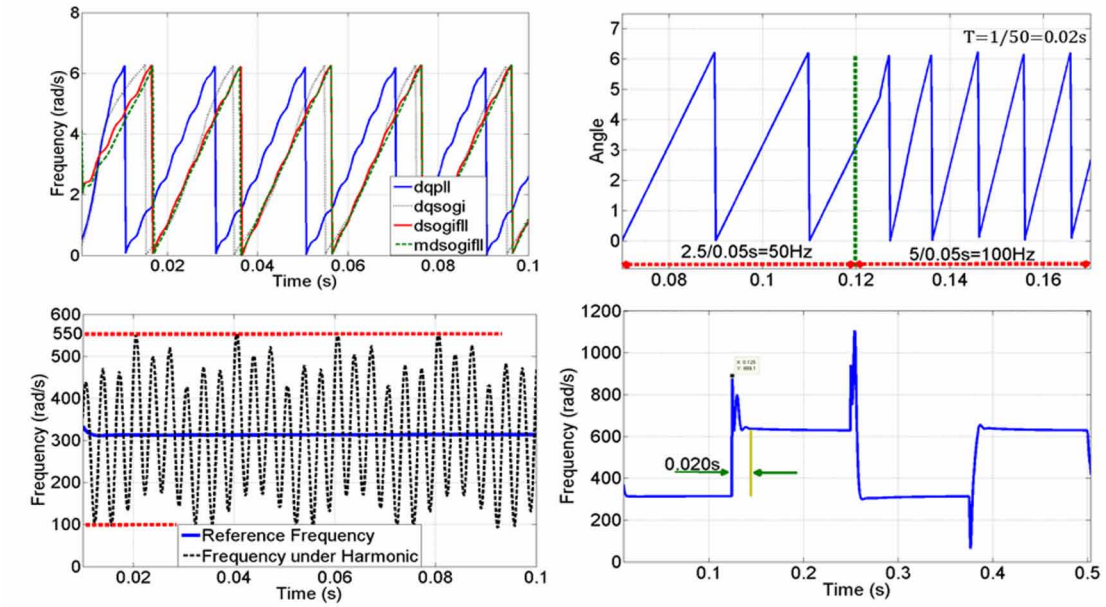
voltage to the load (Veeranna, 2012; Guo, 2013) c) a passive filter bank, with RIC in series and parallel, which eliminates the harmonics from lower to higher orders; d) a block that simulates the behavior of a utility grid with frequency variations, changes in voltages, through a pulse generator, and three-phase programmable voltage source; e) the control vector block which is intended to maintain the quality of the signal using for this purpose a voltage loop, which estimates the phase and frequency, and therefore controls the phase of the current, and a current loop, which compares the currents obtained in photovoltaic and wind generators with utility grid values (Li, 2011; Kahrobaeian, 2013) and finally, f) a Space Vector Modulation block (SVM) in order to maintain an optimum power factor (ϕ), and provide values for commutate sequence of the Source Voltage Inverter (VSI).

The stability of the grid has been evaluated using the frequency and voltage distortions as test parameters.

The model tracks the angle profiles of the network when it is connected to photovoltaic panels and wind generators. The results can be presented (Figure 14) as the evolution of the profile angle of the grid voltage and frequency phase using various synchronization algorithms, such as: dqPLL, dqSOGI, dSOGI, MDSOGI. The presence of harmonics is observed when they appear as the result of instantaneous perturbations to the network. In reviewing the performance of each of the synchronization algorithms, clearly dqPLL delivers a poorer performance when compared to the other algorithms, especially when the voltage signal is monitored: the voltage presents irregularities in the signal and a small time lag with respect to the signal obtained of the other algorithms. Similarly, for the bottom plots, the profile of grid voltage angle is presented. This profile grid angle has no harmonic but changes in the grid frequency are observed when a frequency step of 50Hz to 100Hz is applied at 0.12s.; the signal response of the

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Figure 14. Illustration of technical parameters used for testing the stability of the grid and the response to variable power input from renewable sources. Top: Synchronization phase profiles as obtained with the different synchronization algorithms (left) and the response to a change in frequency from 50Hz to 100Hz in 0.12s. (right). Bottom: Frequency variation to the presence of 5th and 7th harmonics (left) and 50Hz steps (right)

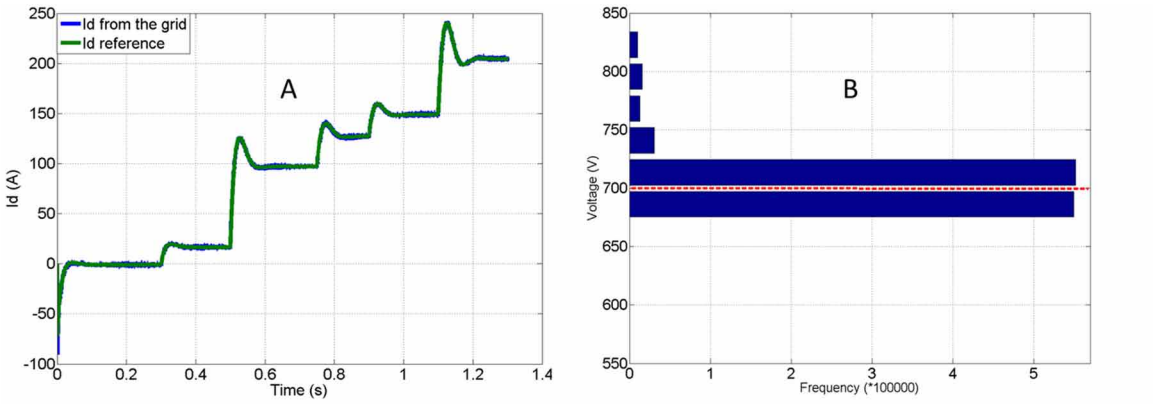


network frequency when the system is subjected to 5 and 7 harmonic is also illustrated in the bottom left plot. It can be noted that when the network is subjected to significant content of harmonic distortions (20%) the performance of the synchronization algorithm is key in maintaining stable benchmark values for voltage and frequency that have been specified in the design. Having a large presence of harmonics in the system values may shift the center frequency to which the algorithm was designed and the system is incapable of recovering bench mark values within a reasonable time delay. Finally, the last plot of Figure 14 (bottom right) shows the response of the synchronization algorithm and how the frequency varies when the system is submitted to a step frequency of 50Hz. Again, a small overshoot which has a retention time of 0.02s is present but very quickly returns to the correct value (in less than 200ms), any overshoot is completely smoothed within 500ms. Monitoring the network frequency signal by the synchronization algorithm is key in maintaining unity power factor which requires tracking the frequency signal at all times.

The aim of the control is to keep stable values for voltage and frequency of the grid even when the injection of power varies strongly in a brief period of time, as is typical of an intermittent power source as wind or PV. The behavior of the current injected to the grid (Id) varies and delivers the additional input of power that needs to match the demand of power delivered to a load connected to any other point in the grid. In Figure 15A, I_d is presented over time, and illustrates this effect: the I_d reference current

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Figure 15. A Current injected when several PV systems are connected simultaneously presenting a different power generation with variations within a few milliseconds. (The range of power is several kWp as shown in Figure 16), B Voltage signal statistics during a long time span (four months)



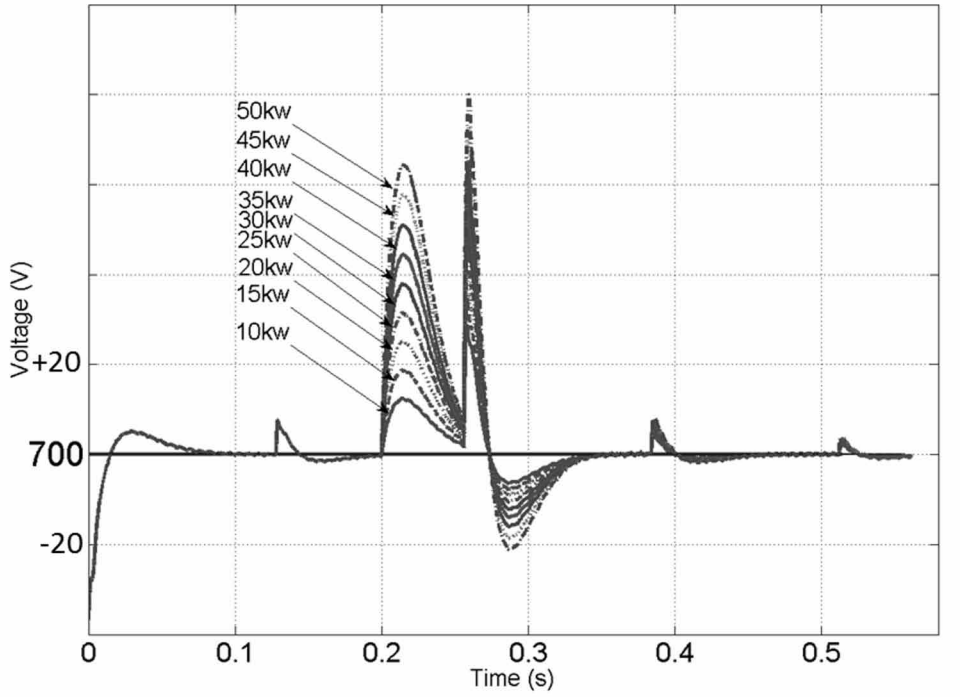
value changes, present slight overshoots upon addition of power, but the overshoot is quickly controlled returning the current I_d to the (new) correct value. It demonstrates a good match between the network synchronization algorithms in converter power and network power. This amount of current injected into the system is created by connecting the PV or wind systems to the network, they have a nominal capacity, but their real time power is changing as a response to the environmental value (irradiance and temperature for the solar panels, wind speed for the wind systems), this variation also comprises the intrinsic variation in parameters which arise from the location of the system in different geographical sites.

In Figure 16 the response of the voltage signal of the network when an additional instant power is supplied from solar panels and wind turbines scattered in the region is simulated. When injecting a variable voltage to the electricity grid, it suffers an "overpeak" voltage, which is higher when the injected power is larger. However, even though the system is subjected to a large increase in voltage, these values tend to return to the reference value of the signal, thus demonstrating that the gains of the PIs are in the appropriate design values. Random increases and decreases of power injection, even if displaced in time, creates a smoothing effect and allows the algorithm control to work more efficiently.

The histogram presented in Figure 15B shows the voltages over the course of four months simulated from environmental values used as input parameters for the simulation. Deviations appear both below and above the reference voltage value which is set to 700V. This fact means that even though in those four months the variability of generated power from wind and PV sources has been large, the voltage value of the Microgrid is always kept approximately equal to the reference thus indicating that the control of powers, currents, angles and voltages from the power inverter and its correction through the synchronization algorithm is being performed correctly. The remaining histogram bars indicates a trend in which values of the grid voltage are not symmetric, but deviates towards higher values; this is an expected behavior since the main problem with the variability of power injection to the grid is the overshoot of voltage values. Nevertheless, future improvement of the control algorithms and fine tuning of proportional, integral and derivative parameters of the control loop may reduce this spread in values.

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Figure 16. Grid voltage response to the injection of variable power arising from different PV facilities located in separated geographical locations (under distinct irradiance). The graph shows the response to steps up to 50kW, which in all cases are stabilized in less than 500ms



SOLUTIONS AND RECOMMENDATIONS

A set of optimum locations both for the installation of photovoltaic and wind systems have been found. Within this set, a few locations have been selected and data series of irradiance and wind speed have been provided in order to be used as input for the modeling using MatLab-Simulink as explained in section 2. The output of the model provides information about the stability of the Microgrids and its dependence with the number of systems interconnected and the variability of environmental parameters. Simultaneous modeling of photovoltaic and wind models using the real data series as input for the simulation has shown that distortions in the grid (defined as voltage and frequency deviations from the nominal 220V, 50Hz) can be minimized and that the geographical distribution of locations, even within the same Region de Murcia, together with the combination of two different technologies for the renewable electricity generation (photovoltaic and wind) creates a smoothing effect that helps to bound the expected distortions arriving from intrinsic variability of renewable sources. Anticorrelation of the output from the photovoltaic and wind systems have been observed when the data at analyzed at different time scales, this result is an indication of the complementarity of both sources of renewable electricity and it could help to minimize the distortions as well as to avoid the need of energy storage, since capacity back-up from other generators (ideally hydro) already installed should be enough to meet electricity demand in real time.

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FUTURE RESEARCH DIRECTIONS

Smarter distribution can be achieved through the fast control of hundreds of individual DER units. This would require real time information on each DER unit and key loads. The control complexity and reliability of such a system is greatly reduced using coupled Microgrids. First a systems consisting of many Microgrids does not need fast communication as discussed above and demonstrated at the AEP test site. Second any communication system would re-dispatch each Microgrid without needing detailed information on each DER unit. Recall that the basic smart distribution system objectives include improved reliability, self-healing, simplified controls and increased generation efficiencies through the use of waste heat. Improved reliability, simplified controls and increased efficiencies are imbedded in the basic Microgrid concepts.

CONCLUSION

The combination of Soft Computing and numerical modeling is a powerful tool to evaluate the performance of Microgrids in which several photovoltaic and wind systems have been connected. Optimum locations using Geographical Information System databases have been selected for the facilities and the simulation of electrical output using real environmental parameters for these locations have shows that distortions to the grid can be minimized. Integration of more systems into the grid and broader distribution of locations were the systems are operating may have an even greater smoothing effect.

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KEY TERMS AND DEFINITIONS

Analytic Hierarchy Process (AHP): A technique for organizing and analyzing complex decisions through hierarchical structures. It helps decision makers find one that best suits their goal and their understanding of the problem.

Fuzzy Logic: A form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets (where variables may take on true or false values) fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions.

GIS: A computer tool which is able to capture, store, analyze, manage, and present all types of geographical data.

MCDM: A set of methods for decision making in a process of selection on different alternatives, based on a set of criteria or points of view, to achieve one or more objectives.

Microgrid: A small scale electrical grid comprising power generators and loads which consume locally the generated electricity. The design of small, efficient, smart grids is a challenge, especially if they comprise renewable power sources. Depending of its size or the interconnection to larger grids, a Microgrid may require the inclusion of electricity storage means.

PV System: A photovoltaic system generates electricity from Sun light. It is composed of solar modules (or panels) and "balance of system" (BOS) components; the BOS may include electronic regulators and inverters, batteries, fixed or tracking mounting systems, etc… depending on the system design, which may be a stand-alone system, or a grid-connected system.

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Technique for Order Preference by Similarity to Ideal Solution (TOPSIS): A proposed decision model for sorting preferences by similarity to ideal solution. The basic principle of the method consists in finding an alternative whose distance from the positive ideal solution is less and whose distance from the negative ideal solution.

Wind System: A wind system generates electricity from wind. It is composed of a rotating aerogenerator which can be of horizontal (the most common) or vertical design, the aerogenerator is coupled to a dynamo which creates electricity from the mechanical motion. The system is completed by electronic systems to control the frequency and voltage of the electricity, which is in most cases fed into the grid.

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Chapter 28
Balancing Formalization and Representation in Cross-Domain Data Management for Sustainable Development

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ABSTRACT

Sustainable development is grounded in complex systems where phenomena and processes are so interrelated and intermingled that they can only be studied in a multiple disciplinary manner. Limitations in understanding such systems can be identified that are either epistemic and cognitive or socio-economic. Both cases are problematic for collaborative and multidisciplinary studies in sustainable development. This chapter explores these difficulties with a particular focus on data management, an activity that is at the same time very important and very sensitive to such problems. To allow users to find their way through data and information spaces, solutions are proposed that take advantage of either the formalization of knowledge; or of representations, such as schemas, mind maps or graphs. Through a careful balance of these two pathways this chapter demonstrates that it is possible to mitigate the difficulties mentioned above and allow a community to work together at profit.

INTRODUCTION

Sustainable development is the possibility to benefit from natural resources without incurring in their depletion or triggering negative side-effects in other domains. This dualism is also reflected in the United Nation's (UN) Sustainable Development Goals (UN resolution A/RES/70/1, 2015), where on one hand the UN lists goals such as end poverty and hunger or ensure healthy lives, while, at the same

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time, claiming that these have to be achieved ensuring conservation of the environment, ecosystems and combatting climate change and its impacts.

This balance is very hard to obtain because it is very difficult to understand all the aspects of the related processes and phenomena and it is very complicated to try to control them. Indeed in sustainable development, understanding is problematic because:

- The necessary skills and competences come from multiple disciplines such as biology, geology, sociology or economics
- Since multiple fields are involved, research projects in this area are very likely to be collaborative and cross-disciplinary
- Approaches and methods needed for sustainable development related to scientific fields are often not as rigorous as those needed in other domains such as for example computer science or engineering
- The need to collaborate with other people can introduce issues that range from simple misunderstanding, to lack of awareness, tacit knowledge, up to politics or rhetoric

It is important to understand that these effects are not due to insufficient efforts spent during coordination or managing of projects but to the intrinsic nature of knowledge, and its usage, in the domain of sustainable development. It is a cultural problem. To address such issues, therefore, instead of organizing the work within a "one-size-fits-all" manner that has been devised for other sectors, we need to develop strategies and perspectives focused on the specific case of sustainable development. In this chapter we will consider the case of data management, an activity where all the above mentioned issues very clearly emerge since data, and the information built on top of those data, are at the base of all sustainable development activity. In this sense it is possible to highlight the existence of a gap between what is required by stakeholders and what can be offered by experts. This is not only a gap but a structural difference. The main focus of stakeholders is on norms, decisions and protocols, while scientists offer observations and hypotheses.

The availability of data is therefore overwhelmingly important. It is necessary to enable information to be built from different perspectives and ways of thinking by actors with different point of views, approaches and aims. To facilitate this, data should be understandable by all the designated community.

To address all this we will, in this chapter:

- Describe the mechanisms that are at the base of the issues that limit and obstruct handling of such topics
- Introduce the concept of representation and its implication in data management and in particular in the case where contrasting cognitive models access the same representation
- Introduce the problem of formalization of knowledge that can be applied to assist data access and to frame collaborative research activities
- Discuss the advantages and disadvantages of formalization and how this can be put in practice and the tools needed
- Discuss whether knowledge can be exploited even without the need to formalize it; how this can be put in practice and the tools needed

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BACKGROUND

Sustainable Development

The Brundtland Commission's report (Brundtland, 1987) defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs". The main point of interest of such a definition is the connection between economic and social development, in particular for people with a low economic standard of living; and the importance of protecting the natural resource base and the environment. If the latter is jeopardized, no improvement can be obtained in economic and social well-being. In addition the exploitation of resources has to consider a long term perspective where the effects of development will condition the environment for future generations.

The study of processes and phenomena in this context is based on two pillars: the socio-economic; and the environmental. Authors such as for example Murphy (2012) highlighted that a specific focus has been put on the environmental side, while socio-economic factors were considered less relevant. On the contrary, they are very important and very complex to handle since they are dependent on the context and on the capacity of each country to respond to each its social problems.

The complexity of the matter was mirrored also in the progressive loss of enthusiasm and rise of scepticism that from the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, through the Johannesburg Summit lead to the current situation, where the focus moved from an all-encompassing attempt to address all issues simultaneously towards a more pragmatic approach where local and simpler issues are under examination.

Sustainable development is therefore a cross-domain field where researchers and stakeholders from different backgrounds, with different interests and different ways of thinking, meet. Processes and phenomena in sustainable development are, in short, complex systems.

MAIN FOCUS OF THE CHAPTER

Limitations of Reasoning in Sustainable Development

Complex systems are entities where multiple factors interact and intermingle at the same time. In these cases it is very difficult to isolate *a posteriori* the contribution that each of these factors might have exerted, while on the other hand it is important to identify them and understand how they can influence the whole system.

As mentioned above scientific disciplines involved in the study of sustainable development span a wide range, from environmental to socio economic studies. Practices, theoretical frameworks, even the mathematics used are often very distinct between disciplines. However, there is one common aspect that can be found in all these domains: the difficulty in providing exact quantitative, unbiased measurements. As a consequence, it is very difficult in the domain of sustainable development to apply what is generally understood to be the standard view of the scientific method. It should be noted that this does not apply only for "environmental related" disciplines, but maybe even more so in the case of socio-economic ones.

The standard view of the scientific method prescribes that scientific experiments should be reproducible, meaning that having set the same conditions we should get the same results. This rarely happens

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in environmental and socio-economic sciences since the factors governing a process and their interdependence are very sensitive to small variations (the so-called "butterfly effect"); they are generally nonlinear systems, so that it is very difficult to exactly replicate the configuration of an experiment. In these domains correlation often does not mean causation, highlighting the role of an underestimated parameter (Lawlor, Davey Smith & Ebrahim, 2004). In addition, laws are often built considering a low number of cases, or cases that only resemble what is under observation, which creates problems in finding analogies (Engelhardt & Zimmerman, 1982).

Another important factor which conditions the possibility to handle reliable measurements is theory laden-ness. This is the unintentional bias that researchers impose on measurements and observations. These latter are based on planned experiments that are based on one or more theories; meaning essentially to what someone is expecting to see. Therefore, quoting Hanson (1958)

Observation of x is shaped by prior knowledge of x.

This generally results in highlighting or neglecting information (Bishop, 1992) (see the section on representation later in this chapter). It is important to say that this happens at all levels, even at the level of perception (Diviacco & Busato, 2015).

The standard view of the scientific method is based on an inductive-deductive loop that from initial observations drives the formulation of a law that later through an experiment could be validated (or following Popper (1963), "corroborated"). It is easy to understand that in the domain of sustainable development, considering what has been said so far, the possibility to validate any theory through observations is very limited. To avoid the short circuit that this situation can generate, environmental and socio-economic sciences tend to substitute to the inductive/deductive loop with what Peirce (1958) called abduction. Abduction is a form of reasoning where the resulting state of affairs and the law is known, while the controlling state of affairs is sought (retrodiction). Abductive methods are very useful in the creation of new ideas[1].

Since abductive reasoning merely suggest that something maybe (Peirce, 1958) it is possible, and is often the case, that multiple explanations can coexist. Of course, adding this to the difficulty in setting experiments for a process or phenomenon, it is easy to see how complex and contradictory the activity of the experts in specific domains can be.

An important point in evaluating the contribution of science in understanding phenomena in domains such as sustainable development is the problem of objectivity and the commonly misleading definition of what is a fact and what is an opinion. In Diviacco (2015), and Diviacco and Busato (2015) these issues are described in depth, but several ideas of note are restated here to show how this can further limit the reliability of the standard methods to understand processes and phenomena in sustainable development.

The standard view depicts scientific research as an objective activity. To understand if this can be true we need first to understand what the term objective actually means. Objectivity is contrasted to subjectivity, and since subjectivity reasonably means "from someone's point of view", the resulting popular idea is that objectivity could be associated with "truth" and "reality", rather than how things may appear or might be imagined. This is an oversimplification. The common definition of objectivity refers to what should be actually called "metaphysical objectivity" meaning a form of objectivity that does not depend on experience, but of course we know that science is based on observation, and therefore we should revert to what we better identify as "epistemic objectivity". This can be defined as the sets of claims or judgments which truth values are not determined privately. Objectivity can be explained

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only as "not just from someone's point of view", objectivity is always limited to the point of view of a certain number of people that agree and converge on a shared vision.

Summing up subjectivity is private and objectivity is public or, to put it another way, only shared points of view are objective (Diviacco, 2015; Searle, 1995).

Now, having defined the difference between metaphysical and epistemic objectivity we can make a further step and understand what a fact is. Facts are metaphysically objective, and as such practically we cannot access to them. What we can handle are merely possible situations that can be expressed by non-contradictory claims that we call "state of affairs."

The Sociologic

We described above the limitations of reasoning in research fields related to sustainable development that force a "relaxed" approach towards the possibility to access reality. We highlighted that these limitations lead to a model where multiple points of view are very likely to emerge, and that therefore multiple competing theories can coexist (without necessarily clashing).

Any explanation of a phenomenon or scientific model, following Woo (1999), have two forms of approximations and uncertainties: the intrinsic ones that depend on the limitations of the model and the aleatory uncertainties that are related to the beliefs of each researcher. In fact each researcher focuses only on what he thinks are the more likely causes of a phenomenon and excludes others. This is bias, a problem which we are not generally prepared to handle. Popper (1963) maintains that bias is unavoidable, and that we instead need to identify it and prevent its influence on research. In this perspective Pshenichny (2004) proposes that bias should be explicitly formulated in the theories and provides tools to take bias into account.

We showed that the state of affairs, meaning what experts consider in their everyday activities, can be seen as shared spaces on which a community needs to converge. It is therefore easy to understand how reasoning in the fields related to sustainable development is strongly conditioned by the social connection of the people working within the same project. Each actor brings his/her bias. It is easy to understand that if identifying the bias of a single actor could theoretically be possible, the interaction between biases of a community can be seen itself as a complex system.

Kuhn (1962) showed that scientists tend to isolate themselves in what he called "paradigms", meaning a mental environment defined by the personal history of the single researcher, their points of view, the tradition they are part of, their models and myths, in general their background. Paradigms condition their "normal" scientific life and tend to gather scientists in groups that, following Becher and Trowler (2001), resemble "tribes". They tend to evolve separately and eventually cannot understand each other (incommensurability). In this space, following Whitley (2000), control over facilities and resources of research define status and identity of researchers and tribes. Following Latour and Woolgar (1979), the lives of scientists and experts are conditioned by the network of allies and by the strategic position that the researcher is able to maintain in the community. In few words "Science is a social construct" (Latour & Woolgar, 1979).

Communication

In this landscape we have to consider a further complication, which is communication. Traditionally, this is layered into syntax, semantics and pragmatics (Morris, 1971, Diviacco 2013). Due to paradigms and

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incommensurability it is easy to understand that communication can be complex and prone to misunderstanding. These effects can be traced at all levels of communication, but while sometimes efforts are spent in trying to agree on a common syntax, those spent in trying to achieve a common understanding and meaning are generally very problematic, while within the scope of pragmatics they are commonly not even considered.

Shannon and Weaver (1949) provided methods to overcome communication difficulties. However these methods were mainly focused on the syntactic level and are more related to the technical implementation of communication. They do not address problems related to the human "contribution" to these difficulties.

Following Mirowski (2002) in Shannon's information theory, information is something that stands apart from and is independent of the processor of information and its internal characteristics, then it deals with encoding, transmission and decoding, not caring about the ability to understand of the payload.

In the case of sustainable development, instead, as we demonstrated, the role of the human-human interaction and therefore the need for a convergence of a community is paramount

We can identify essentially two classes of issues that can generate such difficulties, and namely:

- Epistemic and cognitive ones: that are generally structural, intrinsic, often innate and unconscious, such as tacit knowledge and theory laden-ness
- Socio-economic ones: that are conscious and voluntary, where actors aim to exert an influence on a process, project or activity in general

In the first case, we already described what theory laden-ness is; we will now briefly describe what tacit knowledge is. Tacit knowledge is knowledge that cannot be made explicit because obscured or embedded in practices or even tools. Following Polanyi (1966)

We know more than we can tell.

Tacit knowledge therefore remains often outside communication since cannot be captured.

Socio economic issues are also very relevant. In any community, in order to have control over the evolution of a project, partners are committed to the development and successful strategic positioning of their visions and of themselves as an "obligatory passage point" (Latour & Woolgar, 1979). Actors' contributions will then be ideological and political, which introduce another dimension to take under control in communication. Following David and Bunn (1988) who analysed the possible economic interests that can interfere with the quest for interoperability, this has to be considered at all communication levels: pragmatic and semantic of course, but even at the syntactic one.

SOLUTIONS AND RECOMMENDATIONS

Summing up, in the domain of sustainable development, on one hand we can have serious intrinsic reasoning issues in understanding processes and phenomena, on the other side we have complex social interactions that can affect knowledge building. How can we be optimistic about the possibility to devise any data management tool that can be used in this domain, where, as mentioned above, collaborative work is expected?

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Knowledge

Knowledge can be associated with the acquisition and processing of information that under certain conditions can be used, expressed, shared, and transmitted. The syntax/semantics/pragmatics tri-partition we described in the section about communication, can be roughly associated with the distinction between data, information and knowledge (to delve more into the argument please see Diviacco, 2013 and Diviacco, 2015). The problem we have to deal with is that traditionally only a one-directional path from data towards knowledge was identified in knowledge building. On the contrary, as we demonstrated above, epistemic, cognitive and socio-economic factors, following the opposite direction condition severely information and data acquisition and management (Fox 2014, Diviacco 2013). How can we cope with this?

We can follow essentially two paths:

- Knowledge formalization (controlled vocabularies, ontologies, archetypes). This is based on the identification and definition of the concepts that constitute that particular abstraction of the world and on the construction of a map of their relations. This environment can be later used to classify and reason on the available data and information, and reconfigure that knowledge to adapt to other paradigms
- Non-formalized knowledge (boundary objects, representation). This is based on the introduction of artefacts that could be used to allow multiple paradigms to access the same data and information space from different point of view.

Knowledge Formalisation

In order to truly pursue sustainable development - which in the definition above takes place over the time scale of generations, when data, information or knowledge are captured there must be enough supporting information alongside the new data to allow future users to re-analyse, re-visualise and reinterpret the data without recourse to the data originator. Once this is achieved, environmental observations may be used to evaluate future problems of sustainable development, and even to assess the sustainability of certain development choices. It is also instructive to consider how data becomes knowledge.

A History of Knowledge Formalisation in Marine Data Management

Whilst this may seem at first to be a utopian vision for data managers, it is in fact the mantra that has been used within the International Oceanographic Data and Information Exchange (IODE) community for many years as a way of showing the data management process adds value to data (Lowry, Rickards, & Brown, 2005). This has required the formal definition of marine data models, which have evolved over many years and iterations. Whilst the history of the common vocabulary definitions used within these data models is explored in detail by Buck and Lowry (2016, see chapter 1 this volume) a brief overview of the formal data models produced in the marine science domain is of use in setting the scene for this, and subsequent chapters. Initially, knowledge formalisation in the marine sciences was through definitions of common metadata schema and file formats for exchange of information and results between partners in specific projects. The classical example of this is the GF3 format, developed by the Intergovernmental Oceanographic Commission's International Oceanographic Data and Information Exchange (IODE) and first proposed in 1979 as a generalized formatting system for general use in the transfer of

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marine science data (UNESCO, 1987). A key, indeed prescient, feature within GF3 was the publication of common vocabularies, in a paper form, which is a theme we will return to later in this section in a World Wide Web context. GF3 was eventually refined by the IODE Group of Experts on the Technical Aspects of Data Exchange (GETADE). The GETADE Data Format was developed in response to the perceived agedness of GF3, which had led to many national oceanographic data centres developing their own file formats proving to cause a barrier to the exchange of data between nations. However, the knowledge formalisation within GETADE remained within the GF3 code tables. The first real move away from this model was the Marine XML project. Marine XML was not a project designed to create a new XML standard encoding, but to provide the crosswalks between various standards through knowledge encapsulation. The results of the Marine XML project showed that there was still work to be done on mapping various metadata schema from the different national oceanographic data centres and domain projects; and that access to the GF3 codelists should be improved (Isenor & Lowry, 2005). By the time of the Marine XML project, the codelists had moved from paper to FTP site downloads, but follow-on work in the EnParDis and NETMAR projects and through the use of the successor, web-enabled controlled vocabularies in the SeaDataNet infrastructure has brought these to modern web standards (Leadbetter, Lowry, & Clements, 2014).

The Marine XML project began to bridge the gap between data and knowledge through its crosswalk paradigm, but how can we understand a more general flow of data to knowledge? The data ecosystem may be seen to encapsulate the data-information-knowledge-wisdom (DIKW) model of Shedroff (1994). An ecosystem grows, evolves and thrives on diversity. In the DIKW model, data may grow through presentation and organisation into information. Information itself may evolve into knowledge as consumers from a wider context than the data were originally collected in bring their experience to conversations about the data and information which can then tell new stories. Taking the example of marine science data above, the raw data straight from the research vessel cruise obviously fits into the data part of the model. Through organisation and presentation of the raw data into something cleaner and more usable, at the "beta" stage in the software release metaphor, the lines between data and information have become blurred and the data are evolving towards information. At the "release" stage where the data are organised and presented in such a way that they are totally reusable, and may even have a dataset description paper from an academic journal to accompany them, the evolution to information is complete. These "information-sets" can now provide the stimulus for researchers to converse about what they contain and to begin building knowledge, While many of the drivers for data sharing examined in this paper have come from the sciences, the idea of research data evolving into information, knowledge and wisdom has touchstones in the arts, particularly the field of literature. As Will Self (Guardian, 2008) notes, creative writing is "not building things. You are removing things, chipping away at language to reveal a living form." Indeed, as scholarly communication in all disciplines is currently predicated on the peer-reviewed, written research paper it could be seen that all synthesis of research data into the information and knowledge these papers contain is a creative writing process.

The Current State of the Art in Marine Data Management Knowledge Formalisation

There are emergent technologies throughout the fields around oceanography which we will incorporate into oceanography, and through that convergence we will make oceanography into something even more magical. (Delaney, 2010)

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In the emerging Web Science (the study of large-scale socio-technical systems, such as the World Wide Web and the relationship between people and technology, the ways that society and technology co-constitute one another and the impact of this co-constitution on broader society, Shadbolt & Berners-Lee, 2008) the concepts of both the Semantic Web and Linked Data are very powerful tools in the formalisation of knowledge. Indeed the Semantic Web was born of Tim Berners-Lee's vision to create a Web of Data analogous to the World Wide Web of documents (Berners-Lee, 1998). The Semantic Web is a standards based approach to the Web of Data which promotes common data formats and exchange protocols on the Web, most fundamentally the Resource Description Framework (RDF). According to the World Wide Web Consortium, "the Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries" (Herman, 2008). The Semantic Web encapsulates knowledge in a spectrum of formalisation, from low to high. The points of this spectrum, often called the "ontology spectrum" or "semantic spectrum", are defined by McGuinness (2003). In overview, the simplest point on the spectrum is the catalogue (or glossary, as in Navigli & Velardi, 2008) that simply provides a list of terms used to annotate data and their definitions. A catalogue is not necessarily published to either the WWW or Semantic Web. Nor does a catalogue require a group of experts to provide governance over its content. Complexity is increased in the controlled vocabularies (Warner, 2002) and data dictionaries (Kumpati, 1985, IBM, 1993) which add, respectively, naming conventions and publication on top of the catalogue. A data model (van Renssen, 2005) then adds some definition of the relationship between the entities of a data dictionary. A taxonomy further adds a tree hierarchy with the concepts at the bottom of the tree inheriting the properties of those concepts at the top of the tree (Navigli & Velardi, 2008). A concept can be viewed as the definition of an idea or notion; a unit of thought (Miles & Bechhofer, 2009). A more complex point of the semantic spectrum is the ontology. An ontology describes all the concepts in a given domain and the relationships between them, and following best practice (Cox, 2012), is conceptualised using Uniform Resource Identifiers (URIs) for each of the data elements, relationships and property types. An ontology can be parsed by a reasoning engine and then used to infer knowledge about the domain.

Similarly, Linked Data makes use of these Semantic Web publication patterns, but then uses the expectations of a Web document (URIs are used to identify things; when looked-up those URIs resolve over HTTP; the resolution returns a document compliant with standards; links are provided to other URIs so users may discover other resources) to provide connections to other data published on the Semantic Web (Berners-Lee, 2011). Leadbetter, Cheatham, Shepherd & Thomas (2016, see chapter X this volume) further explore the use of Linked Data in the marine science domain. These approaches, as well as the emergence of real-time analytical applications for marine data streamed from instruments to data centres, have given rise to the concept of using the Web as the query and programming interface for marine data (Chandler & Arko, 2015). While born of the Linked Data paradigm, this is also seen in the Sensor Web Enablement activities of the Open Geospatial Consortium, and in products such as NOAA's ERDDAP server (Mendelssohn & Simons, 2008). What remains, however, is a suite of non-standard, domain specific interfaces without a common unifying "glue".

Semantic Web practitioners have developed the notion of the upper ontology in response to this problem of using data encoded with the knowledge of different domains. The upper ontology should describe concepts which are common across all domains, and in this regard bridges the difference between the information modelling ontology and the philosophical ontology. An important function of an upper ontology is to support very broad semantic interoperability between large numbers of ontologies which are accessible ranking "under" this upper ontology. As the rank metaphor suggests, it is usually a

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hierarchy of entities and associated rules (both theorems and regulations) that attempts to describe those general entities that do not belong to a specific problem domain. The World Wide Web Commission has published both a Provenance Data Model (Missier, Belhajjame, and Cheney 2013), and a Semantic Web encoded version of this model as the Provenance Ontology, or PROV-O (Lebo et al. 2013). PROV-O may be considered an upper-level ontology as it provides a very broad level of semantic interoperability between more domain specific ontologies, or it is "a domain-independent common-sense theory constructed by aggregating suitable contributions from areas such as descriptive metaphysics, philosophical logic, cognitive science and linguistics" (Guizzardi 2006). PROV-O is based around a simple model of three classes:

- Entity a physical, digital, conceptual, or other kind of thing with some fixed aspects; entities may be real or imaginary
- Activity something that occurs over a period of time and acts upon or with entities; it may include consuming, processing, transforming, modifying, relocating, using, or generating entities
- Agent something that bears some form of responsibility for an activity taking place, for the existence of an entity, or for another agent's activity

A number of attributes have been defined which describe the relationship between the classes by characterising the influence that an instance of one class has on another instance, either of the same class or of a different class. There are several examples of PROV-O being used as an upper ontology in the Earth Sciences (Compton, Corsar, & Taylor, 2014; Ma et al., 2014; Leadbetter & Vodden, 2015). Its limited number of classes mean that there is a clear pathway for ontology alignment by placing the classes of a domain-specific ontology into the class structure provided by PROV-O. Taking the alignment of the Semantic Sensor Network with PROV-O as a first case study (Compton, Corsar, & Taylor, 2014), it can be seen the Semantic Sensor Network Observation class defines an observation an interpretation of real-world events and the results of those events. For example, a stimulus (wind) spins the cups on a wind sensor, generating a current, and through an equation modelling the relationship between this and the physical property of wind speed the sensor outputs a value that we can choose to interpret as an observation of the wind speed at that moment. The observation is the social construct of the interpretation, not the act of the observing itself. Following the Semantic Sensor Network model, Observation would be aligned with the PROV-O class Entity. This however contrasts with the view of the ISO 19156 Observations and Measurements (O&M) model, which states that an Observation is an action whose result is an estimate of some property of a feature-of-interest, obtained through the use of a specific procedure (Cox, 2006). In O&M an Observation therefore aligns with a PROV-O Activity. Therefore, alignment can be achieved between the two lower-level ontologies as PROV-O Activity is not a disjoint class with PROV-O Entity. However, care needs to be taken in this regard as the Observation class from the two different lower-level ontologies also represents subtly different concepts the record of an observation in the Semantic Sensor Network and an Observation Event in O&M (Cox, 2015). It can therefore be seen that this use of PROV-O as an upper ontology helps to both align the ontologies for interoperability but also highlights the specific differences of the creation philosophy of the ontologies being aligned.

One ontology which describes, in general terms, oceanographic deployments, such as research vessel surveys, is the Ocean Data Ontology (ODO, http://www.ocean-data.org/). This ontology should be able to be aligned with other ontologies describing specific details of the sensors deployed (for example the Semantic Sensor Network Ontology) or the observations made in the environment during the deploy-

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ment (for example, O&M). From ODO, the classes of interest are Dataset, which describes a collection of observations made during a Deployment and is linked to the specific research project making the deployment and the funding award which paid for the deployment; and Parameter which links an instrument on a deployment to the environment property it is observing as well as describing the observable properties recorded within a Dataset. It can be seen that these classes should be available for users from a range of disciplines who wish to use the data in decision making tools or other applications, and therefore these classes will be aligned with PROV-O. As shown by Leadbetter and Vodden (2015), the oceanographic domain often uses the term "parameter" where the O&M community use the term "observable property", therefore the "Parameter" class of ODO should be most closely aligned with O&M's Observable Property, showing that formalization is community dependent and that bridging between models of knowledge formalization must be done at a human level. This is an attribute of the O&M class Observation, so therefore in a PROV-O model could come from any of the three classes. It makes no sense for the Parameter to be an agent as it bears no responsibility for the Observation activity taking place or the creation of an Entity; likewise the Parameter is not an Activity as it does not act upon or with Entities. Therefore, a Parameter, or Observable Property, is an Entity and an Observation Activity can use said Entity. Similarly, within the Semantic Sensor Network a sensor, or instrument, observes a property, or an ODO Parameter. A sensor is known to be defined as both a PROV-O Agent and Entity (Compton, Corsar, & Taylor, 2014), therefore an ODO Instrument should also be defined in this way and a Parameter may be attributed to it. As we have seen, Observations are PROV-O Activities, resulting in PROV-O Entities (either O&M Results or Semantic Sensor Network Observations). From here, a group of results should also be a group of PROV-O Entities, and therefore a PROV-O Entity should sufficiently describe an ODO Dataset. Therefore, an ODO Dataset can be said to be derived from the PROV-O Entities which are the O&M Results of the Observations made using an ODO Parameter.

Archetypes as an Alternative Method in Marine Data Management Knowledge Formalisation

An alternative strategy for true knowledge capture and interoperability across domains both within and without the marine sciences to that of the upper ontology alignment method may be found by looking further afield than the Earth Science informatics domain. By taking Delaney's approach that there are interesting developments in other domains on the fringe of ocean sciences and looking to the field of health informatics, where much work has been done on the topic of separating information models and knowledge models we can see that archetypes (Beale, 2002) offer one solution to a true encoding of knowledge. As the volumes of observational data from Argo floats, gliders and ocean observatories increases and the desire to semantically annotate the data at source also grows, solutions have been designed as a strategy to compensate for the fact that data captures only a part of what researchers can expect from an observation (Diviacco et al. 2014, Fredericks, 2015), we are reaching an age of ubiquitous marine computing which should allow for more user friendly and comprehensive data capture (Garde, Hovenga, Buck, & Knaup, 2007). However, this precludes the heavy manual involvement of the data manager in the process of creating the "utopian" vision of users not wishing to continually return to the data originator in order to understand their datasets. Archetypes have been used in healthcare informatics to define integrity constraints; data required for the interpretation of a measurement; multilingual support; and replication of domain knowledge in ubiquitous computing environments to address this issue. Likewise, healthcare informatics experts have used archetypes successfully to provide interoperability

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between otherwise heterogeneous data systems (Lezcano, Sicilia, & Rodríguez-Solano, 2011). As Beale (2002) states, with large information models for domains it is often logistically and technically difficult for different data producers and users to agree on a common data model. This makes automated processing and decision support using observational data very difficult to achieve. In the typical archetype use-case, the archetype is used to describe knowledge while the ontology is used to describe information, designed to address issues where knowledge can be volatile (i.e. the definitions of concepts within the information model can change over time), or the number of knowledge entities for a given domain is vast. This second point is likely to be of most use in the marine science domain, particularly when considering the NERC Vocabulary Server (a commonly used Semantic Web resource in the marine data management community; Leadbetter, Lowry, & Clements, 2014) contains some 98,000 knowledge entities (as of October 21st, 2015).

Lezcano, Sicilia, & Rodríguez-Solano (2011) provide a mechanism to match the definitions of archetypes to ontologies and to provide archetypes with computational semantics by providing rules for the encoding of archetypes in the W3C's Web Ontology Language (OWL). This is particularly useful because the definition language used in producing archetypes does not allow for inferencing (Beale, Heard, Kalra, & Lloyd, 2005) but OWL based archetype definitions can be enhanced by the inclusion of Semantic Web Rule Language entries (Horrocks et al., 2004). Given the example of how the Semantic Sensor Network, Observations & Measurements, and Ocean Data Ontology all formalise descriptions of measurements within the environment in slightly different ways, and instructive use case for the application of archetypes to the marine science domain is to prototype an Observation archetype synthesising the knowledge encapsulated by these ontologies. This is expanded below using the Archetype Definition Language (Beale, Heard, Kalra. & Lloyd, 2005).

A prototype observation archetype should capture the following knowledge as already described in this chapter: that an observation event leads to a result, which contains a value and a unit of measure; an observation event requires the observation of a parameter, or observable property; and a process, including a sensor or instrument, acts on the observable property to generate the result. Observations may be combined to generate a set of observations for grouping. An archetype conforming to this definition is shown in Listing 1.

It can be seen that there are growing numbers of methods and results in formalizing cross-disciplinary knowledge, but there are still difficulties arising in achieving a utopian vision where all formalized knowledge is truly interoperable. Therefore, there are many advances in representing knowledge in less formalized ways. This will be discussed below.

METHODS BASED ON NON-FORMALIZED KNOWLEDGE

Representation

We defined above the notion of "epistemic objectivity" as the sets of claims or judgments which truth values are not determined privately. Judgments imply a form of intentional portrayal of things, such as beliefs, precepts, news reports, books, articles, sentences and pictures, which can defines "representation". Intentionality connects epistemic objectivity with representation. Representations can be, amongst other things, theories and models, linguistic and mathematical entities, computer simulations, concrete objects (Diviacco, 2015). Representation can take place in multiple ways: linguistically when

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something is explained; graphically in a map or a graph reporting the observation of a phenomenon; but also in other ways in which the linguistic aspects are less relevant or at least are only a medium for communication and do not necessarily contain all of the message. Diviacco (2015) gives examples of forms of representation where this de-literalization allows us to move the focus toward other forms of communication such as art where concurrent conceptual models can co-exist.

In light of the discussion in this chapter, representation is very interesting because it is communication that can be biased by cognitive and epistemic issues, by ideology or politics; or concurrently by all these factors. Strictly speaking, descriptions of entities and processes afforded by scientific representations are generally false (Chakravartty, 1995). Following Callender and Cohen (2006), representation has features reality does and does not have. It is characterized by omissions and commissions. Omission is the act of neglecting some possible causes among those that can explain a phenomenon; commission is the act of deliberately changing the network of possible causes and explanations of a phenomenon. Representation can then be used to change the parameters of the target system, representing it in a way that constitutes a distortion of its true nature (see the above section on the limitations of reasoning in sustainable development). Similarly in the case of painting or sculpture, it should be possible to distinguish realistic and non-realistic representations. Realism in representation is indicative of an easy to interpret display, even for the non-specialist. Non-realistic representation is such because it requires an interpretation phase where conventions need to be set. Accessibility depends on the ease with which representation can issue the same information and those viewing the representation can internalize conventions.

A key aspect of collaborative work is the possibility to access the same conventions. This can depend on the actual complexity of the phenomenon under study. In fact, using again the similitude with the case of painting; when simple objects are to be described, the iconic use of the image is often easy to grasp, meaning few conventions are needed. When objects are complex, the needed symbology becomes more abstract and therefore need to be managed in a specific way, incurring into the issues we described above.

Boundary Objects

The formalized knowledge paradigm requires large investment of resources in the governance of all the tools it can offer. In addition, the status of such an infrastructure cannot be considered stable, since new concepts continuously appear and have to be mapped in the environment.

An un-formalized paradigm allows a more relaxed approach since is intended essentially to offer access to data and information without imposing a specific viewpoint.

The approach is based on the ethnological studies done in nineties by Susan Leigh Star and James R. Griesemer (1989). They found that different communities, characterized by different languages, cultures and traditions can collaborate effectively notwithstanding the fact that they could have rather different cognitive models. In these cases they found that this process is facilitated by the presence of artifacts that can be used in different ways but that gather users in the same cognitive space bridging concurrent cognitive models through abstraction from all the domains of the partners. To do so artefacts must be weakly structured in common use, but strongly structured in individual use.

Boundary objects are artefacts related to sets of information, conversations, interests, rules, or plans, and are at the centre of communities of practices (Diviacco, 2012; Star, & Griesemer, 1989). Their application to bridge professional boundaries was studied by Kimble, Grenier and Goglio-Primard (2010), while their application in the field of the Arts can be seen in Van Saaze and Dekker (2013)

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The idea of the boundary object can be put in practice through many kinds of artefacts. What is relevant is that, in practice, they are forms of representations. These can be for example: maps, graphs or work flows, to mention a few. These artefacts can be designed in order to expose "nodes" that can be used to gather data and information in the form of files, message threads, wikis or else. Each node can be labelled associating it to a concept, process or phenomenon, so that the artefact will gather all the knowledge of the designated community. On the other hand the artefact is intended as a passive entity, which performs no reasoning: the "work" is done mainly by the users.

Following Scardamalia and Bereiter (2006) knowledge building, in the perspective we are adopting here, can have two forms, and namely: (i) a weak form, where findings only become contributions to community knowledge when they are brought into public discourse, and (ii) a strong version, where the discourse is itself the state of public knowledge in a community.

We find very interesting that the state of knowledge of a community could be not only in the minds of the individual members of the community, but also in the discourse itself. In fact, if the discourse takes place in an artefact, this latter will become the state of knowledge of the designated community (Diviacco 2015) and will follow its evolution: practical implementations of this approach have been proposed by Diviacco (2015), Diviacco (2013), Diviacco and Pshenichny (2011) and Diviacco and Pshenichny (2010)

Limitations to such approach have also been highlighted (Diviacco, 2015). These relates mainly to the flexibility of the artefact itself. For example, a mind map already populated with data and information is very difficult to be changed in a later stage because that could possibly mean moving information across nodes, which of course cannot be automatized. A more flexible approach, which can be applied often, but not in all the cases, could be data annotation. In this case data is represented, for example plotted in a graph or projected in a map, while users are provided with tools to draw objects on the representation, such as lines, circles, arrows to capture the attention of the community on a feature that can be used as a node and therefore gather data, information, messages or else.

FUTURE RESEARCH DIRECTIONS

Considering the two paths identified, namely formalization and representation, we need to identify two groups of future research directions.

In the case of formalized knowledge, while Ontology Design Patterns, as explored by Leadbetter, Cheatham, Shepherd & Thomas (2016), offer one approach to integration of data by publishing data to a given pattern the considerations of this chapter offer two future research directions to use the patterns in different ways. The first would be to align the Ontology Design Patterns with PROV-O in order to use an upper ontology approach to combining data from different domains published under Ontology Design Patterns. The second would be to pull the Ontology Design Patterns up to the higher level in a two-level information model and to rewrite the knowledge captured in the patterns as archetypes.

In the case of representation based knowledge management, we think that a very promising future direction would be to explore the possibility to create on the fly the artefacts that help user to navigate the collaborative knowledge space. This could be possible for example analysing terms used in messaging or annotation. A positive aspect of this approach would be that possibly this could pose a bridge between the two worlds of formalization and representation since an interesting approach could be to ground this activity in controlled vocabularies or ontologies (Diviacco and Fox, in preparation).

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CONCLUSION

This chapter aimed at exploring the difficulties behind data management in sustainable development and at proposing possible solutions to overcome them. We have highlighted the intrinsic limits of reasoning in this domain and the role of relationships and communication between the partners in the designated community. Tacit knowledge and contrasting cognitive models do not allow partners to understand each other's, and therefore knowledge, often can be formalized only with difficulties.

The resulting scenario is very complex. We claim that in spite of the difficulties we have described there are opportunities to address collaborative research in the domain of sustainable development through the exploitation of a careful balance of formalized knowledge and non-formalized knowledge representation. In many senses the practitioners of sustainable development in general, and ocean data management in particular, must look beyond their immediate domains in order to solve these issues.

Where knowledge can be formalized, tools such as controlled vocabularies, ontologies or archetypes can assist partners with different backgrounds to bridge the differences and incompatibilities of their original contexts. Where knowledge remains tacit, or difficult to agree upon different strategies should be introduced. These can be based on artefacts that allow the communication to take place without interfering with it. Such artefacts should be representations of knowledge that while being unique can be interpreted differently by the different communities.

We have introduced concepts from computer science; health informatics; philosophy; and art in order to provide an outline strategy to allow the management, integration and representation of marine data for sustainable development.

Tools based on such strategy will allow the end user to find and access data, information and knowledge on IT systems that eventually become themselves representations of the state of knowledge of a community.

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KEY TERMS AND DEFINITIONS

Archetype: A computable expression of a domain content model in the form of structured constraint statements, based on a reference (information) model. Archetypes are all expressed in the same formalism. In general, they are defined for wide re-use, however, they can be specialized to include local particularities. They can accommodate any number of natural languages and terminologies.

Boundary Object: An artefact that allow two different and incommensurable communities to nevertheless collaborate. They are weakly structured in common use, and become strongly structured in individual use.

Linked Data: Linked Data is a technique that uses the Word Wide Web to connect related data that was not previously linked, or uses the Web to lower the barriers to linking data which are currently linked using other methods. In practice, Linked Data often uses the Resource Description Framework model and Web addresses (as Uniform Resource Locators, or URLs) to achieve these linkages.

Ontology: In computer science, an ontology formally represents knowledge as a hierarchy of concepts within a domain, using a shared vocabulary to denote the types, properties and interrelationships of those concepts.

Semantic Web: The Semantic Web is the World Wide Web of data built on the Resource Description Framework model as a foundation for publishing and linking data online.

Tacit Knowledge: Knowledge that cannot be made explicit because obscured in socio-political phenomena or embedded in practices or even tools.

Theory Laden-ness: Refers to the fact that 7 experience is categorized and preconditioned by prior belief, and that the process of building knowledge always involves the use of concepts from some previous view. This holds both from a logical and a perceptive point of view.

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ENDNOTE

[1] Umberto Eco (1981) used the concept of abduction to describe Conan Doyle's Sherlock Holmes's way of reasoning.

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APPENDIX: LISTING 1

```
archetype (adl_version=2.0.5)
  activity_of_observing.v.1.0.0
language
  original_language = <[iso_639-1::en]>
definition
  ACTIVITY_OF_OBSERVING[id1] matches {
        -- Maps to an O&M Observation or a Semantic Sensor Network Avtivity of
        -- Sensing
        RESULT_OF_OBSERVING[id2] matches{
          -- Maps to an O&M Result or a Semantic Sensor Network Observation
          result_value matches {|-inf..inf|}
            unit_of_measure matches {
                  DV_CODED_TEXT[id3] matches {
                        defining_code <[ac1]>
                  }
            }
        }
        PROPERTY_OBSERVED[id4] matches {
          -- Matches an O&M Observable Property or an ODO Parameter
          DV_CODED_TEXT matches {
            defining_code <[ac2]>
          }
          SENSING_INSTRUMENT[id5] matches {
                DV_CODED_TEXT matches {
                  defining_code<[ac3]>
                }
          }
        }
        CONTAINING_DATASET[id6] matches {http://?}
  }
terminology
  term_definitions = <
    ["en"] = <
      ["id1"] = <
        text = <"Activity of observing">;
        description =
                  <"The act of making an observation or measurement within the
                  environment">
      >
      ["id2"] = <
```


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```
            text = <"Observation Result">
        description =
                  <"The result value and its associated unit of measure for an
                  observation event">
          >
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Chapter 29
The Economics of Renewable Energy Promotion Policies:
A Case of Wind Power in Brazil

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ABSTRACT

Large-scale deployment of renewable energy technologies, such as wind power and solar energy, has been taking place in industrialized and developing economics mainly because of various fiscal and regulatory policies. An understanding of the economy-wide impacts of those policies is an important part of an overall analysis of them. Using a perfect foresight computable general equilibrium model, this study analyzes the economy-wide costs of achieving a 10 percent share of wind power in Brazil's electricity supply mix by 2030. The study finds that the expansion of wind power would increase GDP in Brazil. The study also finds that a production subsidy financed through increased value-added tax would be superior to a consumption mandate where electricity utilities are allowed to pass the increased electricity supply costs directly to consumers. These two policies would impact various production sectors differently to achieve the wind power expansion targets.

1. INTRODUCTION

Brazil is well-known for its hydropower resources. However, a large portion of the economic potential of hydropower has already been exploited and a further expansion is increasingly constrained by environmental sensitivity and the remoteness of much of the remaining resource (REN21, 2014). On the other hand, the country is also endowed with a large potential of wind energy, estimated to be 143 GW (Meisen & Hubert, 2010). Most of the potentials are identified in the northeast and southern parts of the country, especially across the states of Bahia, Rio Grande do Norte and Ceara. While Brazil is currently expanding its thermal power generation capacity (IEA, 2014), the rapidly increasing emissions of greenhouse gases (GHGs) from the power sector is a major challenge to meet its voluntary commitments for climate change mitigation. Therefore, the government is planning to expand wind power, and

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expects wind power to contribute 9% of the total electricity generation by 2021.[1] Moreover, wind power provides an excellent complementarity to hydropower in Brazil, as the high wind seasons coincide with low rainfall seasons.

In Latin America, Brazil is the leader in developing wind power generation capacity. The total installed capacity of wind power increased by more than 6 fold in just four years since 2010 (GWEC, 2014).[2] Brazil made the fourth largest addition of wind power capacity in the world in 2014 with 2,500 MW added in that year alone (REN21, 2015). With this addition, total installed wind power capacity in the country stands at 5,900 MW. Although almost half of the new capacity addition in 2014 was wind power, the total installed capacity of wind power accounts for a only small fraction of the total electricity generation capacity in the country, about 4% of the total electricity generation capacity available in the country by the end of 2014 (REN21, 2015).

A number of policies and programs have been introduced in Brazil to promote large-scale deployment of wind energy. The Programa de Incentivo às Fontes Alternativas de Energia Elétrica (or Incentive Program for Alternative Sources of Energy) introduced in 2004, was one of the first major initiatives. At present, existing policies aimed at wind power development include market (or purchase) guarantee, where the government procures wind power through competitive bidding (Franca, 2011); exemption of some taxes on wind power generation equipment; investment subsidies through grants and soft loans and wind power auctioning (IEA/IRENA, 2015). In addition, the government has launched specific programs to facilitate large-scale deployments of renewable energy, including wind power (REN21, 2015).

The promotion of renewable energy is essential from climate change mitigation and other environmental perspectives; it is also necessary as renewable energy is a vehicle for the development of sustainable energy systems in a long-run. However, it is equally important to ensure that a large-scale expansion of renewable energy is also consistent with short-term economic and social development goals. A large-scale deployment of renewable energy should not adversely affect the competitiveness of energy supply systems, especially in developing countries. Moreover, the economic and regulatory policies to stimulate renewable energy sources should not excessively cost to the final consumers as well as productive sectors. Despite the importance of these issues, relevant literature is limited.

This study analyzes the economic and environmental (mainly climate change mitigation) implications of a large-scale deployment of wind energy in Brazil to increase the share of wind power in the total electricity generation to 10% by 2030. We used a computable general equilibrium (CGE) model as an analytical tool because CGE models are the most appropriate tools for this type of ex-ante assessment of economy-wide impacts of a policy or an economic activity. Existing studies, such as Qi et al. (2014), Timilsina and Landis (2014) and Böhringer and Löschel (2006), have also employed CGE models for analyzing renewable energy promotional policies. We simulated two broad policy instruments: fiscal policy instruments and regulatory policy instruments, and compared them in terms of their economy-wide impacts. In our model, the fiscal policy instruments are represented by a production subsidy[3] and the regulatory measures are represented by a renewable energy consumption mandate.

The remainder of the chapter is structured as follows. In Section 2, a brief description of the computable general equilibrium model is presented followed by discussions of results from model simulations in Section 3. Section 4 concludes the chapter.

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2. MODEL AND DATA

In this section we present the CGE model developed for the study and the necessary data. The model used for this study is a perfect foresight inter-temporal dynamic CGE model. Since the basic description of a standard CGE model is common in most literature that use CGE models for environmental and energy policy analysis, we do not reproduce the detailed description of the model. Instead, we focus on how the two policy instruments are incorporated in the CGE model.

The model has 31 production sectors and 27 goods and services as shown in Table 1. It explicitly identifies wind power as a separate sector. In most existing CGE models, renewable energy technologies including wind power is embedded in a single electricity sector because the share of renewable energy in the total electricity mix is very small. Renewable energy technologies are not treated as separate economic activities or sectors in input-output tables or social accounting matrices, the main database for a CGE modeling exercise. If various technologies to generate electricity are represented by a single technology, it ignores the heterogeneity among the technologies to generate electricity[4]. Moreover, such an aggregate representation of electricity generation technologies does not allow to assess the impacts of the substitution between different types of electricity generation technologies, which is the focus of this analysis. Table 1 shows that our CGE model has seven types of electricity generation technologies: hydro, coal, natural gas, oil, wind, biomass and nuclear. As it will be discussed later, the marginal cost of electricity generation from each of these technologies will be reflected in their prices, which will be then combined through constant elasticity of substitution (CES) functional form to derive an aggregate electricity price that will be faced by the consumers.

The model also identifies various petroleum products (e.g., gasoline, diesel, other petroleum products) separately, which is often not the case in existing literature. This is important in Brazil because Brazil is one of the largest producers of ethanol and the trade-offs between gasoline and ethanol should be reflected in a CGE model developed for policy analysis in Brazil.

All productive sectors or industries, except the electricity generation sectors, follow a nested production structure as depicted in Figure 1. The production structure followed by the electricity sectors is presented in Figure 2. A nested constant elasticity of substitution (CES) functional form is used to represent production behaviors of all industries including electricity generating ones.

At the bottom tier of the nested structure in Figure 1, a CES function combines coal and petroleum products to have a fuel aggregate. The fuel aggregate is then combined with electricity to have an energy aggregate. Energy is combined with land and value added (capital and labor) inputs, and this energy-value added & land composite is then combined through a CES function with intermediate goods and services to produce outputs. The output is distributed to domestic and foreign consumption (i.e., exports) through a constant elasticity of transformation (CET) functional form. On the domestic market, a domestically produced good is aggregated with its imported counterpart using a CES functional form; all internationally tradable goods and services follow this assumption. For the electricity-generating industries, the production structure is different from that in other sectors (see Figure 2). The main difference is that the electricity production structure allows direct substitution between capital and fuel. This is necessary to portray the substitution potential between fossil fuel-based carbon-intensive electricity generation technologies with carbon free but capital intensive renewable energy technologies. The total electricity is the combination of electricity generated using different sources (e.g., coal, natural gas, solar, wind, hydro and biomass). Electricity generation from each technology or source is modeled as shown in the nested CES production structure in Figure 2.

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Table 1. Production sectors and consumption goods considered in the CGE model developed for this study

Industry/Sectors for Production	Goods and Services for Consumption
Sugarcane industry	Sugarcane
Soybeans industry	Soybeans
Other agriculture industry	Other agricultural products
Livestock	Livestock
Forestry	Forest products
Crude oil & natural gas	Crude oil & natural gas
Coal mining	Coal
Metals and mineral mining	Metals and minerals
Food & beverages	Food & beverages
Textile & leather	Textile & leather
Wood industry	Wood
Pulp, paper & furniture	Pulp, paper & furniture
Oil refining	Gasoline
	Diesel
	Other petroleum products
Biofuels	Biofuels
Chemicals	Chemicals
Metal industry	Metals
Non-metallic minerals industry	Non- metals (e.g., cement, lime, glass)
Machinery & equipment	Machinery & equipment
Other manufacturing	Other manufacturing goods
Hydropower	Electricity
Coal fired electricity generation	
Natural gas fired electricity generation	
Oil fired electricity generation	
Windpower	
Biomass fired electricity generation	
Nuclear power generation	
Gas processing industry	Process gas
Construction sector	Construction goods/services
Commercial sector	Commercial services
Transport sector	Transport services
Service sector	Other services

The model assumes that labor is perfectly mobile between sectors, capital is sector specific, and land can be transformed between various applications according to a nested constant elasticity of transformation CET function as shown in Figure 3. While land is not an input to production for many sectors, it is the main input to the agricultural and mining sectors. This is another key feature of the CGE model

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Figure 1. Production structure of industries except electricity

Note: In this figure, X refers to sectoral output, A refers to consumption of goods and services, L and K refer to labor and capital, respectively. Indices i and j are used to denote sectors and commodities. Index t refers to time (year). σ refers to elasticity of substitution.

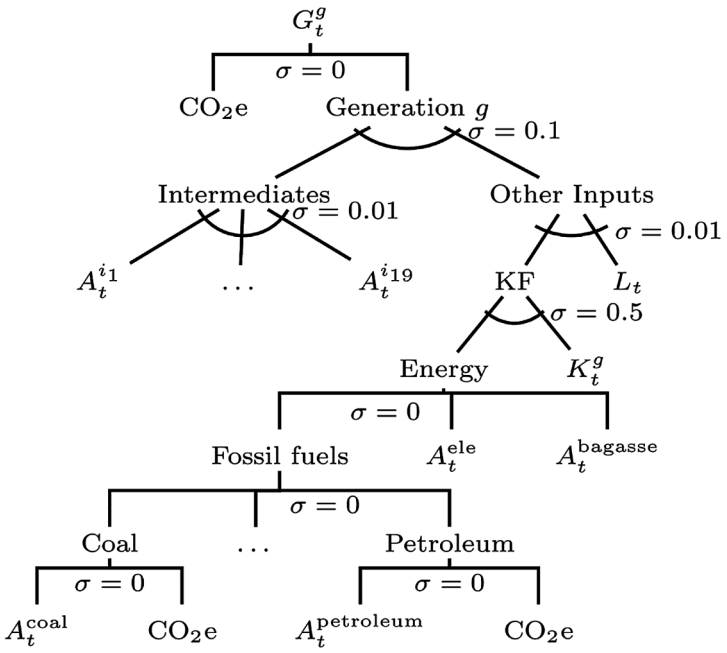
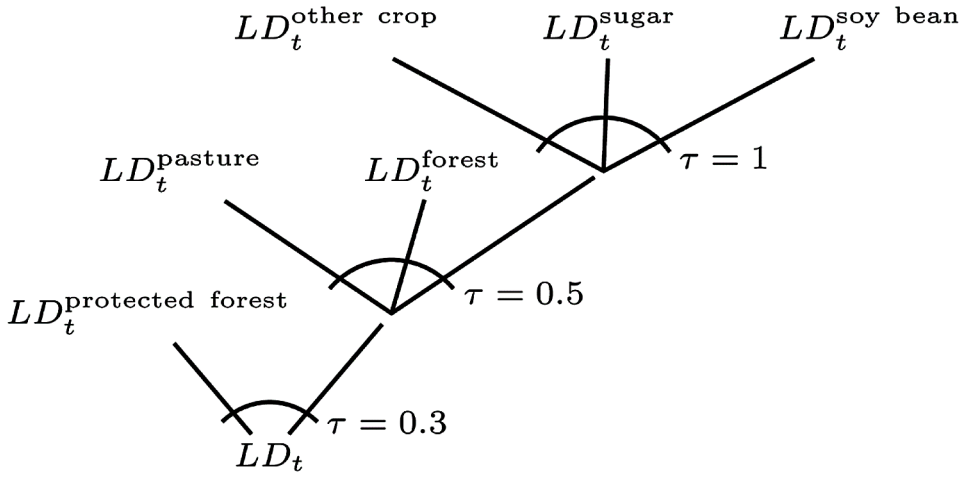


Figure 2. Nesting structure for electricity generation sectors

Note: In this figure, G refers to electricity generation, A refers to consumption of goods and services, F, L and K refers to fuels, labor and capital, respectively. Indices i and j are used to denote sectors and commodities. Index g and t denote type of electricity generation and time (year). KF is the composite of capital and fuel. σ refers to elasticity of substitution.



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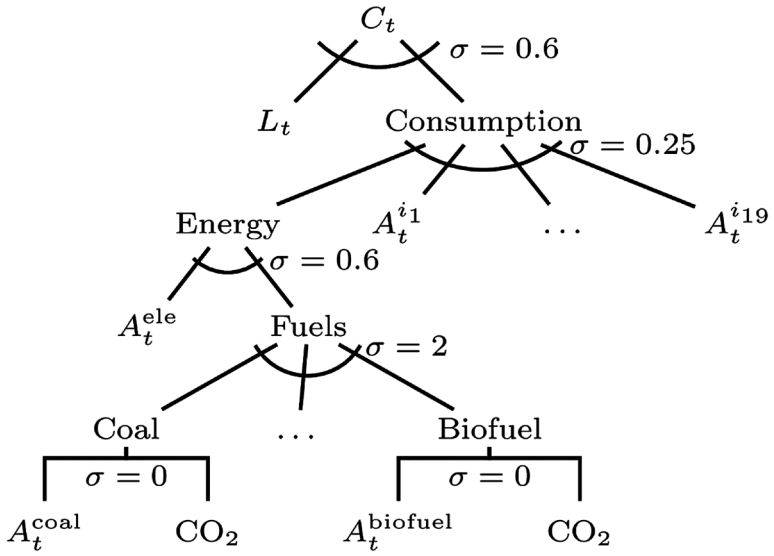
developed for this analysis. Normally, land is not explicitly represented in CGE models analyzing energy or climate change mitigation policies. However, ethanol is one of the main energy carriers in Brazil and to reflect the trade-offs between ethanol and gasoline, it is necessary to explicitly model land allocation in Brazil because land is the main input to sugar cane and the latter is the main feedstock for ethanol production in Brazil.

Capital stocks for production and capacities for power generation are endogenously modeled. Following Clarke and Edmonds (1993), investment in generation capacity is distributed among generation technologies according to a nested multinomial logit choice model. The multinomial logit model assumes that investments in generation capacity, unlike the more aggregated investment in the other production sectors, implicitly entails additional, technology and site specific investments needed to provide the generated power to consumers[5].

Our study follows a standard approach used in the literature to model household behavior. Under the perfect foresight framework, a representative household maximizes a Ramsey type welfare function, where the household maximizes discounted sum of inter-period utility, which is derived from consumption of goods/services and leisure. We used nested CES function to represent the household behavior (see Figure 4). At the top of the nest, the representative household trades off between leisure and consumption of an aggregate of goods and services. In the next tier of the nesting, the representative household chooses an optimal mix of an energy composite and an aggregate of other goods and services subject to household budget allocated for consumption. The energy composite is itself a CES combination of electricity and use of fossil fuels.

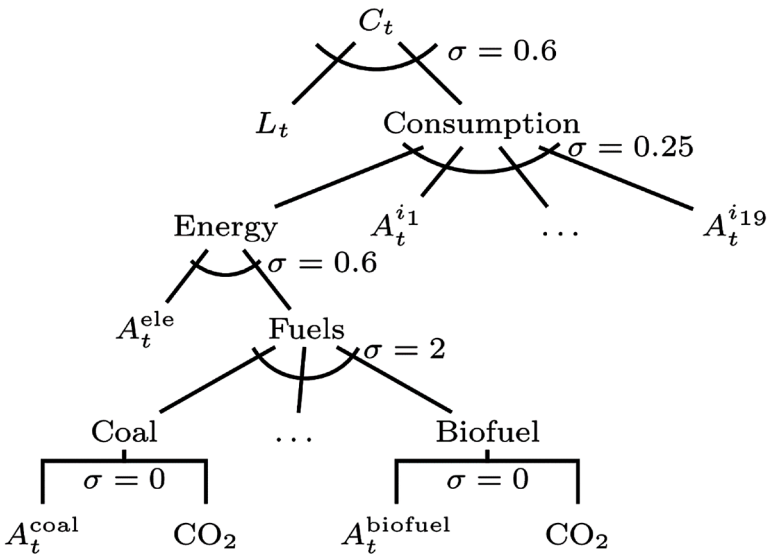
The government raises taxes on labor and capital revenues and levies direct transfers on households. It pays for an exogenously given stream of government consumption as well as for the potential subsidies in the policy scenarios.

Figure 3. CET nesting structure for allocation of land to different uses
Note: In this figure, LD refers to land demand. Index t refers to time (year). τ refers to elasticity of transformation. Note also that demand for protected forest is assumed to be exogenous in our model.



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Figure 4. Representation of household behavior
Note: In this figure, C refers to the aggregate consumption of leisure and goods and services. A refers to consumption of goods and services, L refers to labor. Indices i and j are used to denote sectors and commodities. Index 'ele' refers to electricity. Index t denotes time (year). σ refers to elasticity of substitution.



The actual policy instruments are incorporated in the model through the marginal costs of electricity generation from wind power. We assumed that the electricity price generated from a technology is equal to its marginal cost. Under the production subsidy case, the price of wind power is its marginal cost minus the subsidy rate. The model endogenously determines the level of value added tax required to finance the subsidy so that government revenue remains neutral to the production subsidy policy. Maintaining government budget neutrality is important so that government expenditures from sectors directly related to welfare (e.g., education, healthcare, internal security, etc.) are not diverted to finance renewable energy subsidies. Under the renewable energy consumption mandate case, the aggregate electricity price is increased to reflect the increased electricity supply cost due to the expansion of wind power.

The model is based on two types of data:

1. The social accounting matrix of Brazil, and
2. The elasticities of substitution and transformation.

The SAM is built by Chen and Timilsina (2012) based on input-output tables and other necessary data of year 2008. The sectors and commodities used in the SAM are presented in Table 1. Our assumptions about elasticities are also based on Chen and Timilsina (2012).

3. RESULTS AND DISCUSSION

By the middle of 2015, Brazil has installed 135,364 MW of electricity generation capacity, of which wind power accounts for 4.2%. Other sources, biomass, nuclear and thermal (coal, gas and oil) account

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for, respectively, 9.1%, 1.5% and 19%. The remaining, 66% of the total installed capacity, is supplied through hydro power (Brazilian Electricity Agency, n.d.). In 2012, total electricity generation in Brazil was 552.5 TWh, of which wind power plants generated 5.3TWh or less than 1% (IEA, 2014). This study assesses the impacts of large-scale deployment of wind power so that its share in the total electricity generation mix would reach 10% by 2030. In fact, Brazilian government's Decennial Energy Plan (PDE 2021) aims to increase the share of wind power in the total electricity production to 9% by 2021 (GWEC, 2014). We stayed a bit conservative, considering the rapid growth of total electricity demand.

If the government were to provide a production subsidy to achieve the wind power target, the level of subsidy required to achieve the 10% target would be equivalent to 65% of electricity supply cost of wind power. Now government has to manage sources to finance the subsidy. It could crowd out public expenditure from other sectors, but it would not be desirable to divert public expenditure allocated to areas directly related to public welfare, such as health care, education, internal security, to subsidize wind power. If the government does so, it would cause a direct welfare loss. The most common source of funding is to introduce an extra tax. It could be on fossil fuels or it could be on value added tax (VAT) which is applied to all good and services. Since the VAT has a larger base compared to fossil fuel tax, the welfare impacts caused by a small incremental VAT would be smaller as compared to a fossil fuel tax to generate the same amount of government revenue. Therefore, we considered increasing VAT to finance the wind power subsidy. The incremental VAT needed to achieve the 10% wind power target is small.

When the government introduces a consumption mandate instead of a production subsidy to support wind power, it allows the electric utilities to increase their tariffs so that they can pass the incremental system costs, caused by the wind power addition, to consumers. Meeting the 10% wind power target by 2030 through the consumption mandate would increase the average electricity bill by 6.2%.[6] It is possible that the government could implement both policies, production subsidies and consumption mandates, together. However, we have not considered that case because we aim to compare these two policies in terms of their economic impacts.

3.1 Impacts on the Electricity Sector

The expansion of wind power to share 10% of the total electricity generation by 2030 would lead to an increase in total electricity generation by 1.13% in that year from the baseline if the expansion is triggered through the production subsidy. On the other hand, the total electricity generation would drop by 1.51% from the baseline if the expansion of wind power is stimulated through the consumption mandate. These opposite impacts on total electricity generation between the production subsidy and the consumption mandate cases are explained below.

In the case of the production subsidy, the subsidy would cause the overall price of electricity to drop. This would increase the demand for electricity and ultimately its supply in the equilibrium. Note also that there would be real income drop due to increased VAT to finance the subsidy, however this drop is distributed across the consumption of various goods and services. It could reduce the demand for electricity as well. However, the loss of electricity demand due to increased VAT is smaller than the increase in electricity demand caused by the fall in electricity price.

In the case of consumption mandate, the higher costs of wind electricity relative to that from conventional sources (e.g., hydro, gas, oil) would increase the long-run marginal costs of electricity supply by the grid. Being a profit making entities, electric utilities will transfer the incremental costs to consumers

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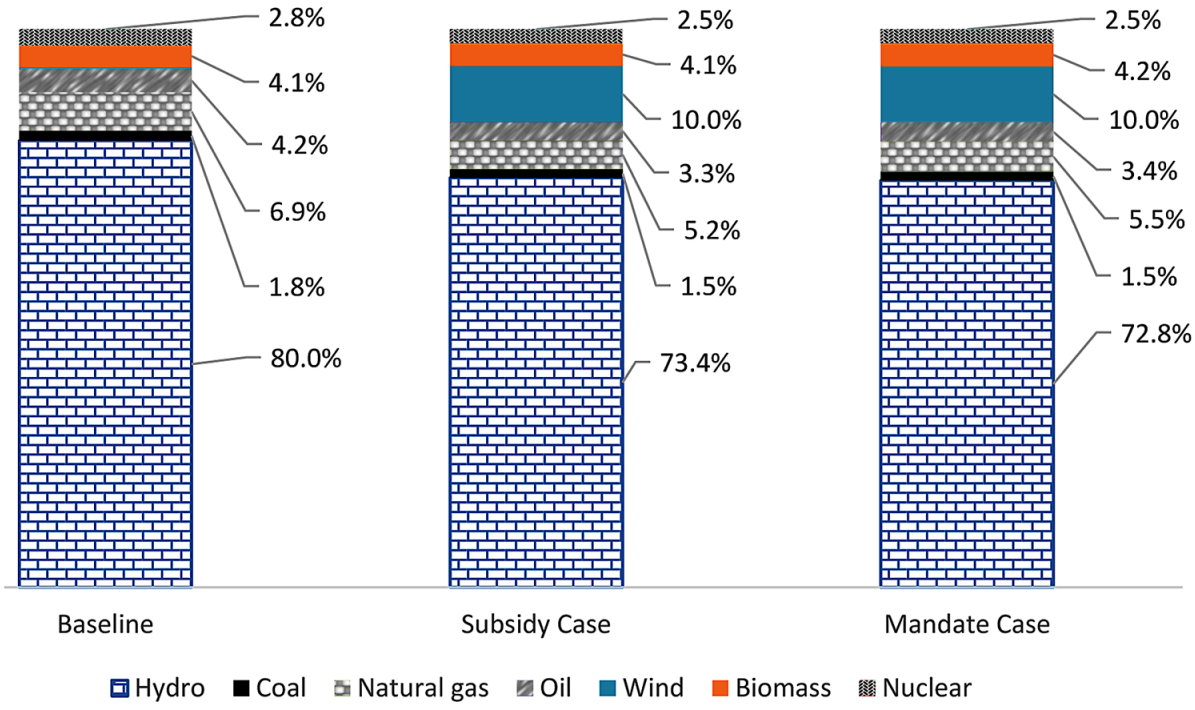
through an equivalent increase in the aggregate electricity price. The increased electricity price would then cause electricity demand to drop. As demand drops, supply also drops in the equilibrium.

An increased share of wind power in electricity generation mix would mean a decrease in share of electricity generated from other sources, such as hydro, nuclear, coal, oil etc. The replacement of various types of electricity generation with wind power is presented in Figure 5. As can be seen from the figure, a 10% penetration of wind power would cause a drop of hydropower by 6.6 and 7.2 percentage points under the production subsidy and consumption mandate cases, respectively. The difference in the replacement rates between these two policy cases is based on the fact that the production subsidy increases the total electricity generation, whereas the consumption mandate decreases the total electricity generation. Similarly, the share of natural gas based generation decreases by 1.7 and 1.4 percentage points under the production subsidy and consumption mandate cases, respectively.

3.2 Impacts on GDP and Sectoral Outputs

The expansion of wind power to share 10% of the total electricity generation in Brazil in 2030 would increase Brazil's GDP by 0.1% from the baseline under the production subsidy case and by 0.009% under the consumption mandate case. While these increases look small in terms of percentage change of GDP, they are quite significant in the absolute term. Brazil's GDP was 2,346 billion US$ in 2014 (World Bank, 2015). If the country maintains a 3% annual growth rate on average, its GDP would reach 3,765 billion

Figure 5. Impacts of 10% penetration of wind power on electricity generation mix in 2030
Note: Baseline refers to a situation in the absence of any policies to promote wind power in Brazil including existing policies. The model shows that if there are no promotional policies, the share of wind in total electricity generation would remain at 0.2% in 2030. However, due to existing policies the share of wind in the total electricity generation was already around 1% in 2012.



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US$ in 2030. The increased GDP due to wind power expansion in 2030 would then be 3.7 billion US$ under the production subsidy case and 339 million US$ under the consumption mandate case.

One would wonder why does expansion of wind power, a relatively expensive technology to generate electricity, increase GDP. This is mainly caused by investment effects of the wind power industry and other industries that supply inputs to the wind power industry. The results from our modeling show that aggregate investment in the economy increases under the both policy instruments. The increase in aggregate investment is much higher under the production subsidy case as compared to that under the consumption mandate case. GDP is the sum of consumption, investment, government spending, and net exports. Our detailed results show that the change in GDP is mainly driven by the changes in consumption and investments. While aggregate investment increases, the aggregate consumption decreases. However, the increase in investments is bigger than the decrease in consumption, leading to an increase in GDP for both policies in 2030. Since the reduction in consumption is smaller and the increase in investment is bigger under the production subsidy case than under the consumption mandate case, the increase in GDP is bigger in the former case as compared to that in the latter.

Table 2 presents the impacts of wind power expansion on the outputs from various production sectors. Two observations can be made in Table 2. First, the impacts on outputs vary significantly across the sectors. Secondly, for a given sector, the impacts are much different between production subsidy and consumption mandate cases. A consumption mandate to promote wind power expansion would reduce sectoral outputs of energy sectors, most notably electricity and oil and gas. This is because the mandate makes electricity expensive thereby reducing its demand. In response, electricity generation to meet the demand also drops. Table 3 shows that electricity demand in all production sector decreases under the consumption mandate policy case. Fuel demand for electricity also decreases thereby lowering their production.

Although a production subsidy to wind power does not raise electricity price, it would still have regressive impacts in certain sectors. This is because, the wind power production subsidy is financed through an increase in value added tax in all other sectors. The value added tax would have negative implications in outputs of sectors which produce relatively higher value added per unit of output (i.e., capital and labor intensive sectors). As expected, sectors which supply goods and services to wind power industry would experience increased value added under both policy scenarios. Examples are construction, machinery industries, commercial services, wood and lumber, forestry.

3.3 Impacts on GHG Emissions

The expansion of wind power to increase its share in the total electricity generation to 10% in 2030 would reduce total energy related GHG emissions in the country by 1.4% and 1.2% in 2030 from the baseline if the penetration was caused by the production subsidy and the consumption mandate policies, respectively. The reductions of GHG emissions comes mainly from the replacement of natural gas fired electricity generation with wind power. The relatively small reduction of GHG is based on the fact that wind power mostly replaces hydropower instead of fossil fuel based power generation in Brazil. This is because there is a good complementarity between hydro and wind power in the country. The production subsidy policy causes higher reduction of GHG than that caused by the consumption mandate policy. This is because the replacement of hydropower with wind power would be smaller under the production subsidy case compared to that under the consumption mandate case. On the other hand, the replace-

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Table 2. Change in sectoral outputs relative to BAU due to expansion of wind power in year 2030 (%)

Sector	Production Subsidy	Consumption Mandate
Agricultural	-0.03	0.01
Sugar cane	-0.33	-0.02
Soybeans	-0.05	0.12
Forestry	0.08	0.07
Livestock	0.02	0.01
Food & beverage	0.00	-0.03
Oil & gas	-1.47	-1.03
Non energy mining	0.30	0.00
Coal mining	-0.25	-0.59
Textile & leather	0.09	0.01
Wood and lumber	0.28	0.26
Pulp paper & furniture	0.08	-0.02
Petroleum refinery	-0.67	-0.10
Biofuel	-0.47	0.23
Chemicals	0.19	-0.01
Non metalic minerals	0.51	0.20
Metal	0.27	-0.12
Machinery	0.26	0.15
Other manufacturing industry	0.15	0.05
Electricity	1.13	-1.51
Processed gas	0.68	-0.63
Construction	0.52	0.41
Commercial service	0.09	0.06
Transport service	-0.01	-0.04
Other service	-0.01	-0.01

ment of natural gas fired electricity with wind power would be larger under the production subsidy case compared to that in the consumption mandate case.

4. CONCLUSION

Fiscal policies (subsidies in particular) and regulatory policies (particularly mandates) are the main instruments introduced in both developing and developed countries to encourage a large-scale deployment of renewable energy, such as wind power. Which policy instrument would be attractive from a broader economic perspective, however, has not been clearly answered yet. This study aims to address this question in the case of wind power expansion in the Brazil.

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Table 3. Change in electricity demand in various industrial sectors and households relative to BAU due to expansion of wind power in year 2030 (%)

Sector	Production Subsidy	Consumption Mandate
Agricultural	1.3	-2.4
Sugar cane	1.0	-2.5
Soybeans	1.3	-2.3
Forestry	1.4	-2.4
Livestock	1.3	-2.4
Food & beverage	0.9	-1.7
Oil & gas	-0.5	-2.8
Non energy mining	1.6	-2.3
Coal mining	0.9	-2.8
Textile & leather	1.0	-1.7
Wood and lumber	1.4	-1.8
Pulp paper & furniture	0.9	-1.6
Petroleum refinery	0.5	-1.0
Biofuel	0.7	-1.9
Chemicals	0.8	-1.1
Non metalic minerals	1.0	-0.8
Metal	0.9	-1.2
Machinery	0.8	-0.9
Other manufacturing industry	1.2	-1.9
Electricity	3.0	-2.0
Processed gas	1.0	-1.2
Construction	1.2	-0.9
Commercial service	1.2	-2.0
Transport service	0.6	-1.2
Other service	0.5	-1.0
Household	0.7	-2.0

Using a dynamic general equilibrium model to assess an ex-ante economic impacts of wind power expansion in Brazil, this study shows that expansion of wind power would increase GDP no matter whether a subsidy or a mandate is used to drive the expansion. However, the increase in GDP would be lower under the consumption mandate as compared to that under the production subsidy case. Since the production subsidy causes higher increase in GDP compared to the consumption mandate and it also causes higher reduction of GHG emissions than a the consumption mandate does, we can draw a conclusion that the subsidy policy is superior to a consumption mandate policy for Brazil's efforts in promoting wind power. Although this finding is consistent with general principles in public finance and with findings in other studies of renewable energy policy (e.g., McCullough et al. 2011; Timilsina & Landis, 2014), it should not be generalized because the results from CGE models are country specific.

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The sectoral results are different not only between the two policy instruments but across the sectors for a given policy instrument. Sectoral outputs of fossil fuel industries decreased under both policy instruments whereas the outputs of industries providing goods and services to wind power industry increased. The consumption mandate would also cause sectoral outputs of other sectors, especially energy intensive sectors, to drop.

The analysis is carried out based on present (2012) data on electricity supply costs of various technologies to generate electricity. The capital costs of renewable energy technologies, including wind power technologies, have declined over time in the past. However, it is difficult to predict how far the cost reduction will go and when wind power technologies would be economically competitive with traditional sources of electricity generation. Even if they are competitive in terms of the levelized costs of electricity generation, utility planners still discount wind and solar because these are intermittent resources to generate electricity and do not provide a firm power or capacity guarantee, which is essential to have a reliable electricity supply system.

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ENDNOTES

1 The Brazilian government's Decennial Energy Plan (PDE 2021) sets a goal of 16 GW of installed wind capacity by 2021, accounting for 9% of national electricity consumption (GWEC, 2014).

2 By the end of 2010, total wind power capacity was 927 MW, it increased to 5,900 MW by the end of 2014 (REN21, 2015).

3 In this study, a production subsidy refers to a premium required to lower the levelized cost of wind power generation to a level to make it competitive to other sources of electricity generation, such as hydro, natural gas etc. In other words, wind power producers can secure their expected rate of returns with the help of this premium which they receive in proportion to the amount of wind electricity they produce.

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[4] However, recognizing the role of power sector on climate change mitigation policies, CGE models developed for climate change mitigation polices started to represent different electricity generation technologies separately instead of lumping them in a single technology (see e.g., Rana, 2003; Paltsev et al., 2005; Timilsina and Shrestha, 2006).

[5] Please see to Timilsina and Landis (2014) for more information on the use of Logit model to represent investment behavior in the power sector.

[6] The subsidy policy averages the premium for wind power into a relatively large base of total consumptions of goods and services in the country whereas the mandate policy averages the premium into relatively smaller base of consumption of electricity only.

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Chapter 30
Ensuring Environmental Sustainability Through Sustainable Entrepreneurship

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ABSTRACT

Sustainability has become an important issue worldwide because of great concerns about the unintended social, environmental, and economic effects of increasing population and economic growth, as well as consumption of natural resources. One recent concept arising from sustainability issue is sustainable entrepreneurship which integrates both the social and environmental aspects, and linking them with entrepreneurial activities. This chapter therefore suggests that efforts of developing countries at promoting entrepreneurship should go beyond engaging in business enterprises but include encouraging the use of entrepreneurial values and approaches to solve sustainability problems. Hence, this chapter is an effort at developing a framework that can be used to influence sustainable entrepreneurship behaviour of the students in developing countries.

INTRODUCTION

As far back as 1970s there has been a great concern about environment and development. This is because of the considerable negative effects that industrialisation is having on the natural environment in term of diminishing the vitality and sustainability of economic systems (World Resource Institute, 2004 cited by Dean and McMullen, 2007). Apart from the problems that are peculiar to local environment like air pollution, surface-water degradation, and toxic wastes in groundwater, there are negative impacts of industrialisation that are of global concern. These, according to the report of United Nations (2004), include ozone depletion, climate change, and the worldwide destruction of ocean fisheries.

The first major international gathering to discuss sustainability was the United Nations conference on the Human Environment held in Stockholm in 1972. The conference led to the establishment of the United Nations Environment Programme (UNEP) as well as the creation of numerous national envi-

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ronmental protection agencies at country level. It was during this period that the concept of sustainable development became popular. The concept was further popularised by the report of the World Commission on Environment and Development in 1987, titled 'Our Common Future' (or Brundtland Report). This report gave the classic definition of sustainable development as development which meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Since then, sustainable development is accepted as a convergence between the three pillars of economic development, social equity, and environmental protection (United Nations, 2010).

The concern about sustainability has also opened new opportunities for entrepreneurship and introduced a new dimension to its study. This is because entrepreneurship is believed to have potential of resolving problems of market failure inherent in the economic system, especially environmental issues. Hence, sustainable entrepreneurship, which is a spin-off concept from sustainability development, integrates both the social and environmental aspects, and linking them with entrepreneurial activities. The strategy of achieving this is the encouragement of green enterprises, which required firms to reconcile sustainability aspects with profitability.

Over the past decade, African economies have experienced rapid advancement towards integration into the global economy. This can be seen from the efforts of many of the countries undertaken significant economic reforms such as improving macroeconomic management, providing conducive private investment climate, liberalising markets as well as widening the space for entrepreneurship to drive strong and inclusive growth (Ahmed & Nwankwo, 2013). These authors however noted that there is much at stake in continuing this process of scaling up entrepreneurship as a dynamic process towards sustainable economic development. One of such is how to ensure that entrepreneurship is able to create value which is economic, social, or ecological in nature.

While the efforts of various governments, especially in developing countries, at promoting entrepreneurship is laudable one, this should however go beyond encouraging business start up where people seek advantages only for themselves or unconsciously run their businesses in a destructive way that generates imbalances. Therefore, solution to unemployment must also consider sustainable entrepreneurship, which requires the use of entrepreneurial values and approaches to solve sustainability problems. That is, application of imagination to challenging problems by conceiving, prototyping and creating solutions that deliver environmental, social and economic value (Pascual, van Klink, & Grisales, 2011). Therefore, policies and programmes of African government on entrepreneurship should be long-term and take the future into account so as to be sustainable in nature.

Though the practice of sustainable entrepreneurship is not new in African countries when considering the waste-to-wealth initiative and recycling process, but a quick look at available literature shows that not many studies are addressing the concept of sustainability entrepreneurship in this continent. This chapter is therefore an effort to fill this gap by synthesising theories from the entrepreneurship, environmental and welfare economics literatures with the view to examine the potential of entrepreneurship to create value within the dimensions of sustainability in African countries. Moreover, the chapter develops a framework which is expected to provide direction for the development of entrepreneurship education that can create and develop sustainable entrepreneurial behaviour in students, especially those in tertiary institutions. The framework can also serve as input into the formulation of policies and programmes by the government of African countries to properly lay the foundation for effective delivery of education for sustainable entrepreneurship based on the best practices in developed countries.

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Since sustainable entrepreneurship is an extension of entrepreneurship, the chapter begins with the concepts related to sustainable entrepreneurship and its definition. Next, the environmental and welfare economics theory is reviewed to conceptualise how entrepreneurial action can be used to address market imperfections so that environmental and natural resources can be efficiently utilised. The chapter then provides the theoretical and empirical background for the drivers or motivation for sustainable entrepreneurship as well as how entrepreneurship education can be used to develop sustainable entrepreneurial behaviours in nascent entrepreneurs. A framework for the development of sustainable entrepreneurial behaviour is then suggested. The chapter is concluded by considering the implication of developing sustainable entrepreneurial behaviour for the entrepreneurship educators and policy makers.

THEORETICAL BACKGROUND

Concept of Entrepreneurship and Sustainability Entrepreneurship

As early as 18th century, various definitions of entrepreneurship have been put forth but with no universally accepted one. According to Venkataraman (1997), entrepreneurship is defined as the process of how opportunities to bring into existence future goods and services are discovered, created, and exploited, by whom, and with what consequences. Recent definition put forth by Stokes, Wilson and Mador (2010) defined it by encompassing all the different definitions, based on what entrepreneurs do, who they are, and what they produced. While referring to Stokes, Wilson and Mador (2010) and synthesising from studies from previous researchers, Majid and Koe (2012) then put forth a definition which is adopted in this chapter. The definition focuses on behaviour, processes and outcomes of entrepreneurs. Entrepreneurship is therefore defined as a process of identifying, evaluating and pursuing opportunities through creativity, innovativeness and transformations to produce new products, processes and values that are beneficial. This definition takes into consideration the modern school of thought on entrepreneurship which is now playing emphasis on sustainability. That is, entrepreneurial thinking process should involve identifying, evaluating and pursuing business opportunities that will be economically viable as well as preserving the environment for the next generation.

The role of entrepreneurship in economic growth is also established in the literature. But the traditional entrepreneurship education usually prescribes to students a profit-driven mentality. This, in the word of Slater and Dixon-Fowler (2010), is termed 'profit-first' mentality, which has no regard for moral considerations or social responsibilities. Recently however, the concern for society gave rise to social entrepreneurship where profit motive is not the primary consideration but on societal problems. Inspite of its non-profit motive, various case studies have shown that there are social entrepreneurs who are able to make profit while creating the social values. Some of these cases include Jacqueline Novogratz (*Acumen Fund*), Bill Drayton (*Ashoka*), Sam Goldman and Ned Tozun (*d.light*), Rafael Alvarez (*genesys works*), and Jane Chen (*embrace*) among others (see http://www.forbes.com/impact-30/list.html for more information). The success story of these social entrepreneurs is what stirs interest in the direction of concern for the environment.

The consciousness towards the environment is therefore compelling the businesses already in existence to 'green' their products or services, processes and distribution. Likewise, the new start-ups are encouraged to start out with the intention of making environmental protection an integral part of the reasons for setting it up (Santiago, 2013; Walley & Taylor, 2002). The concern for the environment and the potential

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of entrepreneurship to exploit the opportunities associated with environmental degradation has led to the concept of sustainable entrepreneurship. This is based on the concept of triple bottom line coined by Elkington (1994). That is, entrepreneurship that contributes equally to economy, ecology and society.

Sustainable entrepreneurship research has now emerged from the larger body of business and environment as well as corporate responsibility research. This is in response to the demand for modifications in business, social and environmental practices. Sustainable entrepreneurship, which is a concept linking development to entrepreneurship, is also variously defined in the literatures (for examples Elkington, 1998; Cohen & Winn, 2007; Dean & McMullen, 2007). But there is an agreement that the feature of sustainable entrepreneurship is based on certain fundamental aspects of entrepreneurial activities, which are personal initiative and skills, to create or discover business opportunities as well as realisation of market success. In addition to these activities, sustainable entrepreneurship also takes into account environmental and societal goals.

Therefore, the concept of sustainable entrepreneurship arises from the understanding that efforts at addressing environmental issues, such as ecosystem degradation and global climate change, requires a fundamental transformation in the way society consumes natural resources and produces energy. Hence, as put forth by Cohen and Winn (2007), sustainable entrepreneurship should result into entrepreneurial rents and also ensures social and environmental sustainability. Sustainable entrepreneurship therefore entails developing businesses which have positive relationships with the society in which it operates (Crnogaj, Rebernik, Hojnik, and Gomezelj, 2014). This means that business ventures arising from sustainable entrepreneurship must stand on the tripod of economic stability (profitability), social equity, and sustainable practice of reducing environmental degradation (Lumpkin & Katz, 2011). Hence, the principles of entrepreneurship can serve as means by which market failures such as environmental and social disruptions can be ameliorated (Crnogaj, Rebernik, Hojnik, & Gomezelj, 2014).

While synthesising the various definitions of sustainable entrepreneurship, Majid and Koe (2012) identified the main issues that sustainable entrepreneurship covers. These include what entrepreneurs can do in preserving economics, environment, social and culture in entrepreneurial ways. Hence, the authors put forth the definition of sustainable entrepreneurship as a process in which entrepreneurs exploit a business opportunity in an innovative manner for economic gains, society equity, environmental quality and cultural preservation on an equal manner. Unlike other definitions which focus on green or social domain only, the definition suggested by Majid and Koe (2012) covers the domains of economic, social, environmental and cultural. Hence, this definition is adopted for this chapter.

In conceptualising sustainable entrepreneurship, many researchers have used the triple bottom line (TBL) to describe sustainability development. The concept identified three main value creating aspects in sustainable business practices. These include economic prosperity, environmental quality, and social justice (Elkington (1997). Therefore, various models of sustainable entrepreneurship, based upon the concept of TBL, have been developed over the years. One of such models is based on the triune of social, environmental and economic to examine whether the entrepreneurs could operate an economically viable venture whilst retaining their environmental and social values (Dixon & Clifford, 2007 cited in Majid and Koe, 2012). Another is the value-based model developed by Tilley and Young (2009) which argue that sustainable entrepreneurship should be treated as the combined efforts of the 12 individual values that drive sustainability.

As it is argued in the definition of sustainable entrepreneurship, that its definition should cover the four domains of economic, social, environmental and cultural, likewise Majid and Koe (2012) proposed another model which included all these four domains in order to be regarded as true sustainable entre-

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preneurship. The argument is based on the thought of Nurse (2006) that sustainability issues, especially in developing countries, should not rely heavily on western scientific knowledge. This is because over dependence on western scientific concepts in managing sustainability can lead to the loss of traditional or indigenous knowledge. This traditional wisdom can actually serves as solutions for sustainable development problems in developing countries. This explains the reason why culture is included as the fourth pillar in sustainable development.

Market Imperfections and Entrepreneurial Opportunities

Central to the environmental economics is the concept of market imperfections, which is the failure of markets to efficiently allocate limited resources in a way that benefits society most. These imperfections contribute to environmental degradation. Fortunately, these market imperfections have been discovered as avenue where opportunities for the creation of radical technologies and innovative business models can be developed (Dean and McMullen, 2007; Cohen and Winn, 2007). These opportunities form the foundations for an emerging model of sustainable entrepreneurship. Exploiting these opportunities can enable existing or would-be entrepreneurs to obtain entrepreneurial rents and, at the same time, improve the social and environmental conditions. Central to the need to understand how market failure may be used to explore sources of entrepreneurial opportunities is the question Venkataraman (1997) raised about 'where opportunities to create goods and services for the future will come from'. The answer is now emerging from the understanding of how market failures can serve as entrepreneurial opportunities.

There are four of these market imperfections identified in the literature and which are also seen as sources of entrepreneurial opportunity. They are: firms are not perfectly efficient, externalities exist, pricing mechanisms work imperfectly, and information is not perfectly distributed. The theoretical background for understanding how each of these market imperfections can create entrepreneurial opportunities is based on the theoretical views on entrepreneurial opportunity, which is synthesised by Sarasvathy, Dew, Velamuri and Venkataraman (2003). First is the allocative view (opportunity recognition) which suggests that opportunities exist when there is potential to redistribute resources to benefit others without adversely affecting others. Second, there is also the discovery view (opportunity discovery) where entrepreneurial opportunities arise from information asymmetries with respect to the true value of resources and the resulting value of the combination of those resources into outputs. Lastly, the creative view (opportunity creation), that is, when opportunities are identified ex-post when entrepreneurs is seeking to maximise the utility functions of multiple stakeholders. Each of these views of entrepreneurial opportunities is useful in establishing how entrepreneurial rents can be achieved through innovations which correct the existing unsustainable use of environment.

Based on the extensive review of literature on the concept of market imperfection by Cohen and Winn (2007), the authors are able to establish the role that each of the imperfections plays in environmental degradation as well as how it can lead to any of the generic types of opportunities stated above. The first imperfection indicates the inability of firms to be perfectly efficient in their resource allocation. The outcome is that both the firms and consumers can only achieve a fraction of the potential efficiencies available from natural resources. Efforts at bringing markets closer to equilibrium will therefore require that the efficiency of resource allocation be increased. This can be achieved through opportunity identification and exploitation using entrepreneurial process. These opportunities derive from the conversion to a cyclic economy (Kirchgeorg, 1999 cited in Cohen & Winn, 2007) in which improvements in efficiency of resource use depend on recycling and recovery at every stage of the process. That is, ability

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to convert industrial and consumer waste into new products and services. From the above, innovating entrepreneurs who discover the potential to reduce that waste (through recycling) will be able to correct the imperfection due to inefficient resource allocation.

The second imperfection is about existence of externalities, which may be positive or negative. This imperfection suggests that the costs or benefits associated with the production or consumption activities of firms are not correctly reflected in the prices of products and services being offered by such firm. Positive externalities occur when the third party benefits without incurring the full cost associated with the value of benefit received. One example of positive externalities is when new good, resulting from research and development investment of a company, is purchased by the consumers at price below what would fully reflect the value of technological improvements (Abereijo & Ilori, 2012). On the other hand, it becomes negative when the third party suffers from the activities of a firm without receiving adequate compensations. Examples of this abound, which include impact of industrial smoke, water pollution, etc, on health and economic activities of surrounding communities. Therefore, if an entrepreneur can substitute current production processes, which results in externalities, with innovative ones, such entrepreneurs would have discovered an entrepreneurial opportunities for new business and also brought about positive environmental externalities. The types of opportunity identification that are most likely are opportunity discovery and creation. In the word of Cohen and Winn (2007), innovative firms that are able to recognise and create opportunities to reverse existing negative environmental externalities (for example, air pollution) can generate triple bottom line results. That is, their entrepreneurial actions can produce social benefits (through improvement in the quality of air within the communities) and environmental benefits (improved ecosystem functioning), and which is being done profitably. Apart from entrepreneurial opportunities resulting from improvement on production processes, there could also be an institutional entrepreneurship. This is type of entrepreneurship involves a process whereby the transaction costs associated with environmental-based externalities is reduced. Institutional entrepreneurship, as defined by Dean and McMullen (2007), is the process of reducing transactions costs through the development of economic institutions by profit-motivated economic actors. Example of institutional entrepreneurship is a legal firm who coordinates the interests of the parties that are being affected by negative externalities. By this effort, the right of the parties concerned can be enforced and the cost of bargaining and contracting with the producer of negative externalities can also be reduced (Dean & McMullen, 2007).

Moreover, the possibility of pricing mechanism working imperfectly is the third market imperfection. This imperfection arises because of the assumption of the conventional economics theory that natural resources are infinitely plentiful and that they have a market value that accurately reflect supply and demand. The reality, as put forth by Kurz and Salvadori (1997), is that many natural resources are exhaustible, undervalued and underpriced. Therefore, if the natural resources are valued more accurately and perfectly priced the demand for the use of non-renewable factors of production will decrease, while demands for more renewable factors will increase. Therefore, entrepreneurship principles can be applied whereby innovative entrepreneurs begin to discover opportunities in renewable factors of production. Example is disruptive technologies which are been sold in the market where consumers cannot buy high end products. The specific examples are Thin Film Technologies producing solar photovoltaic cell being marketed in third world countries without established power grids (Cohen & Winn, 2007).

The fourth market imperfection concerns the imperfect distribution of information. The assumption of neoclassical economics is that suppliers and buyers within free market have perfect information about prices, products and the market. But in reality, there is presence of information asymmetry, which some-

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times is responsible for the unsustainable production and consumption patterns. The imperfect distribution of information are categorised into two by Dean and McMullen (2007). These are knowledge that producers have about supply and demand conditions, and knowledge that customers posses regarding the nature of product or service attributes. Some of the factors that may be responsible for imperfect information are changes in technology, tastes, and demographics. In relation to environment, imperfect information therefore exist when better channels of supply are not known or when markets for environmentally superior products are yet to be discovered. Entrepreneurial opportunities associated with this imperfect information could include the use of new product or process technologies or efficient means of supply which are not damaging to the environment. Also, identifying customers who prefer environmentally superior products or services could also serve as another source of entrepreneurial opportunities. In relation to the second category of imperfect distribution of information, opportunities can also exist for what Dean and McMullen (2007) referred to as customer-focused informational entrepreneurs. These entrepreneurs exploit opportunities by enhancing customer knowledge about the environmental attributes of products and services.

Drivers of Sustainable Entrepreneurship

The existence of numerous market imperfections, with regard to the environment and social conditions, suggests that it is not automatic that entrepreneurs will likely pursue those opportunities from which entrepreneurial rents exist. Hence, there are certain behaviours associated with individuals who prefer to pursue entrepreneurial opportunities based on market imperfections. The theoretical literatures identified certain drivers towards sustainability entrepreneurship orientation, which are categorised as being externally- or internally-driven (Kuckertz & Wagner, 2010; Gibbs, 2009; Masurel, 2007; Schlange, 2006). Government policies and or incentives as well as pressure groups constitute the external drivers, while the entrepreneurs' value system is the internal driver. Whether externally or internally driven, the response to sustainability issues also differs. Hence, Baumgartner (2009) posited that the approach could be introverted, or extroverted, or eco-efficient practices, or visionary strategy. The introverted approach involves responding to the pressures from stakeholders such as government regulation, while the extroverted approach involves highlighting the accomplishments in sustainability reports. The eco-efficient practices by firms involve adopting conservative approach of energy conservation and waste management. It is only the visionary strategy approach that actually integrates sustainability issues in business operations.

Empirically, Schick, Marven and Freimann (2002) discovered in their study that individuals categorised as eco-dedicated were influenced by their families in their childhood. Hence, some authors are of the opinion that subjects and courses that create environmental awareness, at all levels of education, could lead future entrepreneurs in the right direction (Dobson, 2007; Schaper, 2002). The findings of Schlange (2006) also confirmed that one major characteristic of sustainable entrepreneurs is a strong emphasis on ecological aspects in their business vision. It is also discovered that the main driver for a sustainable entrepreneurial motivation is structured along the social and ethical dimension. The results of study on the factors influencing propensity to sustainable entrepreneurship of SMEs in Malaysia revealed that attitudinal (attitude towards sustainability) and perceptual (perceived feasibility and desirability) factors positively and significantly influenced such propensity (Koe, Omar, Sa'ari, 2015; Koe, Omar & Majid (2014). The authors therefore concluded that effort at promoting sustainable entrepreneurship requires entrepreneurs developing sufficient sustainability capabilities, establishing a positive or

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favourable sustainability attitude and creating attractive sustainable entrepreneurial practices. Moreover, prior knowledge and focused attention can also contribute significantly to opportunity recognition in sustainability-related market failure (Bell and Stellingwerf (2012). Another important driver, noted by these authors, is motivations to solve the sustainability-related market failures.

The Role of Entrepreneurship Education

There is recognition in the literature that entrepreneurship education can help promote sustainable entrepreneurship. For example, Shane (2003) postulates that opportunity is likely to be exploited if an individual is better educated. This is because the information and skills acquired through education can increase expected returns for opportunity exploitation. Hence, many universities, especially in developed countries like United States of America, are incorporating sustainability into the curricula of their undergraduate studies (see McEwen, 2013 for examples of sustainability entrepreneurship education activities at the university level). It is also noted in the literature that sustainable entrepreneurship requires a new educational approach. The education should specifically focus on sustainability and be delivered in a way to stimulate sustainable entrepreneurial behaviour in students. In the word of McDonough and Braungart (2002), the goal of sustainable entrepreneurship education should be to equip the students with knowledge and skill needed to operate on renewable energy and to eliminate the concept of waste by making every waste product a raw material or input for another activity or return it into the cycle of nature. Ultimately, students of sustainable entrepreneurship should be able to apply sustainability frameworks to design new products, services, and processes (McEwen, 2013).

Among the knowledge base and skills needed are awareness of local and global environmental problems and future trends, acquisition of environmental values, and engagement in ecological or systems thinking (Richardson, Irwin and Sherwin (2005). Other skills identified by SustainAbility (2008) are the ability to seek alternative and innovative ways of meeting present needs as well as developing new business models that support the resulting innovative products and services. Also the future sustainable entrepreneurs should be able to get inspiration from the solutions already provided by the nature. This is termed biomimicry, which is an approach to innovation that seeks sustainable solution to human challenges by emulating nature's time-tested patterns and strategies (Biomimicry Institute, 2014). It is therefore important to design curricula and pedagogy that can influence the attitudes and actions of existing and, especially, the would-be entrepreneurs. The pedagogy should emphasise active, experiential, inquiry-based learning and real world problem solving in the classroom, on the campus and in the local community (McEwen, 2013). Moreover, to ensure long-term retention of the knowledge, skills and values gained the author proposed that the curriculum should provide learning experiences on real-world problems prevailing within their immediate university environment, larger community, government and industry.

Beyond the pedagogy, there are certain factors identified in the literature that may likely make entrepreneurs to discover sustainable development opportunities. These include their knowledge of the natural and communal environments in which they live as well as their perception about the threats on these environments (Patzelt and Shepherd, 2011). Other, as posited by these authors, includes the extent of their altruism toward others within the community. This again underscores the importance of approach to sustainable entrepreneurship education, which must be appropriately designed to develop these attributes.

Various approaches on education for sustainable development identified in the literature include, first, normative and zero-sum perspectives which involve awareness-building, critical thinking and introduction of tools to support environmental protection (Springett, 2005). Second approach is instrumental

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perspective that highlights the value of sustainability and corporate social responsibility initiatives to build competitive advantage (Kashyap et al., 2006). The more recent approach is the one that highlight the importance of entrepreneurship education to inspire and build awareness of the opportunities inherent in the sustainability arena for self-interest and to benefit diverse stakeholders (Kuckertz & Wagner, 2010). While the first and second approaches are reactive, the third is proactive in nature. That is, the third approach is meant to influence attitudes and intentions related to sustainable development. Drawing from the theory of planned behaviour, the present and future behaviour of an individual is strongly determined by behavioural intentions (Ajzen, 1991). This means that the behavioural intention of sustainable entrepreneurs will depend on attitudes, subjective norms and perceived behavioural control. The theory of planned behaviour is therefore providing the framework within which the link between education and sustainable entrepreneurship can be explored.

Relating this theory to sustainable entrepreneurship, Lourenço, Jones and Jayawarna (2013) posited that formation of sustainable entrepreneurial behaviour intention is dependent on learner's perceived benefits of learning about sustainable entrepreneurship, perceived behavioural control, and subjective norms formed through perceived ease of use of knowledge related to sustainable entrepreneurship. Therefore, it can be proposed that the intentions of would-be entrepreneurs to utilise their learning related to sustainability are influenced by their perception of learning, perception of benefits and the perceived ease with which the learning content can be applied. The empirical finding of Lourenço, Jones and Jayawarna (2013) also confirmed above theory. First, the author found that if prospective entrepreneurs perceive benefits from content related to sustainable entrepreneurship their intentions to exploit such learning will be enhanced. Second, if nascent entrepreneurs learn content related to sustainable entrepreneurship, the likelihood of exploiting such learning will also be enhanced. In summary, the major driver for would-be entrepreneurs to utilise learning is their understanding of the benefits of sustainable entrepreneurship and their perception of learning.

Another important motivation of prospective entrepreneurs to utilise learning about sustainable entrepreneurship is whether or not such entrepreneur has profit-mentality. This argument, proposed by Giacalone and Thompson (2006), is confirmed by the empirical finding of Lourenço, Jones and Jayawarna (2013). That is, profit-minded entrepreneurs will likely pursue those opportunities that promise higher entrepreneurial rents. However, Lourenço, Jones and Jayawarna (2013) discovered that, though a profit-first mentality will influence evaluation of sustainable entrepreneurship, but it is not a significant factor deterring the ability to learn material that could be in conflict with existing institutional logic of profit-first value. Hence, there is still value in introducing learning content related to sustainable entrepreneurship to would-be entrepreneurs with a profit-first mentality. It is then suggested by these authors that providing sustainability-related content in entrepreneurship education and business start-up is a valuable intervention.

The implication of the above, especially for the educators, is the need to develop competences for the delivery as well as the curriculum that can develop sustainable entrepreneurial behaviour in the students.

FRAMEWORK FOR SUSTAINABLE ENTREPRENEURSHIP

Based on the literature review, as discussed above, it is clear that the problem of environmental degradation, arising from the failure of markets, can be resolved through entrepreneurial action. That is, there are entrepreneurial opportunities associated with these market imperfections which can be exploited

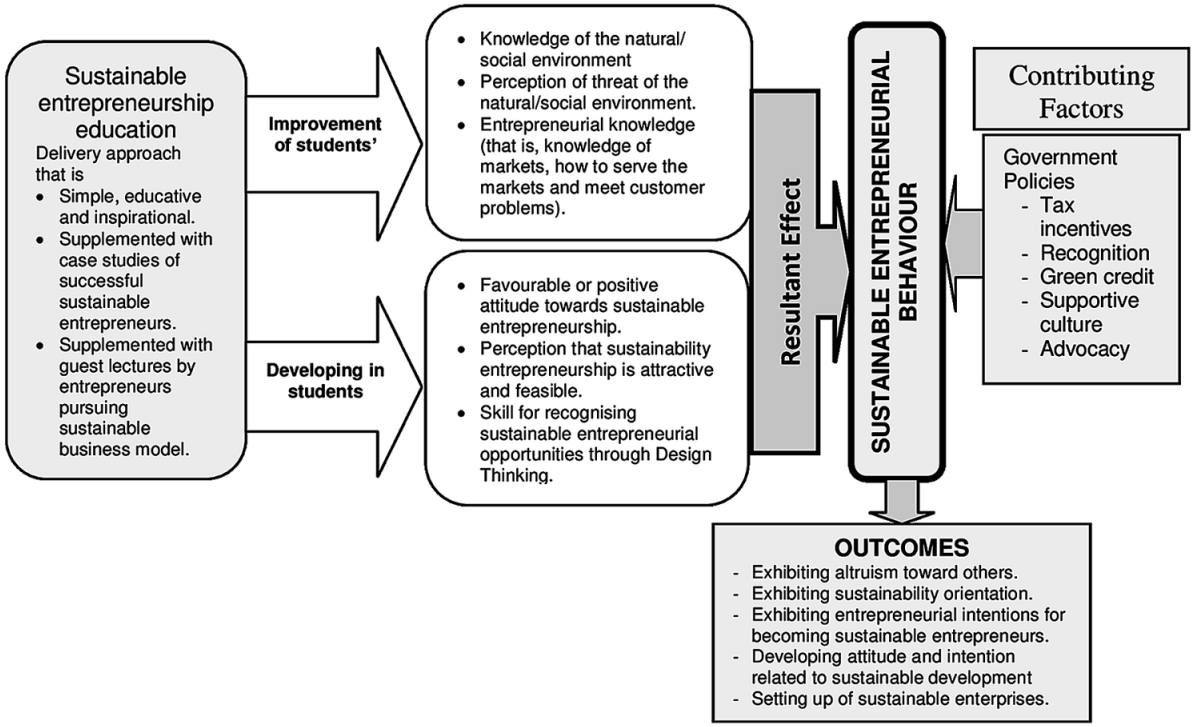
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using entrepreneurial process. Both theoretical and empirical literatures are however suggesting that only entrepreneurs who are sustainability-oriented will likely support the idea of sustainability and exploit the opportunities associated with the market imperfections. This then indicates the importance of entrepreneurship education in fostering the entrepreneurial intentions targeted at opportunities related to sustainable development. The education will help fostering sustainable development-oriented entrepreneurial behaviour, as well as encouraging the nascent entrepreneurs to pursue business that can result in sustainable market offerings.

Considering the complexity inherent in opportunities for sustainable entrepreneurship, the contents and pedagogical input is very crucial, especially on how it can influence learners' attitudes and intentions towards sustainable development. Empirical results showed that when the techniques of delivering the education are simple and easy to learn, the perceptions of the learners about the benefits of learning sustainable entrepreneurship will be raised (Lourenco, Jones & Jayawarna, 2012). Therefore, the combined effect of understanding the benefits of sustainable entrepreneurship and perception of learning are major motivation for exploiting the learning by nascent entrepreneurs.

Figure 1 therefore shows the proposed framework for developing sustainable entrepreneurial behaviour of future entrepreneurs, especially in tertiary institutions in African countries. From this figure, the delivery approach for teaching sustainable entrepreneurship should be simple, educative (well grounded in entrepreneurship and environmental economics theories), and involves intensive hands-on experiences. This is because sustainable solutions require a lot of creativity, and as Schumpeter (1934) noted, the entrepreneurial process in sustainability involves creative destruction of conventional production methods and consumption patterns. To further stimulate the interest of students and make them appreciate the

Figure 1. Framework for the development of sustainable entrepreneurial behavior



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benefits associated with green business ideas there is need for industrial visit to successful businesses with best-practices. Also, the education should be supplemented with case studies of successful sustainable entrepreneurs as well as guest lectures by entrepreneurs pursuing sustainable business model.

It is expected that the approach will achieve two major goals in the learners. First, it will improve students' knowledge and perception of threats in the natural and social environments, as well as improving their entrepreneurial knowledge about the market and how to serve it, and how to meet customers' problems. Secondly, the students will develop favourable or positive attitude towards sustainable entrepreneurship, thereby perceiving sustainability entrepreneurship as being attractive and feasible. The skill for recognising sustainable entrepreneurship will also be developed in the students.

Beyond the contribution of sustainable entrepreneurship education, government policies and programmes are also important. That is, policies and programmes that can encourage and support entrepreneurial actions towards addressing environmental challenges with innovative business solutions should be put in place. Though government might not be able to decide on which market imperfections to address; efforts should however be directed at formulating policies that can foster entrepreneurial behaviour that is oriented towards sustainability, which can be in form of tax incentives, recognition, green credit, and advocacy among others.

FUTURE RESEARCH DIRECTIONS

The framework developed in this chapter is based on the results of findings in developed countries. While these findings can provide direction for sustainable entrepreneurship education, yet it is important to carry out empirical studies on the motivation and attributes of indigenous entrepreneurs in Africa who are already engaging in sustainable entrepreneurship.

CONCLUSION AND POLICY IMPLICATIONS

Attempt has been made in this chapter to contribute to sustainable entrepreneurship literature by synthesised from the various thoughts and findings from the entrepreneurship, environmental and welfare economic literature in general as well as sustainable entrepreneurship in particular. The chapter establishes the need to change the orientation of the future entrepreneurs from being profit-minded alone to being environmental conscious. That is, maintain a balance between profit generation and sustainability development. As it is noted in the environmental and welfare economics literature, majority of environmental problems being experienced results from the failure of market. Fortunately, these market failures provide avenue for business opportunities which in turn can improve the efficient functioning of market. Therefore, instead of the nascent entrepreneurs contributing further to the degradation of the environment they can use entrepreneurial process to discover, evaluate and exploit opportunities inherent in these market failures. Therefore, developing sustainability capabilities and attitude of nascent entrepreneurs which is favourable to sustainability has implication for entrepreneurship educators and policy makers.

On the part of educators, entrepreneurship education should go beyond preparing the students to start small businesses, but also emphasise transformational entrepreneurship that can bring about a complete change in their values and behaviours. Hence, the pedagogy of sustainable entrepreneurship education should be able to stimulate sustainable entrepreneurial behaviour in the students, thereby encouraging

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them to pursue 'green' business ideas rather than opportunistic ones that are driven by self-interest. The education should also be designed in a way that will achieve two major goals. Firstly, efforts should be geared at making the students understand and appreciate the contemporary sustainability challenges, such as climate change and depletion of non-renewable resources among others. Closely related to this is the knowledge of the potential business opportunities for sustainable entrepreneurship associated with these challenges. Consequent on the above, entrepreneurship education should be delivered in a way that will be able to develop the creative ability of students to respond to environmental and social problems as well as to discover opportunities embedded in these problems. Since one of the desired effects of entrepreneurial education is entrepreneurial inspiration, part of the delivery methodology should include case studies of successful sustainable entrepreneurs and guest lectures by entrepreneurs who are committed to pursuing sustainable business model.

Also, the policies and strategies of government should not be reactive alone, whereby established firms are made to be socially responsible, through corporate greening. It has even been found that these efforts have not meaningfully solved the environmental problems (York & Venkataraman, 2010). According to these authors, reactive policies will only bring about incremental reduction in the activities of the firms which have contributed to environmental problems. Such reduction might not be sufficient to achieve the desired economic, environmental and social sustainability. Moreover, reactive policies might not fully resolve existing market imperfections and will not encourage innovative drive necessary to discover opportunities associated with sustainability problems.

Therefore, the policies and programmes of government should support entrepreneurial actions that can encourage entrepreneurs to use entrepreneurial process to resolve environmental challenges with innovative business solutions. This could be in form of tax incentives, recognition, green credit, establishment of eco-business incubators, and patronage of green products and services from such businesses. Government should also create a platform where nascent sustainable entrepreneurs can have access to information about the existence of entrepreneurial opportunities within environmental degradation. Equally important is the effort of government to facilitate collaboration and networking with national and international organisations who can assist in the development of technologies required to solve the environmental problems.

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Chapter 31
Sustainability Reporting in Transitional Economies

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ABSTRACT

This chapter provides insights on some issues associated with the development of sustainability reporting in Egypt as a transitional economy that recently developed the S&P/EGX ESG index. In a dynamic world, and faced with a scientific proof that relates dangerous climatic changes to corporate activity, corporate financial reporting needs to be placed in perspective. Hence, as a social science, accounting should play a vital role in integrating corporate financial and non-financial measures. Semi-structured interviews were employed to investigate the extent to which sustainability reporting is appreciated in the Egyptian market by both business enterprises and the investors. Results indicate that sustainability information is of limited interest to markets except when it is identified as relevant in terms of risk or governance. On the investors' side, returns were seen as the main driver of portfolio selection. However, sustainability issues would be seriously considered when comparing among alternatives with similar returns.

INTRODUCTION

Sustainability reporting is a broad term that describes the disclosures to be made by firms on the positive or/and negative impacts of their activities on the environment, society and the economy. Hence, this mechanism has the potential to enable firms to set goals, measure performance, and manage change in order to make their operations more sustainable (KPMG, 2013: 10; GRI, 2013: 3). Globally, sustainability reporting enables the integration between financial and nonfinancial information, providing stakeholders with enhanced information to make more informed decisions.

Recently, there is an increasing trend among many organizations around the world to make their operations sustainable. Furthermore, the idea that long-term profitability should go hand in hand with social justice and environment protection is gaining ground. Hence, the quest to move to a truly sustainable economy is understood by organizations' financiers, customers and other stakeholders. This suggestion is supported by the findings of a recent KPMG's global reporting survey which highlights that more

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than 50% of reporting companies worldwide include sustainability related information in their annual reports compared to 20% in 2011 (KPMG, 2013: 11).

As a promising exchange, recently the Egyptian market has taken a pivotal step towards fulfilling the innovation in international best practices. In this context, the S&P/EGX ESG index was planned and developed as the principal index in Egypt to address the investors' concern about environmental, social and governance issues. The S&P/EGX ESG raises the profile of listed companies that are the best performing in terms of three parameters; environmental, social, and corporate governance responsibility (ESG). The index employs a unique and innovative methodology that quantifies a company's ESG practices, and then uses a scoring system to rank listed companies based on the established criteria. Unlike previous indices of this kind that measure ESG parameters on a committee and internal consensus basis, the quantitative scoring system of the S&P/EGX ESG is very informative as it provides investors with sustainability related information in addition to financial information. In other words, recognizing the need for an investable index, the selection process requires that eligible companies not only have high ESG scores, but also meet a market capitalization and liquidity threshold.

Legitimacy theory highlights the extent to which corporate social and environmental disclosures are influenced by the boundaries established by the society in order to be appreciated and avoid being penalized by the community in which the company operates. However, this theory does not take into consideration that legitimacy is interpreted differently from one society to another according to societal values, political system and government ideology. On the Other hand, signaling theory suggests that markets react to good and bad signals, most likely these signals are perceived as indicators of potential returns.

Building on this, sustainability reporting that is a voluntary disclosure that releases negative impacts of company's activities on the environment, society and the economy may not be supported. Hence, markets particularly transitional ones may discourage sustainability reporting initiatives that is fundamental if sustainability agenda is to be a meaningful practice. Stemming from this viewpoint, financial accounting researchers should investigate the extent to which capital markets can contribute to sustainable development. As sustainability relating information is voluntary, companies may be selective in releasing such information. This viewpoint is supported by the fact that wealth maximization is the main goal for companies as well as for current and potential investors, even corporate governance codes continue to place shareholders as the main stakeholder.

Drawing from the contextual interplay among accounting, capital markets and sustainable development, qualitative approach has been chosen to best address the research question. To the best of the researcher's knowledge this study is the first to investigate how the Egyptian market perceives sustainability reporting.

SUSTAINABILITY REPORTING: AN OVERVIEW

Sustainability Development

In broad terms, sustainable development is defined as the ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs'' (UNWCED, 1987: 8). From the researcher's point of view, this definition highlights a key theme of sustainable development that is 'needs', which reflects the issue of scarce resources and how current generations should consider the welfare of the future generations. This depicts the interactive relationship between

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the environment and development. This also sends a message to rich societies that the needs of poorest societies should be given a priority as it's one world. In a similar vein, Goeminne (2011: 627) argues that sustainable development raise a need for a more integrated approach to deal with interrelated global environmental and development matters.

The Brundtland Commission highlighted the idea that while the "environment" was previously considered as a sphere separate from human emotion or action, and while "development" term was employed to describe political goals or economic progress, it is more comprehensive to understand the two terms in relation to each other. In other words, the introduction of sustainable development called for the development of an integrated approach to deal with complicated global environmental problems and development issues (Goeminne, 2011: 627).

The Brundtland Commission was developed by the United Nations in 1984, as a result of the rise of environmental concerns by various pressure groups in order to gather countries to work and pursue sustainable development together. *Silent Spring* (Carson, 1962) had raised popular consciousness about the dangers of excessive pesticide use and some progress had been made in improving air and water quality in industrialized areas through 'Clean Air' acts and the like. By the early 1970s Friends of the Earth and Greenpeace had been established as a result of the perceived dangers posed to the planet by new practices such as nuclear tests and dam building. Later on the calls for a UN conference on the environment originated from the Swedish Ambassador to the UN who was particularly concerned with the effects of acidic rains and the acidification of the water systems in Scandinavia. The conference was held in Stockholm in 1972, the issue of pollution widened to include the problems being experienced by developing countries. In 1971, a UN sponsored meeting of experts in pollution met in Founex, Switzerland, and for the first time, made the explicit connection between industrial development, which was a justified desire of developing countries, and environmental degradation, which was seen as the price that should be paid. Since then, environmental protection was seen as one of the barriers towards development (Grubb et al., 1993). However, surprisingly, this meeting concluded that there is no conflict between environment and development, and that these two concerns should be mutually supportive (Engfeldt, 2002). It ended with the *Stockholm Declaration on Human Environment* and the *Action Plan for the Human Environment.* It also led to the establishment of the United Nations Environment Program (UNEP) a year later.

Additionally, during the 1970s the rise of Third world debts and the oil supply crisis, all necessitated taking an action by world's leading countries. Ten years later, a special session of UNEP's governing Council was held to discuss the momentum affairs. It was clear that while the world economy achieved a substantial growth, the least developed are suffering and that many witnessed a fall in per-capita production during the 1980s (Tolba & El-Kholy, 1992). It was at this point that UN developed the World Commission on Environment and Development under Gro Harlem Brundtland. Its aim was to build a future more prosperous, more just, and more secure, resting on ecologically based policies and practices. At the beginning, there was an overwhelming belief that, in order to attain this goal, significant changes in current approaches, would have to be confronted, which would involve changes in individual attitudes and lifestyles and more crucially changes in certain critical policies… and the nature of co-operation between governments, business, science and people (UNWCED, 1987).

This Commission took appreciated steps in order to conceptualize the relationship between the environment and development, in light of the continuing disparity between levels of prosperity in the Northern hemisphere and the Southern, and the thoughts expressed at Founex in 1971. During the sitting of the Commission, which was to last two and a half years, a number of catastrophic events occurred

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which provided a great challenge at that time like the discovery of the hole in the Ozone layer over Antarctica and the explosion of Chernobyl nuclear reactor in the USSR. Such events led the commission to take pivotal steps to place the environment at the core of strategic management (Grubb et al., 1993). It also highlighted notions of justice and fairness to the peoples of the developing world, in terms of fair shares of the world's resources and redistribution of wealth to improve the standards of living of poor populations. The Brundtland Commission officially dissolved in December 1987 after releasing the Brundtland Report entitled 'Our Common Future' in October 1987, a document which coined, and defined the meaning of the term 'Sustainable Development'. In 1988 the organization 'Center for Our Common Future' was established to take the place of the Commission. This report contributed to the development of 'Environmental Accounting'. In its early stages, environmental accounting was mainly influenced by science and economics of sustainable development disciplines (Grayand Laughlin, 2012).

The Need for Sustainability Reporting

sustainability reporting is an emerging form of reports that aims at integrating financial and nonfinancial information with the purpose of providing stakeholders with enhanced information to make more informed decisions. Hence, Sustainability reports provide information that describes the economic, environmental and social impacts of company activities. Accordingly, this adds to the responsibility of accountants who are required to develop their practices to recognize social, environmental and economic interactions between the company and its external environment. Sustainability accounting is seen as an extension of environmental accounting that is initially emerged from social accounting (Grayand Laughlin, 2012; Bebbibgton & Larinaga, 2014).

The motive for this type of reporting arises out of the realization that financial statements alone fail to provide satisfactory information to stakeholders who are looking for comprehensive quantitative and qualitative information that really depicts the overall corporate activities. This argument is supported by Modapothala and Issac (2009), who suggest that sustainability reporting provides a framework through which companies provide reasonable and credible corporate reporting to satisfy various stakeholders' needs for information and, consequently, increase their goodwill. Sustainability reports are more comprehensive than traditional selective reports that only target specific user group(s). Hence, nowadays releasing sustainability reports becomes a common practice among companies operating in developed countries particularly in North America, Japan and Europe as an extension of environmental reports (WBCSD, 2002; KPMG, 2008).

There are many recipients of sustainability related information like investors, legislators, local communities, environmental groups and employees. Enhancing corporate image particularly in the industrial sector which used to be subject to severe criticism from the media and society is becoming an obvious motive for sustainability reporting practice. The corporate scandals witnessed during the last two decades raised the need for many user groups to exert pressure on companies to improve their level of transparency to include in addition to financial performance related information, environmental and social responsibility related information (KPMG, 2008).Consequently, many countries like Japan, Netherlands and New Zealand have implemented statutory requirements to push companies towards carrying out their environmental and social responsibilities (Kolk, 2003). This in turn, can play a vital role in spreading the culture of environmental protection among the management of such companies.

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Sustainability related information is published either in a separate report or presented as a separate section in the company annual report. It is also a common practice among companies to release sustainability information on their websites (Salama, 2009).

Recently sustainability related information concerning environmental, social and governance issues is becoming one of the most significant trends in financial markets. Many modern investors are aware about the importance of sustainable responsible investing (SRI), and corporate management's focus on corporate social responsibility (CSR). Furthermore, many international organizations have taken important steps in order to pave the way for incorporating sustainability related concerns among business organizations' priorities. For example the United Nations backed Principles for Responsible Investment (UN PRI). Additionally, the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP) and the Sustainability Accounting Standards Board (SASB) are strongly supporting sustainability reporting (Clark, Feiner & Viehs, 2014: 6).

SASB is a registered non-profit organization in the United States (US), that was officially commenced its activity in 2012. SASB aims at developing and disseminating industry-specific accounting standards for material sustainability issues for the purposes of integrated reporting. The SASB standards are suitable for disclosure in standard filings. Additionally, they are applicable and relevant globally for companies looking to report on material environmental, social and governance issues.

SASB is developing standards for 88 industries in 10 sectors using a multi-stakeholder, transparent process. The standards describe both impacts as well as opportunities for innovation. Consequently, following such standards enable companies to create value for their future success in the business world.

SASB was conceived following research conducted by the Initiative for Responsible Investment at Harvard University on determining industry-specific material issues and associated key performance indicators. After an irresistible positive response by businesses, SASB development supported in order to set industry tailored performance integrated indicators (integrating ESG and financial aspects) that take into consideration the materiality of sustainable development concerns (Gilman & Schulschenk, 2013).

SASB developed a number of principles to guide the improvement of the sustainability accounting standards. Such standards should satisfy the following criteria (Gilman & Schulschenk, 2013: 16):

1. Being applicable to all investors on an evidence based approach.
2. Being pertinent and relevant across an industry, based on robust evidence.
3. Being focused on driving long term value creation and risk mitigation
4. The expected benefits exceed the perceived costs.
5. Being applicable by the companies.
6. Being easily verified such that they are measurable, quantifiable when possible, comparable, replicable and auditable.
7. Being objective and support decision making.
8. Being of the highest quality possible at any given time
9. They embody the minimum set of standard criteria which include relevance, usefulness, applicability, cost-effectiveness, comparability, completeness, directionality and auditability.
10. Being reflective of the views of stakeholders.
11. They support the shift to integrated reporting.
12. They support the convergence to international accounting Standards.

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SASB is committed to a transparent multi-stakeholder process in the development of its sustainability accounting standards. The process is well defined and consists of the following steps (Gilman & Schulschenk, 2013: 16-17):

1. SASB creation of the Sustainable Industry Classification System (SICS) to categorize industries according to their resource intensity and their sustainability innovation potential. The system is tied back to standard classification systems.
2. SASB development of a materiality map as the starting point for understanding the relative materiality of issues per industry.

The materiality map follows a three step process looking at:

1. Evidence of interest
2. Evidence of economic impact
3. Forward looking adjustment

Using these tests, the material issues are then ranked and a threshold is established by which material sustainability issues are determined for each industry. The SASB research team then reviews these material issues.

1. This is followed by an in-depth industry research to provide context within which the sustainability issues are analyzed, including industry trends, key environmental, social and governance issues. This research also includes the identification of existing metrics and practices used to quantify and articulate each material issue. Following this, the SASB research team selects those KPIs and disclosures that are of the highest quality from the existing population or creates new ones where none exist or those that do are not of sufficient quality.
2. Subsequently, Industry Working Groups (IWGs) are established to review the sustainability accounting standard developed by the SASB research team, providing comment and feedback to SASB.
3. The IWGs are comprised of members with a depth of industry knowledge and expertise and members from the following interest groups:
    a. Market participants (investors, research analysts, exchanges)
    b. Corporations
    c. Public interest and intermediaries (government, NGOs, academics, accountants, auditors, consultants).
4. The SASB research team then incorporates the IWG feedback and publishes the performance indicators publically and requests comments thereon. Public comment is open for 30 days.
5. The SASB research team then incorporates the public comments into the standard.
6. Afterwards the standard is reviewed by the SASB Standards Council to ensure consistency, completeness and accuracy and compliance with the standards setting process with American National Standards Institute guidance and SASB principles. Upon their approval, the sustainability accounting standard is deemed complete and will be published.

SASB standards provide companies with standardized sustainability metrics designed to communicate performance on sustainability topics. By supporting comparability, relevance, understandability, and

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verifiability, SASB standards help companies ensure that their disclosures on sustainability are useful for decision making purposes.

SASB standards are intended to provide the basis for "suitable criteria" that meet the following attributes:

- **Objectivity**: Criteria should be free from bias.
- **Measurability:** Criteria should permit reasonably consistent measurements, qualitative or quantitative, of subject matter.
- **Completeness**: Criteria should be sufficiently complete so that those relevant factors that would alter a conclusion about subject matter are not omitted.
- **Relevance**: Criteria should be relevant to the subject matter. SASB identifies accounting metrics for each sustainability disclosure topic in the SASB standards.

SASB recommends that each company consider using these sustainability accounting metrics when preparing disclosures on the sustainability topics. As appropriate when disclosing a sustainability topic identified by this Standard, companies should consider including a narrative description of any material factors necessary to ensure completeness, accuracy, and comparability of the data reported.

Where not addressed by the specific accounting metrics, but relevant, the registrant should discuss the following, related to the topic:

- The registrant's strategic approach to managing performance on the topic;
- The registrant's relative performance with respect to its peers;
- The degree of control the registrant has;
- Any measures the registrant has undertaken or plans to undertake to improve performance; and
- Data for the registrant's last three completed fiscal years (when available).

SASB recommends that registrants use SASB standards specific to their primary industry as identified in the Sustainable Industry Classification system. If a registrant generates significant revenue from multiple industries, SASB recommends that it also consider sustainability topics that SASB has identified for those industries and disclose the associated SASB accounting metrics.

In disclosing to SASB standards, it is expected that registrants disclose with the same level of rigor, accuracy, and responsibility as they apply to all other information contained in their SEC filings.

The SASB standards are intended to provide guidance for companies that engage in public offerings of securities registered under the Securities Act of 1933 (the Securities Act) and those that issue securities registered under the Securities Exchange Act of 1934 (the Exchange Act). Disclosure with respect to the SASB standards is not required or endorsed by the SEC or other entities governing financial reporting, such as FASB, GASB, or IASB.

Unless otherwise specified, SASB recommends that:

- A registrant disclose on sustainability issues and metrics for itself and for entities that are consolidated for financial reporting purposes as defined by accounting principles generally accepted in the United States for consistency with other accompanying information within SEC filings.
- For consolidated entities, disclosures be made, and accounting metrics calculated, for the whole entity, regardless of the size of the minority interest; and

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- Information from unconsolidated entities not be included in the computation of SASB accounting metrics. A registrant should disclose, however, information about unconsolidated entities to the extent that the registrant considers the information necessary for investors to understand the effect of sustainability topics on the company's financial condition or operating performance (typically, this disclosure would be limited to risks and opportunities associated with these entities).[1]

Sustainability Reporting: The Theoretical Foundation

Many scholars suggest that corporate disclosure behavior is influenced by the political and socio-economic environment within the country in which the company operates (e.g., Elnaby & Mosebach, 2005; Nobes, 2006; Qu & Leung, 2006; Hassaan, 2013). Consequently, managers' incentives may differ from one country to another and from one company to another due to the differences in societal values as well as company characteristics.

To date there is no single theory that can comprehensively interpret or predict corporate financial disclosure practices. However, legitimacy theory and signaling theory are the most commonly employed in interpreting sustainability disclosure practices.

Legitimacy theory highlights how management reacts to community expectations to avoid legitimacy costs and being penalized by the community (Brown & Deegan, 1998; Wilmshurst & Frost, 2000). Hence, this theory emphasizes the importance of societal acceptance for company continuity, on the grounds that, company actions affect the environment in which it operates (Ghazali, 2004; Hassaan, 2013). ''Legitimacy itself can be considered to be a condition or status. Legitimation, on the other hand, is a process which organizations can undertake (perhaps through particular disclosure strategies) to take them to this state'' (Brown & Deegan, 1998: 23). This theory is mainly used to explain social and environmental disclosures on the grounds that companies as members in the society are expected to carry out their activities within the boundaries established by the society within which the company operates (Wilmshurst & Frost, 2000; Ghazali, 2004). However, this theory is criticized on the grounds that, it does not take into consideration that legitimacy is interpreted differently from one society to another according to societal values, political system and government ideology (Ghazali, 2004; Hassaan, 2013). Additionally, in a transitional economy where sustainability reporting is an emerging application, it seems that gaining legitimacy is not a priority to companies operating in such economies. On the other hand, signaling theory suggests that markets react to good and bad signals, most likely these signals are perceived as indicators of potential returns.

Building on the above, sustainability reporting that is a voluntary disclosure that releases negative impacts of company's activities on the environment, society and the economy may not be supported. Hence, markets particularly transitional ones may discourage sustainability reporting initiatives that is fundamental if sustainability agenda is to be a meaningful practice. On the other hand, as long as sustainability related information is voluntary, companies may be selective in releasing such information. This viewpoint is supported by the fact that wealth maximization is still the main goal for companies as well as for current and potential investors particularly in transitional economies where environmental and social issues are not a major concern, even corporate governance codes continue to place shareholders as the main stakeholder.

Based on the above discussion it will be interesting to investigate the applicability of the legitimacy and signaling theories in the Egyptian context as one of the promising transitional economies.

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LITERATURE REVIEW

The modern concern with human-environment interactions was highlighted since 1972 in Stockholm conference on human development. The following three decades have witnessed a widening of the debate concerning the relationship between human development and the environment and emerges against a background of concern about the environmental crisis, the under development of the majority of the world's population and social responsibility (e.g., Pirages, 1990; Bartelus, 1994; Esteva, 1992; Tolba & El-Kholy, 1992; Gray et al., 1995; Sachs, 1995; Gray, 2002; O'Donovan, 2002; Patten, 2002; Parker, 2005; Campbell, 2007; Pulver, 2007; Crane, Matten & Spence, 2008; Chen & Roberts, 2010).

Since the 1980s environmental accounting began to emerge as a distinct topic of research. During that time, some legal requirements addressed the necessity for disclosing environmental liabilities by business enterprises (Bebbington & Larinaga, 2014:397). Consequently, some researchers investigated the association between environmental disclosures and corporate characteristics (e.g., Trotman & Bradly, 1981). The focus of such studies was to shed light on the disclosure of environmental issues that were local in nature. However, after the issuance of the Brundtland Report (UNWCED, 1987), many research papers directed towards environmental accounting.

The Brundtland Report was a starting point that inspired many developed countries to take actions to protect the environment from abuse. For instance, in the UK, the Brundtland Report encouraged Department of the Environment to ask economist David Pearce to write a report on environmental economics ultimately giving rise to the influential Blueprint for a Green Economy (Pearce, Markandya & Barbier, 1989; Bebbington & Larinaga, 2014). Consequently, the Chartered Association of Certified Accountants commissioned Rob Gray to describe how accounting might contribute in the wake up of Pearce et al. (1989). This resulted in the publication of The Greening of Accountancy which helped in creating the base for environmental accounting (Bebbington & Larinaga, 2014: 397). Environmental accounting literature in the early nineties was strongly inspired by ideas imported from both the science and the economics of sustainable development (Gray and Laughlin, 2012). The emerging literature at that time, was mainly concerned with the interaction between accounting and environmental valuation (eg.,Hines,1991; Power, 1992).

Later on, environmental accounting began to attract researchers from different areas of accounting such as management accounting, financial accounting and auditing (Thomson, 2007; Bebbington & Larinaga, 2014).This literature provided the basis for the recognition of sustainability as a policy issue and also formed the starting point for many of the more recent research papers on sustainability and sustainable reporting(e.g., Adams, 2004; Ballou, Heitger & Landes, 2006; Aras & Crowther, 2008; Jackson, 2009; Milne, Tregidga & Walton, 2009; Gray, 2010; Bansal & Hoffman, 2012; Bebbington & Larrinaga, 2014; Bebbington & Larrinaga, 2014; Unerman & Chapman, 2014; Cho, Laine, Roberts & Rodregue, 2015).

Increasing organizational interest in sustainability reporting and accountability, along with increased academic investigation of these accounting issues, have resulted in greater evidence and public awareness of sustainability. The recognition of social and environmental issues by corporate board of directors is most likely reflected via corporate sustainability reporting practices, which have in recent years spread swiftly and perceived as a component of the information stream produced by business organizations. Moreover, currently many organizations are developing a growing array of accounting, accountability and assurance practices to enable identification and handling of sustainability related risks and opportunities (O'Dwyer, Owen & Unerman, 2011; Malsch, 2013; Cho et al., 2015). Moreover, the development of such practices have emerged critiques and debates, supported with insights from academic research,

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regarding the degree to which such practices might be considered as applicable(Gray, 2010; Cho et al., 2015). The issue of corporate sustainability related assertions and practice has been investigated by many researchers who produced inconsistent results (e.g., Archel, Husilos & Spence, 2011; Dhaliwal, Radhakrishnan, Tsang & Yang, 2012; Malsch, 2013; Milne & Gray, 2013; Unerman & Chapman, 2014).

Opponents of sustainability reporting argue that voluntary sustainability reporting scope is limited (O'Dwyer et al., 2005) and that it is employed by businesses as a means to gain legitimacy and serve their own interests rather than signaling rational plans and commitments (Adams, 2004; Milne and Gray, 2007; Cho et al., 2012; Patten, 2012; Milne and Gray,2013). Hence, company reputation will be the main factor that governs its decision regarding what type of sustainability relating information to release, with corporate management being most concerned with bending, obscuring, or rationalizing their poor social and environmental performance (Cho et al., 2010; Cho et al., 2015). On the other side, proponents of sustainability reporting argue that it improves corporate accountability and transparency regarding social and environmental impacts of its activities (Bebbington, et al., 2014). Additionally, sustainability related assertions are to some extent considered as signals to the market that the company is proactively managing its social and environmental risks (Malsch, 2013).

Many researchers who investigate the emergence of corporate sustainability reporting practice (e.g., Ferguson, 2007; Llewellyn and Milne, 2007;Bebbington et al., 2008;Laine, 2009; Gray, 2010), argue that the information presented in such reports are just vague narratives of little value with respect to sustainable development. This may be attributed to the absence of a clear description of sustainability development on the level of organizations accompanied with the absence of credible sustainable development accounts in practice (Gray & Milne, 2004; Gray, 2010;Bebbington & Larinaga, 2014).

From the perspective of cost accounting studies, full cost accounting is performing well as it moves beyond the entity to detect external factors(Bent, 2006; Frame & Cavanagh, 2009; Fraser, 2012; Xing, Horner, El-Haram & Bebbington, 2009). Hence, such studies are appreciated as it recognizes the interactive relationship between the entity and its surrounding environment. However, still sustainability accounting needs further effort from accounting researchers in order to depict a competent accounting treatment for sustainability related issues within accounting paradigm. This requires opening the door for conscious discussions about social, environmental and economic issues associated with sustainable development, between accounting researchers from one side and stakeholders and researchers from other disciplines on the other side. From the point of view of some researchers (e.g. Gray, 2010; Bebbington & Larinaga, 2014), accounting for sustainable development calls for a research approach that is distinctively different from that of accounting, environmental accounting and social accounting by avoiding a purely narrative focus.

Building on the above, it can be said that, the development of corporate sustainability reporting oriented research requires careful consideration from accounting researchers. A clear definition of sustainability accounting should be wisely stated, issues associated with sustainable development should be determined and included into accounting paradigm and the criteria for analyzing managerial behavior and evaluating financial and non-financial indicators must be clear to all parties affecting and being affected by sustainability reporting. Grounded theories should be identified to illustrate all aspects associated with corporate sustainability reporting.

The review of the prior research that investigates sustainability reporting reveals the lack of consensus among earlier researchers regarding the issue of sustainability reporting. Hence, there is a need for further research particularly in transitional economies whereas sustainability reporting is considered as a newly imported practice.

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EGYPT'S STOCK EXCHANGE AND SUSTAINABILITY REPORTING PRACTICES: AN OVERVIEW

The Arab Republic of Egypt has always been a regional leading reformer. In general terms, the Economic development in this country has gone through four significant phases: Pre-nationalisation (before 1956), Post-nationalisation (1956-1973), Open Door Policy (1974-1990), and the Extensive Economic Restructuring (1991 to date). Each reflects the political strategy adopted by the ruler. Additionally, the performance of the Egyptian Stock Exchange is always heavily influenced by government foreign policies which subsequently affect internal economic performance (Hassaan, 2013).

The Egyptian economy is unique as Egypt is one of the few developing countries that transformed from a capitalist economy to a planned economy, and then returned to a capitalist one. In other words, the move to a free market economy in the 1990s was challenging to the government, private sector institutions as well as the accounting profession. Consequently, to promote foreign direct investment, it was necessary to develop the financial reporting system and improve disclosure and transparency to comply with the international best practices.

The legislation regulating companies listed on the EGX includes: Firstly, the Capital Market Law No. 95 of 1992 and its Executive Regulations No. 135 of 1993 concerned with regulating the EGX by monitoring the market status in general and maintaining steadiness and growth. Secondly, the Central Depository Law No.93 of 2000 which maintains all registration, clearance and settlement procedures associated with trading transactions, the main purpose being to reduce risks associated with trading physical securities, to enhance market liquidity, and to assure fast securities exchange. Thirdly, Decree No. 30 of 2002 of the Capital Market Authority Board of Directors on Securities Listing and De-Listing Rules of the Cairo and Alexandria Stock Exchanges (ROSC, 2009).

As a promising exchange, since 2012 the Egyptian market has taken a further step towards fulfilling the innovation in international best practices. In this context, the S&P/EGX ESG index was planned and developed as the principal index in Egypt to address the investors' concern about environmental, social and governance issues. The S&P/EGX ESG includes listed companies that are the best performing in terms of three parameters; environmental, social, and corporate governance responsibility (ESG). The index employs a unique and innovative methodology that quantifies a company's ESG practices, and then uses a scoring system to rank listed companies based on the established criteria. Unlike previous indices of this kind that measure ESG parameters on a committee and internal consensus basis, the quantitative scoring system of the S&P/EGX ESG is very informative as it provides investors with sustainability related information in addition to financial information.

The population from which the S&P/EGX ESG Index constituents are derived is the top 100 Egyptian companies by ESG scores, listed on the Egyptian Stock Exchange (EGX). All 100 companies in the population were chosen after being subjected to a screening process which incorporates environmental, social and governance indicators against which the company's disclosure practices are evaluated.

There are two screens; one focusing on environment & social indicators that is based on output obtained from the mapping of Global Reporting Initiative (GRI), Global Compact (GC) and Millennium Development Goal (MDG), and the other one focusing on corporate governance indicators that is an adaptation of Standard & Poor's existing corporate governance methodology to suit the Egyptian market.

The screening process ultimately yields a score, or an evaluation, for each of the companies in the population. The evaluation process seeks information relating to companies' disclosure of the ES&G screen indicators available in the public domain, such as a company's annual report, Web site, bulletins

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and/or the disclosure made on the stock exchange. The final aim is to determine whether a company has made transparent disclosure, in such documents, on any of the indicators that are part of the ES&G screening system.

In cases where a company discloses a well-known public indicator, it is awarded a score of one; and if it did not it is awarded a score of zero. Similarly, public disclosure of 'extra-point' indicators is awarded a score of three; non-disclosure is, again, given a zero.

The weight for each index constituent is set in the following manner (S&P EGX ESG Index Methodology, 2012: 6-8):

1. **Quantitative Score**: Each of the companies trading on the Egyptian Stock Exchange is assigned a quantitative ranking based on three factors – transparency and disclosure of:
   a. Corporate governance,
   b. Environmental practices and
   c. Social governance.
   d. Raw values for each factor are calculated for each company in the index. These values are, then, standardized. The three standardized values are summed up and the companies are ranked in a descending order.
2. **Qualitative Score**: Those companies with the highest scores under the transparency and disclosure (T&D) process are selected for the qualitative scoring. Independent sources of information, news stories, Web sites and CSR filings are used to evaluate the actual performance of the company on a scale of 5 to 1, with 1 being the lowest and 5 being the highest. Then a final qualitative score is assigned for each company.
3. **Composite Score**: A composite score is calculated for each company by summing up the quantitative and the qualitative scores. Based on this, the top 100 stocks are chosen as the eligible pool, from which the final 30 stocks will be derived.
4. Each company's weight in the index is determined as a function of its ESG score. The index is calculated by means of the divisor methodology used in most S&P Indices. On any given day, t, the index value is simply the index market value divided by the index divisor (Figure 1).

The SWF is set only once a year at the index rebalancing date (August, 1). Therefore, the stocks will be weighted in exact proportion to their ESG Scores only at the rebalancing date. The weights of stocks in a score-weighted index between rebalancing dates depend on their relative price performances. The SWF might be adjusted between rebalancing dates. Additionally, since the S&P/EGX ESG index is score-weighted, the weights of individual stocks are not affected by corporate actions such as stock splits, spin-offs and rights offerings. Consequently, from the researcher point of view, the S&P/EGX ESG index applicability is ideal given the unique nature of the Egyptian Capital Market.

RESEARCH METHODOLOGY

Given the complex nature of sustainable development, and the relative lack of knowledge about the mechanisms by which businesses undertake sustainability reporting, semi-structured interviews were undertaken. Building on the review of prior research and the S&P/EGX ESGindex a relatively standardized set of questions was created. The following themes were developed within the interviews:

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Figure 1.

$$\text{Index Value}_t = \text{Index Market Value}_t \Big/ \text{Index Divisor}_t$$

$$\text{Index Market Value}_t = \sum_{X=1}^{n} IWF_{X,t} * \text{Modified Index Shares}_{X,t} * Price_{X,t}$$

$IWF_{X,t}$ = Investable Weight Factor of stock X on date t

$Price_{X,t}$ = The price used for stock X in the S&P/EGX ESG Index computation on date t

n = The number of stocks in the S&P/EGX ESG Index on date t

$\text{Modified Index Shares}_{X,t}$ = Shares used for stock X on date t

This term is calculated in the following manner:

$$\text{Modified Index Shares}_{X,t} = \text{Index Shares}_{X,t} * SWF_{X,t}$$

$$\text{Index Shares}_{X,t} = \text{Shares Outstanding}_{X,t} * IWF_{X,t}$$

The Score Weight Factor (*SWF*) term ensures the index weights each stock with its ESG Score. This is accomplished by setting the SWF at the rebalancing date, d, as follows:

$$SWF_{X,d} = k * Score_X / (IWF_{X,d} * \text{Index Shares}_{X,d} * Price_{X,d})$$

The constant k is used as a multiplier since the quotient $Score_x / (IWF_{x,d} * \text{Index Shares}_{x,d} * Price_{x,d})$ results in a very small value.

1. The clarity of 'sustainable development' concept
2. How sustainability reporting is perceived by the interviewees

Sample Selection

The researcher planned to conduct 20 interviews; ten persons from each group (board of directors of companies listed on the EGX whether their companies are listed on the S&P/EGX ESG index or not and securities brokers as sustainability reporting users). However, despite the original intention, the researcher could only complete 15 interviews (75%), six from the first group (two of them are members in the Board of Directors of companies listed on theS&P/EGX ESG index, particularly participants 5 and 6)and eight from the second group.

Before conducting any of the interviews, the researcher contacted the potential interviewees to explain the purpose of the study and to obtain their permission to participate. People who agreed to be interviewed were asked to determine the suitable time and were informed of the themes to be covered during the interview to allow them to consider the information being requested.

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Interview Questions and Ethical Considerations

The interviews were semi-structured and lasted between 30 and 40 minutes and were conducted between November 2014 and January 2015. The interview questions were open-ended to encourage free expression of participants' views, ideas, and perceptions. Firstly, Interviewees were asked if the concept 'sustainable development' is known by them. Then discussions moved to questions directly relating to sustainability reporting with respect to how it is valued by them.

Measures to ensure the trustworthiness of the study were also incorporated in the interviews. Each began by emphasizing that complete anonymity would be provided to interviewees. Notes were taken during the interviews, as the interviewees were not prepared to be tape-recorded. Interviewees were encouraged to speak freely, and for verification purposes, they were asked to read the notes taken by the researcher during the interview to make sure that their views were accurately reported. The questions were translated into Arabic, as this was the language used. The researcher then translated the transcripts from Arabic to English, and to further guarantee the validity of the texts, the researcher asked a linguistic specialist to review her translation.

In constructing the interview questions the researcher followed the recommendations of Collis and Hussey (2003) to keep questions simple, avoid using unnecessary jargon or specialist language, phrase questions to keep the meaning clear, avoid asking negative questions because they are easy to misinterpret and avoid leading or value-laden questions. The researcher decided to use a manual method as the number of interviews and the interview material were manageable. Also, as qualitative data analysis depends mainly on deep understanding of data by the researcher and as software programs do not analyze qualitative data in depth, it was decided that the use of software was inappropriate.

RESEARCH RESULTS

The Clarity of 'Sustainable Development' Concept

The interview data indicates that all participants are aware about the concept of sustainability. However, it is more recognized in relation to the environmental impact of organizational activities as reported by 11 interviewees. '' …it is a newly developed concept that is concerned with how to carry out your economic activity without polluting the environment or harming its natural balance'' Interviewee 3 (first group).''…it is an emerging culture among businesses worldwide that requires them to be environmentally responsible" Interviewee 10 (second group). The association between sustainability and economic, environmental and social endeavors is recognized by only four participants; three from the first group and 1 from the second group."…it is to achieve the economic, environmental and social objectives to improve the welfare of the current population without preventing the coming generations from that right'' Interviewee 5 (first group). ''…it is to be environmentally and socially accountable while achieving economic objectives'' Interviewee 15(second group).

How Sustainability Reporting is Valued

The interview data collected from the first group is contradictory with respect to the importance of sustainability reporting. Members of the board of directors of companies listed on the S&P/EGX ESG

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index believe in the importance of sustainability reporting and perceive it as part of transparency and accountability '' …we used to support any recommended practice so we decided to take the initiative and release sustainability reports…our reputation and our image in the eyes of the community means a lot… we used to provide a role model in transparency and accountability to our competitors and to other businesses'' Interviewee 6(first group).However members of the Board of Directors of companies not listed on the index consider releasing sustainability reports as unreasonable cost.''…we believe in social and environmental responsibility of business organizations…we are already working on decreasing the harmful impacts of our activity on the environment and that costs us a lot of money… but we think releasing sustainability reports is an extra unneeded cost as the majority of people if not all do not consider such reports and it is not a mandatory requirement'' Interviewee 4(first group).

With respect to the perception of the first group participants regarding whether releasing negative impacts of their activities throughout sustainability reports may affect their financial performance, all interviewees agree that investors are initially looking for investment opportunities that provide them with the highest return regardless of the economic, social and environmental impacts of investee activities as long as the company is not violating laws that increase their risk.'' …our main responsibility is to achieve the highest return on capital invested… investors put their money in the company that provides them with the highest return…they do not think about the impact of its activity as long as it is not subject to governmental regulations that may increase the company risk'' Interviewee 2(first group).

With respect to the perceptions of the second group participants regarding the importance of sustainability reports, they all argue that it is a good practice that reflects company's accountability. However, they all mentioned that returns on investment is the main factor to be considered in deciding which company to invest in. ''sustainability reporting is an appreciated practice that reflects social and environmental responsibility of business organizations and improved transparency…when deciding which company to invest in, the returns on investment is the main aspect ''Interviewee 8(second group).''… of course sustainability reporting is a good thing but when we talk about investment decisions the best investment opportunity is the one that provides the highest return'' Interviewee 13(second group). Four interviewees mentioned that sustainability related information is most likely to be considered when comparing investment opportunities with similar returns.''…to be honest sustainability related information most likely to be considered when you choose among investment opportunities of similar returns'' Interviewee 12(second group).''…when comparing between two investment opportunities with similar returns, the optimum choice will be the one which is more socially and environmentally responsible'' Interviewee 15(second group).One participant argued that when the company reputation is affected due to its harmful activities it is better to avoid investing in such company even if it is the best available investment opportunity''…if the company reputation is affected due to irresponsible activities that harm the environment and the community it will not be a good decision to invest in this company even if it is currently paying the highest return because at any time its value will be at stake…it is a risky investment that you should avoid'' Interviewee 9(second group).

SUMMARY AND CONCLUSION

Based on the interview data, the following generalizations could be concluded:

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1. All participants are aware about the concept of sustainability. However, it is more recognized in relation to the environmental impact of organizational activities.
2. The interview data collected from the first group is contradictory with respect to the importance of sustainability reporting. Members of the board of directors of companies listed on the S&P/EGX ESG index believe in the importance of sustainability reporting and perceive it as part of transparency and accountability. However, members of the Board of Directors of companies not listed on the index consider releasing sustainability reports as unreasonable cost.
3. With respect to the perception of the first group participants regarding whether releasing negative impacts of their activities throughout sustainability reports may affect their financial performance, all interviewees agree that investors are initially looking for investment opportunities that provide them with the highest return regardless of the economic, social and environmental impacts of investee activities as long as the company is not violating laws that increase their risk.
4. With respect to the perceptions of the second group participants regarding the importance of sustainability reports, they all argue that it is a good practice that reflects company's accountability. However, they all mentioned that returns on investment is the main factor to be considered in deciding which company to invest in.
5. Half of the interviewees from the second group mentioned that sustainability related information is most likely to be considered when comparing investment opportunities with similar returns and one participant argued that when the company reputation is affected due to its harmful activities it is better to avoid investing in such company even if it is currently the best available investment opportunity because at any time its value will be at stake.
6. The interviewees responses partially supported the use of both the legitimacy and signalling theories in interpreting sustainability reporting practices. To some extent, it seems that there is an emerging awareness among different parties affecting and being affected by sustainability reports regarding the importance of sustainability reports in shedding light on the economic, social and environmental consequences of corporate activities. However, in the meantime, interviewees responses indicate that sustainability information is not of high priority neither to investors or companies operating in the Egyptian market. This emphasizes the impact of socio-economic factors and cultural values on corporate transparency and disclosures.
7. As long as sustainability reporting is voluntary (i.e., not enforced by law), companies will be encouraged to be selective in releasing sustainability relating information. This viewpoint is supported by the fact that wealth maximization is still the main goal for companies as well as for current and potential investors particularly in transitional economies where environmental and social concerns are not yet part of decision making inputs and where the complementary relationship between corporate financial and non-financial performance is not considered.

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KEY TERMS AND DEFINITIONS

EGX: The Egyptian Exchange previously referred to as Egypt's Stock Exchange. It encompasses two exchanges, Cairo and Alexandria, both governed by the same board of directors and sharing the same trading, clearing and settlement systems.

Legitimacy Theory: It highlights the extent to which corporate social and environmental disclosures are influenced by the boundaries established by the society in order to be appreciated and avoid being penalized by the community in which the company operates.

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S&P/EGX ESG Index: It was planned and developed as the principal index in Egypt to address the investors' concern about environmental, social and governance issues. This index raises the profile of listed companies that are the best performing in terms of three parameters; environmental, social, and corporate governance responsibility (ESG).

Signaling Theory: Suggests that markets react to good and bad signals, as such signals are perceived as indicators of potential returns.

Sustainability Reporting: It is a broad term that describes the disclosures to be made by firms on the positive or/and negative impacts of their activities on the environment, society and the economy.

Sustainable Development: Describes the development that satisfy the needs of the present generations without limiting the ability of future generations to meet their own needs.

The Brundtland Commission: The World Commission on Environment and Development developed by the United Nations in 1984 under Gro Harlem Brundtland, as a result of the rise of environmental concerns by various pressure groups in order to gather countries to work and pursue sustainable development together.

The Brundtland Report: Refers to 'Our Common Future'report, thatwas issued in 1987 by the UNWorld Commission on Environment and Development. This report placed environmental issues into political agenda by emphasising the necessity of dealing with environment and development as one single issue.

The Global Reporting Initiative (GRI): An international non-profit independent standards organization founded in 1997, that helps businesses, governments and other organizations understand and communicate their impacts on issues such as climate change, human rights and corruption.

ENDNOTE

[1] For more details see: https://navigator.sasb.org/standards-overview

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Chapter 32
The Strategic Association Between Information and Communication Technologies and Sustainability:
A Country-Level Study

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ABSTRACT

The authors investigate the strategic association between information and communication technologies (ICTs) and sustainability using empirical data. Their hypothesis is that ICTs can promote a country's sustainability. In their framework the authors include the ICT factors of access, quality, affordability, applications, and institutional efficiency & sustainability. Sustainability is represented by individual development indicators, grouped in the clusters of environment, transportation infrastructure, energy consumption efficiency, economic development, and education. Using secondary data on ICTs and sustainability development indicators for countries from the World Bank, meanwhile controlling for the wealth effect, our main multivariate result indicates that ICTs factors have a positive association with sustainability. ICTs, therefore, have the potential to promote sustainability. The authors' results are useful in shaping strategic policy decisions that involve the nature and extent of investment in ICT infrastructure at the country level.

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1. INTRODUCTION

The purpose of this exploratory work is to examine the association between information and communication technologies (ICTs) and sustainability at the macro level. When we talk about the macro level, we are referring to the sustainability impact that arises out of the application of ICTs across society (Avgerou, 2010; Bengtsson & Agerfalk, 2011; Heeks, 2010; Mascarenhas, 2010; Melville, 2010; Millet & Estrin, 2012; Spence & Smith, 2010; Watson et al, 2010). Many of these papers have discussed the macro impacts of ICTs as net positive. Therefore, it is worth investigating the actual association between ICTs and sustainability. Although the greening of ICTs, for example, the reduction of electronic waste or of the energy consumed by computers – is an important goal of the information technology community, the focus of this research is "greening through ICTs," that is, the applications of ICTs to promote sustainability broadly (Millet & Estrin, 2012).

In this paper we develop a framework for conceptualizing and studying the association between ICTs factors and sustainability development indicators at the country level. Our research is motivated by various propositions that ICTs' factors such as access, affordability and applications, and the like — have the potential to improve country sustainability at the macro level. Once in place, these improvements may lead to improved environment, efficient transportation, efficient delivery of energy, increased economic development, and higher literacy.

This study addresses the relationship empirically. Although studies in past decades have examined and generally confirmed the positive role of ICTs in development, productivity and other macro level indicators (Avgerou, 2010; Bengtsson & Agerfalk, 2011), none have examined the quantitative role of ICTs in enabling sustainability. Despite the anecdotal evidence and the potential, the relationship between ICTs and the broader social goal of sustainability is not well understood (Berkhout & Hertin, 2004). Scant research has been conducted into whether and what types of ICT favorably influence sustainability (Jokinen et al., 1998). Unlike many of the others, our study provides empirical data on which country leaders can base decisions to allocate their limited resources to ICT infrastructure selection and development and thus derive maximum benefits.

In this study, sustainability is characterized by a number of world development indicators that collectively specify the sustainability level of a country (Carraro et al, 2009; Hueting & Reijinders, 2004; Pinter et al, 2005; Spangenberg, 2005; UN, 2007). The indicators are grouped into the broad research constructs of environment, transportation, energy, economic development and education (World Bank, 2010). The ICTs are represented as a group of factors in the global ICT index developed by the World Bank (2010) for each country (Minges & Qiang, 2006). This group of factors has been used in prior studies on ICTs and country-level public health delivery (Raghupathi & Wu, 2011a) and ICTs and country-level governance (Raghupathi & Wu, 2011b). The data for all the indicators and factors are derived from various country-level World Bank data sets. We believe that important insights can be derived from studying potential associations between ICTs and sustainability development indicators.

This study makes several contributions. First, we introduce the contemporary literature on sustainability and ICTs' role as a potential enabler to the information systems research community. Second, we develop an initial framework of the relationship between ICTs and sustainability. Third, we empirically examine the relationship with a large data set, so generalizability of the conclusions is possible. Fourth, by studying the macro effects, countries can make selective investments in ICTs to promote different aspects of sustainability.

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The balance of the paper is organized as follows: we first provide background information with respect to sustainability at the macro level and the potential of ICTs to enable sustainability at the country level. We then describe the conceptual framework of the association between ICTs and sustainability and develop the corresponding hypotheses. Third, we describe our methodology. Fourth, we discuss the results of our statistical analysis and implications. Finally, we discuss the scope and limitations of our study as well as the key contributions, and suggest directions for future research.

2. BACKGROUNG AND LITERATURE REVIEW

The World Summit for the Information Society (WSIS) is specific in its Declaration of Principles, "Building the Information Society: a Global Challenge in the New Millennium," that ICTs serve as powerful instruments for productivity and economic growth through job creation and employability, leading ultimately to improved quality of life overall (http://www.itu.int/wsis/docs/geneva/official/dop.html). The Global e-Sustainability Initiative (GeSI) considers extending the influence of ICT to all aspects of socio-economic development and applying these technologies to both rich and poor countries in order to achieve the strategic principle of sustainable development across the globe (http://www.gesi.org ; http://www.itu.int/wsis/basic/about.html). Likewise, the United Nations Development Program (UNDP) says, "ICT is an increasingly powerful tool for participating in global markets; promoting political accountability; improving the delivery of basic services; and enhancing local development opportunities (http://www.undp.org/)" as reported in GeSI (2005) (http://www.gesi.org). These macro effects are believed to be widespread and complex (Berthon & Donnellan, 2011).

The UN defines ICTs "as tools that facilitate communication and the processing and transmission of information and the sharing of knowledge by electronic means." The definition encompasses the full range of electronic digital and analog ICTs, from radio and television to fixed and mobile telephones, computers, and such electronic-based media as digital text, audio-video recording and the Internet (http://www.un-gaid.org/). More recently, the National Research Council has suggested that "the ultimate goal of much of ICTs in sustainability can be viewed as informing, supporting, facilitating and sometimes automating decision making that lead to actions with significant impacts on achieving sustainability objectives" (Millet & Estrin, 2012).

Today, globalization is characterized by an important shift to knowledge-based societies – mainly driven by ICTs – where knowledge and information increasingly represent new patterns of growth and wealth creation and open up possibilities for more effective poverty reduction and sustainable development (Griese et al., 2001). Knowledge has become a principle force of social transformation. Without the global ICT infrastructure, financial trading as well as global trade and travel would collapse. A recent study by Vodafone (2005) on the effect of mobile phones in Africa provides evidence that mobile telephony has improved economic growth significantly. Moreover, this impact was twice as large in developing countries as in mature economies, with developing countries averaging 20 phones per 100 people and increasing GDP growth by 0.6% (Vodafone, 2005).

In this global arena, the governments of nearly all countries have expressed the goal of transforming their countries into learning economies and knowledge societies. This 'knowledge-based' and 'knowledge-led development' has the potential to tackle many of the problems confronting societies. One could hypothesize that 'knowledge' and 'information,' deployed equitably and systemically, could alleviate key sustainability challenges. At the country level, ICTs have the potential to bridge the digital divide (Pee

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et al, 2010). They can be used to "manage the boundaries between knowledge and action in ways that simultaneously enhance the salience, credibility and legitimacy of the information they produce (Cash et al., 2003)." At the company level, ICTs can help 'green the organization' as well as manage resources more effectively (Berthon & Donnellan, 2011; Dao et al, 2011; Des Autels & Berthon, 2011; Watson et al, 2011). This has a positive wholesale effect on investment and society.

Drawing on recent literature (Mathews, 2003), three primary groups of effects are identified in which ICTs have the potential to play a wide range of important roles in enabling sustainability across the various constructs (Berkhout & Hertin, 2004; Goehring, 2004; Jitsuzumi et al., 2000; Jokinen et al., 1998; Mitomo & Oniki, 1999). *First-order effects* or *direct effects* arise from the increased efficiency in manufacturing and other activities through the use of various types of ICTs. Examples include ICT control of air conditioning equipment to reduce energy consumption and energy savings in transport by the use of intelligent transport systems (ITS). This phenomenon is known as immaterialization. *Second-order effects* or *indirect effects* are changes in the behavior of individuals and organizations arising from lifestyle and work-pattern changes enabled by the use of ICT. For example, telework/tele-commuting (T/T) not only reduces an employee's daily commuting time but also the energy consumed in commuting. Other examples are the deployment of remote sensing devices to monitor the state of the global environment as well as the use of computerized bidding mechanisms for trading the right to emit carbon dioxide (CO_2). This role is termed amaterialization. The second-order effects are often labeled as enabling effects. *Third-order effects* are also indirect effects and reflect the *promotion of the overall decision-making capability of a society* refers to the implementation of sustainable public policies via information systems that gather, organize, and disseminate relevant information (Heinonen et al, 2001). Third-order effects are often called systematic effects. In addition, ICTs can be used very effectively to communicate accumulated knowledge on sustainable development. Our conceptual framework is based primarily on the second order of effects.

As documented in the literature, ICTs contribute to the overall productivity and economic growth of a country (Fors & Morens, 2002). In addition to preventing waste and generating savings through efficiency, knowledge systems assist with the coordination of sustainability efforts, both locally and globally. As the information economy expands and information societies are formed (Heinonen et al., 2001), developing countries— rural areas, in particular—can move toward parity (Greller & MacKay, 2002) in many of the indicators, such as education level, transportation, public health, and quality of the environment (Gholami et al, 2010; Loh et al, 1998; Techatassanasoontorn et al., 2011). Through ICT-enabled sustainable development, countries can envision improved growth and better quality of life overall (Hughes & Johnston, 2005). The literature review strongly suggests that empirical studies in the association between ICTs and sustainability development indicators will go a long way in eliciting key policy issues.

3. CONCEPTUAL FRAMEWORK AND HYPOTHESIS

Based on the background discussion above, we draw broadly from the literature in several disciplines, including the conceptual basis for sustainability (Komiyama & Takeuchi, 2006; Lane, 2011; Larson, 2011), ICTs & sustainability (see Bengtsson & Agerfalk, 2011; Berthon & Donnellan, 2011; GeSI, 2008(a); Melville, 2010; Millet & Estrin, 2012; Watson et al., 2011), global development (European Commission, 2005; Parikh, 2009; Shih et al., 2008; UNESCO, 2002; WEC, 2005; WWF, 2008), and

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the substantive number of publications at NRC (2010, 2011) and the World Bank (2010), to develop the conceptual framework for this study. Many studies consider the several macro effects of ICTs, such as on development, growth and productivity and found them to be positive (e.g., Meso et al., 2006; Meso et al., 2009).

Specifically, we drew from the report SMART 2020: Enabling the Low Carbon Economy in the Information Age (http://www.theclimategroup.org/publications/2008/6/19/smart2020-enabling-the-low-carbon-economy-in-the-information-age/) to adapt and extend for our framework. This report by Millet & Estrin (2012) organizes the potential application of ICTs to sustainability in terms of three broad categories, namely, (1) infrastructure and systems (e.g., energy, transportation), (2) ecosystem services and the environment, and (3) socio-technical systems (e.g., economic development and education). As such, we capture sustainability from five dimensions – environment, transportation infrastructure, energy consumption, economic development, and education – in this study.

We adapt the framework from Raghupathi & Wu, (2011a, 2011b) which have served as the basis for studies on the relationship between ICTs and country-level public health delivery and ICTs and country-level governance. While first-order effects of ICTs on sustainability have been studied extensively in the literature (Berthon & Donnellan, 2011), Raghupathi & Wu (2011a, 2011b) studied the second-order of ICTs on country-level public health delivery and country-level governance. In particular, they explored the association or relationship between ICTs and public health delivery and ICTs and governance in the aggregate.

Take Raghupathi & Wu (2011a) work for example. They empirically investigated the relationship between ICTs and the delivery of country-level public health. The underlying hypotheses suggested that ICTs improve the efficiency and effectiveness of public health delivery mechanisms. They conceptualized ICTs as five factors – accessibility, quality, affordability, applications, and institutional efficiency, and sustainability. The public health delivery was represented by the changes in the indicators of immunization coverage, TB infection, sanitation, undernourishment, life expectancy, mortality rate, and health care expenses. Results indicated in most cases ICT factors had a significant contribution to a country's delivery of public health over and above a country's income level. ICT accessibility factor contributed to improved delivery for nearly all of the public health indicators followed by ICT applications factor. The findings were useful at the country level for informing policy decisions regarding the nature and extent of investment in ICT infrastructure for the delivery of public health.

In the second study (Raghupathi & Wu, 2011b), they investigated the relationship between ICTs and country-level governance. Again the five factors of ICTs were modeled as independent variables and their impacts on governance indicators were assessed. Using secondary data from the World Bank, and controlling for the wealth effect, the main multivariate result indicated that ICTs – with the exception of the institutional efficiency and sustainability factor – had a positive relationship with governance indicators. They also found that accessibility was the most important ICTs' factor to enhance governance.

The three-order effects of ICTs are also the often-cited characterizations of the linkages between ICTs and sustainability (EITO, 2002; Hilty, 2008; Hilty et al, 2006; Kohler & Erdmann, 2004; Yi & Thomas, 2007). The macro models used for assessing the sustainability impacts of ICTs often differentiate between the orders of effects (Hilty, 2008; OECD, 2010). The first-order effects look at the impacts related directly to the life cycle of ICT hardware, including the production, use, recycling and disposal of ICTs (Ropke & Christensen, 2012). For example: how can hardware and software production and network architectures become greener (Servaes, 2012)? Apparently, the focus is on ICT sustainability itself, that is, green computing (Dao et al, 2011).

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The second-order (indirect) effects are the impacts and opportunities created by the ongoing use and application of ICTs. These effects, also called enabling effects, ask such questions as: how can ICTs reduce energy consumption in other sectors – video conferencing in lieu of traveling, home work place, intelligent traffic systems, smart buildings, and others (Servaes, 2012)? They address the impacts due to the application of ICTs that have the power to change the processes of production, transportation, consumption, etc. For instance, this category includes the energy savings achieved by ICT-enabled optimization of production processes or by replacing a physical product with a service (Ropke & Christensen, 2012).

The third-order effects are the impacts and opportunities created by the aggregated effects of large numbers of people using ICTs over the medium to long-term. Also called systematic effects, they look at green ICTs as a model for knowledge accumulation and innovation (Servaes, 2012). How can ICTs change the way we live and work resulting in a reorganization of production and consumption? For example, the third-order effects address the environmental impacts related to the medium or long-term adaptations of behavior and economic structures that follow from the availability of ICTs and the services they provide. Additionally, the rebound effects that emerge from efficiency gains can be included in these effects (Ropke & Christensen, 2012).

Most of the benefits of ICTs lie in the second-order effects via increased efficiency, transparency, and speed of transactions, rapid market-clearing, long-tail effects, and others (Yi & Thomas, 2007). For example, the average transatlantic business flights use 80,000 to 100,000 pounds of fossil fuel (Cohen, 2000), which could be easily avoided by the use of teleconferencing. The results from various studies differ – for instance, depending on the extent to which rebound effects are taken into account. Several recent studies addressing the second-order effects have reported positive results in the environmental sector (Erdmann & Hilty, 2010; The Climate Group, 2008). The current emphasis on the positive potential of ICTs is also reflected in the recent special issue of Journal of Industrial Ecology where the focus is on the "Benefits Side of the Equation" (Masanet & Matthews, 2010).

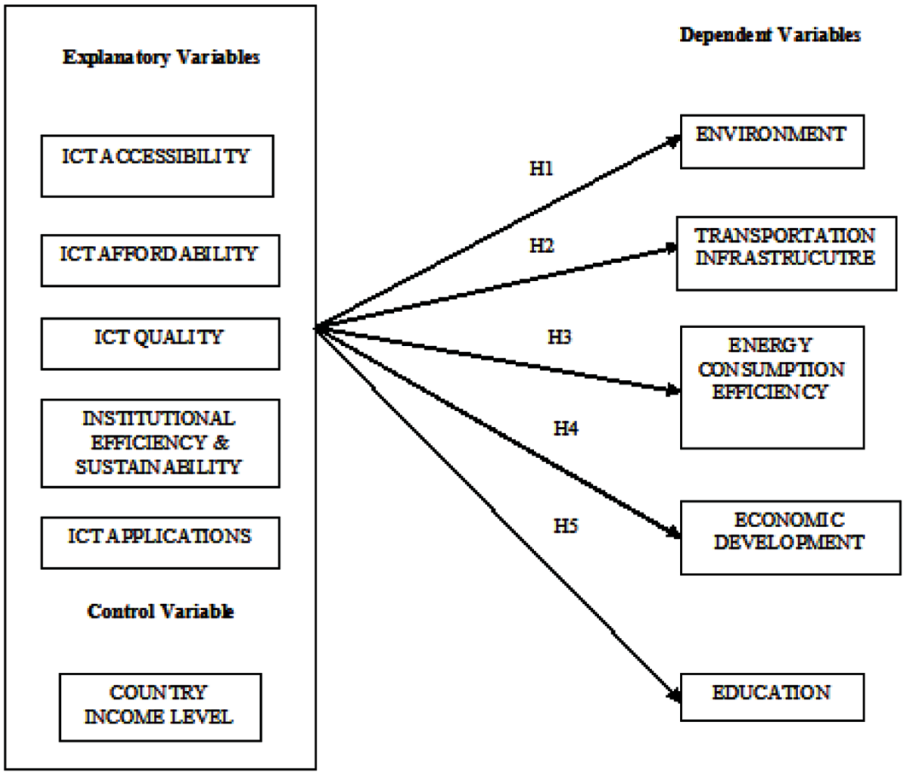
Based on all these works and the prior frameworks established in Raghupathi & Wu (2011a; 2011b) linking ICTs to second-order effects on health care delivery and governance, this framework is extended to characterize the association between ICTs and the second-order effects on country sustainability and presented in Figure 1.

- **Environment:** ICTs can have a positive impact on the environment for example, improving air quality, among other factors (Casal et al., 2005; Elliot, 2011; Melville, 2010). The ICTs are linked to the environment in the millennium development goal as well. They provide researchers with critical tools for the observation, simulation, and analysis of environmental processes such as in monitoring air quality and mitigating poor air quality (Climate Group, 2008; Millet & Estrin, 2012). ICTs play a key role in environmental management in activities ranging from optimizing clean production methods to decision making. The information gathered, processed and disseminated by ICTs can help ensure that natural resources are used efficiently and sustainably.

Additional research reports from Cisco (2008), McKinsey (Boccaletti et al. 2008), the Economic Intelligence Unit (EIU, 2008), The Climate Group (2008) and the European Union (Barroso, 2008) discuss the promise of ICTs to enable environmental sustainability. For example, greenhouse gas emissions (GHG) have been identified as a major driver of changes to the climate and human activity has been identified as the probable cause of rising GHG emissions particularly carbon dioxide (CO2) emissions. ICTs have the potential to make a positive contribution to reducing the levels of GHG. Broadband (Broadband

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Figure 1. Conceptual framework



Commission, 2012; Budde et al, 2011), one type of ICTs can help various sectors of a country to reduce GHGs through dematerialization of physical products and applications, for example substituting travel with collaborative tools of substituting need to produce physical products by delivering e-products and services (Qiang et al, 2009). The power of broadband also forms the basis for the collection, sharing and analysis of vital data on the environment gathered via satellite, for example, or by direct sensor technology. The information can be used to predict natural disasters such as floods or famines and take mitigating steps (Broadband Commission, 2012; Budde et al, 2011). Therefore, ICTs have the potential to mitigate GHG emissions and improve air quality. Based on the premise that ICTs lead to improved environment, the following hypothesis is tested:

H_1: Information and communication and technologies (ICTs) are positively associated with a country's environment.

- **Transportation Infrastructure:** Transportation infrastructure also provides important opportunities for more sustainable development, especially in cities. By using ICTs, the manufacturing of transportation systems itself can be changed. 'Smart transportation systems' involve the use of sophisticated ICTs including analytics, smart meters, sensors and toll systems. ICTs have a central role in these efforts (Millet & Estrin, 2012). By incorporating intelligence in the systems, one can reduce congestion and fuel use and even cut CO_2 emissions. Both air and rail infrastructures can be made more efficient and effective. As such,

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ICTs can lead to improved air and railway infrastructure in the aggregate. Therefore, to test the association between ICTs and transportation, the following hypotheses is formulated:

H_2: Information and communication and technologies (ICTs) are positively associated with a country's transportation infrastructure.

- **Energy:** Energy is another important construct in sustainability. It's been suggested that the biggest role ICTs can play is in improving energy consumption efficiency in power transmission and distribution (T&D) and in transporting goods (GeSI, 2008b). The report estimates ICT-enabled energy efficiency translates, in economic terms, into approximately $950 billion in cost savings through such applications as smart motor systems in Chinese manufacturing, smart logistics in Europe, smart building in North America, and smart grids in India.

ICTs can foster sustainable development by enabling better resource and energy use and by dematerializing transactions (GeSI, 2008a; EIU, 2008; Harter et al., 2010; Jitsuzumi et al., 2001). For example, mobile technologies enable m-banking, eliminating the need for physical branches. Other smart ICT applications have the potential to contribute to higher energy efficiency by making offices, homes and transportation system more 'intelligent' with, say, smart thermostats. Moreover, the ICT based services and working methods, such as teleworking and videoconferences, can result in lowering carbon emissions from business activities. Smart grid projects are already helping consumers save 10% on their bills and reducing peak demand by 15%. Imagine the potential savings when scaled to include companies, government agencies and universities. The investment by the federal government could yield almost a quarter of a million jobs first in digitizing the grid and in related industries such as alternative energy and automotive. Such an investment could enable new forms of industrial innovation by creating exportable skills, resources and technology (Millet & Estrin, 2012). Broadband technologies, for example, can enable intelligent home networks that can assist in controlling indoor climates and monitoring energy (Broadband Commission, 2012; Budde et al, 2011). Overall, we would expect an improvement in consumption efficiency and a move to more efficient energy sources. Therefore, we formulate the following hypothesis with regards to ICTs and energy:

H_3: Information and communication and technologies (ICTs) are positively associated with a country's energy consumption efficiency.

- **Economic Development:** The rapid and ubiquitous use of ICTs in all aspects of economic development is transforming the way that people live and work. ICTs have been demonstrated to contribute to economic growth and development by stimulating the productivity of people, organizations and nations (Avgerou, 2010; Djiofack-Zebaze & Keck, 2009; Flor, 2001; Gigler, 2011; Heeks, 2008, 2010; Mascarenhas, 2010). ICTs can improve the infrastructure capacity and efficiency of the private sector; increase production efficiency; and promote greater competition in the marketplace for delivery of goods and services. For example, the poor can have better access to the market with micro-level and economic networks, for example, via the use of village pay phones and knowledge centers that improve agricultural practices through access to information on crop selection, irrigation, fertilizers, and fishing and livestock conditions, thereby raising yields and reducing poverty and hunger (Von Braun & Toreno, 2006). Therefore, overall, ICTs can play a critical role in economic development, in the agriculture, manufacturing, and service sectors. Accordingly, we formulate the following hypothesis:

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H_4: Information and communication and technologies (ICTs) are positively associated with a country's economic development.

- **Education:** The role of ICTs in education is linked to the millennium development goal of all children receiving primary school education by 2015. ICTs can mitigate the chronic shortage of facilities and teachers by enabling distance learning and supplementing teaching with electronic resources. This in turn can lead to improved attendance and higher literacy rates. Furthermore, ICTs can enhance the learning process by enabling increased access to knowledge and more collaborative and interactive learning methods. Additionally, scientific research and educational networks can be established. Both mobile technologies and the Internet have the potential to play a critical role in the delivery of school education (Mascarenhas, 2010). Overall, with ICTs, enrollment has the potential to increase with improved education quality. Therefore, we formulate the following hypothesis with respect to education:

H_5: Information and communication and technologies (ICTs) are positively associated with a country's education coverage and education quality.

Given that the purpose of this study is to look at the association among ICTs and sustainability development indicators, ICTs are the key factors. But one could argue a country's income level is a common element with the potential to influence both ICTs and sustainability. That is, countries with a high-income level typically have more resources and therefore can invest more in sustainability initiatives. Thus, wealth effect must be considered in the research model. Accordingly, we include a country's income level in our research framework and control for the wealth effect in the assessment of the relationship between ICTs and sustainability. The findings then will be more convincing in terms of the importance of ICTs.

4. METHODOLOGY

4.1. ICTs Factors and Measurement

Several attempts have been made in the past few years to measure the relative levels of ICT development in individual countries. These efforts have highlighted the significance of ICTs as key factors contributing to a country's economic and social transformation, and as a cohesive force for integrating a country into the global economy (Cieslikowski, et al, 2009; Minges & Qiang, 2006; World Bank, 2010).

The World Bank ICT Index provides a holistic view of ICTs by incorporating 21 ICT sector specific variables reflecting five factors of ICTs: access, quality, affordability, application usage as well as efficiency and sustainability. Instead of using a single ICT index, we consider the five factors of ICTs so as to provide concrete and further understanding of the relationships between ICTs and country sustainability. We follow the work of Raghupathi & Wu (2011a, 2011b), whose measurement of ICTs is primarily based on World Bank ICT framework. Under this framework, the composition of each factor has been defined. As such, each ICT factor is viewed as formative construct where the indicators influence the construct. These indicators are often called 'causal' indicators and the construct is often termed as a combination variable (Maccallum et al. 1993) or composite variable (MacKenzie et al. 2005). Table 1 summarizes the scope of each factor and lists the component variables for each factor used in this study.

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Table 1. Scopes and measurement of ICT variables

ICT Factors	Scope	Variables
ACCESS	Variables that reflect the availability of ICTs, such as fixed and mobile telephones, computer, the Internet, and televisions.	Telephone mainlines (per 1,000 people)
		International voice traffic (minutes per person)
		Mobile phone subscribers (per 1,000 people)
		Population covered by mobile telephony (%)
		Internet users (per 1,000 people)
		Personal computers (per 1,000 people)
		Households with television (%)
QUALITY	Variables that reflect how well networks perform by measuring telephone faults, and also measuring their bandwidth and international Internet capability	Telephone faults (per 100 mainlines)
		Broadband subscribers (per 1,000 people)
		International Internet bandwidth (bits per person)
AFFORDABILITY	Variables that measure the price of ICT services and the capacity of citizens to pay for them.	Price basket for residential fixed line (US$ per month)
		Price basket for mobile (US$ per month)
		Price basket for Internet (US$ per month)
		Telephone average cost of call to US (US$ per three minutes)
ICT APPLICATIONS	Variables that reflect the viability of the sector in terms of revenue generation and labor productivity	Information and communication technology expenditure (% of GDP)
		Secure Internet servers (per 1 million people)
		Schools connected to the Internet (%)
		E-government readiness index (scale 0-1)
INSTITUTIONAL EFFICIENCY & SUSTAINABILITY	Variables that measure the extent to which ICTs are used in different sectors of the economy, such as government and business	Telecommunications revenue (% GDP)
		Telecommunications investment (% of revenue)
		Telephone subscribers per employee

Note: Dimensions and items came from *World Bank – ICT at a Glance* 2004.

All the ICT variables were screened for non-normality, and those with high skewness and/or kurtosis underwent log transformation. The variables used in the later analysis do not have significant non-normality problems. One *Affordability* item and one *ICT Applications* item were deleted from further analysis due to a high proportion of missing values.

As formative constructs, we created a factor score for each ICT factor that averages its measurement items: the average of *Access* variables was denoted as AVGAC; the average of *Quality* variables as AVGQU; the average of *Affordability* variables as AVGAF; the average of *ICT Applications* variables as AVGICT; and the average of *Institutional Efficiency & Sustainability* variables as AVGIES. Since the measurement items are in different metrics, each measurement item was first standardized to mean as zero and standard deviation as one to make them in the same metric scale before taking the average. The factor scores were used to explain the variance of sustainability development indicators across the countries.

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4.2. Sustainability Development Indicators

Indicators are not ends in themselves. They are purpose-driven tools to guide, support and monitor decision-making (Carraro et al., 2009; CGSDI, 2001; Grunfeld, 2007; Hueting & Reijinders, 2004; IISD, 2000). Sustainability is a very broad term. Based on the literature (Adelle et al, 2009; Hughes & Johnston, 2005) we characterize sustainability in terms of the five constructs discussed above (environment, transportation infrastructure, energy consumption efficiency, economic development, and education). Each construct is then represented by one or more factors. Each factor is further derived by one or more measurement items which are extracted from the World Bank's World Development Indicators – WDI database (http://data.worldbank.org/data-catalog/world-development-indicators/). This is justified by the fact that indicators that address social, economic, environmental and institutional dimensions, although not designed for the special requirements of the knowledge society, are appropriate starting points for sustainability (Pinter et al., 2005; Spangenberg et al., 2002; U.N., 2007; UNDSD, 2001a, 2001b, 2008).

For example, environment, though a complex construct covering air, water, natural forest, etc, is mainly represented by air quality because the high missing values in other aspects restrain us from developing a more comprehensive construct. Air quality in turn is characterized by carbon dioxide emission, a world development indicator. Transportation infrastructure sustainability was gauged by the capacity of freight and passengers in air and rail transportation. Energy sustainability was assessed by energy consumption efficiency. Economic development sustainability was reflected in the percentage of added value of agriculture, manufacture, and service sectors in the GDP. Education sustainability was indicated by coverage of education and quality of education. The detailed information on the sustainability constructs, factors, and measurement items is summarized in Table 2.

Several of the sustainability development indicator variables suffered from non-normality. They were corrected by log transformation to comply with the basic assumption for ordinary least square in order to obtain best linear unbiased estimates.

4.3. Data Source and Research Model

In order to estimate the degree of association between ICTs sustainability development indicators, we extracted data from two World Bank databases. The data for the individual ICT variables were pulled from The World Bank ICT At-a-Glance country database (http://go.worldbank.org/FDTYJVBR60) for the year 2004, the last year of a complete and public data set. The same data can also be found at the web site of the International Telecommunications Union (ITU) (http://www.itu.int/ITU-D/ict/publications/world/world.html).

The data for country income and sustainability development indicators were obtained from the World Development Indicators database (WDI) for 2009. The countries were then classified as high-, middle-, or low-income countries (http://go.worldbank.org/CWTURYIPS0).

The datasets of ICTs' factors and sustainability development indicators (WDI) were merged based on the unique identification information of country name. The final dataset contained data for 196 countries.

In the phase of research design, we consider that the effect of investment in ICT may take time to generate effect. Put alternatively, a time lag is needed to allow us to see the long-term association between ICTs and sustainability. Yet, there was no suggestion on how long the lag needs to be in the existing literature. In the data collection phase, we also want to use the most recent and complete data. The data for the individual ICT variables were pulled from The World Bank ICT At-a-Glance country database

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Table 2. Sustainability Constructs, Factors, and Measurement Items

Constructs	Factors	Measurement Items	Index
Environment	Air quality	Carbon dioxide emission (metric tons per capita)	
Transportation Infrastructure	Air infrastructure	Air transport, freight (million tons per km) Air transport, passengers carried Air transport, registered carrier departure worldwide	The three items were standardized and averaged to form an index.
	Rail infrastructure	Rail lines (total route – km)	The three items were standardized and averaged to form an index.
		Railways, goods transported (million ton – km)	
		Railways, passengers carried (million passenger – km)	
Energy consumption efficiency	Energy consumption efficiency	Electric power transmission and distribution loss % of output)	
Economic development	Agriculture sector net output	Agriculture, value added (% of GDP)	
	Manufacturing sector net output	Manufacturing, value added (% of GDP)	
	Service sector net output	Service, value added (% of GDP)	
Education	Education coverage	School enrollment, preprimary (% of gross)	The mean value of the enrollment in four different categories
		School enrollment, primary (% of gross)	
		School enrollment, secondary (% of gross)	
		School enrollment, tertiary (% of gross)	
	Education quality	Pupil-teacher ratio, primary Pupil-teacher ratio, secondary	The mean value of pupil-teacher ratio in two categories.

for the year 2004, the last year of a complete and public data set. The data for sustainability development indicators were obtained from the World Development Indicators database (WDI) for 2009. Though data were available for the more recent years, but numerous values were missing. Overall, the five-year lag between ICTs data and the sustainability development indicators' data is a compromise between the conceptual consideration and the availability of the data.

Multiple linear regression analysis was conducted to test each hypothesis in SPSS, the statistical software. The five ICT factors served as explanatory variables and the sustainability development indicators (Y) were the outcome variables, as shown in the following regression function. The country income level (the categorical variables of high, medium, and low, denoted as *CT* in the equation) served as a proxy for a country's wealth in the regression analysis to control for the wealth effect.

5. RESULTS AND DISCUSSION

Table 3 reports the descriptive statistics for all the ICTs' and sustainability factors. None of them indicate severe kurtosis and skewness after transformation. Table 4 reports the correlation matrix among the key variables. Most of the independent variables are correlated at $p<0.05$. Therefore, we used graphical methods in SPSS to detect potential heteroscedasticity by plotting the residuals versus fitted (predicted)

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Table 3. Descriptive statistics of all constructs

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
AIRQU	-1.67	1.65	.27	.72	-.57	.18	-.49	.35
AIRTR	-1.88	2.71	-.02	.95	.33	.21	-.42	.41
RAILTR	-2.72	2.25	-.026	.93	.14	.26	.35	.52
ENGEF	.34	1.85	1.03	.28	.11	.21	.21	.42
AGR	.042	58.19	13.48	13.15	1.38	.19	1.57	.39
MFG	1.38	46.00	13.27	7.41	1.24	.20	3.24	.40
SERV	19.52	90.43	58.12	14.30	-.22	.19	-.52	.39
EDUQ	7.04	87.33	23.06	14.01	1.75	.20	4.15	.41
EDUC	7.08	115.81	73.67	22.21	-.55	.19	-.18	.38
AVGAC	-1.67	2.319	-.057	.88	.64	.18	-.53	.35
AVGAF	-1.21	4.26	.011	.80	1.67	.19	5.26	.37
AVGQU	-2.03	2.38	-.038	.86	.84	.20	.61	.40
AVGICT	-1.42	2.33	-.18	.82	.52	.18	-.47	.36
AVGIES	-2.36	2.52	-.017	.68	.45	.21	2.30	.41

Note: AIRQU - air quality; AIRTR – air transportation infrastructure; RAILTR – rail transportation infrastructure; EDUQ – education quality; EDUC – education coverage; AGR – agriculture sector value added; MFG – manufacturing sector value added; SERV- service sector value added; ENGEF – energy consumption efficiency.

Table 4. Correlation matrix of all constructs

	AVGAC	AVGAF	AVGQU	AVGICT	AVGIES	AIRQU	AIRTR	RAILTR	EDUQ	EDUC	AGR	MFG	SERV	ENGEF
AVGAC	1													
AVGAF	.17*	1												
AVGQU	.780*	.136	1											
AVGICT	.68**	.127	.626**	1	.									
AVGIES	.14	-.012	-.037	.000	1									
AIRQU	.74**	.06	.51**	.60**	.07	1								
AIRTR	.53**	.09	.48**	.69**	-.02	.49**	1							
RAILTR	.29**	-.07	.20	.49**	.04	.42**	.66**	1						
EDUQ	-.65**	-.04	-.48*	-.47**	-.15	-.79**	-.29**	-.23**	1					
EDUC	.55**	.18**	.52**	.53**	.10	.61**	.31**	.39**	-.61**	1				
AGR	-.70**	-.17*	-.49**	-.64**	-.07	-.84**	-.47**	-.30**	.71**	-.59**	1			
MFG	.15	-.12	.11	.32**	.12	.26**	.39**	.04	-.22*	.15	-.32*	1		
SERV	.65**	.35**	.55**	.57**	.08	.48**	.25**	.22	-.51**	.48**	-.61**	-.02	1	
ENGEF	-.58**	-.06	-.45**	-.45**	-.16	-.43**	-.38**	-.25**	.37**	-.30**	.34**	-.21*	-.27**	1

Note: (1) The green area reports the correlations among the independent variables (ICT factors); the pink area reports the correlations among the dependent variables (sustainability dimensions); and the blue area summarizes the correlation between independent and dependent variables. (2) *: Correlation is significant at the 0.05 level (2-tailed); **: Correlation is significant at the 0.01 level (2-tailed).

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values. The plots indicated that heteroscedasticity was not a threatening issue in this study and should not cause much problem to ordinary least square (OLS) estimates of the variance (and, thus, standard errors) of the coefficients. Still, we called in HCREG macro to SPSS to estimate OLS regression models but with heteroscedasticity-consistent standard errors (Hayes and Cai, 2007). The *t*-test statistics of regression coefficients (*p*-value) in later regression analysis (Table 5) were calculated based upon the heteroscedasticity-consistent standard errors.

Table 5 summarizes the multivariate regression analysis results. Before we run the multiple linear regression for each dependent variable, we ran a simple linear regression with only the control variable in the model, and we found that it explained a big proportion of the variances already in most of the cases (Table 5). For example, a country's income level explains 67% of the variance of air quality, 24% of the variance of air transportation infrastructure, 27% of the variance of the energy consumption effi-

Table 5. Multivariate regression results

		Independent Variables							
Hypothesis	**Dependent Variables**	**AVGAC**	**AVGQU**	**AVGAF**	**AVGIES**	**AVGICT**	**Country Income Level**	**R^2 Change**	**Sig. of F Change**
H1	Air quality						0.82**	0.67	<0.001
		0.22	-0.25**	-0.18**	-0.06	0.17*	0.75**	0.07	<0.001
H2	Air infrastructure						0.49**	0.24	<0.001
		0.03	0.10	-0.03	-0.04	0.62**	0.10	0.25	<0.001
	Rail infrastructure						0.22	0.05	0.06
		0.11	-0.19	-0.12	0.03	0.60**	-0.08	0.23	0.002
H3	Energy Consumption efficiency						-0.52**	0.27	<0.001
		-0.39*	-0.01	0.06	-0.09	-0.11	-0.13	0.08	0.037
H4	Agriculture value added						-0.80**	0.63	<0.001
		-0.03	0.20*	0.06	0.02	-0.31**	-0.74**	0.06	0.001
	Manufacturing value added						0.23*	0.05	0.014
		-0.43	-0.08	-0.22*	0.13	0.43**	0.44*	0.15	0.002
	Service value added						0.56**	0.31	<0.001
		0.50**	0.08	0.26**	0.03	0.24*	-0.14	0.20	<0.001
H5	Education coverage						0.62**	0.38	<0.001
		-0.23	0.21	0.02	0.08	0.24**	0.51**	0.06	0.035
	Education quality						-0.68**	0.46	<0.001
		-0.23	0.06	0.15*	-0.05	-0.05	-0.53**	0.04	0.11

Note: The table reports the standardized regression coefficients. Regression coefficients significant at $p < 0.05$ are marked by *, significant at $p < 0.01$ are marked by **.

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ciency; 31% of the variance of service output out of GDP; and 46% of the variance of education quality. Then we conducted the multiple linear regression analysis with the control variable and independent variables (five ICT factors). We reported the change of R^2 with the addition of ICT factors to reflect their own contributions. In all the cases, we found that the model explanatory power has been improved significantly at $p<0.05$ (mostly at $p<0.01$) except for education quality.

The multiple linear regression model to test H_1 has demonstrated a great explanatory power (adjusted $R^2 = 0.74$), indicating that major factors have been included in the model. Country income level has a strong positive association with carbon dioxide emission. That is, high-income countries have higher levels of carbon dioxide emission or lower air quality than low-income countries.

Higher emissions in the developed countries could be a result of large industrial infrastructure, thriving of e-business, and change of business models. For instance, many retailing giants strengthen online business on the top of traditional brick-and-mortar model. The business-to-customer model requires frequent fulfillment of individual orders, which makes it less environmental friendly. Similarly, manufacturing companies adopt Just-in-Time (JIT) production system so as to minimize the inventory investment, but unfortunately JIT requires more frequent delivery of goods, which increases the carbon footprint.

ICT factors too contribute to higher emission; however, their impact is less significant compared to income level. While country income level could explain 67% of variance of emission, ICTs factors all together could only explain 7%. We found three ICTs factors influence emission level substantially, quality ($b = -0.25$, $p<0.01$), applications ($b = 0.17$, $p<0.01$), and affordability ($b = -0.18$, $p<0.01$). Apparently, their impacts are mixed with the positive and negative effects canceling each other out, resulting in a small net impact, so H_1 is not well supported.

We note, only the factor of ICT quality is associated with a reduction in emission and improved air quality. For example, broadband underlies the gathering, dissemination and analysis of key environmental data gathered via satellite or by sensor technology. This information can be used to predict natural disasters such as floods or famines. Natural disasters typically pollute the environment (e.g., earthquake in Fukushima leading to tsunami and nuclear disaster). Also, improved supply chain management with quality ICT infrastructure could collect point-of-sale data and optimize replenishment for different locations through order consolidation. As a result, fewer trucks are needed on the roads and emission is lowered. Additionally, video conferencing means less travel for employees. Electronic media reduces the manufacture of physical products. All these indicate less pollution to the air.

Considered in aggregate, it is conceivable ICTs themselves have a rebound effect or reverse effect – that is, their production and usage could possibly lead to emission and lower air quality. This is the reason ICT application is found to enhance emission. An example is the likelihood that the reduction in vehicle usage resulting from telecommuting will be accompanied by increased use of vehicles for leisure activities and the growth of long distance travel. Another example is the increase in the increased manufacture and use of computers and other electronic devices as paper flows are replaced by e-flows; while there is a reduction in paper usage (and decrease in tree cutting) there is increased potential for e-toxic waste to be generated. Rebound effects are pervasive across different effects, and the role of ICTs must be examined carefully in the context of trade-offs. A rebound effect also occurs when efficiency gains (directly or indirectly) trigger new demand, thereby counter-balancing the positive environmental effects. For example, there appears to be a positive correlation between the use of email and business travel, one instigating the other. Replacement may occur in the economy with use of ICTs (e.g., replacement of printed books by e-books); however, it may be outweighed by the increased consumption of alternative energy resources.

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Hypothesis 2 looked at the possible association between ICTs and the transportation infrastructure. The testing of H_2 required us to run two separate regression models, with air and rail transportation capacity as dependent variables respectively. These two regression models showed similar results: the wealth effect was insignificant or mildly significant yet ICT factors as a whole explained much of the variance in air and rail transportation capacity. Specifically, ICT applications contributed the most to the explanatory power of the regression model (b = 0.62 and 0.60 respectively, $p<0.01$). H_2 is, therefore, supported. From dynamic, computerized systems that monitor flights and trains to the processing of real-time data for optimization and efficient allocation of resources, ICTs can help improve the air and rail infrastructure. Widespread availability of ICTs, especially communication infrastructure results in more widespread use of ICTs in transportation. Passenger reservation and ticketing systems can result in improved infrastructure. Smart air and rail systems can monitor capacity and utilization more effectively. From smart cards to pay for fares, to advanced analytics applications for scheduling, ICTs have potential to improve operational efficiency and reduce greenhouse gases.

With regards to Hypothesis 3, a regression analyses was performed to examine association between ICTs and energy consumption efficiency. It evaluated the potential association between ICTs' reductions in a country's electricity transmission loss (this is a reverse measure of consumption efficiency). We found that while country income level influences electricity transmission loss, the accessibility of ICTs also did. That is, the accessibility was significant in the reduced electricity transmission loss (b = -0.39, $p<0.01$). This in turn improved consumption efficiency. As such, H_3 is well supported.

Three additional regression models were developed to test Hypothesis 4. This hypothesis addressed the relationship between ICTs and economic development. First, the results showed that agriculture value added is effectively determined by a country's income level type: high-income country had low value added. Indeed, the ICT applications factor is associated with a further reduction in the agriculture value added (b = -0.31, $p<0.01$). Anecdotally, the use of smart sensors and analytics in agriculture has potential to improve agricultural practices in the long-term. As for the manufacturing sector, affordable ICTs and increased usage of ICT applications are associated with an increased manufacturing industry value added on the top of the wealth effect (b = 0.43 and -0.22 respectively, $p<0.01$). For the service sector, while high-income countries appear to be associated with high value added, greater ICT access and increased usage of ICT applications are associated with improved service value added (b = 0.50 and 0.24 respectively, $p<0.01$). Interestingly, the more expensive the ICT applications, the higher value added percentage. This can be explained by the fact that the more expensive the technology, the higher the payoff. For example, sophisticated real-time applications and large, enterprise applications are costly, but implemented properly they can result in greater payoffs. Overall, ICTs are associated with an increase in a country's value added in all sectors (particularly, the manufacturing and service sectors) with or without the wealth effect. Therefore, H_4 is largely supported.

It is well established as cited in several articles above that ICTs have a positive effect on various aspects of development. This study confirms some of these findings. It is conceivable, in developed countries, the role of technology in agriculture has reached its full potential and therefore, there is not much value added. However, there is great opportunity for technology usage, such as electronic monitoring of crops, metering water usage, prediction and forecasting tools and analytics in agriculture in developing countries to optimize the production, storage and distribution systems (World Bank, 2010). With regards to manufacturing and service, overall, ICTs' access, affordability and applications are playing a critical role. Taking a holistic view this implies ICTs from mobile phones & computing to broadband and the Internet, have become pervasive across manufacturing and service industries as vast amounts of data

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are collected, analyzed, and disseminated for decision making and insight. ICTs enable the key aspect of communication and facilitate the development of markets and financial institutions (Mascarenhas, 2010; Murray, 2008). They lead to the "efficient, scalable, affordable and pervasive delivery of goods, services, and information flows between people, government and firms".

The assessment of Hypothesis 5 required the conduct of two analyses — examination of the association between ICTs and education coverage, and that of ICTs and education quality. On the one hand, we see the wealth effect playing a strong role in education coverage and education quality. Essentially, in high-income countries a larger proportion of students attend school and each student receives more attention from the teacher. On the other hand, increased school enrollment is associated with ICT applications ($b = 0.24$, $p<0.01$). Also, improved education quality is associated with ICT affordability ($b = 0.15$, $p<0.01$). H5 is well supported. From academic records to information on student mobility and attendance, data mining is helping schools monitor student performance more effectively. Additionally, the use of various ICTs in the delivery of curriculum and e-learning and distance learning are having a major impact on the coverage and quality.

6. CONCLUSION

This study empirically confirms the positive association between ICT factors and various sustainability development indicators beyond the wealth effect. Our cross-country regressions document that sustainability is stronger in countries associated with better ICT infrastructure. Interestingly, the wealth effect is negative in some areas. For example, rich countries have higher carbon dioxide emissions and higher energy consumption from non-renewable sources. All the results have policy implications and provide clear strategic guidance for countries to be more sustainable via ICTs. The results are especially encouraging to developing countries with resource constraints. Our study indicates which ICT factors and sustainability development indicators to focus on and where the promise of improvement has the most potential. Strategically, the improvement of ICT infrastructure needs to become a priority. All ICT factors have an influence on some aspect of sustainability. Therefore, resource allocation to overall ICT infrastructure development is the key to enabling a country's sustainability. Additionally, the study also shows which ICT factors play a key role in each sustainability indicator. For example, ICT application was associated with education coverage while affordability was associated with education quality. Countries can therefore juggle their resources depending on their sustainability priority.

6.1. Scope and Limitations

It is important to recognize the limitations of this exploratory study from the perspective of the nature of the study, measurement of constructs, model specification, data availability and the nature of the available data. First, the study assesses the relationship of ICTs and sustainability indicators across countries. It is a cross-sectional study, though lagged data were used in the analysis. Given the nature of this study, it does not indicate a direct causal relationship between ICTs and sustainability. We only take a snapshot and conclude there is a strong association between ICTs and improved sustainability. Yet, sustainability might also influence the decision of ICTs investment. The more complicated relationship can be studied with longitudinal data.

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Second, in order to test the proposed hypotheses, we have to operationalize the theoretical constructs using observable and objective measures. The measurement for ICT five factors has been defined by World Bank and established the face validity, and we simply adopted that in this study. The measurement for the sustainability variables were selected as a compromise of face validity of constructs in hypothesis and data availability.

Third, the data acquired from the World Bank and the International Telecommunications Union are secondary in nature. WB database is evolving, the variables it tracks also vary at different time periods, and it takes time to collect and compile the country level data. For instance, the number of ICT variables in the current database is far less than that in the older database. 2004 is the last year that WB provided a complete and public dataset in ICT At-a-Glance country database, which contains 21 variables for five sector performance for each country. We believe all these variables together paint a much comprehensive picture of a country's ICT sector performance. The five factors of ICTs also enrich the study by allowing us to explore which ICT dimension is more associated with a country's different sustainability indicators.

Fourth, the data is only as good as how it is reported by the countries. However, in the past several years, several researchers have used such country-level data in e-government studies (see for example, Krishnan et al. (2013) and Srivastava and Teo (2007)). We build on these and other articles to validate our study in the use of such data sets.

Fifth, a robustness test was not explicitly conducted; however, the findings of the study do show the robustness of the relationships. The data used in this study continue to evolve with frequent updates to the World Bank database. The regression models were run twice. In the first run, the relationship between ICTs in 2004 and sustainability indicators in 2007 was examined with a three-year time lag; in the second run the same test was conducted with sustainability indicators in 2009 (i.e. a five-year time lag). The results were similar indicating the relationships are robust. The plausible reason behind the robust results is that all the variables are stock variables measured up to a specific time point. In other words, they are not the change variables from one year to another. As all the variables provide macro level information there are only marginal value differences in the variables across years. So the analytics may not show dramatic difference in findings.

Lastly, the current research model contains only one control variable. Though it is a critical one, as can been seen from the results in Table 5 (the control variable captures a good proportion of the variation in all sustainability indicators), variables such as country characteristics and non-technological strategies to promote sustainability may add additional information into the study and should be considered in the future studies. Additional variables relating to technology transfer, innovation, R&D, export/import regulation, tax laws, intellectual property and others may impact the study.

6.2. Contributions

Despite some of the limitations discussed above, this study makes a number of important contributions to the literature and provides strategic direction to country-level policy makers in governmental and non-governmental organizations and in the private sector regarding the role of ICTs in enabling and promoting sustainability. First, it is only recently that case studies and anecdotal narratives have emerged regarding the use of ICTs in sustainability initiatives. There is a need for understanding the impact at the national as well as global level. By studying the association between ICT factors and country-level

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sustainability development indicators, our study contributes to the sparse but emerging literature at the country level. The findings can help global policy makers strategize on sustainability resource allocation and invest to maximize the global sustainability benefits. Second, nearly all of the related studies have focused on 'green ICT,' which addresses how ICTs can become self-sustaining (e.g., green data center etc.) (Berthon & Donnellan, 2011). On the other hand, this study examines the strategic and transformation role of ICTs in enabling sustainability. We show that ICTs are not the only pathway to sustainability. A country's income level, to a large extent, explains the level of sustainability. It seemed obvious that poor countries faced greater challenges in natural resource utilization. Indeed poor sustainable practices would have negative effects on economic development. The flip side is high-income countries had greater carbon emissions. Donor countries, global institutions and nonprofit agencies and foundations can make better choices in terms of investments. In addition, while ICTs may make substantive contributions to sustainability beyond the wealth effect, some of the effects may take longer to be observed (e.g., reduced carbon emission, increased literacy rate, safer and smarter transportation). Some of the insignificant results should not be viewed as distress signals so much as encouragement that with continued investments over time, poor countries may realize greater benefits. From a methodological perspective, we make novel use of publicly-available fee and non-fee based databases to enhance our understanding of the association between ICTs and sustainability development indicators. This study is an incremental step in the direction of more robust quantitative studies.

For policy makers and stakeholders, this study does show ICTs have a favorable impact on various sustainability constructs. Decision makers in environment, transportation, energy, economic development and education can carefully develop policy and implementation strategies based on the findings. For example, providing access to ICTs is important; likewise, the ready availability of ICT applications and the assurance of their quality play critical roles. However, policy makers must be fully aware of the socio-technical nature of the role of ICTs in sustainability constructs. They have to be aware of unintended consequences and rebound effects, that is the positive application of a technology in one aspect may lead to negative consequences in another.

6.3. Future Research

Future research may focus on cross-country and regional as well as longitudinal studies. Best practices also need to be documented. What works in one region may not in another. Cultural, political and economic environments have to be considered. Other variables relating to health, urban planning (NRC, 2010), and water and sewerage planning may reveal additional associations and effects (e.g., smart city design). Others may research the diffusion of ICTs for effective sustainability practices in developing countries and the development of coordinated global strategic models of ICT integration and use. Additionally, the innovation, leap-frog effect, and globalization aspects have to be addressed. An important aspect to study in sustainability is the *rebound effect*, which occurs when efficiency gains stimulate new demand that counterbalances, or even outweighs positive environmental gains. For example, the efficiency improvements (time, fuel, energy), made possibly by technological advances, are counteracted by an increasing demand (growing consumption volumes) of energy, products, services, passenger and freight transport. Another rebound effect is rematerialization, e.g. virtual information products are accessed via the Internet and then printed out or burned onto a compact disc or DVD.

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Section 4
Utilization and Applications

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Chapter 33
Integration of Renewable Energy in Refrigerated Warehouses

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ABSTRACT

Refrigerated warehouses are large energy consumers and account for a significant portion of the global energy demand. Nevertheless the opportunity for integration of renewable resources in the energy supply of large cold storage facilities is very often unjustifiably neglected, whereas the employment of renewable energy for many other industrial and comfort applications is actively promoted and explored. In that context, the purpose of this chapter is to bridge the existing gap by raising the public awareness of stakeholders, researchers, practicing engineers and policy makers about the availability of a number of smart engineering solutions and control strategies to exploit renewables of different nature (solar, wind, geothermal, biogas, etc.) in the food storage sector, as well as by calling the readers' attention to the specialised knowledge in the matter, which has been published so far.

INTRODUCTION

On 5 June 2014 the UN Secretary-General launched the "UN Decade of Sustainable Energy for All", urging leaders from around the world to "deliver new and expanded commitments and partnerships that will transform the global energy landscape" ("UN Secretary-General", 2014). Increasing the integration of renewable energy sources (RES) in the global energy supply chain is one of the key aspects of sustainable development. Hence, one of the goals of the Sustainable Energy for All (SE4ALL) initiative is doubling the share of renewable energy in the global energy mix by 2030. As the International Energy Agency (2007) states, renewable sources are "essential contributors to the energy supply portfolio as they contribute to world energy supply security, reducing dependency on fossil fuel resources, and provide opportunities for mitigating greenhouse gases".

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According to Coulomb (2006) and the International Institute of Refrigeration (2007, 2015), refrigeration (including air-conditioning) currently accounts for about 17% of worldwide electricity use, while over 80% of the global warming impact of refrigeration systems is due to this electricity use. Industrial refrigeration, comprising over 550 million m^3 of cold storage space worldwide (International Institute of Refrigeration, 2015), is a major consumer of about 8% of the electrical power on a global scale (consistent with the circumstance that approximately 40% of the global food output require refrigeration). In the context of sustainable development, designing or retrofitting of a cold store refrigeration plant should consider the possibility of using RES to provide at least a portion of the required energy input.

Although there are a number of RES-assisted technologies for different refrigeration applications, many of these tools are still at rudimentary stages of development, either not commercially viable or only applicable for relatively small-scale systems. However, integration of RES in refrigerated food storage facilities might provide a cost-efficient way of: (i) reducing electricity consumption from the grid, and/or (ii) shifting refrigeration loads from peak to low consumption periods, thereby contributing to the overall balance of the power supply system and minimizing the environmental footprint of the cold store. While many of the today's engineering solutions are not yet cost efficient by themselves, various governmental policies in support of renewable energy developments and integration are carried out around the world, which can substantially enhance the economic feasibility of RES-powered installations.

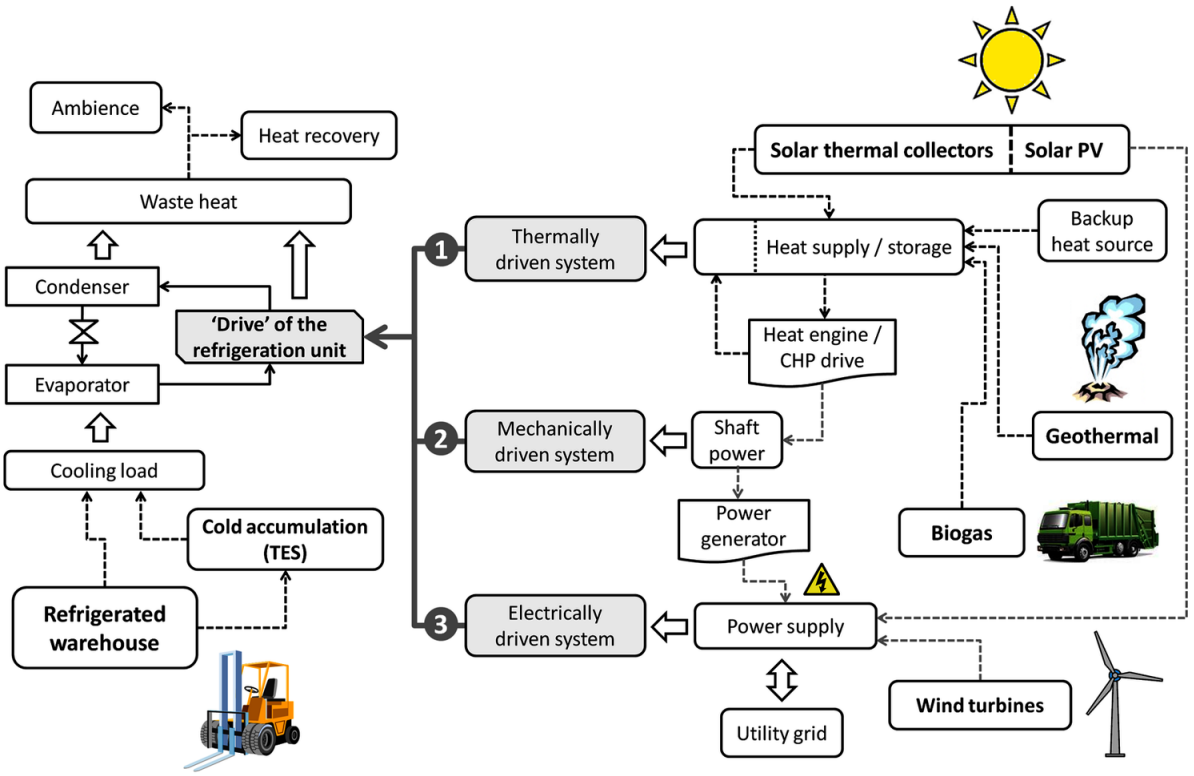
The objective of this chapter is to familiarise the readers with: (i) state-of-the-art RES-based technologies applicable to refrigeration systems, including their technical and economic performance, (ii) different strategies to integrate these technologies in the energy supply of refrigerated warehouses in an efficient way, (iii) practical examples, pilot projects and on-going research involving RES utilization for cold storage facilities, and (iv) government incentives which can facilitate investment in RES projects. The material is primarily intended to serve as guidance for cold store operators and refrigeration stakeholders, who are still unaware of the latest RES technologies and the opportunities to employ them in the food refrigeration industry. As the chapter has no ambition to analyse in-depth any of the concerned technologies, the readers are advised to examine additional literature in order to gain more comprehensive knowledge on the particular topics of interest (e.g., see the list of references as a starting point).

BACKGROUND

Integration of renewables in the energy supply of cold storage facilities can be accomplished in a variety of ways, as illustrated in Figure 1. Solar photovoltaic cells and wind turbines can be used for on-site power generation, while solar thermal collectors, geothermal sources and biogas combustion can serve as a heat source for thermally driven refrigeration systems. In addition, thermal sources can be used to drive cogeneration or trigeneration systems, thereby simultaneously producing electricity, heating and refrigerating output. Thermal energy storage for heat and cold accumulation can be integrated in the system to shift energy supply and/or demand as to permit better overall utilization of renewable energy. Provided that proper interaction is established between the cold store operator and the electric utility, on-site RES-generated power can be fed to the utility grid, which permits to sell excessive energy at attractive prices (especially in the presence of convenient government policies). The latter and the inclusion of thermal energy storage can overcome a major inconvenience of many RES technologies, i.e. the intermittent energy supply due to the fluctuating availability of the energy resource.

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Figure 1. Various options to integrate renewable sources in the energy supply of refrigeration systems for cold storage facilities



Cold store operators can consider and evaluate different alternatives for RES integration in order to screen out the best option in terms of both technical and economic performance. Several metrics exist, which can be used to compare diverse alternatives. One of the main parameters, employed to evaluate the overall performance of refrigeration systems driven by renewable energy, is the overall system efficiency (*OSE*) defined as:

$$OSE = \frac{Refrigerating\,capacity}{Capacity\,of\,the\,renewable\,source} = \frac{Q_E}{E_R} = \frac{Q_E}{E_S} \cdot \frac{E_S}{E_R} = COP \cdot \eta_{es} \tag{1}$$

$$COP = \frac{Refrigerating\,capacity\left(useful\,output\right)}{Supplied\,input\,capacity\left(required\,input\right)} = \frac{Q_E}{E_S} \tag{2}$$

where *COP* is the coefficient of performance of the refrigeration system and $\eta_{es} = E_S/E_R$ is the energy conversion efficiency of the energy supply system utilizing RES (which is a product of the efficiencies of each consecutive stage of energy conversion prior to the refrigeration system, beginning from the device that captures the renewable resource).

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As a measure of performance, *COP* can be used not only to compare different refrigeration systems, but also to define system efficiency in comparison with the theoretically possible maximum. Thermodynamically the maximum possible efficiency of a refrigeration cycle operating between two temperatures (T_A – temperature of the heat sink, e.g. ambient temperature, and T_L – temperature of the refrigerated space, both in K) is the Carnot efficiency defined as:

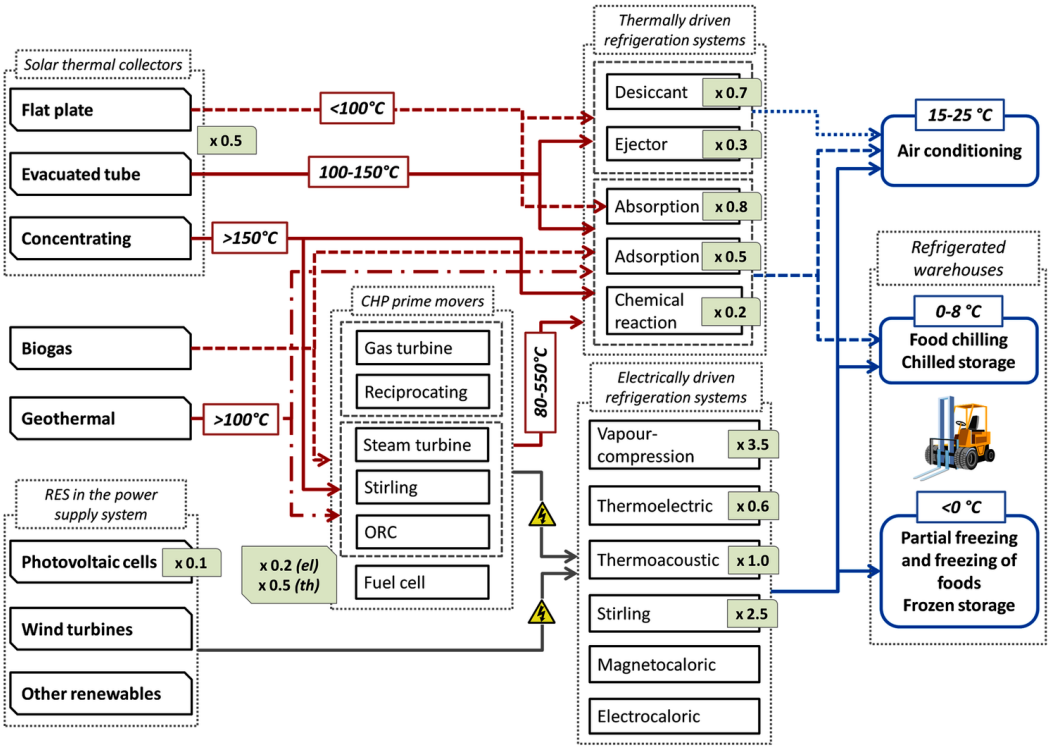
$$\eta_{C,rc} = \frac{T_L}{T_A - T_L} \tag{3}$$

The actual efficiency of the real refrigeration cycle, i.e. *COP*, can be represented as a product of the Carnot efficiency and the anticipated fraction, α_r, of the Carnot efficiency that the cycle is expected to achieve:

$$COP = \alpha_r \cdot \eta_{C,rc} \tag{4}$$

Various possible configurations of RES-driven refrigeration systems based on different physical principles and indicative values of the respective efficiencies, for the consecutive stages of energy conversion, are shown in Figure 2.

Figure 2. Applications and indicative energy conversion efficiencies of refrigeration systems powered by renewable energy sources



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Many of the configurations shown in Figure 2 are commercially viable, while a number of these technologies (involving thermoelectric, thermoacoustic, magnetocaloric and electrocaloric principles of refrigeration) are still in an immature R&D phase of their elaboration. Part of the indicated configurations (e.g. those involving solar-driven desiccant and ejector refrigeration systems) are only feasible for air-conditioning applications and included just for completeness. Nevertheless, this chapter focusses on RES technologies and engineering solutions which are applicable for large-scale refrigeration systems suitable for cold storage facilities.

While technically feasible, some configurations may not be economically efficient. Several metrics can be used to assess the economic performance of different RES technologies. In some cases the installed cost per peak useful output is used, e.g. $/W or €/W. Depending on the context, useful output can be the refrigeration capacity or the output capacity of the energy supply system (which represents the required input capacity for the refrigeration system). Another relevant metric, used to evaluate the economic efficiency of RES, is the levelized cost of energy (*LCOE*), i.e. the ratio of the lifecycle cost of the system to the energy produced over its operational lifetime (Intergovernmental Panel on Climate Change, 2014):

$$LCOE = \frac{Present\,value\,of\,total\,costs\left(\$\right)}{Lifetime\,energy\,production\left(MWh\right)} = \frac{CRF \cdot I + OM + F}{E_S} \tag{5}$$

$$F = FC \cdot \frac{E_S \cdot FLH}{\eta_{es}} \tag{6}$$

where I is the total investment costs, including initial costs, construction costs and decommissioning costs, OM is the net annual operation and maintenance (O&M) costs, FC is the fuel costs per unit of energy input and FLH is the number of annual equivalent full-load hours. The capital recovery factor is calculated as:

$$CRF = \frac{r}{1-\left(1+r\right)^{-L_T}} \tag{7}$$

where r is the weighted average cost of capital (e.g. 5 or 10%) and L_T is the project duration, i.e. operational lifetime of the system (Intergovernmental Panel on Climate Change, 2014). *LCOE* is a particularly popular metric for RES power generation systems.

Opportunities for Integration of Renewables in Cold Stores

Various opportunities for RES integration in refrigerated warehouses are grouped and outlined hereafter in three sections of this chapter, entitled as follows: (i) *"Thermally Driven Refrigeration"* (which reviews the possibilities of using heat derived from RES to drive sorption refrigeration systems); (ii) *"Refrigeration through On-site Power Generation"* (which discusses distributed generation of electricity through RES technologies, including the use of cogeneration), and (iii) *"Integration of Renewables Involving*

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Thermal Energy Storage" (which examines engineering solutions for cold accumulation to utilize RES more efficiently in the context of the smart power grid).

THERMALLY DRIVEN REFRIGERATION

Solar Thermal Collectors

Solar thermal collectors are devices that capture solar radiation to heat a solid, liquid or gaseous substance. Collectors used for heating liquids (typically water or a glycol solution) are reviewed in this chapter.

While solar energy is an intuitive source for heating applications, its use for refrigeration is not so obvious, although there is usually a good match between the peaks of solar irradiation and cooling loads (in terms of both time and geographic location). In developing countries with no or unreliable power supply, where conventional fuels are difficult or too expensive to obtain, a number of solar refrigeration applications (e.g. vaccine storage or fish and milk preservation) have been known for decades. In industrialized countries, characterized with reliable supply of electricity from the grid, comparatively little interest has been shown in using solar energy as a driving source for refrigeration systems, because a number of technical and market barriers have led market actors to perceive these technologies as uneconomical.

The high initial cost of a solar system, whose largest portion is usually taken up by solar collectors, is one of the main obstacles. Solar radiation, however, is the primary source of energy for the planet and the potential of converting this energy for powering different processes, including refrigeration, is certainly huge. It is estimated that while 376,680,000 TWh of solar energy are dissipated into surface heating each year, only about 266 TWh are captured by solar collectors, of which 74% by thermal collectors, 24% by photovoltaic (PV) collectors and 2% by concentrated solar power (CSP) systems (Infante Ferreira & Kim, 2014). Since this energy is free whenever available, the only necessity is to find appropriate energy conversion technologies which can make utilization of this energy source technically and economically feasible.

One of the main inconveniences, common for all solar systems, is the fluctuating availability of solar radiation. Although this availability has more or less predictable annual and daily cycles, the solar energy to be captured is also determined by weather conditions, which are quite difficult to predict. Even in the presence of dedicated systems for thermal or electrical storage, it is very challenging to manage a system that relies solely on solar energy. Hence, efforts are to be concentrated on integrating the solar system with another energy source (primary or supplementary) in the most efficient manner, taking into account local climatic conditions and energy costs.

The design of a solar thermal system should be optimized to capture the largest possible amount of solar radiation through the smallest possible collector area in an economically efficient manner. Solar collectors can be installed at a fixed tilt, the optimum of which depends on location and season, e.g. for summer the optimal tilt is usually considered to be equal to the site latitude minus 10°. Alternatively, a movable sun tracking system can be used to automatically tilt the collector depending on the position of the sun – single-axis and two-axis trackers are available for this purpose. Tracking systems are necessary for concentrating solar collectors, but their involvement increases the complexity and cost of the system.

Flat plate and evacuated tube collectors are most common, because of the design simplicity and reasonable cost. Concentrating solar collectors use geometric optics to enhance collector efficiency, but this works effectively only for direct (i.e. beam) solar radiation and not for diffuse radiation, which in

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some locations may represent the greater share of total solar radiation. Hence, concentrating collectors are beneficial mainly for sunny locations relatively closer to the equator, which receive high amounts of direct solar radiation. Table 1 summarises different types of solar collectors and the range of temperatures they are expected to provide to the circulating heat transfer fluid. Weiss and Rommel (2008) compiled a detailed survey of recent advances in the design and optimisation of solar thermal collectors for a wide range of operating temperatures between 80°C and 250°C.

The efficiency of a solar thermal collector is defined as the ratio between the heat supplied to the heated substance, Q_{sol}, and the total amount of solar radiation reaching the surface of the collector, i.e. the product of the solar irradiance I_β (W/m^2) and the surface area of the solar collector A_s (m^2):

$$\eta_{sc} = \frac{Q_{sol}}{I_\beta \cdot A_s} \tag{8}$$

This efficiency depends on operating temperatures (i.e. T_A – the ambient air temperature and T_M – the mean temperature of the heat transfer fluid) and can be defined as Lazzarin (2014):

$$\eta_{sc} = \eta_0 - a_1 \cdot x - a_2 \cdot x^2 \tag{9}$$

$$x = \frac{T_M - T_A}{I_\beta} \tag{10}$$

The three coefficients: a_1, a_2 and η_0 can vary significantly depending on collector types and constructions, and are normally determined by the manufacturer. Example values for four of the most commonly used solar collector types are shown in Table 2, along with indicative figures for the installed cost per unit area of the collector. The values given in Table 2 are derived from two different sources, i.e. the works of Infante Ferreira & Kim (2014), above, and Lazzarin (2014), below (shown in parentheses).

Table 1. Types of solar thermal collectors (Adapted from Kalogirou, 2009)

Collector Type	Sun Tracking	Absorber Geometry	Concentration Ratio	Indicative Temperature Range
Flat plate	No	Flat	1	30-80°C
Evacuated tube	No	Tubular	1	50-200°C
Compound parabolic	No	Tubular	1-5	60-240°C
	Single-axis	Tubular	5-15	60-300°C
Linear Fresnel	Single-axis	Tubular	10-40	60-250°C
Cylindrical trough	Single-axis	Tubular	15-50	60-300°C
Parabolic trough	Single-axis	Tubular	10-85	60-400°C
Parabolic dish	Two-axis	Point	600-2000	100-1500°C
Heliostat	Two-axis	Point	300-1500	150-2000°C

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Table 2. Examples of zero-loss collector efficiency, heat loss coefficients and installed cost for different types of solar thermal collectors

Collector Type	η_0	a_1	a_2	Installed Cost
Flat plate	0.8 (0.79)	3.02 (3.94)	0.0113 (0.012)	€371/m^2 (€350/m^2)
Evacuated tube	0.84 (0.71)	2.02 (0.974)	0.0046 (0.005)	€750/m^2 (€650/m^2)
Parabolic trough	0.76 (0.52)	0.22 (0.475)	0 (0.0031)	€540/m^2 (€450/m^2)
Parabolic dish	0.82	0.22	0	€270/m^2

Solar Sorption Refrigeration

Sorption refrigeration machines are based on either the absorption or adsorption principle, which utilize physical or chemical attraction between a pair of substances to produce the required refrigeration output. In both cases heat, which can be supplied by solar thermal collectors, is used to regenerate the sorbent, while only small amounts of electricity are required to drive circulation pumps. The *COP* of sorption refrigeration systems is the ratio of the refrigerating capacity, Q_E, to the sum of the required input heat capacity, i.e. heat provided by the solar system, Q_S, and the power capacity of circulation pumps, P_P (which is usually negligible):

$$COP = \frac{Q_E}{Q_S + P_P} \approx \frac{Q_E}{Q_S} \tag{11}$$

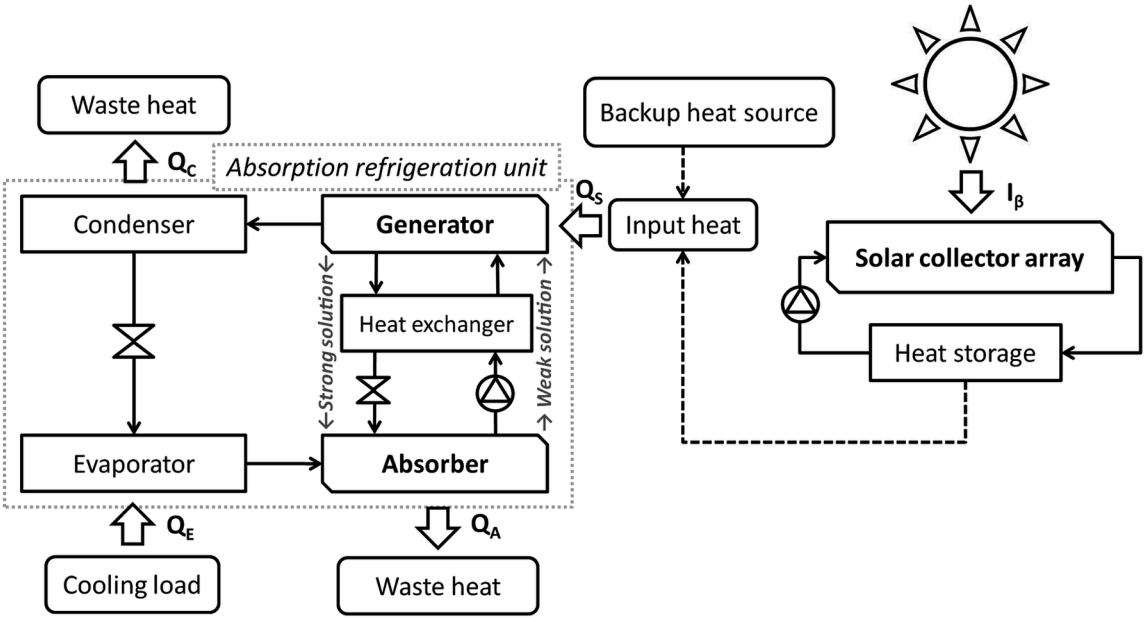
In an absorption machine, the sorption effect takes place in an absorber and desorption occurs in a generator which utilizes heat, Q_S, to regenerate the sorbent. The refrigerant vapour generated in this process condenses in the condenser, rejecting heat, Q_C, to the ambience and flows back through the expansion valve to the evaporator. After evaporating and removing heat from the refrigeration load at the evaporator, Q_E, the refrigerant is absorbed by the substance used as sorbent, while sorption heat generated during this process is rejected to the ambience, Q_A. The process is illustrated in Figure 3.

Typically, the refrigerant-sorbent working pair of absorption refrigeration systems is either water-LiBr (lithium bromide) or ammonia-water. Ammonia-water systems require higher mass circulation rates and higher operating pressures than water-LiBr systems (ASHRAE, 2009). While water-LiBr absorption chillers are popular for air-conditioning applications, ammonia-water systems can operate at sufficiently low temperatures down to –60°C (Rutz, Mergner, & Janssen, 2012), which makes them suitable for food refrigeration purposes.

A solar-driven single-stage absorption refrigeration system is depicted in Figure 3. Multistage cycles are also available with one or more of the four basic heat exchangers (generator, absorber, condenser, evaporator) present at two or more places in the cycle, at different pressures or concentrations (ASHRAE, 2009). Several types of two-stage cycles have been developed, including double-effect and triple-effect cycles. These advanced configurations can provide better performance than single-stage systems, but also add complexity and increase unit costs. Typical *COPs* are in the range of 0.65-0.8 for single-effect

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Figure 3. Single-stage ammonia-water absorption refrigeration system powered by solar energy



and 0.9-1.2 for double-effect absorption systems (Rutz *et al.*, 2012). Advanced ammonia-water systems have comparable efficiencies with water-LiBr systems, e.g. the basic GAX (generator-absorber-heat exchanger) cycle has comparable performance with a single-effect water-LiBr system, the branched GAX cycle has comparable performance with a double-effect water-LiBr system and the vapour exchange GAX cycle would yield the same performance as a triple-effect water-LiBr system (ASHRAE, 2009).

Absorption refrigeration is in fact one of the oldest industrial refrigeration techniques, preceding vapour-compression refrigeration. Industrial absorption refrigeration units were developed in the mid 19th century by the Carre brothers in France and have been used during the American Civil War in the gunpowder production industry (ASHRAE, 2014). Another reported 19th century application is for ice production via wood-fired absorption systems (Briley, 2004). The concept of solar refrigeration is also not new. Augustin Mouchot demonstrated an absorption refrigeration machine driven by a concentrating solar collector at the Exposition Universelle of 1878 in Paris (Podesser *et al.,* 2010). The main reason for the modest market penetration in more recent years, as compared with the vapour-compression technology, is the high investment costs of absorption units. One of the causes is that while all components of vapour-compression systems are mass produced by different manufacturers, sorption refrigeration machines are usually manufactured as a whole unit by a single producer (Podesser *et al.*, 2010). Moreover the number of manufacturers of absorption refrigeration units is relatively small.

Solar-driven absorption refrigeration units have been applied and tested mainly for air-conditioning applications. Experience with cold storage facilities is limited and more research is needed to provide optimized solutions for larger scale systems. Experimental solar-driven absorption systems, which refrigerate small-scale cold storage compartments, have been investigated within the EU-funded SOLERA Project. In Freiburg, Germany, a linear Fresnel collector with a total aperture (mirror) area of 132 m^2 has been used to drive two ammonia-water absorption refrigeration units with a total refrigeration capacity of 24 kW. Weber *et al.* (2014) reported that such collectors have been operated at an efficiency

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of 50-60%, providing heat at 100-205°C to the absorption units, whose *COP* has been in the range of 0.4-0.8 and refrigerating temperatures down to –12°C have been achieved (enough for storing ice with a thermal capacity of about 110 kWh). In a very similar configuration in Umkirch, Germany, a linear Fresnel collector with aperture area of 88 m^2 (Figure 4) is used to drive an ammonia-water absorption unit with nominal refrigerating capacity of 12 kW and *COP* of 0.6, which is tested for a 32 m^2 cold storage space. The absorption unit cools a water-glycol mixture to –5°C and charges an ice storage system with a thermal capacity of about 52 kWh (Döll, Bentaher, & Morgenstern, 2014).

Vasilescu & Infante Ferreira (2014) carried out a theoretical study of a large-scale system featuring a double-effect ammonia-lithium nitrate absorption unit with a refrigeration capacity of 343 kW (when cooling a fluid to –20°C, with input heat at 195°C and inlet cooling water temperature of 30°C), driven by a parabolic trough collector with an aperture area of 1,000 m^2. The study showed that for the climatic conditions of Naples, Italy the solar collectors can provide 50% of the heat required to cover the refrigeration demand of 600 kW in a food processing facility.

Instead of liquid absorbents, adsorption refrigeration systems utilize solid sorption materials with highly porous structure. Classical working pairs (refrigerant-adsorbent) for adsorption refrigeration are water-zeolite, water-silica gel and methanol-activated carbon (Podesser *et al.*, 2010). When saturated, the adsorbent can be regenerated with heat provided by a solar thermal system or another renewable source. Chemical adsorbents, e.g. metal hydrides, can also be used. Chemical adsorption is characterized with stronger bonds between the refrigerant and adsorbent, but it is more difficult to reverse and therefore more heat is required to drive the cycle (Pridasawas, 2006).

Unlike absorption systems, solid sorbents cannot be circulated and adsorption and desorption have to occur at the same solid adsorbent bed. The process is therefore intermittent and multiple adsorbent beds

Figure 4. Linear Fresnel collector used to drive an absorption refrigeration system at Umkirch, Germany. (© 2012, suncooling GmbH, a member of the KRAMER GROUP, Germany. Used with permission.)



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are required to permit continuous operation of the system (Kim & Infante Ferreira, 2008). Advanced adsorption cycles (e.g. heat recovery cycle, mass recovery cycle and thermal wave adsorption cycle) have been developed to cope with this issue (Lewis, Chaer, & Tassou, 2007). Schematic of a thermal wave cycle adsorption system driven by solar energy is presented in Figure 5.

Adsorption refrigeration systems offer several advantages as compared with absorption systems, including less corrosion issues when working at higher temperatures and the possibility of being activated by lower temperatures – as low as 50°C, as compared with 90°C for absorption systems (Wang & Vineyard, 2011). Additional advantage of adsorption systems is that they involve few moving parts, which means reduced noise and vibrations. This can also decrease maintenance efforts, but the external hydraulic circuits have to be carefully designed (Podesser *et al.*, 2010). However, the *COP* of adsorption machines is typically lower, e.g. 0.2-0.5, with α_r in the range of 0.04-0.33 (Infante Ferreira & Kim, 2014). Chemical reaction systems have much lower *COPs* in the range of 0.1-0.2 (Pridasawas, 2006).

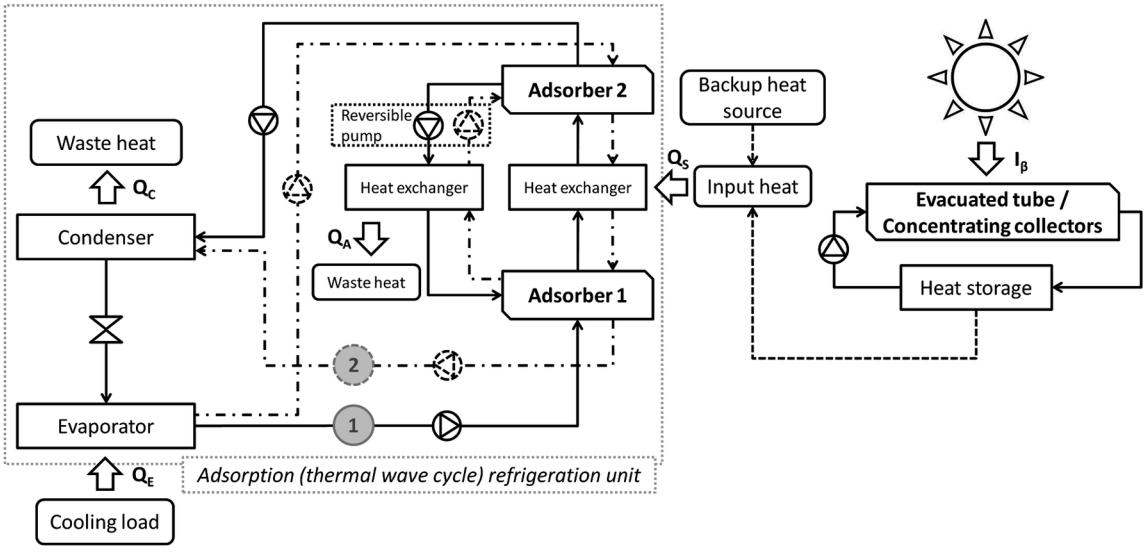
The number of manufacturers of adsorption systems is even lower than that of absorption systems. Commercially available large-scale units (larger than 100 kW) are manufactured by the Japanese company Mayekawa, while small-scale units (less than 15 kW) are produced by the German companies Invensor and SorTech (Podesser *et al.*, 2010). Commercial adsorption systems are still limited to mostly air-conditioning applications, while low-temperature adsorption refrigeration systems, potentially applicable to industrial facilities for cold storage, are still in a R&D stage (Lewis *et al.*, 2007).

The overall system efficiency of solar sorption refrigeration systems can be defined as:

$$OSE = \frac{Q_E}{I_\beta \cdot A_s} = \frac{Q_E}{Q_S} \cdot \frac{Q_S}{Q_{sol}} \cdot \frac{Q_{sol}}{I_\beta \cdot A_s} = COP \cdot \eta_{hd} \cdot \eta_{sc} \tag{12}$$

where η_{hd} is the efficiency of the heat distribution system and η_{hd} is the efficiency of the solar collector. *OSE* is typically low for solar refrigeration systems. Lazzarin (2014) estimated an *OSE* of 45% for a

Figure 5. Thermal wave cycle adsorption refrigeration system powered by solar energy



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single-effect absorption system driven by evacuated tube collectors and 40% for a double-effect absorption system driven by a parabolic trough collector. Comparing the prices of sorption refrigeration units, Kim & Infante Ferreira (2008) showed that the investment cost per refrigerating capacity (€/kW) of adsorption systems is in the range of €500-855/kW, as compared with €210-400/kW for single-effect and €300-855/kW for double-effect absorption systems.

Other Renewables as a Heat Source

Thermally driven refrigeration systems can operate with heat acquired from other renewables (e.g. via combustion of biofuels or geothermal sources). Holdmann (2008) reported a geothermally driven absorption system with a refrigeration capacity of about 180,000 BTU per hour (or approx. 53 kW), developed for the Ice Museum of Chena Hot Springs Resort in Alaska. Small-scale biofuel-driven or geothermally driven sorption refrigeration systems are available, but for large-scale applications combined heat and power (CHP) generation can be a more feasible option. Such systems are discussed further in this chapter.

REFRIGERATION THROUGH ON-SITE POWER GENERATION

Solar Photovoltaic Systems

Photovoltaic (PV) modules are solid-state semiconductor devices which employ the photoelectric effect to convert solar radiation into direct current (DC). This DC power can subsequently be used directly or converted to alternating current (AC) to run electrically driven refrigeration systems. If an appropriate interaction is established between the cold store operator and the electric utility, PV-generated power can also be sold to the utility grid.

Due to the reduced prices and increased efficiencies of PV systems, whose use is continuously fostered by various government incentive programs, total global operating capacity of solar photovoltaic systems has grown rapidly since the beginning of the new millennium – from 1.8 GW in 2001 to 100 GW in 2012, with the top markets currently being Germany, Italy, China, the United States, and Japan (REN21, 2013). According to the U.S. Department of Energy (2012), prices of PV modules have declined by 95% between 1976 and 2010 and as of 2010 the installed cost of a commercial PV system (including the price of the modules, power electronics and BOS costs) per peak power capacity was roughly $5/W. According to Lazzarin (2014) the unit cost of a PV module on per area basis is on the average €650/m^2.

The most common types of PV cells are based on the monocrystalline and polycrystalline silicon technologies, which currently hold 85% of the PV market share. Another major type employs thin-film PV cells, which are about 100 times thinner than crystalline silicon cells. Thin-film cells most commonly use cadmium telluride (CdTe) as a semiconductor material, amorphous silicon and alloys of copper indium gallium diselenide (CIGS). Among thin-film technologies, CdTe-based PV modules have experienced the highest market growth during the last decade (U.S. Department of Energy, 2012). Concentrating PV systems are also available, but their market share is still small (REN21, 2013). Typical lifetime of solar PV modules is in the range of 20-25 years.

The efficiency of PV modules is defined as the ratio of generated electrical power to the product of solar panel surface area and incident solar radiation:

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$$\eta_{PV} = \frac{P_G}{I_\beta \cdot A_s} \tag{13}$$

This efficiency depends on the module type and design. According to the U.S. Department of Energy (2012), crystalline silicon modules currently have efficiencies in the range of 14-16%, non-standard high-quality designs achieve module efficiencies of about 17-21%, while thin-film modules have lower efficiencies in the range of 6-14%. Manufacturers provide reference values for η_{PV} determined under standard conditions, but the actual efficiency of PV modules varies according to ambient conditions. Lazzarin (2014) proposes the following equation to calculate the operating efficiency of PV modules as a function of ambient air temperature and solar irradiation:

$$\eta_{PV} = \eta_{PV,R} \cdot \left[1 - \beta \cdot \left(T_A - T_{Ref}\right) - \frac{\beta \cdot \tau\alpha \cdot I_\beta}{U_L}\right] \tag{14}$$

where T_{Ref} is the reference temperature at which the reference efficiency $\eta_{PV,R}$ is evaluated (e.g. 25°C); β is a temperature coefficient of the PV cell (e.g. 0.004 K^{-1} for monocrystalline cells); $\tau\alpha$ is the product of glass transmissivity and cell absorptance (typical value is 0.95) and U_L is the overall heat loss coefficient of the PV cell (e.g. 20 $Wm^{-2}K^{-1}$). This equation shows that the operating efficiency decreases when ambient air temperature and solar irradiation are higher. Apart from the efficiency of the PV module itself, the efficiencies of the other components of the PV system have to be taken into account.

The overall efficiency of a refrigeration system driven by a PV system can be defined as:

$$OSE = \frac{Q_E}{I_\beta \cdot A_s} = \frac{Q_E}{P_S} \cdot \frac{P_S}{P_G} \cdot \frac{P_G}{I_\beta \cdot A_s} = COP \cdot \eta_{pd} \cdot \eta_{PV} \tag{15}$$

where P_S is the power supplied to the refrigeration system and η_{pd} is the efficiency of the power distribution system. A conservative estimate for *OSE* of a vapour-compression refrigeration unit driven by a photovoltaic system, using indicative values as shown in Figure 2 (η=0.1 and *EER*=3.5), would be 35%. If the system involves energy storage then this value would be somewhat lower. The *LCOE* of PV systems can vary significantly depending on local conditions. Comparing several situations, the U.S. Department of Energy (2012) estimated indicative values of *LCOE* for commercial systems in the range of $120-340/MWh.

PV systems can serve as a primary or supplementary energy source for any of the electrically driven refrigeration cycles, as depicted in Figure 2. Photovoltaics, among other solar systems, have varying energy production as a result of the varying availability of incident solar radiation. The power supply of the refrigeration system must therefore be designed to cope with this varying electricity production rate. For smaller scale systems DC power generated by the PV modules can be used to directly operate the DC motor of a compressor in a vapour-compression system. In that case a major consideration is to appropriately match the electrical characteristics of the motor driving the compressor with the available current and voltage being produced by the PV array (Klein & Reindl, 2005). Electric batteries can serve as a buffer between the PV system and the load, providing electrical storage. If the PV system

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is connected to the utility grid, a proper energy management system (EMS) can provide the means for shifting power supply from/to the grid depending on the variation of the PV power supply and the power demand of the cold storage facility. The overall performance of the EMS can be enhanced through the thermal energy storage (TES) strategies described further in this chapter.

The relatively low energy conversion efficiencies, varying power production and high prices have traditionally been a barrier for wider implementation of solar PV systems. For many applications they are not economically viable or the associated payoff periods are too long, which often deters investments. Traditional cold storage applications of PV modules have been primarily for milk, fish and vaccine preservation in developing countries, especially in areas with no or unreliable power supply, but these are usually small-scale storage compartments with refrigeration capacities in the range of a few kilowatts. In developed countries with reliable power grids the use of PV systems for refrigerated warehousing has been limited until recently.

Large flat roofs of refrigerated warehouses are, however, a very convenient location for PV systems because of the presence of both a large unoccupied area for placing of PV modules and a substantial consumer of energy at the site of its generation. In addition, peak power demand in cold stores tends to coincide with the time when the intensity of solar radiation is at its highest, although higher temperatures and solar irradiation decrease the efficiency of PV modules. Similarly to all power generating systems, roof-mounted PV systems should be carefully designed and safely maintained in order to prevent fire hazards. Government incentives are among the most important drivers which enhance market penetration of PV-based technologies. Such measures are described in more detail in the section *"Policy instruments in support of renewable energy integration"*. The ease of demonstration, visibility and publicity of such PV projects promote public interest and stakeholders' confidence in renewable energy technologies as a whole.

Promising prospects are revealed today for a sound integration of PV systems in refrigerated warehouses. A number of state-of-the-art engineering solutions around the world employ large PV arrays (including some in the megawatt range) capable of meeting a significant portion of the power demand of the cold storage facilities they serve. Some of these recent developments are summarised in Table 3.

Top-view photographs of three of the facilities listed in Table 3 are shown in Figures 6, 7 and 8.

Solar Thermo-Mechanical Systems

Solar thermal collectors can provide energy to a heat engine for conversion of heat into mechanical work. This mechanical work can be used to drive the compressor of a vapour-compression refrigeration machine (Figure 9). In a basic configuration, the collector utilizes solar radiation incident on its surface to heat a fluid, which is usually water being converted to steam supplied to the heat engine, Q_S, which converts it to mechanical work, W, and rejects waste heat to the ambience, Q_A. The mechanical work, in turn, drives the compressor of the refrigeration machine, to remove heat from the evaporator, Q_E. Waste heat of the refrigeration cycle is rejected to the ambience at the condenser, Q_C. A storage tank can be included to provide some high temperature storage and serve as a buffer between the solar collectors and the heat engine.

The overall system efficiency of a solar thermo-mechanical refrigeration system can be defined as:

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Table 3. Some recent installations of large-scale solar PV systems at refrigerated warehouses

Location/Source	Technical Features	Cost / Economic Benefits
Refrigerated warehouse at the Gloucester Marine Terminal in New Jersey (Holt Logistics Corp., 2014)	• 27,528 roof-mounted modules (102,200 m^2) • 9 MW installed capacity • Capable of producing 11 GWh per year (meeting 80% of facility power demand) • 3-4 MW expansion is planned	• Investment of $42 million • $11 million in federal tax credit • Continued support of solar renewable energy credits (RECs) through the New Jersey renewable portfolio standards (RPS) scheme • Expected return on investment in 10 years or less
Cold storage facilities in La Mirada and Livermore, California, and Phoenix, Arizona ("DelSolar Completes", 2011; US Foods, 2011a, 2011b, 2011c)	• La Mirada: 4,998 modules with 1.15 MW installed capacity (annual production of approximately 1.65 GWh, 16% of power demand) • Livermore: 4,354 modules with 1.18 MW installed capacity (annual production of approximately 1.3 GWh, 40% of power demand during daylight hours) • Phoenix: 3,934 modules with 0.9 MW installed capacity (annual production of approximately 1.5 GWh, 15% of power demand)	• Facilities have earned Green Business Certification • The project in La Mirada has been partially funded through the California Solar Initiative program • Solar systems are leased from renewable energy providers
Seven cold stores at various locations in England (Yearsley Group, 2012)	• 8,997 roof-mounted modules • Capable of producing 1.753 GWh per year	• Investment of £3.5 million • The project is intended to meet carbon reduction commitments as part of ISO 14001 environmental certification
Refrigerated warehouse and distribution centre at Goldthorpe near Barnsley, England (Bennett, 2014)	• 6,000 roof-mounted modules (15,000 m^2) • 1.5 MW installed capacity • Estimated to provide 1.2 GWh per year	
Multi-purpose distribution center (including food storage facilities) in Heddesheim, Germany (Wirsol, 2013)	• 33,096 roof-mounted modules (110,000 m^2) • 8.1 MW installed capacity • Capable of producing 7.9 GWh per year	• Pre-certified by the German Sustainable Building Council (DGNB) with gold certificate
Three cold stores in New Jersey (EDF Renewable Energy, 2009; Milk, n.d.)	• 30,000 roof-mounted PV modules of different technologies with total capacity of 3.2 MW • 21% reduction in grid power consumption	Part of the solar system is owned by the cold stores operator: • Investment of $9 million • $4.6 million in state and federal incentives, including 30% federal tax credit, a New Jersey state subsidy, and accelerated depreciation Part of the solar system is owned by a renewable energy provider: • Electricity production is fed to the cold stores at a fixed price under a power purchasing agreement (PPA)
Cold storage facility in Wilmington, Los Angeles, California ("California Green Designs", 2011)	• 7,500 roof-mounted modules with installed capacity of 1.49 MW • Capable of meeting 75% percent of facility power demand	• Average savings of between $40,000 and $42,000 per month on electricity costs • Benefits from government and utility incentives, including 30 percent federal grant, one-year accelerated bonus depreciation and rebate from the Los Angeles Department of Water & Power
Cold storage facility in San Diego, California ("ICE Cold Storage", 2009; Milk, n.d.)	• Roof-mounted modules with 1.1 MW installed capacity • Capable of meeting 72% of facility power demand • Average production of 1,295 kWh per day during the winter months and 3,383 kWh per day in summer months	• Investors share renewable energy credits (RECs) Part of the solar system is owned by the power provider: • Part of San Diego Gas & Electric Sustainable Communities Program that supports renewable energy initiatives Part of the solar system is owned by the cold store operator: • Investment of $3.5 million before any subsidies • 40% reduction of the investment cost as a result of 30% federal tax credit and a five-year California refund (on a kWh basis)
Refrigerated warehouse in West Sacramento, California (Milk, n.d.; "Tony's Goes Green", n.d)	• 5,700 roof-mounted modules with installed capacity of 1.2 MW • About 43% reduction of grid power consumption	• Investment of $7.2 million before any subsidies • About 50% reduction of the investment cost as a result of federal tax credit and a $3.5 million rebate from Pacific Gas & Electric • In times of excessive production electricity is fed to the grid on a net metering basis • Average savings of $22,000 per month on energy costs

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Table 3. Continued

Location/Source	Technical Features	Cost / Economic Benefits
Refrigerated warehouse at the Port of Baltimore, Maryland (HelioSage, n.d.)	• 3,136 roof-mounted modules with 736.9 kW installed capacity • Providing 824 MWh per year (capable of meeting 20% of facility power demand)	• Benefits from sale of solar renewable energy credits (SRECs) • Expected payback in less than six years
Cold storage facility in Portland, Oregon (Henningsen Cold Storage Co., 2010)	• 1,386 roof-mounted thin-film modules (3,017 m^2) • 200 kW installed capacity • Capable of meeting 20% of facility power demand	
Food Bank of Contra Costa & Solano, California (Food Bank of Contra Costa and Solano, n.d.)	• 516 roof-mounted modules	• Investment of $450,000 • California Energy Commission rebate
Cold storage and packing facility in San Joaquin Valley, California (REC Solar, 2014)	• Ground-mounted system on a four acre field adjacent to the cold storage facility • 1.07 MW installed capacity • Capable of meeting 75% of facility power demand	• Local rebates • 30% federal investment tax credit and other tax incentives • Expected payback in five years

Figure 6. Solar park on the roof of MTC Logistics' cold store at the Port of Baltimore. (© 2011, HelioSage. Used with permission)



$$OSE = \frac{Q_E}{I_\beta \cdot A_S} = \frac{Q_E}{W} \cdot \frac{W}{Q_S} \cdot \frac{Q_S}{Q_{sol}} \cdot \frac{Q_{sol}}{I_\beta \cdot A_S} = COP \cdot \eta_{he} \cdot \eta_{hd} \cdot \eta_{sc} \tag{16}$$

where η_{he} is the thermal efficiency (i.e. the ratio of the work output to the heat input) of the heat engine. The *OSE* of solar thermo-mechanical refrigeration is usually quite low (e.g. around 5%), which is unfavourable for the market penetration. According to Klein & Reindl (2005), such systems can be competitive if concentrating solar collectors with tracking systems are used to provide high temperatures for large-scale refrigeration applications (e.g. over approx. 3,500 kW).

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Figure 7. The Los Angeles' largest commercial solar installation on the rooftop of the Konoike-Pacific cold-storage warehouse in Wilmington. (© 2011, California Green Designs: www.ca-green.com. Used with permission)

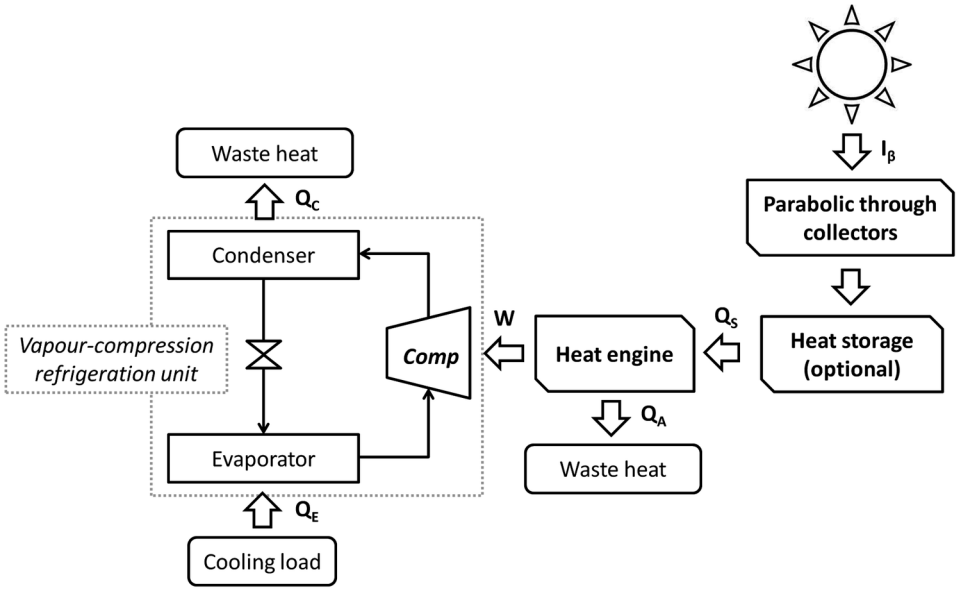


Figure 8. Solar park at the U.S. Foods' facility in La Mirada, California. (© 2011, Neo Solar Power Corporation. Used with permission)



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Figure 9. Solar thermo-mechanical refrigeration system



Rankine and Stirling engines are the main options as far as the heat engine for a solar thermo-mechanical system is concerned. Stirling engines can be used at very high temperatures (e.g. above 750°C). These are therefore preferable when parabolic dish collectors are employed, while Rankine engines are applicable for lower temperatures and can be successfully combined with parabolic trough collectors (Infante Ferreira & Kim, 2014).

Applications of solar thermo-mechanical systems are limited and currently this technology is available only from a small number of large manufacturers (Podesser *et al.*, 2010). Another possibility is to use the heat engine for power generation. Aye *et al.* (2012) investigated the performance of a small-scale system with a solar-driven Organic Rankine cycle (ORC) engine, providing power for a vapour-compression refrigeration system, used for field storing of chilled blueberries at a storage temperature of 4°C. In addition, waste heat of the engine can be utilized for a thermally driven refrigeration system. Combined heat and power generation (CHP) systems using solar energy are discussed further in this chapter.

Wind Turbines

Wind turbines are devices that convert the kinetic energy of wind into electrical power. There are two main types of wind turbines – horizontal-axis wind turbine (HAWT) and vertical-axis wind turbine (VAWT). The Darrieus and Savonius wind turbines are recognizable VAWT types, but in general HAWTs are more common. Different designs are available, but the main components of a typical HAWT include blades, rotor, pitch system that turns the blades and controls rotor speed, low-speed and high speed shafts, gearbox that connects the low-speed shaft of the rotor with the high speed shaft which drives the generator (converting mechanical energy into 50-60 Hz AC current) and control system (including an anemometer, windvane, controller, and brake) which switches the machine *on* or *off* depending on wind speed. Upwind positioned HAWTs also include a yaw drive to keep the rotor facing into the wind

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as the wind direction changes. Sizes and tower heights of wind turbines vary significantly. Some are available with small rotor diameters and capacity of only a few kilowatts, while the largest unit is 125 m tall, with a rotor diameter of 190 m and has a peak capacity of 10 MW. Like solar PV systems, wind turbines can be used as an off-grid energy source for electrically driven refrigeration systems or can be connected to the utility grid.

Wind has been used as an energy source since ancient times primarily for the purposes of grinding grain, pumping water and moving ships, while the use of wind turbines to generate electricity dates back to the late 19th century (Royal Academy of Engineering, 2014). Nowadays their use is growing rapidly and, according to REN21 (2013), global installed capacity of wind turbines reached 283 GW in 2012, up from 24 GW in 2001. Naturally, wind turbines are most beneficial in locations with steady winds, both onshore and offshore. The top markets of wind energy are currently the United States and China, followed by Germany, India and the United Kingdom (REN21, 2013).

Wind turbine prices reached their peak in 2008 and have been falling since then, before stabilizing in 2012, while the O&M costs have dropped significantly (REN21, 2013). A study by Tegen *et al.* (2013) on the economic performance of wind turbines in the United States indicates that as of 2011 the installed cost of onshore wind turbines varies in the range of $1.4-2.9/W and LCOE varies in the range of $60-100/MWh for operational lifetimes of 20-30 years. Both cost metrics have much higher values for offshore turbines (Tegen *et al.*, 2013). Comparison of the above metrics with those of solar PV systems indicates that wind turbines can be less expensive on a levelized basis, while the operational lifetime of both is similar. However wind turbines are usually more efficient for large-scale utility generation systems, while PV systems are more versatile and can be combined in smaller increments to produce varying capacities. The major consideration should be the availability of the energy resource, as wind and solar energy can have very diverging potentials in different locations.

Industrial examples for cold storage facilities featuring on-site wind turbines are already available. A landmark RES project is the Testa Produce's LEED Platinum-certified refrigerated food distribution facility in Chicago, Illinois, which features a 72 m high wind turbine with a capacity of 750 kW, along with PV modules and other sustainability oriented solutions, as visible in Figure 10 (Grover, 2011; Epstein, 2013). The wind turbine has an installed cost of $1.6 million and is capable of meeting up to 40% of the facility's energy demand (Podmolik, 2011). The Walmart distribution center in Red Bluff, California also features a wind turbine (80 m in height, with a rotor diameter of 76 m), which has an installed capacity of 1 MW. The turbine has an estimated production of 200 MWh annually and is capable of meeting 15-20% of the facility's electricity demand ("Walmart unveils", 2012). Furthermore, Walmart Corp. (2014) reports that the company has renewable electricity generation capacities (in operation or under development) amounting to a total of 2,200 GWh per year.

Combined Heat and Power Generation

Combined heat and power (CHP) generation, also known as cogeneration, is the simultaneous production of electricity and useful heat, whereas the heat is a by-product of the electricity generation process, i.e. waste heat, which would otherwise be discharged to the environment, is utilized as an energy source. Any system that simultaneously generates heat and electricity can be classified as a CHP system, but most commonly it involves a heat engine using the combustion of a carbon-based fuel to drive a power generator and the waste heat left is used as a thermal source for heating purposes or a thermally driven cycle. A thermally driven refrigeration system can be integrated with the CHP system to exploit this

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Figure 10. Testa Produce's LEED Platinum-certified refrigerated food distribution facility in Chicago, featuring a 750 kW wind turbine. (© 2013, Epstein. Used with permission)



waste heat as an energy source for refrigeration. Such configurations are often referred to as trigeneration systems. CHP systems have traditionally been used for district heating power plants and more recently for district cooling systems. They have also been used in places without reliable power supply. With the development of smart grids and increasing share of distributed power sources, linked to the utility grids, CHP systems are becoming more common, although they are still not a customary feature.

Various RES configurations can provide the primary energy for a CHP system. Different operable combinations of prime movers (heat engines) and renewables for CHP generation are shown in Table 4.

Biogas-fuelled and solar-driven systems are two of the more promising options for RES-driven trigeneration systems of refrigerated warehouses. Geothermal systems are also an interesting opportunity where Earth heat is plentiful. The power provided by the CHP unit can drive any of the known electrically-driven refrigeration systems, while the residual heat can run a thermally driven refrigeration system, depending on the temperature and amount of heat available.

Solar-Driven CHP Systems

Solar energy can be used as a heat source for CHP systems when conditions are favourable for installing concentrating solar collectors that can provide sufficiently high temperatures for the heat engine (e.g. above 150°C). Stirling or Rankine cycle heat engines are most commonly used for solar-driven CHP systems. Rankine cycle systems using organic working fluids, i.e. organic Rankine cycle (ORC) systems,

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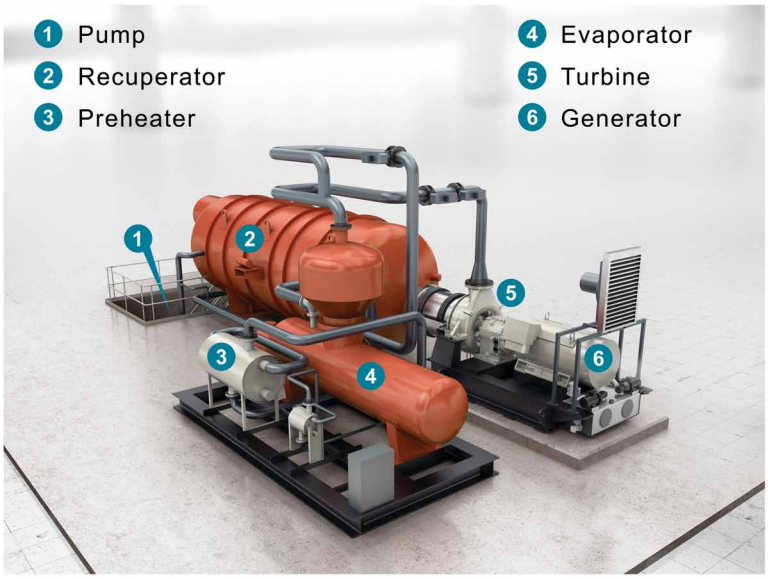
Table 4. Combinations of renewable sources and heat engines for CHP systems, which can be technically and economically feasible. (Adapted from Obersteiner et al., 2008).

Heat Source / Heat Engine	Biogas	Liquid Biofuels	Solid Biomass	Geothermal	Solar Thermal
Gas turbine	✓	✓			
Reciprocating engine	✓	✓			
Steam turbine (Rankine cycle)	✓	✓	✓	✓	✓
Screw-type steam engine	✓	✓	✓	✓	✓
Stirling engine	✓	✓	✓	✓	✓
Organic Rankine cycle engine			✓	✓	✓

are arguably the most promising technology for solar-driven CHP systems, because they operate at lower temperatures, which can be achieved by concentrating solar collectors in smaller-scale systems. Stirling cycle engines typically require parabolic dish concentrating collectors, while ORC systems can also operate with parabolic trough collectors. Linear Fresnel concentrators are also a suitable choice for ORC systems (Quoilin, 2011). Both Sirling cycle and Rankine cycle heat engines, specifically designed for use with solar concentrating collectors, are available. Commercially available ORC systems with various capacities are reported to operate with heat source temperatures in the range of 74-350°C (Arvay, Muller, Ramdeen, & Cunningham, 2011). Figure 11 illustrates a commercially available 1 MW ORC module designed by Siemens (Siemens AG, 2014).

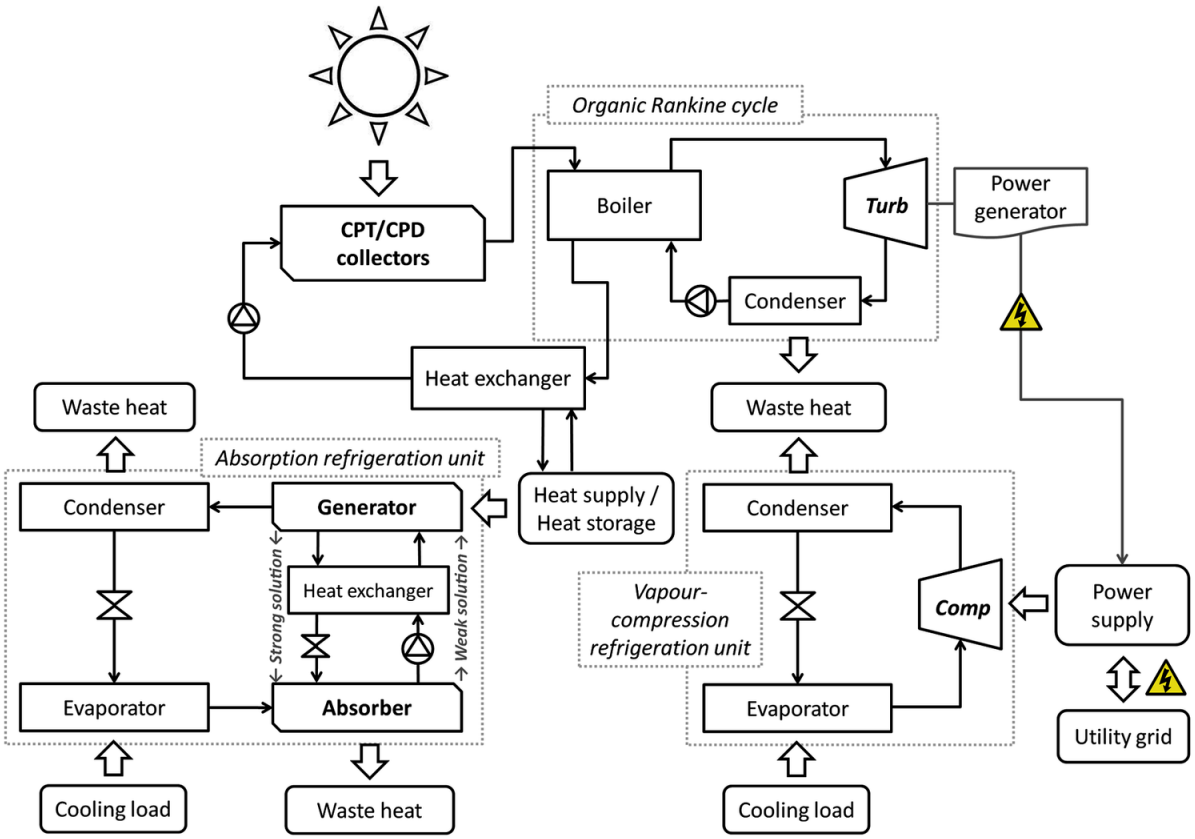
A possible configuration of trigeneration system with a solar-driven ORC engine, providing energy for both vapour-compression and absorption refrigeration units, is depicted in Figure 12.

Figure 11. A Siemens AG ORC module with a power output of up to 1 MW (© 2014, Siemens AG. Used with permission)



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Figure 12. Single-stage absorption and vapour-compression refrigeration systems powered by a solar-driven ORC engine



The electrical, $\eta_{el,CHP}$, and thermal, $\eta_{th,CHP}$, efficiencies of a solar-driven CHP system can be defined as:

$$\eta_{el,CHP} = \frac{P_G}{I_\beta \cdot A_S} = \frac{P_G}{W} \cdot \frac{W}{Q_S} \cdot \frac{Q_S}{Q_{sol}} \cdot \frac{Q_{sol}}{I_\beta \cdot A_s} = \eta_{pg} \cdot \eta_{he} \cdot \eta_{hd} \cdot \eta_{sc} \tag{17}$$

$$\eta_{th,CHP} = \frac{Q_R}{I_\beta \cdot A_S} = \left(1 - \eta_{he}\right) \cdot \eta_t \cdot \eta_{hd} \cdot \eta_{sc} \tag{18}$$

where P_G is the generated power [W], Q_R is the recovered (utilized) residual heat [W], η_{pg} is the efficiency of the power generator, η_{he} is the thermal efficiency (i.e. the ratio of the work output to the heat input) of the heat engine, η_{sc} is the efficiency of the concentrating solar collector and η_t is the fraction of the waste heat utilized. The overall efficiency of the solar-driven CHP system is therefore:

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$$\eta_{CHP} = \frac{P_G + Q_R}{I_\beta \cdot A_S} = \eta_{el,CHP} + \eta_{th,CHP} \tag{19}$$

This overall CHP system efficiency does not account for the individual efficiencies of the refrigeration systems which use the energy. According to Müller-Steinhagen & Trieb (2004), annual electrical efficiencies of solar-driven CHP systems can be expected in the range of 8-25% depending on technology (e.g. 10-15% for systems using parabolic trough collectors). For electrical efficiencies of over 20%, a solar tracking system is required, but this increases cost and decreases reliability, which is particularly undesirable for smaller-scale distributed generation systems (Norwood, 2011). The overall thermal efficiency of a Rankine cycle heat engine, driven by a variety of solar collector configurations, can be expected to reach more than 50% (Norwood, 2011). Thus, the overall efficiency of a solar-driven CHP system can reasonably be expected to exceed 60%, given the global average efficiency of CHP units is 58%, while state-of-the-art CHP systems can achieve overall efficiencies of over 85% (Intergovernmental Panel on Climate Change, 2014).

Indicative figures for the installed cost of a solar-driven ORC CHP system (per peak electrical and thermal capacities) are $\$3.2/W_{el}$ and $\$0.4/W_{th}$ (Norwood, 2011). According to the Intergovernmental Panel on Climate Change (2014), the *LCOE* of concentrated solar power systems is generally in the range of \$100-480/MWh (median of \$150-320/MWh) for plant lifetime of 20 years, but this does not account for the benefit from the recovered heat. Norwood & Kammen (2012) performed life-cycle analysis (LCA) of a solar-driven CHP system for air cooling in Oakland, California (which uses a single solar dish collector and a Rankine cycle) and predicted a levelized cost of \$250/MWh (electricity) and \$30/MWh (heat).

Geothermal CHP Systems

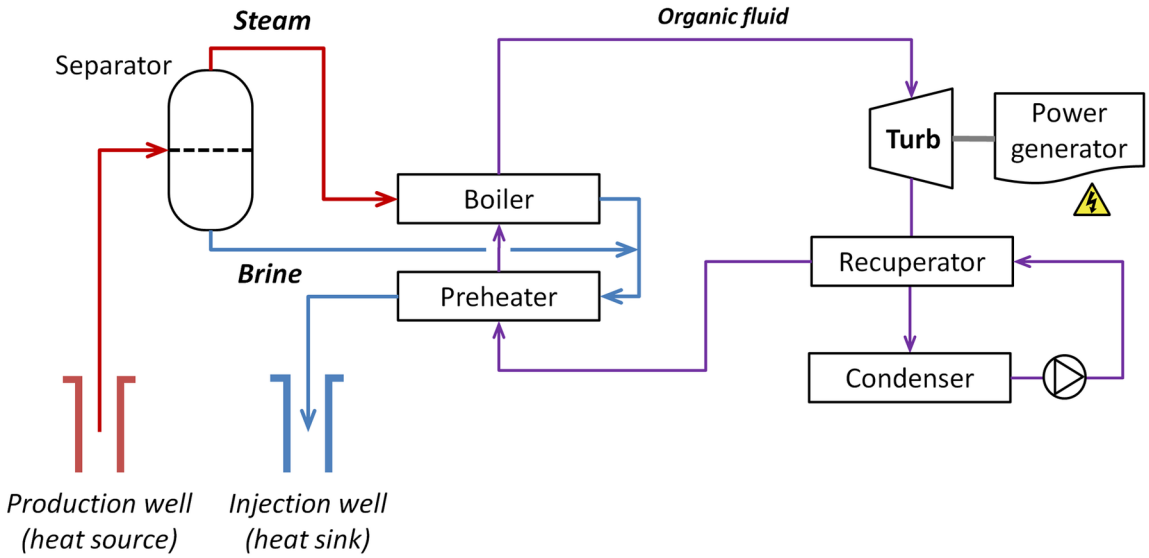
The comparatively lower heat source temperatures, needed to run the organic Rankine cycle engines, makes geothermal energy another viable option for implementing ORC-based CHP systems, wherever Earth heat is readily available. Geothermal sources are typically available with temperatures in the range of 110-180°C (Arvay *et al.*, 2011), but can also reach up to 300°C (Quoilin, 2011). As previously mentioned, this is within the operating range of commercially available ORC engines and geothermal sources with temperatures as low as 74°C can be utilized (although efficiency is low at such low temperatures).

A setback concerning geothermal systems is the high cost of drilling. In order to attain higher source temperatures, a geothermal system would generally require drilling of deep boreholes for the production and injection wells which, according Quoilin (2011), can reach up to 70% of the total investment for a geothermal ORC plant. Typically, a fluid (e.g. brine) is circulated through the production well (heat source) and injection well (heat sink), which in turn requires high pump power consumption. For low-temperature ORC plants this consumption can account for 30-50% and more of the system's electrical output (Quoilin, 2011).

ORC systems designed for geothermal applications have been developed by Ormat Technologies. In most cases, the fluid circulated through the production and injection wells is separated into a stream of steam, fed to the boiler of the ORC engine, and a stream of brine in a dedicated separator (Kaplan, 2007). The condensate is afterwards mixed with the separated brine to provide preheating of the organic fluid fed to the boiler in order to increase the thermodynamic efficiency of the cycle. Figure 13 shows

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Figure 13. Configuration of a geothermally driven ORC engine (Adapted from Kaplan, 2007)



a configuration with an additional heat exchanger (recuperator) which is applicable when the expansion in the turbine is done in the dry superheated zone and the expanded vapour contains heat which has to be extracted prior to condensation (Kaplan, 2007).

Biogas-Fueled CHP Systems

The heat for driving a CHP system can be provided by combustion of biofuels (solid, liquid and gaseous), as shown in Table 4. In fact, most of the installed CHP systems employing ORC engines use biofuels as an energy source (Quoilin, 2011). An important advantage of biofuels over other renewables is reliability, as the resource is generally non-intermittent and energy production is easier to control. One of the most important considerations for efficient utilization of biofuels is the availability of biomass feedstock in close proximity to the CHP plant (U.S. Environmental Protection Agency, 2007).

Residual biomass, as opposed to biomass derived from energy crops, can be derived from various sources, among which wood wastes, crop residues, manure biogas, wastewater treatment biogas, municipal solid waste, food processing residues, etc. (U.S. Environmental Protection Agency, 2007). Combustion of biogas, derived via anaerobic digesters from biodegradable waste or from wastewater treatment facilities, is suitable for CHP systems of cold storage facilities. In particular, this can be beneficial for refrigerated warehouses of (or near) large food processing plants. Common food-processing wastes are fruit pits, cheese whey and meat processing residues, but these can be difficult to utilize as a fuel source because of the varying characteristics and properties of different waste streams. Hence, such wastes are most often disposed of as industrial wastewater and discharged to a local wastewater treatment plant (U.S. Environmental Protection Agency, 2007).

Food and other biodegradable wastes, composed of organic material, are subject to anaerobic decomposition of the organic matter and produce biogas with high methane (CH_4) content of 45-70% (Rasi, 2009). Methane yields of selected feedstock from the food and other industries are reported by Rutz *et*

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al. (2009). Methane, which is the primary ingredient of natural gas, has high heat of combustion and substantial global warming potential (GWP). Thus, its capture and utilization in waste-to-energy systems is stimulated by many countries, some of which have put in place (or are planning to adopt) climate change mitigation policy instruments for that purpose. According to Eriksson (2010), the energy content of biogas can be expected in the range of 4.5-8.5 kWh/Nm^3, while pure methane has an energy content of 9.81 kWh/Nm^3. Through appropriate upgrade processes biogas can be converted to biomethane with methane content of about 90% (Rasi, 2009).

As indicated in Table 4, biofuels can be used as a heat source for various CHP prime movers. In the case of biogas, a gas turbine engine is especially suitable, as biogas can directly be fed to the combustion chamber of the engine. A disadvantage of biogas-driven CHP systems is the high capital and maintenance costs, along with the system complexity due to the need for involvement of appropriate equipment for conversion of biogas and pre-processing of the produced fuel in order to meet engine requirements. More information on biogas conversion is published by Hillen *et al.* (2010), Krich *et al.* (2005), Rutz *et al.* (2012) and the U.S. Environmental Protection Agency (2007).

The high capital and maintenance costs can lead to long payback periods if no government incentives are available. A feasibility study of biogas-fuelled CHP systems for meat processing facilities in Australia indicates a payback period in the range of 9.2-13.4 years. The financial benefits from savings of CO_2 emission permits to reduce the payback period for such systems to 7-9.2 years (McPhail & Rossington, 2010). Table 5 details typical performance parameters of biogas-fuelled CHP systems with different prime movers, while Table 6 shows estimates for the capital and operating costs associated with biomethane production, based on a study of Krich *et al.* (2005) about the production and use of biomethane from dairy waste.

The waste heat of the flue gases, which exit the CHP system at rather high temperatures of 80-550°C (Rutz *et al.*, 2012), can be utilized as heat source for a thermally driven refrigeration system. Suamir & Tassou (2011) evaluated the performance of an integrated system combining biogas-fuelled trigeneration and CO_2 refrigeration, designed to supply supermarkets with heating, cooling and electrical power. The today's technology level of such systems still requires relatively long payback periods. Waste heat of the primary system can also be used for additional power generation through a heat engine operating at lower temperatures (e.g. an ORC engine). Rutz *et al.* (2012) estimated that waste heat from a CHP plant with 1 MW electrical capacity can be used for an ORC engine to generate 7-10% (0.07-0.1 MW) additional power, thereby increasing the efficiency of the system by 45%. The CHP system can directly

Table 5. Prime movers for biogas-fuelled CHP systems (Adapted from U.S. Environmental Protection Agency, 2007)

	Gas Turbine	Microturbine	Reciprocating Engine	Steam Turbine	Stirling Engine	Fuel Cell
Capacity	0.5-40 MW	0.03-0.25 MW	< 5MW	0.05-250 MW	< 0.2 MW	< 1 MW
Field experience	Extensive	Extensive	Extensive	Extensive	Limited	Some
Electric efficiency based on HHV	22-36%	22-30%	22-45%	5-30%	5-45%	30-63%
Installed cost of CHP system ($/W)	$0.7 -2/W	$1.1-2/W	$0.8-1.5/W	$0.35-0.75/W (w/o boiler)	$1-10/W	$3-5/W
O&M costs ($/MWh)	$6-11/ MWh	$8-20/ MWh	$8-25/ MWh	< $4/MWh	~$10/MWh	$10-40/ MWh

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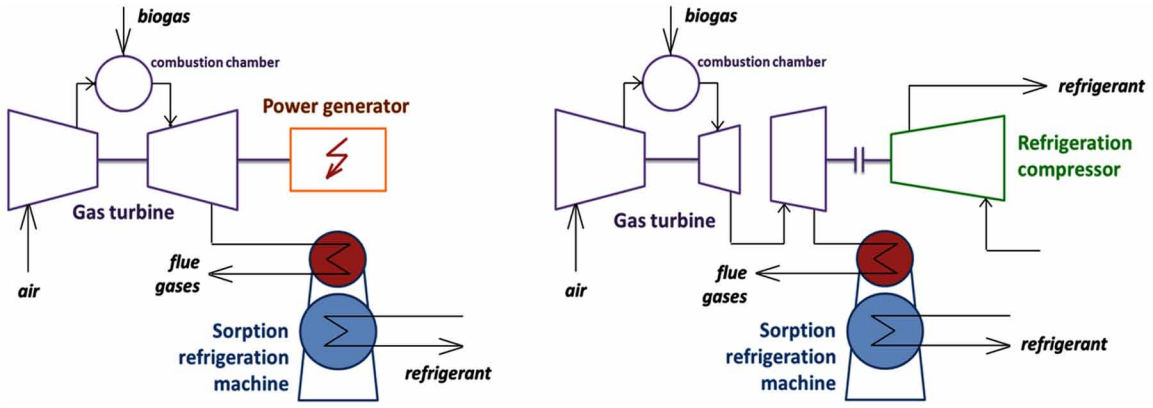
Table 6. Indicative cost ranges for biomethane production equipment (Adapted from Krich et al., 2005)

Equipment	Cost
Anaerobic digester	
Capital cost	\$88-164 per 1000 m^3
Operating cost	\$17-21 per 1000 m^3
Biomethane upgrading plant	
Capital cost	\$55-110 per 1000 m^3
Operating cost	\$130-240 per 1000 m^3
Biomethane storage	\$0-100 per 1000 m^3
Biomethane transport	\$0-32 per 1000 m^3

be used to mechanically drive the compressor of a vapour-compression refrigeration system, while the waste heat could drive a sorption refrigeration system (ASHRAE, 2008). Figure 14 shows simplified schematics of two possible configurations of trigeneration systems driven by a gas turbine.

A number of refrigerated warehouses around the world feature CHP systems fuelled by on-site produced biogas. For instance, the Cannington Cold Stores' Bridgwater site in the United Kingdom features a system with anaerobic digestion tanks and gas holders for on-site biogas production and storage (Figure 15). Biogas is produced from various food wastes originating from the 45,000 m^3 cold store, which provides ambient, chilled and frozen storage down to –25°C ("Cannington Cold Stores", n.d.). The produced biogas is used for heat and power generation via an on-site CHP system. Electricity generated by the CHP system is used to power the cold store and surplus electricity is fed to the utility grid under the Renewable Obligations scheme established in the United Kingdom. Waste heat from the CHP system is fed to the digesters to run the biogas generation process ("Cannington Cold Stores", n.d.). According to Kirk Group (2014), the total digestion volume of the facility is expected to reach 18,000 m^3, while the generating capacity is expected to exceed 3.3 MW. Another example of a biogas production plant, using food wastes in the United Kingdom, is the Premier Foods' RF Brookes ready-meal factory at Rogerstone, Wales. The plant is estimated to generate 1.4 million m^3 of biogas with an energy content

Figure 14. Schematics of two possible configurations of biogas-fuelled trigeneration systems



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Figure 15. Biogas production plant at the Cannington Cold Stores site. (© 2014, Kirk Group. Used with permission).



of about 8.4 MWh, which is fed to a CHP system, thereby displacing 10% of the factory's fossil-fuel consumption ("Serving up food-factory waste", 2011).

INTEGRATION OF RENEWABLES INVOLVING THERMAL ENERGY STORAGE

Integration of solar, wind and other distributed renewable energy sources in the power grid can be challenging, especially for traditional centralized grids with top-down structure. This is caused by the mismatch of supply and demand of energy, as total generation has to match total consumption in the grid at any moment. Grid balancing problems are common for both developed and developing economies worldwide. Peak summer loads because of the high energy demand for air-conditioning have become a typical problem for the U.S. power grid, while in Europe, which possesses a higher share of RES in its power supply system, the problem with the intermittency of renewable sources is even more pronounced.

The development of "smart grids" involves transition from the traditional top-down approach of power supply to a more distributed and flexible electricity supply and distribution system. Within this framework, industrial cold storage facilities can become a more active player within the grid by either selling excessive on-site generated electricity or by improving the power grid balance through smart temperature control, involvement of TES and energy management, thereby providing substantial economic benefits to the cold store operator (Fikiin, 2012a).

Thermal Energy Storage for Cold Accumulation

Embedding TES systems as part of the cold-store refrigeration plants is a quite logical and intuitive measure, employed for years by the cold chain operators to profit from the cheaper electricity tariffs

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at the low-consumption periods. Simultaneously, TES appears to be a powerful tool for increasing the RES share in the cold storage sector by accumulating the excessive renewable energy, generated on-site, unless it is sold to the electricity grid (Fikiin, 2012a, b).

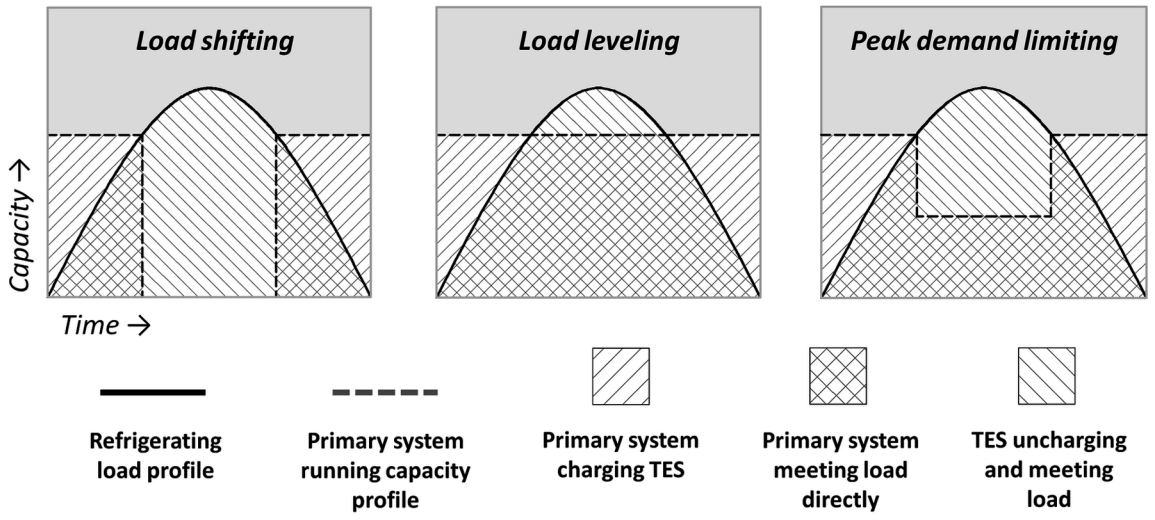
In fact, TES does not reduce (and might even increase) the overall energy consumption, but it distributes the loads during time in a much more efficient way. The main benefits for the store operator can be summarised as follows (Fikiin, 2012b; ASHRAE, 2008):

- Overall energy expenditures of the facility are lower;
- Peak capacity is reduced, which brings down the investment and the equipment size;
- Plant operation and maintenance are optimized, because when the refrigeration plant operates with large load variations, especially at capacities much lower than the designed maximum capacity (i) its efficiency drops substantially, (ii) control becomes more complicated, and (iii) some plant components may experience technical problems to cope with these variations.

Figure 16 gives a simplified example of peak demand reduction strategies when using TES. A TES system typically serves as a thermal buffer between the primary refrigeration circuit and a secondary circuit which supplies cold by pumping secondary refrigerant to air coolers placed in the refrigerated rooms of the store. The TES systems accumulate in tanks or special vessels the superfluous cold produced when running the primary circuit, thereby cooling the secondary refrigerant even when the compressors are switched off. This type of thermal storage is often referred to as "active" storage.

Comprehensive information on TES systems and their various benefits can be found in relevant literature (ASHRAE, 2008; Stoecker, 1998). TES systems can be classified in accordance with: (i) type of thermal storage medium, (ii) whether they store primarily sensible or latent heat, or (iii) the way the storage medium is used (ASHRAE, 2008). Thermal storage media may consist of water, aqueous solutions, pure or multicomponent liquids (e.g. containing glycols and alcohols), ice and phase-change materials (PCM),

Figure 16. Charging and discharging strategies for TES to meet peak refrigeration loads (Adapted from ASHRAE, 1993)



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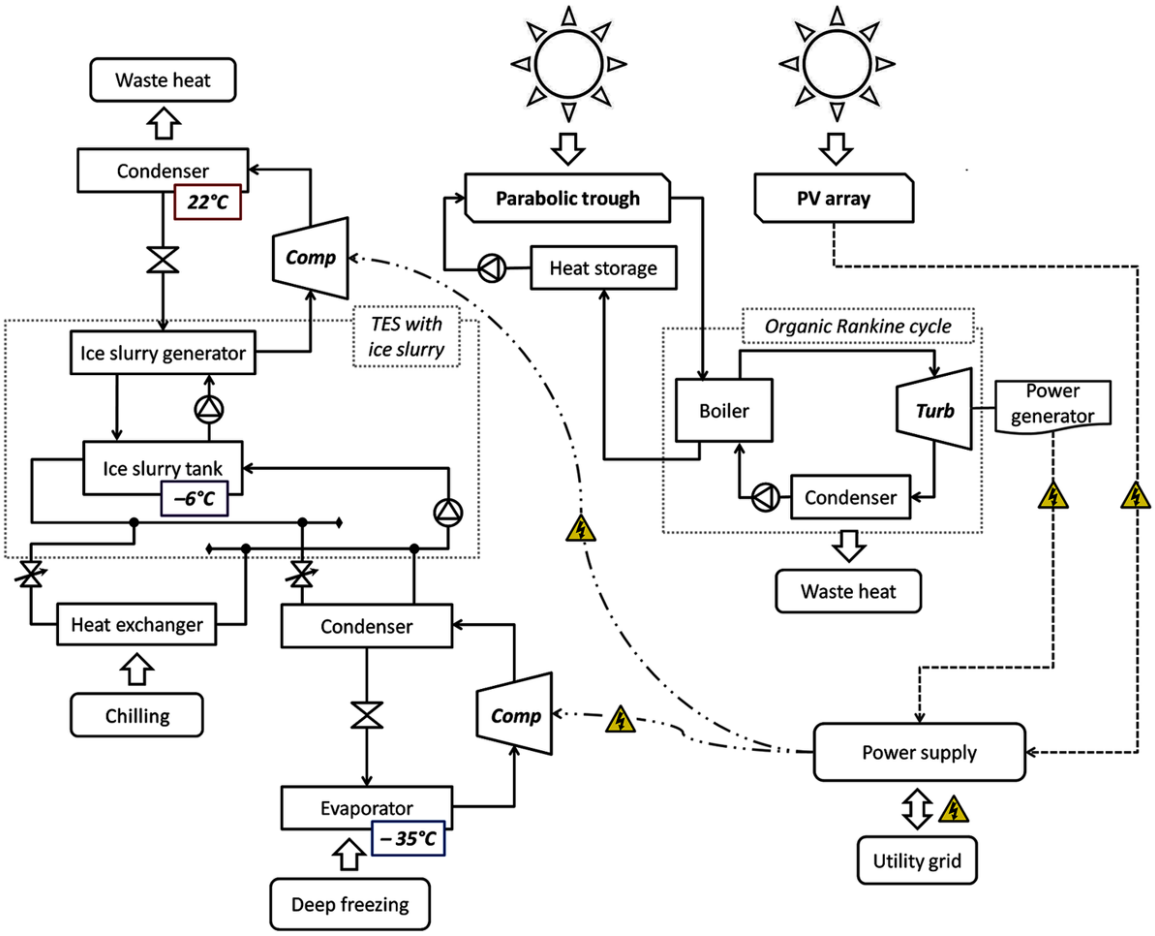
along with microcrystalline ice slurries, PCM slurries, etc. For example, Fikiin, Kaloyanov, Filatova, & Sokolov (2002) analysed a number of refrigeration systems and technologies involving ice-slurry-based TES for different industrial scenarios. Another useful review has been published by Tassou *et al.* (2005).

There are practically unlimited opportunities and numerous engineering solutions for integrating renewable energy in TES systems and cold accumulating facilities of refrigerated warehouses. Figure 17 illustrates a possible arrangement of such a refrigeration plant employing ice-slurry and powered by a solar-driven ORC engine.

Temperature Control for Passive Thermal Energy Storage

Temperature is generally considered as the "single most important factor determining the food quality and safety". This definition means that a lot of other process parameters or storage conditions may more or less influence upon the food product in different industrial situations, but temperature is the

Figure 17. Possible arrangement of a solar powered refrigeration plant using ice slurry (Adapted from Van Bael, 1996; Fikiin et al., 2002)



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only physical value whose importance is always enormous. Hence, proper temperature control is the prime simple receipt for the success of every food processor, store operator and retailer (Fikiin, 2003). The temperature-controlled cold supply chain for refrigerated processing, storage, distribution, retail and household handling of foods is therefore of paramount importance for guaranteeing safety, quality, wholesomeness and extended shelf-life of perishable commodities (Fikiin, 2003; Cleland, 2010).

From the viewpoint of product safety and quality, the "golden rule" is that storage temperature must be maintained as constant as possible. In that context, numerous product-specific data for the practical storage life of different chilled and frozen commodities kept at the well known constant storage temperatures are published in the specialized literature (ASHRAE, 2014; Fikiin, 2003). However, as Table 7 implies, the "golden rules" and strategies for energy savings might often contradict safety and quality related requirements. For instance, the so-called "passive" thermal energy storage involves artificial temperature fluctuations to accumulate cold in the refrigerated products, when excessive and cheap energy is available, and to release this energy at the time of peak loads, when the energy demand is higher (Altwies & Reindl, 1999; Van der Sluis, 2008). Such approaches are very intuitive and proven in real practice for many years. The need for additional investment to build up "active" TES systems is thus avoided.

Recent advancements in information technologies and automatics make it possible to implement sophisticated temperature control strategies for intelligent energy use. Such an intelligent approach could be illustrated by a comparatively simple strategy, called "Night Wind", investigated under EU's FP6 Project No. 020045 "Grid Architecture for Wind Power Production with Energy Storage through Load Shifting in Refrigerated Warehouses" (Van der Sluis, 2008). The "Night Wind" strategy combines the advantages of using a passive TES principle and a way to involve renewable wind energy when meeting the electricity demand of cold stores on a local, regional or Europe-wide level. As discussed further in this section, similar strategies have been applied outside of Europe as well.

Table 7. Electricity saving strategies for refrigerated storage (Estrada-Flores, 2010)

Electricity Saving Strategies	Temperature-Related Heuristics For Quality Preservation
For Frozen Products	
• Peak avoidance techniques • Sub-cooling of the warehouse during weekends • Intelligent matching of load (variable and fixed compressor's capacity) • Adaptive defrost	• Peak avoidance and sub-cooling techniques should maintain product temperatures within –8 and –25°C
For Chilled Products (Dedicated Storage)	
• Peak avoidance techniques (see heuristics) • Intelligent matching of loads	• Sub-cooling to temperatures below 0°C is not recommended for horticultural products (or others susceptible to freezing damage) • Sub-cooling to –2°C can be well tolerated by some dairy products (e.g. milk, butter, cheddar cheese)
For Controlled Atmosphere storage	
• Increasing evaporation temperature above the recommended storage temperature is a possibility (see heuristics)	• Tolerance of commodities to temperatures above the recommended storage temperature needs to be investigated experimentally. No temperature tolerance guidelines have been fully established for controlled atmosphere storage

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The "Night Wind" Concept

Distributed renewable energy resources (such as wind and solar energy) have a substantial potential for energy supplies and reducing CO_2 emissions but have been difficult to integrate so far because of their intermittent contribution. The integration of wind power into the nationwide and transnational energy supply systems becomes more complicated with increasing the production capacity of installed wind turbines, because of the mismatch of supply and demand of energy. The wind energy is generated at random times, whereas the energy use pattern shows distinct demand peaks during day time and office hours, and low consumption during the night. Refrigerated warehouses are constant power consumers (day and night), where electricity is converted by the refrigeration plant into thermal energy. The use of a refrigerated warehouse for storing renewable wind energy affords economic benefits resulting from the cost difference between low and peak-hour electricity tariffs and permits to offset undesirable demand peaks in the electrical grid (Van der Sluis, 2008; Fikiin, 2011; Fikiin, van der Sluis, Paraskova, Iserliyska, & Tsokov, 2009, 2010). Energy is stored by producing more cold than necessary (thereby refrigerating the products below the prescribed temperatures), while turning off the refrigeration plant releases virtual energy matching the difference between the average and the zero cold store demands, thus letting foods warm up back to the recommended temperatures of storage. For example, if the temperature of stored frozen products throughout the European Union is permitted to vary by 1 °C only, all refrigerated warehouses can act as a giant battery on the grid – they could store twice the EU's wind power production, as estimated for 2010 by Van der Sluis (2008). Refrigerated foods themselves are thereby used for passive TES as accumulators of cold (Fikiin *et al.*, 2009; Fikiin, 2012c). In particular, frozen foods are thus employed as a phase-change material (Fikiin, 2011, 2014). While balancing wind power production by fossil fuel power generation is inefficient, such balancing by refrigerated warehouse load management is a sustainable (environmentally friendly and cost effective) alternative with reduced running costs for the cold chain operators (Van der Sluis, 2008; Butler, 2007; Fikiin, 2011).

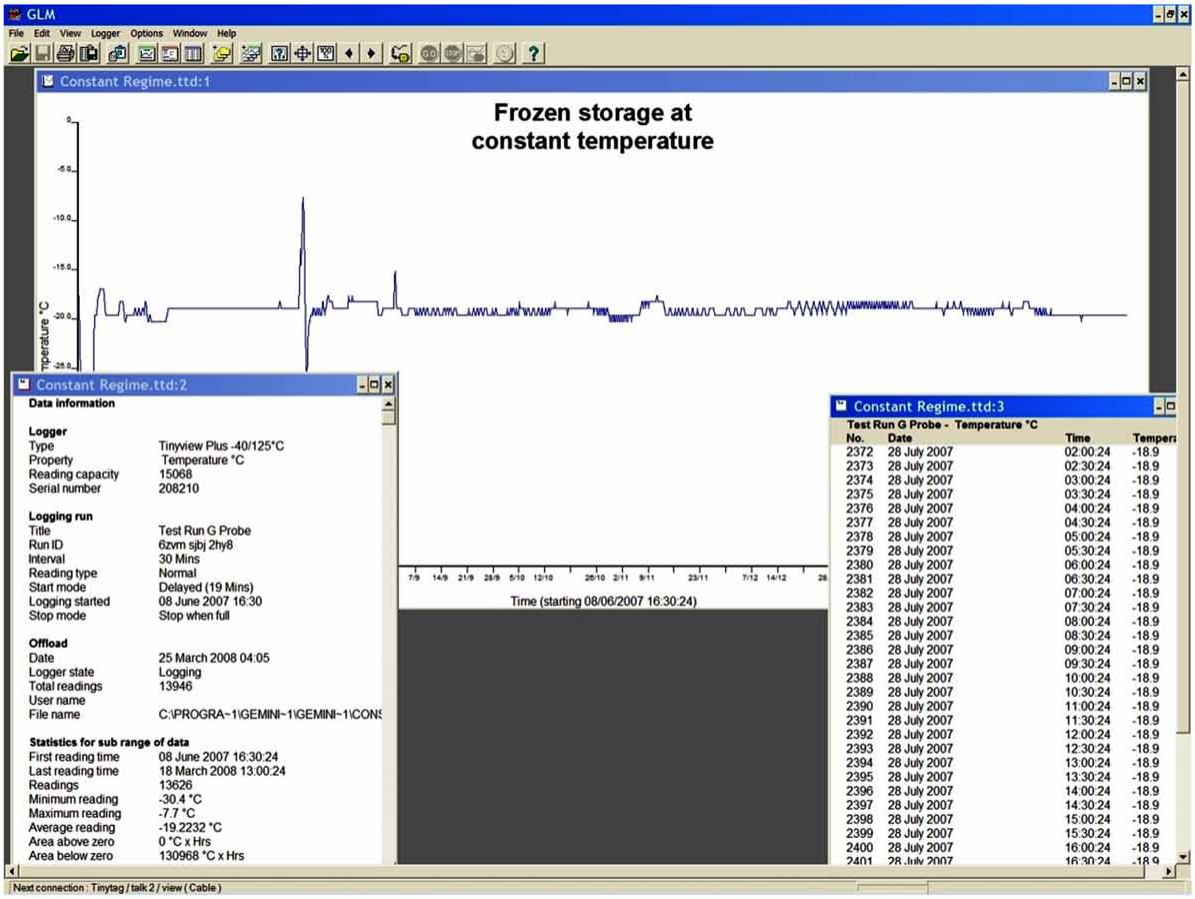
Quality Attributes of Frozen Foods Undergoing Temperature Fluctuations (Freeze-Thaw Cycles)

Special attention is to be paid to the refrigerated food quality as affected by the "Night Wind" technology. For that purpose, quality attributes of selected frozen foods undergoing temperature fluctuations (freeze-thaw cycles) have been investigated. Parallel tests have been conducted with 10 different food samples of identical type, shape and size, stored during 8 months at constant and variable temperature regimes (Fikiin, 2011; Fikiin *et al*., 2009, 2010). The samples – meat (bacon), fish (smoked Mackerel fillet), bakeries (fruit pie), fruit (strawberries), vegetables (tomatoes, melons and peppers), potatoes (blanched/semi-grilled French fries) and ice cream have been wrapped in plastic bags and boxes, evacuated and frozen at a constant air temperature of –19 °C as well as at a variable temperature (with day-night cycles) ranging from –16/–18 °C down to –26/–28 °C, as shown in Figure 18 and Figure 19 (Fikiin, 2011; Fikiin *et al.*, 2009, 2010).

After 3 days, and 2, 4, 6 and 8 months of frozen storage, the samples have been thawed in air ambience up to a temperature in the product centre of 20-22 °C. Thus, a number of quality attributes have periodically been evaluated – texture (by penetrometric measurements), colour (by the method of Gardner) and drip losses. Sensory evaluation has also been carried out (with the aid of a taste panel) to estimate the

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Figure 18. Frozen storage at constant temperature (classical)



product appearance, colour, flavour and consistency. Data obtained have been summarized in the form of tables, graphs and predictive equations (Fikiin, 2011; Fikiin *et al.*, 2009, 2010).

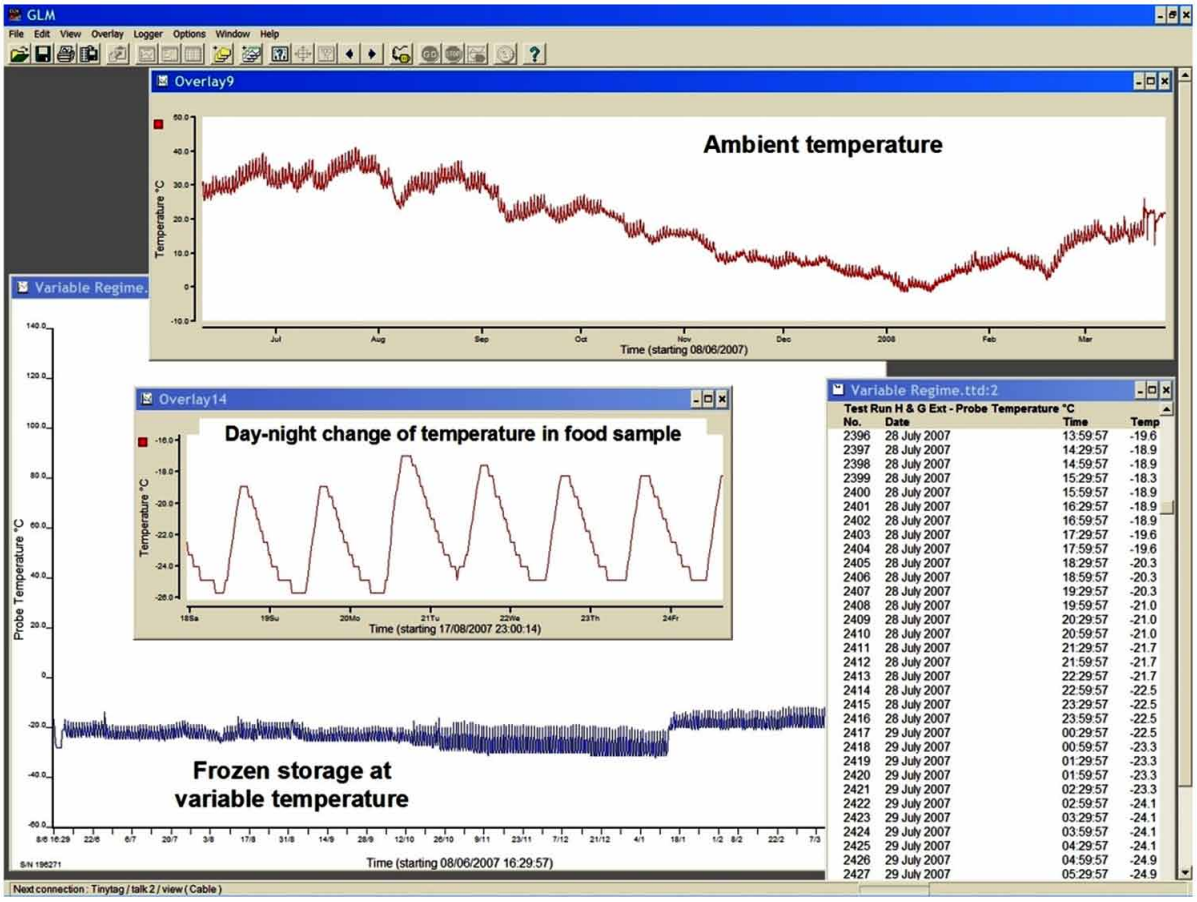
This study revealed that the quality of frozen products, subject to fluctuations of storage temperature, is generally acceptable but, as expected, inferior in comparison with food maintained at a constant temperature (in compliance with the established food refrigeration standards and good practices). However, for many products this quality decay is rather negligible and can be offset by the obvious economic and sustainability-related advantages of the "Night Wind" technology (Fikiin, 2011; Fikiin *et al.*, 2009, 2010). In that context, potatoes (French fries) appeared to be the most robust "Night Wind friendly" product (Fikiin, 2011; Fikiin *et al.*, 2009, 2010).

Decision Support and Automated Control

The "Night Wind" concept needs optimal strategies for fine control of the cold store operation, based on economic criteria, e.g. balance between the instantaneous wind energy production and actual electricity demand, predicted dynamic/stochastic variations of electricity tariffs on the stock market, etc., along with engineering and food quality requirements. For that purpose, a control system (Figure 20) has been

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Figure 19. Frozen storage at variable temperature (Night Wind)



created to manage in real time wind power integration, depending on the store's refrigeration demand, the intermittent availability of wind energy, the variations of electricity prices as per a stepwise subscription plan or in a stochastic manner on the stock market, and other factors (Van der Sluis, 2008; Fikiin, 2011).

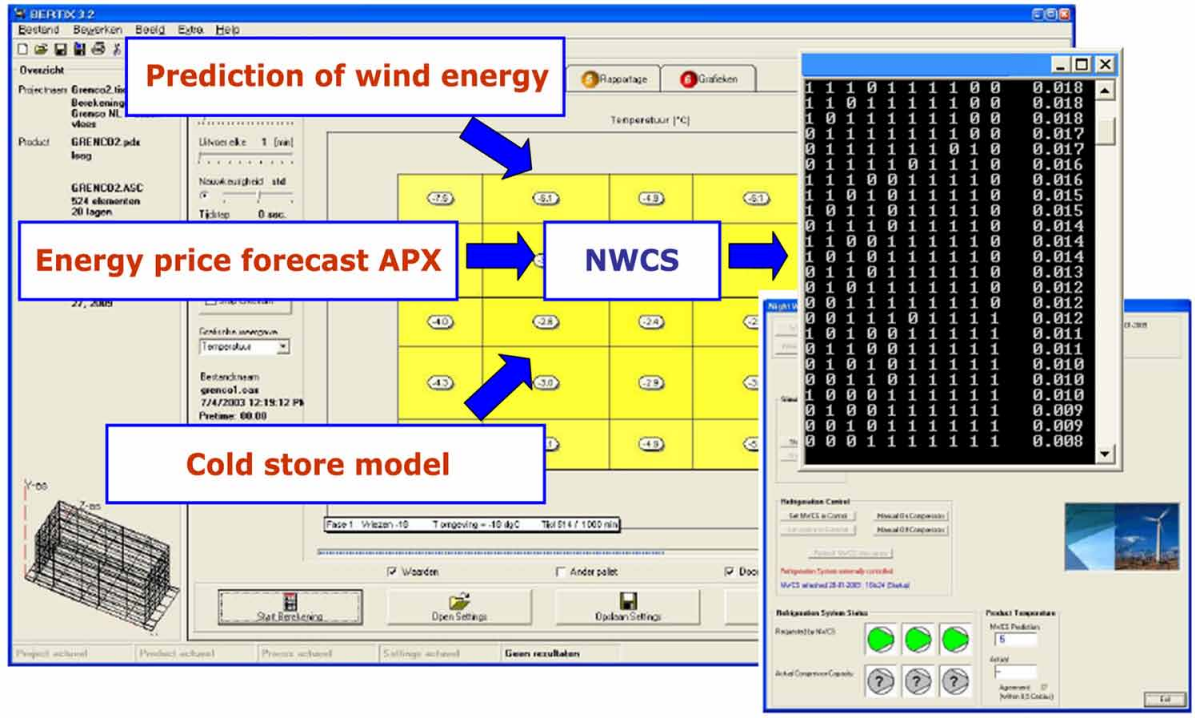
The control system can serve: (i) as a decision-support information system to assist the cold chain operator when taking decisions on the most profitable pattern of energy use, or (ii) as an expert system embedded in the hardware and software for fully automated control of the store.

Economic Benefit and Precautions

The "Night Wind" temperature control strategy has been demonstrated at the store of Partner Logistics BV at Bergen op Zoom, the Netherlands – one of the largest frozen food stores in Europe (for 680,000 pallets). This refrigerated warehouse stores basically French fries, whose quality remains almost the same after daily temperature fluctuations and freeze-thaw cycles. Van der Sluis (2008) reported a very substantial real profit from implementing the "Night Wind" technology at this facility. Other pilot projects following the concept behind "Night wind" have also been started. Curry (2010) reports application in a 155,742 m^3 refrigerated warehouse in Cuxhaven, Germany used to store frozen fish at –20°C.

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Figure 20. The "Night Wind" control system (Adapted from Van der Sluis, 2008)



Another example is the SnoTemp Cold Storage facility in Albany, Oregon used for storing blueberries (Scruggs, 2013). The EU-funded "e-harbours" project has also examined this strategy for cold stores in the Antwerp and Hamburg harbours. An interactive simulation which visualizes the concept is available online at: http://eharbours.eu/simulation/.

Implementing the "Night Wind" technology for passive TES should be made with extremely high attention, care, due diligence and compliance with the established food standards and regulations. Small inaccuracies might badly damage the stored produce. The best approach is to seek professional advice of competent food technologists, food refrigeration experts or to approach directly the "Night Wind" coordinator (http://www.nightwind.eu). Many delicate products are not at all suitable to endure temperature fluctuations, so that a careful and detailed in-situ examination of each specific product is needed before any dangerous industrial exercises with large quantities of expensive produce.

POLICY INSTRUMENTS IN SUPPORT OF RENEWABLE ENERGY INTEGRATION

Policy instruments are a type of leverage that governments and other public authorities often utilize to improve the competitiveness of renewable energy developments, as the latter are often capital intensive and require some form of support in order to become economically efficient. Cold store operators can benefit from such policy instruments when integrating renewable energy sources in their energy supply. The most common policies in support of renewable energy developments are described below, including examples of implementation of such policies in some countries. REN21 (2013) reports that, as of early

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2013, policy instruments in support of renewable energy are in place in 127 countries worldwide. A summary of different types of policies enacted by some of the countries is given in Table 8 (where the acronyms in the headers denote different policy instruments described further in this section).

Detailed up-to-date information on active policies in different countries can be found online at: http://www.res-legal.eu/ (for the EU), http://www.dsireusa.org/ (for the USA), and http://www.iea.org/policiesandmeasures/renewableenergy/ (worldwide).

Regulatory Policies

Feed-In Tariffs

Feed-in tariff (FIT) schemes provide renewable energy producers with long-term agreements, usually with duration of 10-25 years, which typically involve guaranteed access to the power grid and oblige electric utilities to purchase electricity, generated by eligible renewable sources, at specified prices for every kilowatt-hour (kWh). The price can depend on type of technology, project location and size, among others, but can also be bound to decline over time, in track with expected reductions in the cost of renewable energy technologies. Feed-in tariff schemes may also be linked to streamlined administrative procedures, which reduce bureaucratic overhead, minimize project costs and accelerate the pace of project development (Couture, Cory, Kreycik, & Williams, 2010). FITs can be designed with a fixed tariff level or as a premium over the prevailing market price of electricity.

Table 8. Renewable energy support policies adopted by various countries – nationwide (●); at a state or provincial level (○) (Adapted from REN21, 2013)

Country	FIT	NM	RPS	REC	FI	PT	Country	FIT	NM	RPS	REC	FI	PT
Australia	○			●	●		Japan	●	●	●	●	●	
Brazil		●			●	●	Jordan	●	●			●	●
Bulgaria	●				●		Kazakhstan	●			●		
Canada	○	○	○		●	●	Kenya	●				●	
China	●		●		●	●	Mexico		●			●	●
Denmark	●	●		●	●	●	Nepal					●	●
Egypt		●			●	●	Netherlands	●	●		●	●	
Finland	●			●	●		Philippines	●	●	●		●	●
France	●			●	●	●	Russia					●	
Germany	●				●		South Korea		●	●	●	●	
Greece	●				●		South Africa					●	●
India	●	●	●	●	●	●	Spain	●	●			●	
Indonesia	●		●		●	●	Sweden			●	●	●	
Israel	●		●		●	●	United Kingdom	●		●	●	●	
Italy	●	●	●	●	●	●	United States	○	○	○	○	●	●

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The feed-in tariff is the most widely adopted policy instrument for supporting renewable energy developments and, according to Couture *et al.* (2010), has promoted approximately 75% of global PV and 45% of global wind deployment. Historically feed-in tariffs are considered a German model and have been the driving force behind the sustained development of renewable energy projects in the European Union, where this mechanism has been applied for about two decades, but has more recently spread to other regions, including North America, Australia and Southeast Asia.

In Germany feed-in tariffs apply to various technologies, e.g. €48.7/MWh for onshore wind developments, €110.2-159.2/MWh for solar systems, €250/MWh for geothermal systems and €60-143/MWh for biomethane, with various degressions of tariffs and additional premiums applicable (KPMG International, 2013). In France feed-in tariffs for onshore wind developments amount to €82/MWh for the first 10 years and the same or a reduced rate for the next 5 years, while tariffs for solar PV systems vary in the range of €172.7-315.9/MWh, depending on the type and size of the power plant, €200/MWh for geothermal systems and €81.2-133.7/MWh for biogas (KPMG International, 2013). Feed-in tariff policies in the United States vary according to state. According to the U.S. Energy Information Administration (2013), state-level programs are established in California, Hawaii, Maine, Oregon, Rhode Island, Vermont and Washington, while various programs have been established independently by different utilities in some of the states, including Florida, Georgia, Indiana, Kentucky, Mississippi, New York, North Carolina, Texas, Virginia and others.

Net Metering

Net metering (NM) is a service to power consumers that are also power producers, under which electricity generated on-site and fed to the utility grid is used to offset electricity provided to the consumer by the utility during the applicable billing period. This is similar to the feed-in tariff mechanism, but the significant difference is that in a net metering program electricity fed to the utility grid is compensated at the regular retail rate at which the utility sells power to the consumer, i.e. the equivalent of subtracting the amount of electricity (kWh) generated on-site and fed to the grid from the amount (kWh) consumed from the grid and paying the remaining electricity to the utility at normal retail prices. The feed-in tariff scheme may therefore be more beneficial to a RES producer.

Renewable Portfolio Standards and Renewable Energy Certificates

Quota obligations, also referred to as renewable portfolio standards (RPS), require or encourage electricity producers within a given jurisdiction to supply a certain minimum share of their electricity from designated renewable resources (U.S. Energy Information Administration, 2012). This regulatory mechanism is typically imposed on electric utilities or producers, with a certain penalty being imposed in case of failure to comply. To facilitate compliance, often RPS schemes are accompanied by a renewable energy certificates (RECs) program.

RECs are tradable credits (usually in the form of electronic records) which represent the value of electricity produced from renewable sources not connected to the grid of the respective utility (Van der Linden *et al.*, 2005). Such programs permit electric utilities or producers, unable to meet their RPS obligations, to buy RECs from other suppliers, even when there is no physical connection (i.e. power grid) between the respective entities. Because the possession of RECs can serve for compliance and

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avoidance of penalties, RECs attain monetary value and can be traded like other commodities, i.e. they can be purchased directly from the renewable energy producer or from intermediaries (Van der Linden *et al.*, 2005). The RPS and RECs systems are also related to the feed-in tariff system and these are sometimes used in combination.

REN21 (2013) reports that renewable portfolio standards are enacted at the national level in 22 countries, as well as in 54 states or provinces in the United States, Canada, and India. An RPS system, known as Renewable Obligations scheme, is established in the United Kingdom, whereby renewable power producers receive tradable renewable obligation certificates, i.e. RECs, the amount of which depends on technological maturity and *LCOE*. There is a penalty for non-compliance to the RPS scheme which amounted to £42.02/MWh as of 2013-2014 (KPMG International, 2013). In China a 15% renewable quota is imposed on utilities, while Norway and Sweden have established a common green certificate (i.e. RECs) market (REN21, 2013). According to the U.S. Energy Information Administration (2012), most of the states in the USA have renewable portfolio standards, among them California which requires electric utilities to derive 33% of their retail sales from eligible renewable energy resources by 2020, with an interim target of 25% by the end of 2016.

Fiscal Incentives

Governments often provide financial incentives, in the form of subsidies, grants, rebates and loans, in order to reduce or offset the installed cost incurred by the investor in a renewable energy project. Grant programs usually provide, on a competitive basis, one-time lump-sum payments that are not repayable and are often based on a percentage of the total investment costs. Rebates provide a refund or discount off the initial cost of the project, often based on the installed capacity of a system, e.g. $/kW, and are generally acquired through an application process (Lantz & Dorris, 2009). Another support mechanism is soft loans, involving below-market interest rates among other benefits, provided to RES developers. Most countries use at least some of the aforementioned mechanisms to promote renewable energy developments. For instance, in the United States various grant and loan programs are applied at the federal level, while many of the states have their own rebate program.

Tax incentives in the form of tax deductions or tax credits are another popular mechanism. Tax incentives can be based on the amount of investment or production and may include: exemption of investments in renewable energy projects from income or corporate taxes, exemption of RES from energy taxes, tax refunds or lower VAT rates for renewable electricity and other stimuli (Van der Linden *et al.*, 2005). Tax incentives are similar to rebate programs, but the main difference is that they only reduce tax liability and therefore have a less direct impact. Tax incentives are a widespread policy adopted by many governments. For instance, a number of tax incentives related to renewable energy are available in China, including reductions in corporate income taxes and VAT (KPMG International, 2013). In the USA investment and production tax credits are enacted at the federal level. According to the North Carolina State University (2014), as of 2013 renewable electricity production tax credits vary in the range of $11-23/MWh, depending on the renewable source and generally apply to the first ten years of operation, while investment tax credits amount to 30% of the investment costs for solar, fuel cell and small wind installations and 10% for geothermal, microturbine and CHP installations, with limitations on maximum amount and system size.

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Another less common incentive mechanism is green marketing whereby individual power consumers voluntarily pay a premium on the electricity bill to promote renewable electricity, which is subsequently at least to some degree paid to the RES producer. The scope and effect of this policy has been until now much more limited.

Public Competitive Bidding

Public competitive bidding, also referred to as public tendering (PT) or pubic auction, is a procurement mechanism whereby public authorities solicit bids for a given amount of renewable energy supply or capacity and the contract is awarded to the most competitive bid, but typically at prices above standard market levels (REN21, 2013). Electric utilities are hence often obliged to purchase the electricity at the price proposed by the winning bids and are sometimes supported by a government fund (Van der Linden *et al.*, 2005). Separate auctions can be carried out for different RES technologies. This mechanism has been used in some countries, including the United States, United Kingdom, Ireland, France and China (Van der Linden *et al.*, 2005).

POLICY CONTEXT AND POTENTIAL FOR FUTURE RESEARCH

As stated by the UN Secretary-General "New and renewable sources of energy stand at the centre of global efforts to induce a paradigm shift towards green economies, poverty eradication and ultimately sustainable development" (Food and Agriculture Organization of the United Nations, 2011). Renewable energy can be used throughout the food sector either directly to generate energy on-site or indirectly by integrating this energy into the existing conventional energy supply system. Renewable energy sources tend to be widely dispersed throughout agricultural areas. Reliable and affordable energy supply is an essential component for sustainable development (Food and Agriculture Organization of the United Nations, 2011, 2012; United Nations, 2013; European Strategic Energy Technology Plan, 2010).

Wherever good renewable energy resources are available, farmers, fishermen, food processing and preservation businesses have various opportunities to install equipment for generating wind power, solar power, micro-hydropower, etc. In the future, it may also be possible to obtain electricity from sea and ocean resources. Solar thermal, biomass and geothermal resources generated from decentralized facilities can serve for both heating and cooling. The IPCC report *"Renewable Energy and Climate Change Mitigation"* (Intergovernmental Panel on Climate Change, 2011) assesses in more detail each of these technologies and analyses their integration into existing and future energy supply systems. Issues concerning sustainable development, costs and potential revenues and supporting policies are also considered in this report (Intergovernmental Panel on Climate Change, 2011; Food and Agriculture Organization of the United Nations, 2011).

The worldwide market for industrial refrigerated storage of food, beverages and pharmaceuticals is large and constantly growing. Conventional refrigeration plants deliver temperatures in the range of –50°C to 20°C, while the refrigeration capacity of most plants commonly varies in the range of hundreds of kWs to dozens of MWs. Large electrically-driven vapour-compression refrigeration machines supply cold to a distribution network and operate with a *COP* ranging, most often, from 3 to 6 as a function of the required refrigerating temperature and other working conditions. Large cooling towers are usually employed to dissipate condenser heat to the environment. Industrial installations, using heat from

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waste processes and RES to operate thermally-driven refrigeration equipment, become competitive with the vapour-compression systems in areas where the electricity supply is unstable. For example, solar thermally-driven refrigeration systems might employ roof- or ground-mounted, low- and medium-temperature solar collectors but very few industrial systems have been implemented and studied so far. The rising price of electricity increases the interest in solar refrigeration whose capital cost is still relatively high and prevents a wider market uptake. Further research on equipment simplification, unification and cheapening is thus critically important (European Solar Thermal Technology Platform, 2008; European Technology Platform on Renewable Heating and Cooling, 2014).

Developing of knowledge-based energy and resource management systems for improved efficiency through sharing resources (e.g. plants, conventional and RES energy, water, residues and recycled materials) and integrating multiple production units of a single company or multiple companies on a single industrial production site also represents a rather challenging research trend of multidisciplinary and cross-sectional nature (Sustainable Process Industry through Resource and Energy Efficiency, 2013). Making the cold storage sector a key player in this cross-sectorial interaction and elaborating adequate expert systems for smart automated control of refrigerated warehouses in accordance with such criteria can thus revolutionise the sector, thereby contributing to building a resource-efficient and highly sustainable economy of the future.

CONCLUSION

The opportunity for RES integration in the energy supply of cold storage facilities has often been overlooked so far, because of credible concerns over technical and economic performance, but also due to the lack of sufficient knowledge on the various engineering solutions to the problem. Although extensive information on RES applications and research for heating and power generation is available and easily accessible, studies concerning refrigeration systems are still scarce, while relevant information is fragmentary and dispersed. In order to bridge this gap, the present chapter provides a broad, albeit not entirely exhaustive, review of recent developments and ongoing research on state-of-the-art technologies for RES utilization in industrial refrigeration plants, with a particular focus on refrigerated warehouses for storage of perishable food commodities.

Presently, the RES use for on-site power generation, especially through solar PV systems, appears to have gained more ground than RES-powered thermally driven refrigeration systems, as far as large refrigerated warehouses are concerned. There is significant progress in the application of roof-mounted PV systems, due to their easy implantation and substantial government incentives. Whilst on-site wind turbines and wind parks are still rare, in a smart grid context, the proposed "Night Wind" strategy can substantially benefit both cold store operators and electric utilities.

Solar, geothermal and biogas-driven CHP and trigeneration systems are still uncommon, but recent developments and research show promising trends. Solar-driven Stirling engines are actively investigated and developed by several companies, while development of the organic Rankine cycle technology affords encouraging prospects for low-temperature solar and geothermal applications. CHP and trigeneration systems driven by biogas present a valuable opportunity for food-processing factories which generate large amounts of food wastes. Thermally driven refrigeration systems need further improvements in order to become technically feasible and competitive for large refrigerated facilities, but the number of pilot and research projects is growing. In general, further research is required to make RES-powered systems

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(which are currently viable for small-scale air-conditioning and cooling applications) competitive for larger refrigeration capacities as well. In the medium term, building up of experience and increased number of market actors should significantly enhance the technical and economic performance of the aforementioned technologies.

RES-related projects are often hardly plausible to cold store operators, because of the difficulties associated with technical implementation and high initial investments. In addition, such projects need a pro-active and/or interactive approach towards the energy supply system, require increased organizational efforts and thus demand greater resulting involvement of the cold store operator. Hence, it might appear to be more comfortable for the operator just to count on its traditional role of passive electricity consumer from the utility grid, especially in the short term. Nevertheless, RES integration is a paramount trend for sustainable growth of the cold storage sector around the globe. The RES attractiveness constantly increases because of the escalating costs of conventional energy resources. While the capital costs for initial investment in RES technologies are comparatively high, the renewable resources are practically free in most cases, i.e. the running costs are marginal. The selection of the most appropriate RES technology for a particular industrial scenario should be based on (i) a thorough evaluation of resource potential of the concrete site, (ii) dynamic modelling and simulation, along with a comprehensive life cycle analysis of the concerned RES system, and (iii) a survey of local government policies and incentives. Furthermore, knowledge-based optimisation and accurate energy management are indispensable to ensure that the RES system is operated in the most efficient manner.

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KEY TERMS AND DEFINITIONS

Cold Accumulation: Preliminary cooling or freezing of a thermal energy storage medium with the aim of shifting refrigeration loads and permitting more efficient operation of the refrigeration system and/or more beneficial energy consumption patterns.

Cold Storage: Storage of perishable commodities (e.g. food, pharmaceuticals and biomaterials) in a refrigerated environment, thereby preserving their natural qualities for extended periods of time.

Cold Store (Refrigerated Warehouse): Industrial facility for refrigerated storage of foods or other biomaterials in chilled or frozen state.

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Distributed Generation: Decentralized generation of electricity, involving small-scale power generation systems located at the site of consumption, often allowing the consumer to act as a producer of electricity within the power supply system.

Passive Thermal Energy Storage: Strategy for shifting the energy demand of a refrigeration system by allowing temperature fluctuations in the refrigerated warehouse thereby accumulating cold in the stored products and/or the cold store construction.

Policy Instrument: Leverage mechanism used by public authorities to stimulate certain developments (e.g. investments in renewable energy projects) in order to overcome existing barriers and achieve predefined objectives, such as increased share of renewable energy in the energy supply mix.

Renewable Source: Energy resource which is non-depletable in a reasonable time frame, because it can be replenished in a relatively short period through naturally recurring processes.

Smart Grid: Electrical grid with advanced infrastructure, incorporating sophisticated information technology and control mechanisms, to balance the generation, distribution and consumption of electricity in the most sustainable, efficient, reliable and economic manner.

Sustainable Development: Societal development which provides the mankind with the capability of maintaining acceptable living standards without causing severe harm to the native environment and irreversible exhaustion of the natural resources available to the present and future generations.

Trigeneration: Simultaneous production of electricity, heating and refrigerating output, where residual heat of a cogeneration (CHP) plant is used to run a thermally driven refrigeration system.

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APPENDIX

Table 9. Nomenclature

a_1, a_2	Temperature dependent heat loss coefficients of the solar collector
A_s	Surface area of the solar collector [m^2]
CRF	Capital recovery factor
E_R	Capacity of the renewable energy source [W]
E_S	Input capacity required by / supplied to the refrigeration unit [W]
FC	Fuel costs per unit of energy input
FLH	Number of annual equivalent full-load hours
I	Total investment costs, including initial costs, construction costs and decommissioning costs
I_β	Solar irradiance [$W.m^{-2}$]
L_T	Project duration / operational lifetime of the system [years]
OM	Net annual operation and maintenance costs
P_G	Generated electrical power [W]
P_P	Power capacity of circulation pumps [W]
P_S	Required input power capacity [W]
Q_A	Waste heat rejected to the heat sink / ambience [W]
Q_C	Waste heat of the refrigeration cycle rejected at the condenser [W]
Q_E	Refrigerating capacity [W]
Q_R	Utilized residual heat of the CHP system [W]
Q_S	Supplied input heat capacity [W]
Q_{sol}	Heat supplied to the heated substance by solar collectors [W]
r	Weighted average cost of capital
T_A	Ambient air temperature / heat sink temperature [K]
T_L	Temperature of the refrigerated space [K]
T_{Ref}	Reference temperature at which the reference efficiency ηPV,R is evaluated [K]
U_L	Overall heat loss coefficient of the PV cell [$W.m^{-2}.K^{-1}$]
W	Mechanical work output of the heat engine [W]
α_r	Anticipated fraction of the Carnot efficiency that a refrigeration cycle is expected to achieve
β	Temperature coefficient of the PV cell [K^{-1}]
η_0	Zero-loss efficiency of the solar collector
$\eta_{C,rc}$	Carnot efficiency of the refrigeration cycle
η_{CHP}	Overall efficiency of the CHP system
$\eta_{el,CHP}$	Electrical efficiency of the CHP system
η_{es}	Energy conversion efficiency of the energy supply system
η_{hd}	Efficiency of the heat distribution system
η_{he}	Thermal efficiency of the heat engine

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Table 9. Continued

η_{pg}	Efficiency of the power generator
η_{PV}	Efficiency of the PV module
$\eta_{PV,R}$	Reference efficiency of the PV module
η_{sc}	Efficiency of the solar collector
$\eta_{th,CHP}$	Thermal efficiency of the CHP system
$\tau\alpha$	Product of glass transmissivity and cell absorptance

Table 10. Acronyms

CHP	Combined Heat and Power
COP	Coefficient of Performance
CSP	Concentrated Solar Power
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
EMS	Energy Management System
FI	Fiscal Incentive
FIT	Feed-In Tariff
GAX	Generator-Absorber-Heat Exchanger
GWP	Global Warming Potential
HAWT	Horizontal-Axis Wind Turbine
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Analysis
LCOE	Levelized Cost Of Energy
LEED	Leadership in Energy and Environmental Design
NM	Net Metering
ORC	Organic Rankine Cycle
OSE	Overall System Efficiency
O&M	Operation and Maintenance
PCM	Phase-Change Material
PPA	Power Purchasing Agreement
PT	Public Tendering
PV	PhotoVoltaic
R&D	Research and Development
REC	Renewable Energy Certificate
RES	Renewable Energy Source
RPS	Renewable Portfolio Standard
TES	Thermal Energy Storage
UN	United Nations
VAT	Value Added Tax
VAWT	Vertical-Axis Wind Turbine

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Chapter 34
Green Development:
Case of Turkey, Norway, and China

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ABSTRACT

The focus of this chapter is to assess green or sustainable development concept because of its increased importance throughout the world. Droughts, environmental degradation, air pollution, greenhouse gas emissions are important problems that the humankind have been facing since the Industrial Revolution. Renewable energy sources can be used to overcome these problems. The general tendency of modern-day societies is to transform traditional production techniques and development models to new renewable energy sources and also move towards to sustainable development path. Therefore, this study tries to explain current status of Norway, China and Turkey in terms of their renewable energy sources and policy implementations.

ABSTRACT

The focus of this chapter is to assess green or sustainable development concept because of its increased importance throughout the world. Droughts, environmental degradation, air pollution, greenhouse gas emissions are important problems that the humankind have been facing since the Industrial Revolution. Renewable energy sources can be used to overcome these problems. The general tendency of modern-day societies is to transform traditional production techniques and development models to new renewable energy sources and also move towards to sustainable development path. Therefore, this study tries to explain current status of Norway, China and Turkey in terms of their renewable energy sources and policy implementations.

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INTRODUCTION

Nowadays it's a well-known fact that since the First Industrial Revolution (FIR) we have pumped million tons of carbon dioxide and other harmful gases into the earth's atmospheric layer to which all the living things, human, animal and plants are dependent. The negative effects of the FIR and the climate change prove that we are living in a quite fragile earth. This fragile planet has been used as a huge garbage can for many years. Industrial pollution, global warming and climate and environmental changes have now an unpredicted economic, social, and political effects on 7 billion people throughout the world. However, recently there is a growing demand towards a more green, sustainable and environmentally sensitive way of life since the beginning of twenty-first century. This demand is being supported by renewable energy sources and technological improvements. In twenty-first century, may be in a very near future, it is expected that the fossil fuels have been dominating life of humankind for many years will be replaced by energy-saving way of life in terms of consumption and production.

In the last century, especially inability to avoid the use of fuel and the petroleum based energy sources and greenhouse gasses from carbon emissions have caused the drastic changes in weather patterns never witnessed. The World's being surrendered by fossil fuels since the FIR has made our planet extraordinarily hotter and polluted today.

In addition to these destructive weather changes, the World's poorest countries have had to face many problems such as drought and famine related to the more polluted plant from many aspects. These problems made these countries more fragile than the others.

Today, some developed and developing countries, especially Scandinavian countries in the north Europe, are trying to change their production methods from traditional and harmful techniques, mostly depending on fossil fuels, to the sustainable methods based on renewable energy sources without serious damage to the nature and our planet. Furthermore, the environmental damage that is a result of fossil fuels has been taxed in some industrialized countries. For instance, in Norway contemporary generation is paying a tax for using the next generation's share from nature and environment.

Despite some international environmental regulations such as the Kyoto Protocol, and despite the increasing importance of green and sustainable development in the twenty-first century, we have not yet reached to the desired levels for the sake of our planet in terms of a clean and habitable world. It is, however, potentially seen that in the future environmental pollution based on usage of fossil fuels will face various penalties for non-compliance to the environmental regulations. The Paris United Nation Conference in 2015 represents a powerful commitment to solve the problem of raising greenhouse gas emissions, with the contributions of the action plans of both developed and developing countries throughout the world.

The rest of this chapter is organized as follows: The first part of the chapter introduces the Green Industrial Revolution; the second part is on the innovative green development. After the explanation of the green development we handle some country examples in the third part of the chapter including Turkey, Norway and China. The chapter ends with the evaluation and suggestions as concluding remarks.

GREEN INDUSTRIAL REVOLUTION

The FIR, took place in England in the late eighteenth century, was both a turning point for human history and closure of a pre-industrial production age. Before this industrial revolution, people generally used

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to use animals and some basic materials as their economic power source. In the late eighteenth century James Watt, an English mechanical engineer, changed human history by inventing steam engine. This invention led the way to the revolution in machine base manufacturing (Clark & Cooke, 2015), and improved productivity and production volume in textiles industry with the leading of Great Britain at the turn of the nineteenth century. By the invention of this machine, production evolved from hand-based manufacturing to machine-driven industrial production. We are defining this era in terms of industrial and hence economic and transition of production method from hand made to machinery in England in 1760s as FIR. This transition made drastic changes in industrial production with the development of new machine tools and factory systems. The steam power pave the way for new chemical manufacturing and iron production processes which improved efficiency of waterpower. The coal became one of the major sources in the industrial age instead of wood and other bio-fuels in pre-industrial age. These modern production methods were first used in textile industry (Landes, 1969) and made Great Britain the most powerful country in this factory based mass production.

The Second Industrial Revolution (SIR), took place in United States of America (USA) around the end of nineteenth century, was also a turning point for human history, because an unimaginable world of machines and oil industry with the inventions of electricity by Thomas Edison and the telephone by the Graham Bell in this era revolutionized daily lives of ordinary people. Improvements in transportation systems, telecommunication centers and electrical networks required huge amounts of energy as a natural consequence of this ease in daily life. Economic and technological progress continued during the SIR with an increasing acceleration. The steam power-driven transport systems like railways, boats and ships, the mass production tools and steam-powered factories were evolved to a new characteristic with the increasing adoption of steam power[1] in almost each level of industrial production, especially improvements in the USA in this era is noteworthy.

Both the first and second industrial revolutions have made our planet hotter and smokier, caused very severe environmental problems (Clark & Cooke, 2015). Besides these problems, now our planet is overcrowded and natural resources are getting scarcer day-by-day. If the world continues consuming natural resources at this fast pace as it did in FIR and SIR, in a very near future the planet will be running out of its fossil fuels. In this context, environmental problems and scarcity of energy sources will be the first issue in the future with the increase of extra population in the world. The UN estimates that there will be around 10 billion people by 2050. Most of these people will be from less developed or developing countries, which is meaning that demand to new clothes, homes, electro mechanic tools like televisions, cars, washing and dishing machines, refrigerators, cell phones and other non-durable goods in the daily life will be likely to increase geometrically. Already, developments and demands to industrial products coming from developing countries have been increasing greenhouse gas emissions and pollution for many years.

For the very reason, a new era driven by sustainable development, mostly adopted in Asia in the 1980s, in Nordic Countries in the 1990s as well as then with the leading of Germany at the turn of the 21st Century, is named as "Green Industrial Revolution" (GIR). Some other calls this new era "The Third Industrial Revolution" (TIR). Green energy-driven production methods, innovative smart green technologies and public sensitivity toward the environment (Clark & Cooke, 2015) are fundamental characteristics of this new era, and it is gathering steam across the globe. According to Rifkin (2011), "We are on the cusp of a new energy era and a new economic paradigm that will literally empower hundreds of millions of human beings to create their own energy and share their surpluses with neighbors across regions, nations and continents. The democratization of energy gives rise to a new 'Distributed Social Vision'

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in the twenty-first century that will change our economic, political and cultural institutions as dramatically as the enlightenment vision that accompanied the First Industrial Revolution two centuries ago."

It is a well-known fact and an indispensable reality that demand for clean energy, energy efficient products, buildings, homes, modes of transport and environmentally sustainable production processes will dominate our social and economic life over the coming decades. So that reason, each country has begun to develop a strategy to react to this new era that has already created a new market around the world. The countries leading this transformation from SIR to GIR will increase their benefit enormously in terms of both a healthier life and an economic return. Breathing a healthier air, drinking clean water, economic expansion in the forms of new markets, new jobs, value added products and huge profits are only some of these benefits that a leading country can own in a very near future. In addition to these benefits, the countries that lead this green revolution on the time will also dominate the second half (maybe the first) of the twenty-first century both economically and politically. On the other hand, countries ignore this transformation will be called Luddites[2]of this century (Gordon et al., 2013).

It has been predicted that a greener planet would stipulate sustainable development all around the world since the twenty-first century. Sustainable development depicted in Figure 1 is a complex concept and determined by three main and many sub-main issues. These important pillars are environmental responsibility, economic efficiency and social equity. Environmental responsibility is a key indicator showing capacity of environmental systems and conserving amount of recycling resources to be respected and amount of wastes to be reduced by generations. It is comprised of consumption of resources, materials and waste, risks, rate of change and natural and cultural landscape. Economic efficiency, the second component of sustainable development, is also a key parameter promoting significant improvements in the welfare populations, and is related to sustain economic growth, maximizing profits and expanding the markets. Economic growth, efficiency and competitiveness, flexibility and stability, production/consumption, employment and international trade are sub-titles of this component. The social equity, the third issue, is related to satisfying the diversified needs of population such as food, health and education that are among the essential requirements. Social equity involves living conditions, equal opportunity, social cohesion, international solidarity and maintenance of human capital. Besides these three issues, World Bank also suggest nearly 150 indicators to assess the sustainability, they fit them into five major categories:[3]

1. Energy and air quality,
2. Water, materials and waste,
3. Land and biodiversity,
4. Transportation and livability,
5. Human amenities and health.

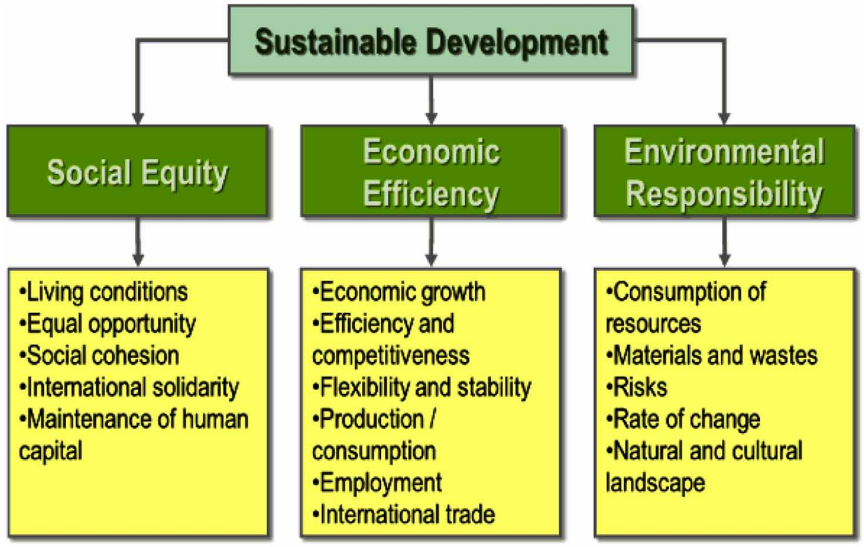
These indicators are also mentioned under the three main determinants of sustainable development in Figure 1 as mentioned before.

Recently, there has been a widespread support for the drastic increment in energy efficiency and change in energy use from fossil fuels to renewable sources (Flavvin & Lenssen, 1994). A renewable source is seen as a key and efficient solution to the environmental problems we face today. That is why it is believed that sustainable development will rise on the shoulder of renewable energy sources.

There is a cause and effect relationship between sustainable development and renewable energy, because renewable energy has been a key parameter in the long run life of a country since fossil fuels tend

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Figure 1. Determinants of sustainable development
Sources: https://people.hofstra.edu/geotrans/eng/ch8en/conc8en/3es.html; Swiss Statistics (2002), Measuring Sustainable Development, Insights into MONET, Neuchatel.

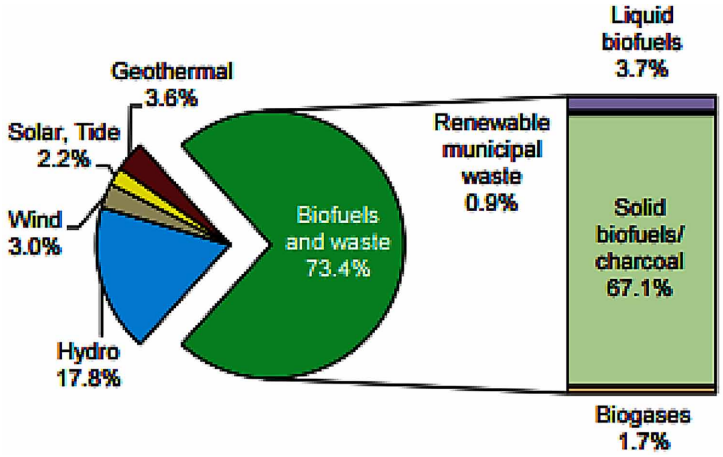


to exhaustion. For instance, the greenhouse gas emissions depending on fossil fuels have higher costs but no benefits for humankind and are related with the unsustainable development (Manso & Behmiri, 2013). Moreover, human beings have been aware of the severe consequences of the traditional energy sources including environmental problems, global warming and climate change that will give damage to their daily life in a near future if a switch to renewable energy is not made in a short time. This led humankind to use renewable energy sources like solar, wind, geothermal, hydropower and wave power[4]. Economic development depends on these alternative energy sources will also be sustainable, because we know that a long run growth is likely to be sustainable if it is not related to fossil fuels. Renewable energy sources mostly based on clean and safe sources, maintaining new resources for the next generations have been a fundamental determinant of sustainable development for nearly thirty years. Hence, exchanging fossil fuels with renewable energy sources or reducing fossil fuels' dependency in buildings, industrial and agricultural sector (Manso & Behmiri, 2013) may decrease growth rate of economy in the short run, but it will promote a healthy economic life to the residents in the long run. Nevertheless, renewable energy share of global final energy consumption in 2009 is only 16.2%. The remaining energy is provided from fossil fuels (81%) and nuclear energy resources (% 2.8) (Renewable Report, 2012). Figure 2 below represents the share of renewables in world energy supply. According to International Energy Agency (IEA:2015) report, biofuels represent the largest renewable energy source in the World renewables energy supply for the year 2013. Hydro-power energy ranks as the second largest energy source with the ratio of 17.8%. The share of other renewables, however, such as geothermal, solar and wind energy are still low in comparison with bio-fuels and hydro-power, so, they do not have equal share and weight in use and supply overall.

These numbers are significant to evaluate the place and importance of the renewable energy sources for societies and countries throughout the world. However, it should be kept in mind that there are important barriers in order to invest in renewable energy sources. Because investments in the energy sources

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Figure 2. Product shares in world renewable energy supply (in 2013)
Source: International Energy Agency, IEA Statistics, Key renewables Trends: Excerpt from renewables Information, 2015, p.3.



are always related with the competitiveness of the energy source, the price structure of renewable and traditional energy sources are significant. The tension between these two markets clearly affects the share and the intensity of each source considerably. Investments in renewable energy sector can also be seen as a new way in our modern societies to maintain energy security of the country. Also, this newly improving field will affect the job creation and increase the growth of country along with its local and national development path. Therefore, the government regulations and implementations both on prices and incentives will be decisive on the plans and investments of private business (GWEC:2014). It is obvious that there are some barriers coming from the government policies on price and incentives, and undeniable contributions to energy security and economy in general.

In this context, The Kyoto Protocol, agreed on in 1997 and seen as a key strategy for reducing greenhouse gas emissions, is accepted as a declaration of using renewable energy throughout the world (Kaygusuz & Kaygusuz, 2002). Renewable energy sources such as solar, hydroelectric, biomass, wind, ocean and geo-thermal energy have many environmental benefits but no cost to the nature when compared to the fossil fuels. The level of greenhouse gas emissions and amount of liquid pollutants of these renewable energy sources is near zero (Boyle, 1998). Energy provided from renewable sources constituted an estimated 19% of global final energy consumption in 2013. Table 1 presents world final consumption of both fossil fuels and renewable energy sources from 1970s to 2030s. What is seen clearly in table is that World's primary energy demand will raise about 60% from 2002 to 2030, meaning that yearly increase will reach to 1.7%. Nonetheless, this yearly growth rate is less than over the past three decades. Therefore, fossil fuels will continue to be the main energy supply source in the near future. The share of renewable energy resources will remain at around 14% (Bilen et al., 2008).

In order to emphasize the current tendency in the regions all over the world, Figure 3 represents the share of renewable energy in total energy supply based on the World regions. It is obvious that the share of renewables in total primary energy supply has increased in each region which is a clear sign of the importance of the renewables. By all means, there are significant differences between regions. For instance, the OECD area has 9% of renewables that indicates a relatively smaller share in comparison with the share of China such as 10.7%.

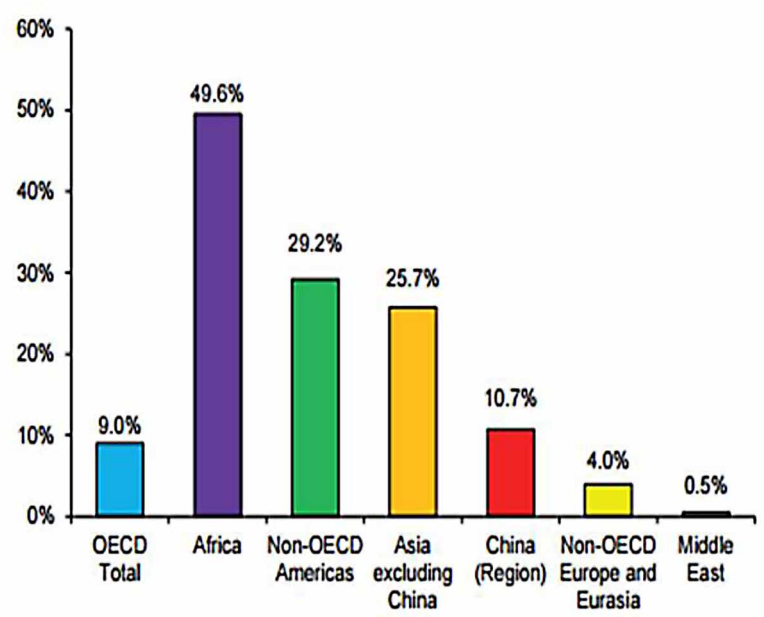
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Table 1. World final consumption (Mtoe)

	1971	2002	2010	2030	2002-2030*
Coal	617	502	516	526	0.2%
Oil	1893	3041	3610	5005	1.8%
Gas	604	1150	1336	1758	1.5%
Electricity	377	1139	1436	2263	2.5%
Heat	68	237	254	294	0.8%
Biomass and waste	641	999	1101	1290	0.9%
Other renewables	0	8	13	41	6.2%
Total	4200	7075	8267	11176	1.6%

Source: International Energy Agency (IEA). World Energy Outlook 2004. Paris: OECD/IEA; 2004, p.68.
*Average annual rate of growth.

Figure 3. Shares of renewables of regional total primary energy supply (in 2013)
Source: IEA Statistics, Key Renewables Trends: Excerpt from Renewables Information, 2015, p.4.



THE GREEN DEVELOPMENT IN TURKEY

The green development in Turkey is mostly related to renewable energy sources. The number of academic studies, however, concentrating on the issue of green or sustainable development is less than those in the developed countries. Of the remaining few studies on sustainable development focus on the long run equilibrium of saving and investment, and carry out their impact on GDP growth rate and foreign debt. Sancak and Demirci (2012), Çetinkaya and Türk (2014) and Şanlı and Aksöz (2014) are three of these studies investigating the effect of domestic savings on GDP growth rate and foreign debt for different

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time periods. The results of these studies suggest that a sustainable development can be achieved with the help of higher domestic savings and less dependency on foreign debt. In this study, however, we are focusing only on some parameters of renewable energy sources in terms of green development in Turkey. In this part, we are firstly depicting a general situation of all renewable energy sources in Turkey, and then concentrating on solar, wind, hydro and geothermal energy sources.

Need to clean, domestic and renewable energy is commonly accepted and seen as a key parameter of long run economic life in Turkey as well as all over the world. Turkey is supposed to build its sustainable development on renewable energy sources because geographical location of Turkey brings many advantages for using renewable energy sources. Three seas, namely the Aegean Sea located to the west, the Mediterranean Sea located to the south and the Black Sea located at the north, surround the country. The average rainfall is about 650 mm, and the annual temperature varies between 18 and 22 degrees Celsius. At the coastal areas of Turkey a typical Mediterranean climate is predominant, whereas at the interior and particularly at high places from sea level show arid and conventional climate characteristics. Benefiting from renewable energy sources in Turkey to reduce greenhouse gas emissions and climate change mitigation should be a necessity not an option due to its geographical location (Bilen et al., 2008). Turkey possesses all kinds of energy sources but these resources are restricted and limited. That's why Turkey is an absolute energy importing country in the world (Kaygusuz & Kaygusuz, 2002).

A high dependency on fossil fuels and growing energy demand make it crucial for Turkey to invest in renewable energy resources. Hydro, wind, solar, geothermal and biomass and biogas are fundamental renewable energy resources of Turkey. The total share of renewable energy in primary energy supply in Turkey is only 6.3%. The economic potential, however, of installed capacity for hydropower, wind and geothermal is only 40%, 9% and 19%, respectively (see Table 2). It is clear that Turkey should expand this potential to a higher level (Bölük, 2013: 156-157).

Table 3 presents the production of fossil fuels and renewable energy sources of Turkey between 2002 and 2011. It is clearly seen that renewable energy supply increased to 7 million tep in 2011 from 3.7 million tep in 2002, and the share of renewable energy sources in total energy supply increased to 6.1 in 2011 from 4.8 in 2002, namely approximately an 87 percent increase took place in 9 years. Such an increase may be not underestimated but this amount of renewable energy production is not sufficient to mobilize the potential of the Turkey. This statistics shows that renewable energy production is still at a negligible level in Turkey (Aydoğuş, 2013).

Table 2. The situation of renewable energy in Turkey

Type of Energy	Technical Potential (MW)	Economical Potential (MW)	Installed Capacity (MW)
Hydropower	54,000	42,000	17,137
Wind	114,000	20,000	1,806
Geothermal	2,000	600	114.2
Wastes (Biogas + Biomass)	4,000	0	125.7
Solar	56,000	-	-

Source: Bölük, G. (2013). Renewable Energy: Policy Issues and Economic Implications in Turkey, International Journal of Energy Economics and Policy Vol. 3, No. 2, 2013, pp.153-167, p. 157; Kucukali and Baris (2011), TEIAS (2011), TUREB (2012).

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Table 3. Primary energy supply in Turkey: 2002-2011 (thousand tep)

	2002	2011	2002 (%)	2011 (%)	Change from 2002 to 2011 (%)
Total primary energy supply	78331	114480	100	100	46.1
Production	24281	32229	31,0	28,2	32.7
Fossil fuels	14266	20653	18,2	18,0	44.8
Coal	11358	17446	14,5	15,2	53.6
Oil	2564	2555	3,3	2,2	-0.4
Natural gas	344	652	0,4	0,6	89.5
OTHER	5974	3555	7,6	3,1	-40.5
Renewable energy	3721	6967	4,8	6,1	87.2
Water	2897	4501	3,7	3,9	55.4
Geothermal	90	597	0,1	0,5	563.3
Wind	4	406	0,0	0,4	10050.0
Solar	318	630	0,4	0,6	98.1
Other heat en.	730	1463	0,9	1,3	100.4

Source: Aydoğuş, O. (2013). Türkiye Ekonomisinin Yumuşak Karnı: Enerji 2, İktisat ve Toplum dergisi, 37: 5-9.

Table 4 indicates the consumption of fossil fuels and renewable energy sources (water, wind, solar geothermal) of Turkey in 2011. Renewable energy consumption is also at the negligible level as well as its production. Water based energy (hydraulic) consumption is at the first order among these renewable energy sources. Although Turkey has a big potential for producing renewable energy sources, it has not been yet realized. The production (Table 3) and consumption shares (Table 4) of the geothermal, solar and wind energy sources are near zero. Especially in industrial and in transportation sectors, Turkey has not yet benefited from solar, wind and geothermal energy sources (See Table 4).

Final energy consumption, estimated for Turkey up to 2030, is shown in Table 5. It is indicating that primarily energy need will continue to be provided from fossil fuels up to 2030 as well as the rest of the world. Total consumption will increase to 463 Mtoe in 2030 from 152 Mtoe in 2010. It is predicted that the share of fossil fuels will decrease to 86% in 2030 from 98% in 2010. Of the renewable energy resources, the hydropower has a share with 50%, which means that half of the total renewable energy consumption will be supplied from waterpower in Turkey in the future.

Table 4. Energy consumption of Turkey in 2011 (million tep)

	Coal	Oil	Natural Gas	Water	Geothermal, Solar, Wind	Bioenergy	Electric	Heat
Industrial	6,9	1,6	7,9	0	0	0	7,4	1,2
Transportation	0	14,8	0,2	0	0	0	0,1	0
Housing	5,8	1,3	7,2	0	1,9	3,5	3,8	0
Total consum.	33,9	30,4	36,8	4,5	3,1	3,7	0,1	0,0

Source**:** Aydoğuş, o. (2013**).** Türkiye Ekonomisinin Yumuşak Karnı: Enerji 2, iktisat ve toplum dergisi, 37: 5-9; International Energy Agency (2013).

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Table 5. Final energy consumption in Turkey (Mtoe), 2000-2030

Energy Sources	2000	2005	2010	2020	2030
Coal and lignite	13.29	20.69	26.15	32.36	35.13
Oil	2.73	1.66	1.13	0.49	0.17
Gas	0.53	0.16	0.17	0.14	0.10
Com. Renewables and wastes*	6.56	5.33	4.42	3.93	3.75
Nuclear	-	-	-	7.30	14.60
Hydropower	2.66	4.16	5.34	10.00	10.00
Geothermal	0.68	0.70	0.98	1.71	3.64
Solar/wind/other	0.27	0.22	1.05	2.27	4.28
Total production	26.71	24.12	39.22	58.20	71.68

Sources**:** Bilen et al. (2008), p: 1549; Ministry of Energy and Natural Resources (MENR). Energy report of Turkey, Ankara, Turkey, 2005; http://www.enerji.gov.tr, (date accessed: 09.10.2015).

Solar and Wind Energy

Solar is the oldest and most efficient renewable energy source, and has been providing energy for the life on the earth for million years. It has been accepted that human beings had begun to control solar energy since 400 BC. At those times, Socrates argued that buildings might be constructed in the north- south directions and south side of the buildings should be covered with more windows to benefit from solar energy efficiently (Kolomoyets, 2010:19, Ulu, 2014: 14). On the other hand, wind energy that is the kinetic energy of moving air was firstly used as an energy source by Paul La Cour to produce electricity in 1891. Wind energy is an indefinite energy source as well as solar, because it needs no raw materials (Bayındır, 2010: 23).

Potential of solar energy is at its highest level at Equatorial belt countries, and it is also at an efficient level in Turkey. It is technically possible to benefit from potential of solar energy throughout the Turkey except north - east part of the Black Sea region. Table 6 shows annual sunshine duration and potential of solar energy of each region in Turkey. Especially southeastern Anatolia region and Mediterranean region have comparative advantages in terms of both solar energy potential and sunshine duration time. Table 6 indicates that the overall potential of solar energy resource of the Turkey is around 9121 kWh/m^2 per year.

In Turkey, June and December are the months that solar energy could be produced more and less, respectively. Turkey could benefit from this energy sources more than average 2000 hours per year depending on its geographical advantage (Ayhan, 2010: 171). There are 96 solar energy plants in Turkey (Ulu, 2014: 14), and according to the statistical data of the EIE-General Management of Renewable Energy board of Turkey- the average annual sunshine duration in Turkey is 2640 hours, i.e 7.2 hours in a day; the total intensity of radiation is 1311 kWh/m2-annual, i.e 3.6 kW/m2 a day (ITU Report, 2007: 93).

Wind power is also an important renewable energy resource in Turkey. Figure 4 presents cumulative installations for wind power plants in Turkey. It is clearly seen that there is an increasing trend on installation of new wind power plants.

The total wind power production of the Turkey has reached to 3 GW (gigawatt) in 2015, while it was only 131.5 MW in 2007. This production makes Turkey the 10th biggest country in Europe in terms

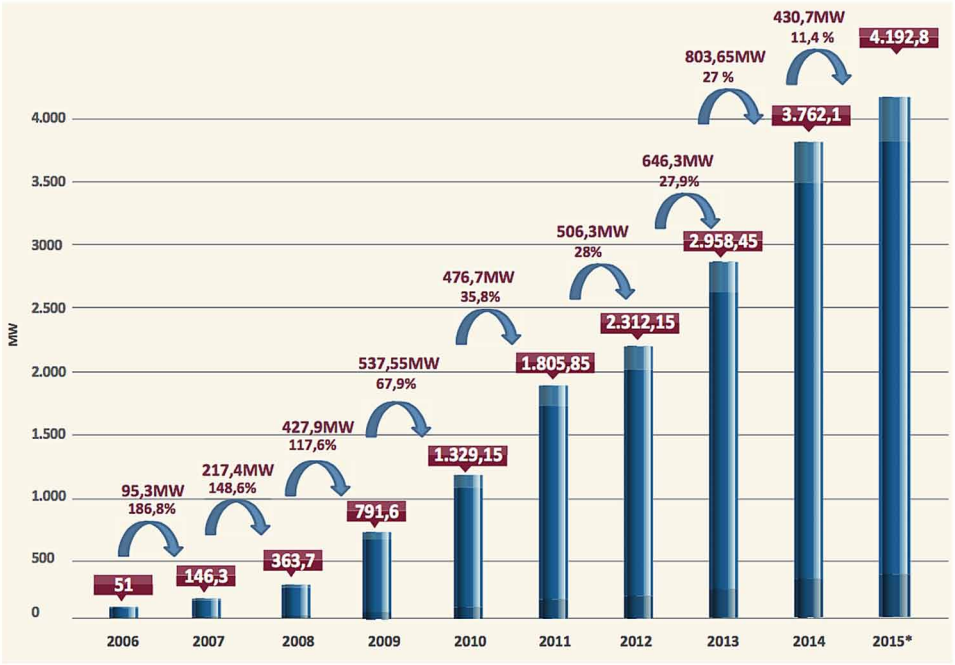
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Table 6. The total annual potential of solar energy of each region in Turkey

Region	Total Solar Energy (kWh/m2-Annual)	Sunshine Duration (Hours/Year)
Southeastern Anatolia Region	1460	2993
Mediterranean region	1390	2956
Eastern Anatolia Region	1365	2664
Central Anatolia Region	1314	2628
Aegean Region	1304	2738
Marmara Region	1168	2409
Black Sea region	1120	1971

Source: EIE; ITU Energy Report 2007, p.94.

Figure 4. Cumulative installations for wind power plants in Turkey (MW)
Source: TUREB, Turkish Wind Energy Statistics Report, July 2015, p. 5.

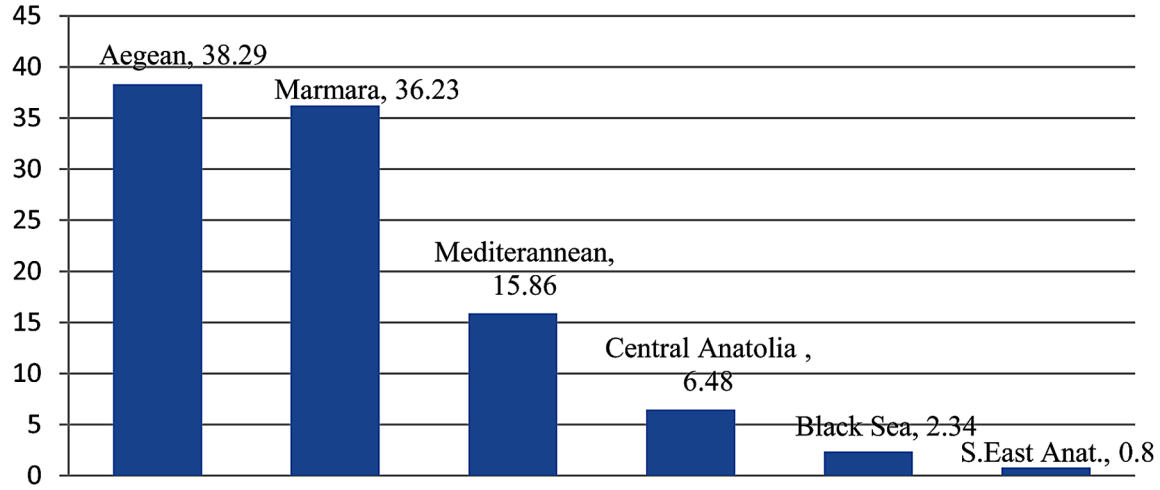


of wind power production (Hurriyet, 2015). However, this energy source cannot be stored yet so it is consumed via electricity grid. Wind energy is currently used to produce electricity in a limited number of wind turbines. The capacity usage ratio in these turbines is between 0.25-0.45. For instance, in USA even for the windiest places, this ratio is limited to 0.48 (İTÜ Report, 2007: 89-90).

When we compare the regions of the Turkey according to installed capacity for operational wind power plants (Figure 5), we see that Aegean region takes the first place with a share of 38.29 percent, and South East region is the last region with a share of 0.8 percent.

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Figure 5. Regions according to installed capacity for operational wind power plants (%)
Source: TUREB, Turkish Wind Energy Statistics Report, July 2015, p. 5.



Waterpower and Geothermal Energy Sources

Waterpower is the commonly used renewable energy source, which uses the potential energy of the water, and transformed it to the kinetic energy to produce electricity. Waterpower was used to via watermill in the past, and after the technological improvements modern dams have been replaced by the watermills. The first dam constructed in Turkey is Çubuk 1 located near the capital of Turkey, Ankara (TMMOB-İMO, 2012; Ulu, 2014:20)

According to the report released by the Energy Market Regulatory Agency (EPDK) in 2012, 44 of the 78 installed power plants that involved in Turkey's Renewable Energy Support (YEK) mechanism are hydroelectricity power plants with a total capacity of 932.26 MWe. 22 of the rests are wind with a total capacity of 684 MWe, 8 are biomass with a total capacity of 73.4 MWe and 4 are geothermal power plants with a total capacity of 72.35 MWe. The Turkish Electricity Production Company (EUAS) owns 11,629 MW of the installed hydropower. The total MW distribution between these dams are as follow: Karakaya (1,800 MW), Ataturk (2,405 MW) and Keban (1,330 MW). In addition to the public investments, a few big private companies like Dogus Holding, Akenerji and Aksa are also active and have some investments in hydropower sector (PWC Report, 2012: 13-20).

The waterpower potential of the Turkey is around 1% of the world and 16% of the Europe. According to statistics released by Ministry of Energy in 2014, the total waterpower of Turkey is 433 billion kWh. However, only 140 billion kWh of this magnitude could be considered economically.

Another renewable energy source is the geothermal energy, stored between layers of the earth, and nowadays considered as a clean energy by almost the entire world. Geothermal energy exploration goes back to 1960s in Turkey. The first explorations focused on areas having a high enthalpy potential like Kızıldere and Germencik. Then, places having mid-enthalpy potential such as Seferihisar, Simav, Salavatlı, Tuzla, Dikili and Caferbeyli are also explored (ITU Report, 2012: 100).

On the other hand, Turkey is one of the leading countries in terms of geothermal energy source with approximately 1000 hot and mineral water sources. 95% of these sources are used for household heating

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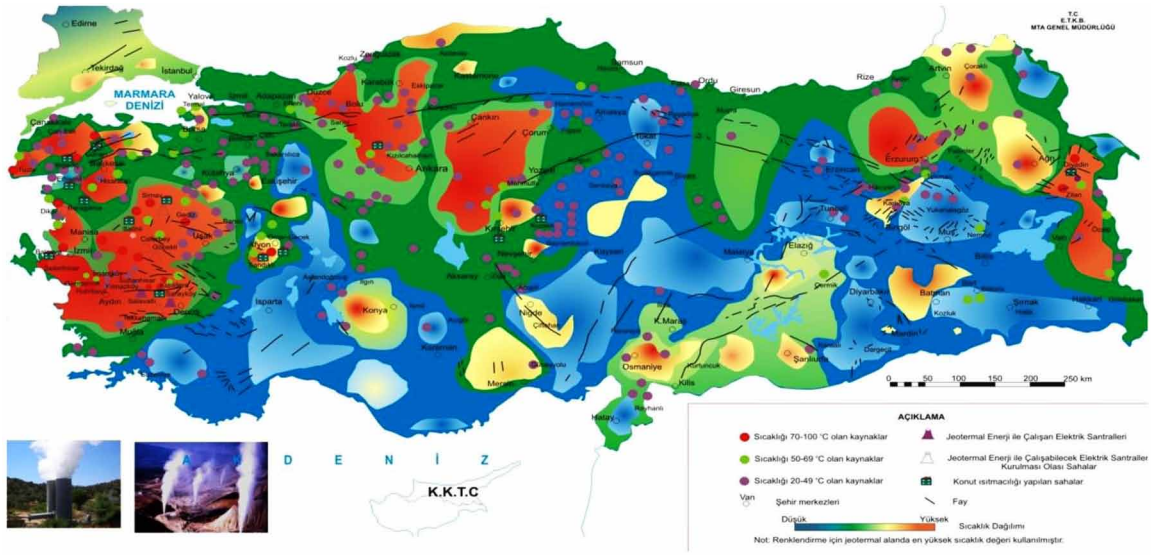
(Ağaçbiçer, 2010: 125) and tourism intended thermal activities. Figure 6 depicts regional distribution of the geothermal sources of Turkey. Hot water sources are mostly located in Aegean, East and Central Anatolia. Exploration activities of new geothermal energy sources that previously only focused in west Anatolia have recently been continuing in a wide area of the rest Anatolia because of the energy demand of the household for heating. In this context, explorations in the last 7-8 years are focused and developed in Izmir-Aliaga, Ş.Urfa-Karaali, Agri-Diyadin, Kırşehir, Nevşehir-Kozaklı, Van-Ercis, Yozgat-Saraykent, Balıkesir-Bigadiç, Afyon- Gazlıgöl and Balıkesir-Havran (TMMOB-EMO, 2012; Ulu 2014: 18).

THE GREEN DEVELOPMENT IN NORWAY

Norway became one of the earliest countries following the way of sustainable development thanks to its prime minister Gro Harlem Brundtland. Although sustainable development has not been an explicit goal four country until 2003, when a National Action Plan for Sustainable Development put into forward, many government policy documents have included sustainable development as an issue should be overcame in the future. Then, an active policy has not been implemented within the framework of this national plan. Nonetheless, strategic sustainable development initiatives from 1989 to now are a phenomena in Norway. Influence of the petroleum economy on distributional politics in Norway has effected sustainable development goals negatively and prevented the implementation of the national plan. Noticing the fact of sustainable development in an early stage has made Norway one of the leading countries in the world in terms of sustainable production and consumption of renewable energy sources at home (Lafferty et al., 2007).

Figure 7 shows the results of technologies for renewable energy and some pictures taken from renewable energy sources produced in Norway. Today, solar energy, bioenergy, winds power, hydropower, ocean

Figure 6. Regional distribution of the geothermal sources of Turkey
Source: www.mta.gov.tr/v2.0/dairebaskanliklari/enerji/images/siteharitalar/3.jpg (date accessed: 24. 11.2015).



**For a more accurate representation see the electronic version.*

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Figure 7. Renewable energy in Norway



Wind turbine in Bjugn

Source: Marius Meyer (2011).



An electric car produced in Norway

Source: www.elbilnorge.no



The Ulla-Førre hydropower complex

Source: Martin NH(2012)

energy, geothermal energy and technologies for renewable energy are critical parameters in Norwegian economy in terms of long run sustainable development.

Norway is the member of European Economic Area, which tries to integrate European Union (EU) member states and European Free Trade Association (EFTA) countries.[5] The policy implementations of EU and common policy areas in EU should be considered significant when the current status and future prospects of Norway are taken into account. In this sense, the Directive 2009/28/EC or The Renewable Energy Directive of 2009[6], put forward the main targets to attain to the desired levels of renewable energy sources in share of total energy sources. By 2020, 20% of the total energy consumption of the European Community should be supplied from renewable energy sources. In general[7] the targets by 2020 indicate as of reduced greenhouse gases by 20%, getting 20% energy purely from renewable energy sources and also to increase the energy efficiency by 20%.

The main characteristics of Norway energy market is summarized as lowness in electricity price, wealth of hydro-power and finally large reserves of oil and gas (Scarlat et al., 2011: 3389). In the work of Gullberg (2013), the possibility of Norway to be a "green battery" of Europe is questioned based on renewable energy sources. What is expected to be a green battery is that the hydro-power resources and reservoirs of Norway can contribute to reach to the renewable energy targets of Europe but the findings based on different scenarios emphasize that this could happen only in the long term.

It should be kept in mind that Norway has already achieved to attain a low carbon electricity system by using hydro-electricity (Gullberg et.al.; 2014: 216).This condition might affect the policy implementation of the country and the decisions that will be given how to cooperate with other countries. For instance, there is a coordination between Sweden and Norway in order to support renewable electricity by using green certificates in this field (Blindheim; 2015:208). This cooperative action can be seen as a way to realize both the local targets and EU directives. With the cooperation of Norway and Sweden, it is expected to have 13 terrawatt hour (TWh) new renewable power product by year 2020 (Trømborg, 2015).

The shares of wind, hydro and biomass energy in total renewables can be seen as 1.3%, 88.7% and 10% respectively (EUROSTAT). This indicates that Norway has an advantage with its vast and rich renewable

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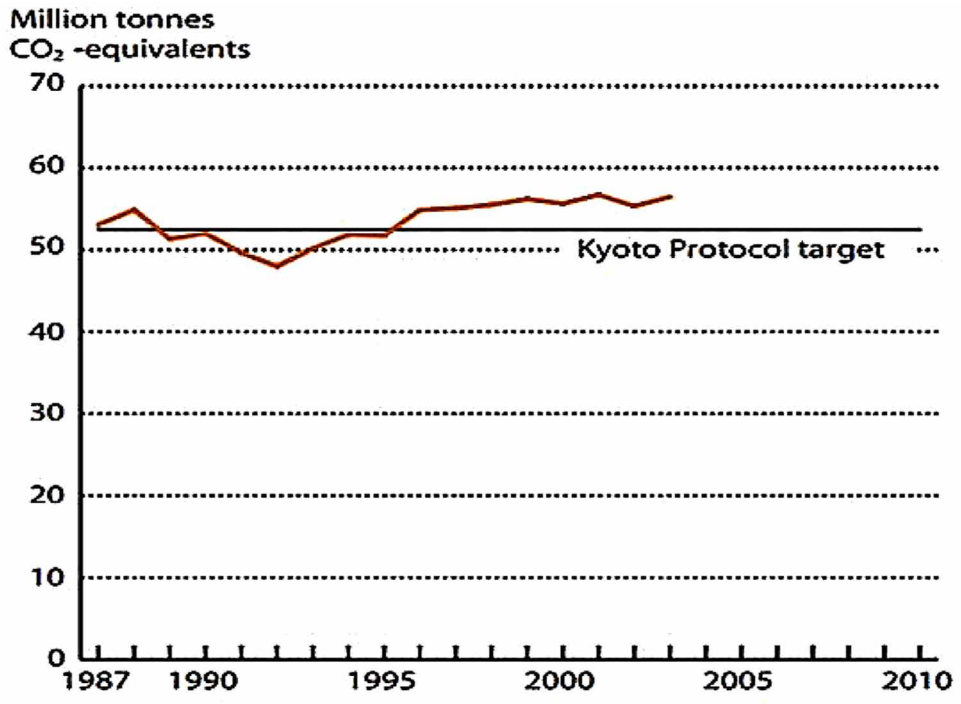
energy sources such as wind, solar, bio-energy, wave and tidal energy from the ocean (RENERGI, Work Programme 2014-2015, p. 13). As one of them, the offshore wind capacity of the country is 2 MW in 2013 and same for the end of 2014. In this context, the Joint Electricity System between Norway and Sweden can be seen as a way to strengthen the use of wind energy as a renewable source (GWEC, 2014).

Figure 8 shows the greenhouse gas emission (GHG) in Norway by comparing the level of GHG emissions with the Kyoto target. The adopted renewable energy sources have an impact on GHG emissions which is negatively related with the climate change. The emission of GHG is higher than the Kyoto Protocol target level since the middle of 1990's till 2005 (Ministry of Finance, 2005). In 2014, the GHG emission in Norway is 53.8 million tonnes of CO_2 equivalents. If the year 1990 is accepted as a reference year according to the Kyoto Protocol, annual GHG emissions were 52.0 million tonnes, and the increase in annual emission is around 3.5%. When the main contributors wanted to be found, the most contribution to the GHG emission is done from oil and gas extraction by 27% (14 million CO_2 equivalents) based on the preliminary results in 2014. Manufacturing industries and mining sectors are ranked as the second by 12 million CO_2 equivalents based on preliminary numbers. (Statistics Norway, n.d.)

Figure 9 shows the GHG emissions based on the source. Oil and gas extraction comes at first ranking and shows an increasing trend since 1990's. In comparison with oil and gas extraction, the contribution of heating and energy supply to GHG emission is relatively low. (Statistics Norway, https://www.ssb.no/, accessed 11.10.2015)

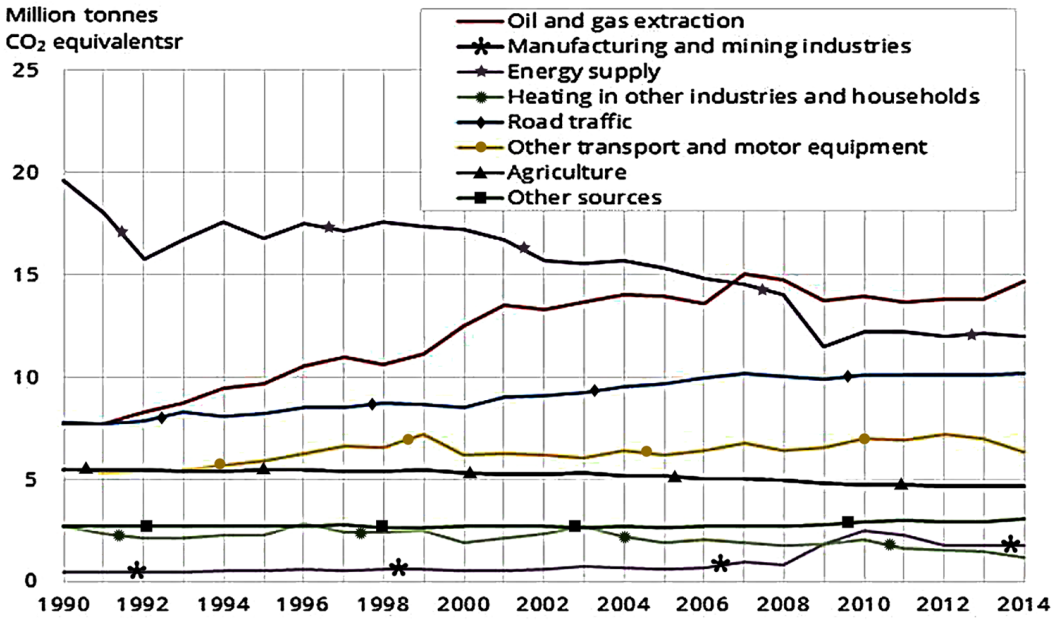
In the document titled "The Government's Environmental Policy and the State of the Environment in Norway (2004-2005)" (The Norwegian Ministry of the Environment, 2005) the problems of the environment across the world in general and particularly in Norway were emphasized as climate change,

Figure 8. Norwegian emissions of greenhouse gases in comparison with the Kyoto target
Source: Ministry of Finance, Indicators for Policies to Enhance Sustainable Development, 2005, p.16.



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Figure 9. Greenhouse gases by source
Source: Statistics Norway, Emissions of Greenhouse Gases: Preliminary Figures, 2015, https://www.ssb.no/en/natur-og-miljo/statistikker/klimagassn/aar-forelopige/2015-05-07.



hazardous waste, emissions and the difficulty to come over the pressures on biodiversity. This document is a clear sign of the awareness in adopting policies to solve the environmental problems on the governmental level.

In this manner, National Strategy for Sustainable Development[8] and National Action Plan for Sustainable Development[9] are the examples of country's commitment to the sustainable development. Both of these documents and the following documents are adopted in order to represent the importance of sustainable development goal. The Rio Earth Summit and Johannesburg Summit in 1992 have all effect on these plans to be created as a part of global action. They both show the role and participation of public sector and the other actors to achieve this goal. The acceptance of inseparability of environmental policy and sustainability can be found in the plans. Also, using collective actions/measures are strongly recommended in the plans. The emphasis is to attain a development approach which is sustainable as economically, ecologically and continuously.

Norway implemented RENERGI (clean energy for the future) programme starting the year 2004 till 2012. RENERGI programme was replaced by ENERGIX programme in 2013. The main purpose of RENERGI programme was to manage the energy sources efficiently and conduct sound energy policies which were in harmony with environment on national level, and also to have a competitive energy sector without neglecting international cooperation (The Research Council of Norway, 2007). These programmes have both short and long term perspectives. Some research and innovation projects were supported in order to constitute energy efficiency within the concept of country's energy policy by increasing the public awareness (RENERGI, 2005).

In this context, ENERGIX programme can be seen as a way to continue to the clean energy strategy of the country. The main framework of the programme is to use and consume renewable energy sources

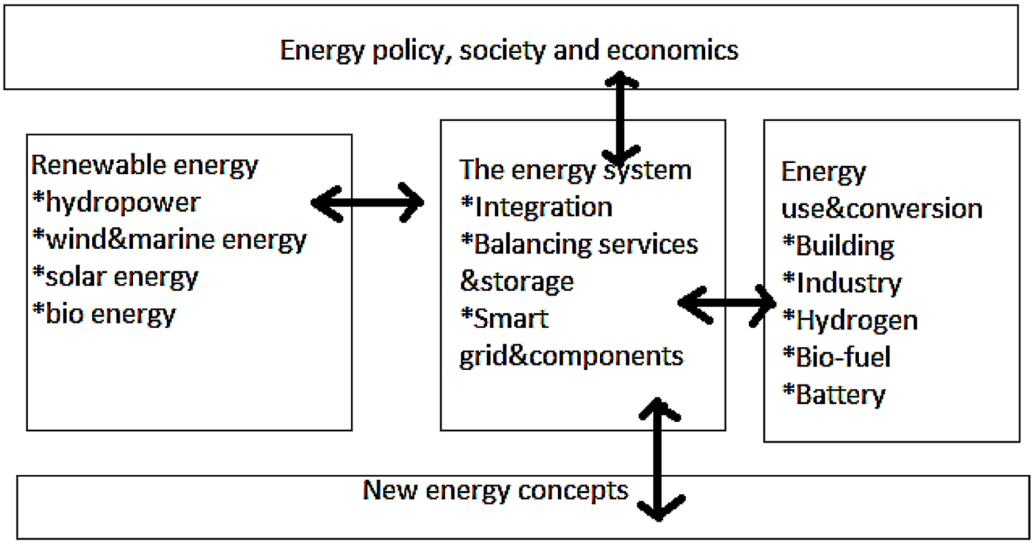
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efficiently; to have reliable energy supply; to reduce GHG emissions; to enhance and strengthen the knowledge and innovation of restructuring energy system of the country in the long run. The prioritized areas can be found in Figure 10 (The Research Council of Norway, 2013:1).

The efforts of each country as keeping rise in the temperature below a specified level or to use clean energy can be seen easily with the international agreements and conferences such as Kyoto and United Nations Conference on Climate Change. Each country has their own national action plans in compatible with global targets. A country can get benefit by coordinating or cooperating with another country in the field of energy and environment. As the case studies of this chapter, the collaboration between China and Norway are mentioned. The bilateral cooperation or collaboration between China and Norway have several undeniable opportunities for both countries. From Norwegian side, it is well known that the China has a big and growing potential of markets in the field of new renewable energy sector. Thus, it is an area to invest and to use the experience that have gained so far. This collaboration can be seen such as government to government cooperation, university/research institutes cooperation, technological research, and the financial and technical support to Research & Development (R&D) activities (Delman & Chen, 2008:ii). There are some challenges, however, that can be found in difference at scale and coordination. Norway can take the leading position but it should be kept in mind that standing alone, Norway has not the power and weight like international organizations or integrations such as European Union. Lastly, due to the numbers of actors that want to participate this process, a competition arises between national area of Norway (Vik & Smith, 2008).

The international cooperation of Norway regarding renewable energy sources is not with China but also with other countries such as India, Indonesia and South Africa in order to cut the greenhouse gas emissions. The role of Norway here is to transfer technology and make investments by using its expertise and experience (Norwegian Ministry of Environment; 2006-2007).

Figure 10. Thematic priority areas in Norway Regarding energy
Source: The Research Council of Norway (2013). Work Programme 2013-2022, p.2.



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THE GREEN DEVELOPMENT IN CHINA

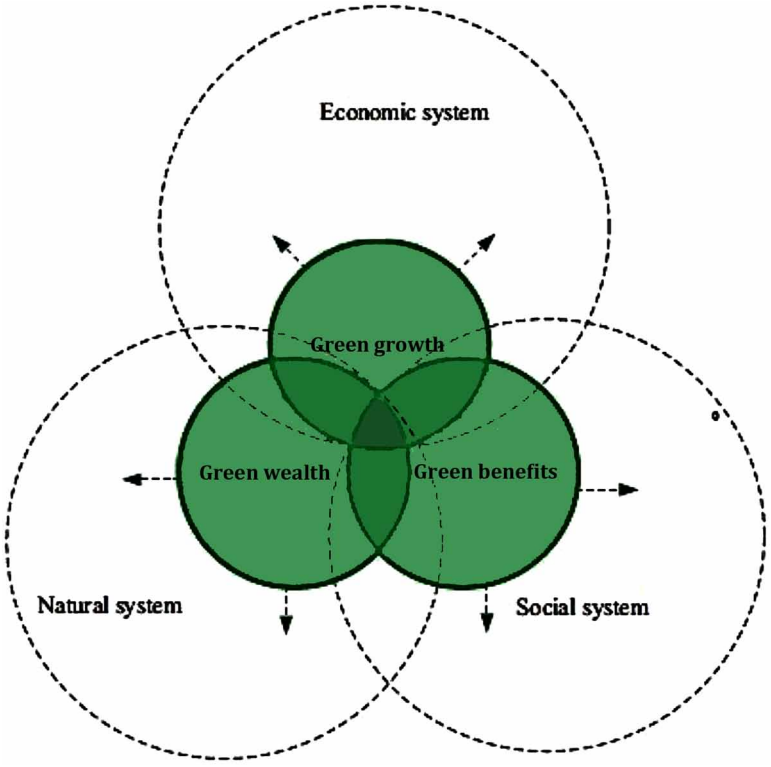
China deserves a special interest because of its leading position in the world economy in terms of industrial production. The growth trend of the country has been increasing and also is decisive for the performance of the global economy. The pressure to industrialize and to keep high scores of growth also affect the environment of the country and the world as well. The nature and the environment are accepted as our common property resources. Therefore, the policies taken by each country have an impact of our future. In this section, the past and current status of China will be evaluated based on environment and energy.

The concept and the theory of green development in China are considered from a perspective of three forces:

1. Harmony of nature and mankind,
2. Marxist approach to nature,
3. The existence of sustainable development reality (Hu, 2014:16).

This figure represents the systemic structure of green development. Green development is strictly and closely related with economic, natural and the social system of the related society. It also shows us that the concepts of green growth and green development are inseparable. These three dimensions affect each other and also are affected from each other. So, one policy implication in one dimension will

Figure 11. The relationship between three "green" concepts
Source: Hu, 2014:39.



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be decisive for the other dimensions. However, the meaning of green growth has expanded over time, it affects overall production. This effect comes from the adaptation of the production system to the environmental, resource-saving processes and structures (Jänicke, 2012:14).

The history of green development in China consists of four different stages:

1. Pre-1949 period was heavily dominated by an agricultural society characteristics and was also influenced by the Confucianism and Buddhist tradition.
2. 1949-1978 period with the increasing importance of economic growth, witnessed an important urbanization and industrialization process.
3. 1978-2004 period was also labeled not just its rapid urbanization and ongoing economic growth, but the negative outcomes such as environmental degradation.
4. After 2004, the new paradigm was adopted in order to harmonize the balance between nature and mankind (Hu, 2014).

It is impossible not to have any link between the actions of humankind and environment. Humankind intend to protect the environment but move towards an opposite way with a good and bad grace. Some kind of evidence can also be found in Chinese history. One of them is the result of being an agricultural society. In this intensively agricultural society, agricultural activities have an impact on soil erosion, water and environment pollution and deforestation (Ottley & Valauskas, 1983:85).

It can be easily said that what China has been through recently is a kind of transition from black/old/traditional development model to green/new/non-traditional development model (Hu, 2006). By adopting green development strategies, China has both a chance to protect environment and to meet the basic needs of the people. This issue is important not just for Chinese citizens but also for the world population. Therefore, all the efforts as green development embedded in the sustainable development strategy should be accepted as a way to transform the country into a modern society (Li & Obertheitmann, 2009:1412). Environment, energy and sustainable development are related with each other. Every energy source whether it is traditional or not has an environmental impact. If the energy efficiency is increased, the negative outcomes of an energy source will be removed. So, getting success in the efficient use and utilization of energy sources affect the aim of sustainable development positively (Dincer & Rosen, 1999:437).

OECD Review of Innovation Policy in China (OECD, 2008) emphasizes the pioneer position of China in science and technology and also for the research and development, but it is also mentioned that China still has some shortcomings and deficiencies regarding innovation capability and performance in comparison with OECD countries. Therefore, the country has to adopt national innovation systems in order to implement regulations and to increase the cooperation between all related actors. This innovative capacity is important in order to improve the technology that is used in the field of energy production and consumption which is vital for renewable energy.

Developed and developing countries- China is also included- has been trying to implement some plans and programmes on renewable energy because of its positive effect on sustainable development. Renewable energy can affect the whole economy to create new job opportunities and to protect environment in accordance with their sustainable development goals. In a world where countries such as Japan, UK, The Netherlands, US and Denmark are in a leading position in some of the renewable energy areas (electronic technology, wind turbine etc.), China has good reasons and incentives to support renewable energy. According to US energy Information Administration Report (IEA, 2015) by 2011, China was the largest energy consumer of the world. Coal, as a type of fossil-fuel, is a widely used energy source

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in China. China can be labeled World's number one coal producer and importer. This intense and overwhelming use of coal has a negative effect that can be seen as increasing carbon-dioxide and sulfur dioxide emissions. It can be easily seen that there is an increasing trend in coal consumption since 1965. It was about 114.4 million tonnes of equivalent (Mtoe) in 1965; 524,7 Mtoe in 1990; 699,9 Mtoe in 2000 and 1.962,4 Mtoe in 2014. The numbers in 2014 corresponds to the 50.6% as a share of total (BP Statistics; 2015). This increasing amount of use has both economic (high healthcare costs, bias in public spending) and environmental (land degradation, air pollution) effects that are a major concern for citizens (Mattis).

In China, The Circular Economy Promotion Law was adopted in 2008. It is a commitment to create a regulatory framework to transform the development way of the country into sustainable development (OECD, 2009) and green economy (Zhu, 2014). It consists of three-layer approach (Yuan et.al., 2006:232):

- **1st Circle (Micro/Corporate Level):** The aim is to facilitate cleaner production by firms.
- **2nd Circle (Meso/Inter-Firm Level):** In order to maintain an eco-industrial network to protect environment.
- **3rd Circle (Macro/Social Level):** By developing eco-cities, eco-provinces to integrate all the efforts spent for environment protection and energy conservation.

Basically, this approach is related with the recycling, reusing, and reducing the waste capacity (China Circular Economy Promotion Law, n.d.) of economy whether it is the result of production or consumption. Although, circular economy triggers the decisions of local and domestic firms to increase investment and create job opportunities, still faces some challenges and barriers. These barriers are classified in the fields of policy, technology and public participation (Geng & Doberstein, 2008:234). Unawareness of citizens to participate and support this approach, not having an appropriate tools to measure the efficiency of the process, and lack of integrated regulation system in the country are the instance of the factors that affect the success of implementation (Geng & Doberstein, 2008: 234; Zhou et al., 2014:7-10).

By the awareness of the importance of renewable energy in the world, China has also planned some strategies for the renewable energy development from 2010 to 2100 based on four phases. It starts with the partially commercialization of renewable energy sources and the traditional energy sources will gradually be replaced by the renewable energies. By the 2100, the structure of energy use in the country will be completely changed (China National Energy Strategy and Policy 2020, 2013).

The government in China has been giving some subsidies to the renewable energy sector since 1950's. These subsidies vary from research and development activities, providing some low-interest loans to the sector and to tax incentives. It should be kept in mind that the country has not got any price-setting mechanism in this area. The coverage of government support and subsidies have been expanded considerably from 1950's to 1990's (NREL; 2004). It is also seen by tax incentives of the renewable energy producers. Overall the general value added tax (VAT) is around 17%, the kinds of renewable energy (wind 8.5% and small hydro-power 6%) have a level of much lower tax. This lower tax rates are positively related with the price of the renewable energy power (Junfeng et.al, 2006:14).

The trend in the growth rate can be seen in the both Figure 12 and Figure 13. The growth rate is 11% in 1995 and in the year of global financial crisis of 2008 it is around 9.6% and 7.4% in 2014. When the long run trend of the growth is analyzed (starting from 1965), the trend is fluctuated between in the range of 20% and minus 5% and mostly positive, with a few years of exemption (see Figure 13).

As a country with high growth rates, China is known with regional income distribution inequities (Ginting et al, 2013:24-31). These inequalities have also some unignorable effects on the nexus of en-

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Figure 12. Annual GDP growth rate of China: 1995-2014
Source: World Bank Development Indicators.

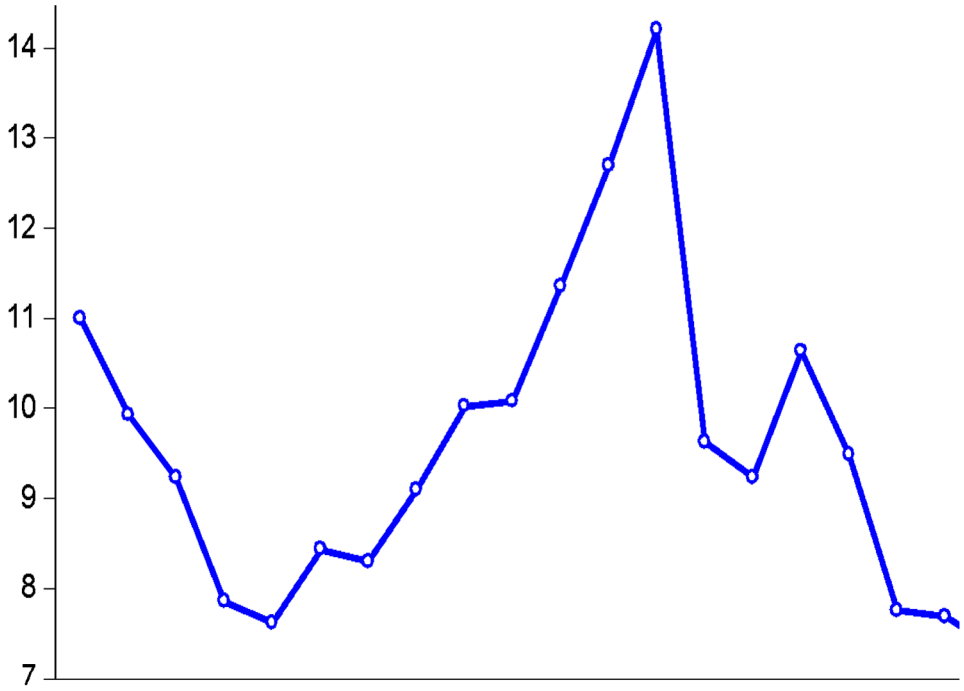
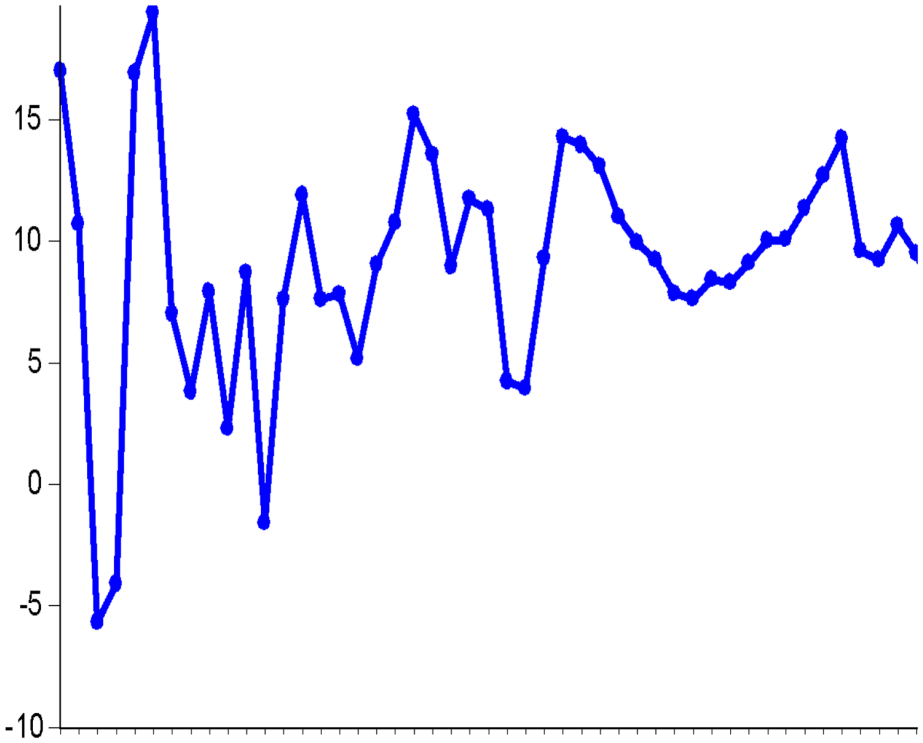


Figure 13. Annual GDP growth rate of China: 1965-2014
Source: World Bank Development Indicators.



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ergy and environment such as the concentration of emissions and energy use of different regions. Policy implications should be done by alleviating regional disparities in order to produce an integrated policy. As it is seen from Graph 2, country has been performing sound economic growth trend since 1970's. It should be kept in mind that these fast growth numbers have some negative side effects such as increased environmental degradation and social problems (Li & Obertheitmann, 2009:1421-1423).

Being a rapidly expanded and growing country, China has been facing great pressures in order to reconcile the necessities of economic development and environment protection. China was at the crossroads in this sense in order to find a way to meet the future energy needs without giving any harm to the environment. China's Agenda 21 was accepted as a statement of this effort. By applying this "Agenda" from the year 1994, China declared what kind of policies and implications will be taken or have been taken so far in order to maintain sustainable development (China's Agenda 21, n.d.). China's Agenda 21 shows medium and long-term plans on economic and social development (Li & Obertheitmann, 2009:1413). It contains both sector specific and general development measures and strategies of the country. Implementation of family planning, preventing the degradation of desertification, decreasing Sulphur dioxide emissions, developing cleaner energy sources are some targets of the Agenda in order to get success in the field of sustainable development (China's Agenda 21, n.d.). In their critical work, Bradbury and Kirkby (1996:106) emphasize that as a consequence of wide ranging implementations in the "Agenda", success can be measured only in certain elements. In addition to this, serious efforts and incentives should be performed by the government to reflect their commitment to sustainable development.

In order to improve sustainable development strategy, Chinese government published Program of "Action for Sustainable Development in China in the Early 21st Century" (n.d.) in 2004. This program clearly stated the successes and problems of the country in the context of sustainable development. Then the main objectives, principles and guidelines were given for maintaining sustainable development. For example, in relation with industrial restructuring, the main target is given as to raise efficiency in the utilization of both land and water resources in conjunction with the strengthened energy conservation and efficient energy utilization (Program of Action for Sustainable Development in China in the Early 21st Century, n.d.: 5-6). Graph 3 shows the CO_2 emissions for the selected regions of the world such as China, United States and European Union. The increasing trend in general is very common for these selected regions. From 2000's the average rate for China is higher than the rest of the regions.

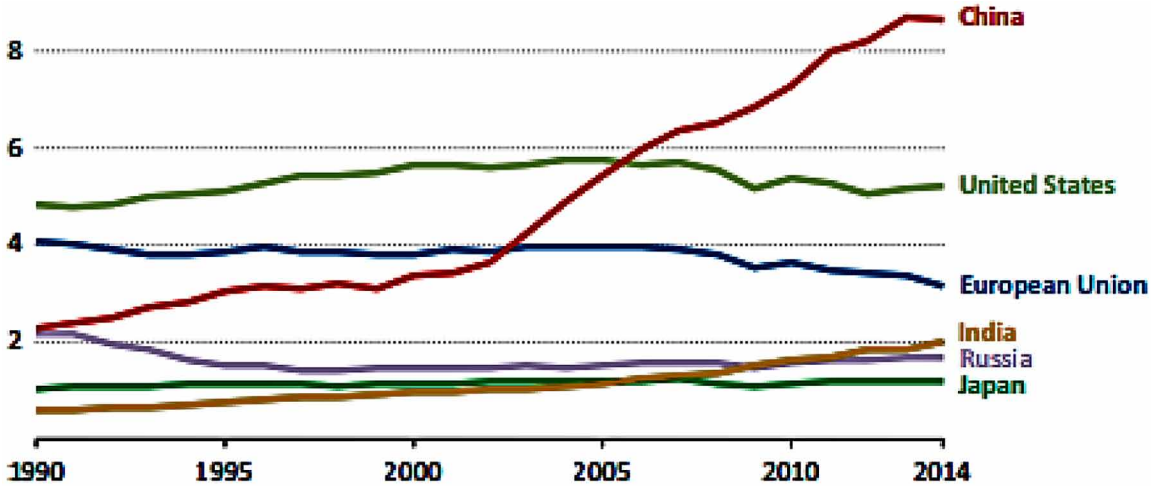
Table 7 shows the total energy consumption and its composition in China. The total energy consumption has been increasing since 1978. The share of coal as an energy source is decreasing but it is still high around 66%. In comparison with this traditional energy source, the renewables such as hydro, wind and nuclear can get only 9.8% share from the total energy consumption.

Global World Energy Council Report (GWEC;2014) emphasized the sign of increased wind industry capacity as for one single year in 2014. China is worth-mentioning due to the wind installations that took in place as of new wind power (23,196 Mega- Watt) all alone within this year. By the end of 2014, the total wind capacity of the country has reached 114,629 Mega-Watt, in which reflects the improving effect on the wind capacity of Asian region and the World. (GWEC;2014). These numbers can be seen in Table 8.

In China, the quota system was implemented to accelerate the pace of the transition to the low carbon economy by increasing the use of renewable energy sources. The responsibility of the provinces and regions in China is to use wind, solar and biomass energy sources for electricity consumption. Provinces that met their quota criteria will be rewarded, if not, they will be suspended from the new fossil fuel power generations projects (RE100, 2015:4). It should not be forgotten that each province has different

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Figure 14. CO_2 emissions in selected regions
Source: IEA, World Energy Outlook, 2015, s.27.



quotas based on the type of renewable energy source of the specified region (Ng, 2014). Ziong et al. (2014:1190) emphasize the effect and significance of the Renewable Energy Quota System in China. It is clearly stated that this system can be used as a new policy instrument and a way to increase the generation of renewable energy. However, some researchers such as Zhou et al. (2010) also found the quota system beneficial to cut the energy use in the times of government tight control over the state-owned enterprises which dominated mostly the industry structure, nowadays the changing nature of the control and dominance cannot allow to use this system as efficient as it was in the past. Thus, the expected effect of promoting renewable energy sources cannot be obtained, quite the contrary a displacement or substitution effect can occur as claimed in the case of European Union (Eurosolar Info; 2006).

The decisions and implementations regarding energy and energy-infrastructure are crucial not just for China but for the whole world in terms of global warming and climate change. Also, the challenges in water resource are worth to mention. The clean water demand in China will be increasing due to the population increase and urbanization. Problems in water supply/resource security affect some policy areas such as environment, energy and health. The best way is to use new infrastructure services for giving opportunities in reducing carbon and water footprints, and saving the energy costs (Chen & Warren, 2011:90-92).

In history of China, the implementation of energy conservation policies by law can be found. For instance, as one of them, Law of the People's Republic of China on Energy Conservation (2015) was adopted in 1997. The main purpose of this law was to provide energy conservation in all sectors of the economy. The responsibility of the State was emphasized such as using new and renewable resources of energy, supporting research and development activities and also implementing policy and plans such as tax and pricing. Another example can be given as Law of the People's Republic of China on Promotion of Cleaner Production (2015) adopted in 2002. The aim of this law is basically to protect human health and environment, and to reduce pollutant factors and processes. Some measures have been taking in order to maintain building energy conservation by implementing building efficiency standards and regulations since 1960's in China (Yao et al., 2005:1979). When the high energy consumption of office

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Table 7. In China, 1978-2013, total consumption of energy and its composition

Year	Total Energy Production (10 000 Tons of SCE*)	As Percentage of Total Energy Production (%)			
		Coal	Crude Oil	Natural Gas	Hydro-power, Nuclear Power, Wind Power
1978	62770	70.3	23.7	2.9	3.1
1980	63735	69.4	23.8	3.0	3.8
1985	85546	72.8	20.9	2.0	4.3
1990	103922	74.2	19.0	2.0	4.8
1991	104844	74.1	19.2	2.0	4.7
1992	107256	74.3	18.9	2.0	4.8
1993	111059	74.0	18.7	2.0	5.3
1994	118729	74.6	17.6	1.9	5.9
1995	129034	75.3	16.6	1.9	6.2
1996	133032	75.0	16.9	2.0	6.1
1997	133460	74.3	17.2	2.1	6.5
1998	129834	73.3	17.7	2.2	6.8
1999	131935	73.9	17.3	2.5	6.3
2000	135048	73.2	17.2	2.7	6.9
2001	143875	73.0	16.3	2.8	7.9
2002	150656	73.5	15.8	2.9	7.8
2003	171906	76.2	14.1	2.7	7.0
2004	196648	77.1	12.8	2.8	7.3
2005	216219	77.6	12.0	3.0	7.4
2006	232167	77.8	11.3	3.4	7.5
2007	247279	77.7	10.8	3.7	7.8
2008	260552	76.8	10.5	4.1	8.6
2009	274619	77.3	9.9	4.1	8.7
2010	296916	76.6	9.8	4.2	9.4
2011	317987	77.8	9.1	4.3	8.8
2012	331848	76.5	8.9	4.3	10.3
2013	340000	75.6	8.9	4.6	10.9

Source: China Statistical Yearbook(2014).
*SCE:Standard Coal Equivalent,

*Table 8. Wind power capacity (MW)**

Country	End 2013	New 2014	End 2014
China	91.413	23.196	114.629
World total	318.644	51.473	369.597

Source: GWEC(2014).
(*)megawatt.

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and residential buildings in China by the proportion of 16% of total energy use, new building projects have to meet the energy consumption criteria based on the Design Standard for Energy Efficiency of Public Buildings since 2005 (OECD;2009).

China's Eleventh Five-Year Plan was prepared for the years 2006-2010. In order to have a sustainable growth in the long run, all the main targets (about economic growth, natural development, human society) were maintained in the Plan. There were targets about economic growth to have an annual growth of GDP at 7.5% and GDP per capita 6.6% between 2006 and 2010. In relation to natural environment, the reduction of emission of major pollutants and reduction of energy consumption per unit of GDP targets are the examples of restricted (the responsibility of fulfilling these targets belongs to the state) targets. Lastly, the targets about human society vary from urbanization, population growth to health and education (Fan;2006).

Chinese government announced Twelfth Five Year Plan for the period of 2011-2015. The main emphasis of the Plan was the growth but an inclusive and higher quality growth. Therefore, the Plan was closely interested with the regional inequalities, well-being of citizens and the protection of the environment by improving energy efficiency. It's noteworthy that seven industries were selected to be developed for sustainable green development. Three of them are closely related with the aim of sustainable growth such as energy savings, new energy and clean energy methods and vehicles (KPMG; 2011).

Both Eleventh and Twelfth Five-Year Plans are a manifesto to follow the road to sustainable development. The targets and aims of the Plans were chosen for the best performance in the content of green growth. As well as having resemblances, there were some new implementations. What is new in the Twelfth Plan can be found in Table 9.

Regarding energy use and renewable energy source efforts of a country can be found both on local and global level. By having international collaboration both sides can get benefits. As an example of international cooperation, the U.S. and China declaration about climate change can be given. Both countries cooperate in a way to reduce GHG emissions and try to be the examples of low-carbon economies. In this manner, by 2030 the main target of China is to increase the share of non-fossil fuels in consumed energy to around 20%. The U.S. sets the target of reducing its GHG emissions by 28%. The success of these targets depend on the bilateral cooperation based on theoretical and practical level (The White House:2014). Their success or failure in pursuing this cooperation might also have effect on the global level.

Considering to move towards a green economy, China has been facing some challenges and barriers such as:

Table 9. Comparison of 12th five year plan to 11th five year plan

What's New in the 12th Five-Year Plan?
Two new pollution targets (10% reduction in nitrogen oxide and ammonia nitrogen)
Increase in average life expectancy by one year
Increase in patents (3.3 patents per 10.000 people)
Increase in high school enrollment rate from 82.5% to 87%
Development in affordable housing

Source: KPMG (2011).

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1. Institutional barriers which are related with the role and size of the government existence and intervention in the market,
2. Some deficiencies in implementation of regulations and coordination mechanisms, and
3. Pressures from international community and organizations because of the increased importance of China in global economy (CCICED; 2011:216-218).

The success of the future energy system of China depends on the struggle between traditional and new renewable energy sources. The competitive and the efficient one will be the decisive power of the country (The Guardian, 2015).

CONCLUSION

Nowadays it is a big reality that the big and indispensable fact we should overcome in future is fighting against droughts, heat waves, rising sea levels and concerns about catastrophic climate changes or la nina. These problems or today's mounting threats should be resolved by involvement of many countries within the framework of openness, participation, and science. Because of these reasons, the era of sustainable development or third industrial revolution must be built on water security, green industrial growth and intertemporal consumption, which requires making a fair share of total resources, one country have, between generations.

Sustainable development can be achieved by using renewable energy sources, because there is a long run relationship between sustainable development and renewable energy sources. The effect of renewable energy sources comes from their flexibility and low operational cost in comparison with traditional/old/black energy sources (Dinçer & Rosen, 1999:436). It is common for countries to adopt renewable energy policies and implementations due to its close relationship between environment protection and sustainable development.

Amount of renewable energy sources of Turkey are less than its long run potential level, although it has a good geographical and strategic position on the world within the context of renewable energy sources including wind, solar, geothermal or others. Therefore the share of renewable energy in total energy production and consumption is also at ignorable levels, near zero percent.

Norway, as a member of EFTA, but not a member of EU, has relevant energy policy strategies with EU. Especially with its position in renewable and clean energies, Norway cooperates with other European countries and also with China in order to help them to reach its targets.

China has shown high and sustainable growth rates almost a decade and this situation has been questioned whether it is possible to sustain these numbers or not. A continuous and sustainable growth is related with environment and use of natural resources. With an increase in factors of production either quantitatively or qualitatively, each country can grow. This brings on mind the question of what kind of growth strategy should be adopted from the countries. The short term growth should not prevent the future growth potential of the given country. Therefore, growth should be sustainable and environment-friendly. According to the latest numbers from Bloomberg New Energy Finance (2015), the total investment amount of clean energy was about $310 billion in 2014 in worldwide. One of the reason of this high score is the success of some countries and regions about clean energy investment such as China with a record of to 32% from previous year (Bloomberg New Energy Finance, 2015).

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The trend in modern societies is to realize the green growth strategies. Every country tries to stop or at least to decrease the negative consequences of rapid growth such as air pollution, environmental degradation and climate change. Individual measures are necessary but not sufficient. Based on cooperative actions or international decisions, countries are trying to reach sustainable development in long run. In this sense, the policy implementations, measures and tools used become more important.

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Chapter 35
Transforming University Curricula Towards Sustainability:
A Euro-Mediterranean Initiative

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ABSTRACT

The UNESCO Chair ICT in Education for Sustainable Development in cooperation with the RCE Crete (Regional Centre of Expertise) on Education for Sustainable Development responding to the UN Decade of Education for Sustainable Development (DESD 2005-2014) took the initiative to establish a North-South Network for embedding sustainability in higher education institutions. A Consortium with 12 universities (six from Europe and six from Middle East) led by the UNESCO Chair and the RCE Crete at the University of Crete prepared a proposal submitted to the Tempus- European Commission programme for funding. The RUCAS (Reorient University Curricula to address Sustainability) project, studied in this chapter, has initiated various activities in the partner countries' institutions, which seem to exert significant curricular changes. The changes include the revision of courses, building the appropriate infrastructure, the development of an online community of practice and the RUCAS Toolkit that are being used as drivers for reorienting university curricula to address sustainability. As a result, a growing number of academics in the partner institutions are concerned with the current sustainability crisis and claim for a transformative shift in what they teach and how teaching is practiced.

ORGANIZATION BACKGROUND

The RUCAS project is initiated by the RUCAS Consortium of 12 Universities and three NGOs financially supported by the European Commission for a three-year period (2010-13) and it is coordinated by the University of Crete, Greece. More specifically, the project aims to:

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1. Support the development of Education for Sustainable Development (ESD) in the Higher Education sector in Egypt, Jordan and Lebanon.
2. Build capacity amongst university staff to embed ESD in curricula and pedagogy.
3. Review and revise undergraduate curricula to address ESD in line with Bologna and Lisbon processes.
4. Assist the coordination and dissemination of ESD policy, research, curriculum reform and practice relating to ESD in the partner institutions that are expected to function as role models in the region.

It adopts a multi/inter-disciplinary and systemic approach contextualized in the three partner countries, namely Egypt, Jordan and Lebanon. The approach entails the following key outcomes:

- Establish continuous dialogue with university faculties regarding directions and means of education for sustainability.
- Develop ESD competences for university students contextualized to the European Union and Arab region.
- Evaluate ESD student competences in the participating Higher Education Institutions (HEIs).
- Establish and apply a Virtual Learning & Management System for running a community of practice in reorienting university curricula to address sustainability.
- Develop an ICT-based training Toolkit on ESD curriculum reform and innovation in Higher Education, reflecting the ESD student competences framework.
- Establish Virtual Training Centers in each partner university to support the process of reorienting university curricula to address sustainability.
- Build capacity amongst university staff to review, revise, infuse and embed ESD in undergraduate university curricula; and institutionalize and disseminate ESD curriculum reform.
- Apply and evaluate the revised university curricula with respect to the ESD student competences.
- Bridge the gap between HEIs and society through the placement of at least 100 students from each of the six partner institutions (600 in total) in the Arab partners in local stakeholders dealing with ESD local/regional issues.
- Promote reorienting HE towards ESD as a viable avenue for "whole institution" curriculum reform, research and teaching across all HEIs in the Arab region and the other member institutions.

Transforming university curricula towards sustainability is defined as a process that integrates ecological integrity, social and economic justice and human wellbeing into course content and instructional methodologies. This definition places faculty at the center in curriculum transformation. It has been argued that learning processes which can enable transformative changes largely depend on academic staff and their capabilities and willingness to support such processes (Hegarty, 2008; Ceulemans & De Prins, 2010; Barth & Rieckmann, 2012). Embedding sustainability in the university curricula is therefore seen as a process and praxis in transforming faculty perspectives and increasing their active global competence and sustainable citizenship. Sustainability does not simply require an 'add-on' to existing structures and curricula, but implies a change of fundamental epistemology in our culture and hence also in our educational thinking and practice. Seen in this light, sustainability is not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organisational change, of policy and particularly of ethos (Sterling, 2004, p.50).

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SETTING THE STAGE

Who Is Involved in the RUCAS Initiative?

The RUCAS Consortium consists of 12 universities, six from European Union (EU), namely: University of Crete, Greece, Dublin City University, Ireland, University of Athens, Greece, University of BordeauxIII, France, University of Stockholm, Sweden & University of Padova, Italy and six from Egypt (Heliopolis University & Suez Canal University), Jordan (Hashemite University & University of Jordan) and Lebanon (Notre Dame University & La Sagesse University), as well as three NGOs (SEKEM, MIO/MEdIES & IndyACT). The University of Crete, as the leading University supported by the other EU Universities has the task to coordinate all the processes and practices to achieve the set objectives and outcomes in the six Middle Eastern Universities.

Challenges Identified for the RUCAS Initiative to Consider

- The great challenge of the 21st century for institutions of higher learning is to train professionals who are critical of, and capable of acting in transforming their frames of reference to achieve sustainable development goals and objectives.
- Although, interdisciplinary teaching and learning is highly prioritised in the participating institutions, in practice, there is lack of interdisciplinary perspective and motivation among teaching staff. Interdisciplinary collaboration is essential for modernizing higher education and it is a necessary condition for any transformation to meeting the challenges of climate change and sustainable development in the region.
- Reorienting university curricula to address sustainability (RUCAS) is very urgent and necessary to equip graduates with knowledge, skills, perspectives and values of sustainability so as to assume responsibility for creating a sustainable future and lifestyle.
- The greatest educational impediment to facilitating inquiry and asking critical questions may well be the linear way of viewing course content and pedagogy. Reflective inquiry is thus needed for engaging learners in dealing with complex sustainability issues and constructing meaning.
- A division of knowledge into fields of specialization continues to characterize modern educational systems, which challenge the RUCAS participating institutions.
- Lack of staff readiness to address sustainability issues from a transformative perspective is observed.
- Existing administrative and other infrastructures were not ready to respond to and support the transformation of university curricula to address sustainability.

The emphasis here is placed on the role of academic staff and staff capacity building programmes as one potential catalyst for transforming university curricula to address sustainability considering four main questions. The first main question is a "*What*" question, and focuses on which competences a student graduating from a university should have in relation to sustainable development. The second main question is a "*How*" question that focuses on how can the pedagogical processes make the sustainability competences achievable. The third main question is a "*Where*" question that looks at the perspective of the curriculum for promoting a 'transition from transmissive education to transformative education. The fourth and last question is a "Whom" question that focuses on the roles and readiness of academic staff

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to implement curriculum and pedagogy transformation towards sustainability. In this context this paper describes the case of a Euro-Mediterranean initiative and analyses the extent to which this programme has contributed on transforming curricula changes in partner universities.

CASE DESCRIPTION

Defining Sustainability Competences: The "What" Question

The term "competency" or "competence" echoes everywhere and it has generated hot debates in terms of its definition and application (Barth et al., 2007; Rauch & Steiner, 2013). Drawing on the OECD DeSeCo work, Rychen and Salganik defined competence as

the ability to successfully meet complex demands in a particular context through the mobilisation of psychosocial prerequisites (including cognitive and non-cognitive aspects' and as the 'internal mental structures in the sense of abilities, dispositions or resources embedded in the individual' in interaction with a 'specific real world task or demand'. (Rychen and Salganik, 2003, p.43)

The concept of Gestaltungskompetenz in Germany is characterized in particular by key competencies that are required for forward-looking and autonomous participation in shaping sustainable development (Seitz & Schreiber, 2005; De Haan, 2006). The Gestaltungskompetenz concept can be viewed as a combination of the emancipatory and the instrumentalist approach to ESD, as it emphasizes both individual autonomy and active participation in societal transformation.

Measuring Sustainability Competences

A framework consisted of three levels has been developed to be used as a guide for the design and validation of ESD-related competences for students at the university level (Makrakis et al., 2012). The first level refers to the process of identifying the initial corpus of generic and disciplinary ESD competences (conceptualisation). The second level leads to the development of a consensus-based corpus of generic and disciplinary ESD competences and its refining through measuring construct validity and reliability analysis (validation). The third level goes further with the verification and possible refinement of competences (implementation). Implementation concerns the effort to verify the piloted scale in the previous step through re-testing its reliability with the target group (Makrakis, 2011a; 2011b). Through consensus reached by 32 panellists, sustainable development was defined as

to making informed, contextual and conscious decisions driven by the principles of solidarity, justice, accountability, equity and transparency for the good of present and future generations, locally and globally and to act upon those decisions for advancing social, economic and environmental wellbeing. (Makrakis, 2011b, p. 411)

Education for sustainable development was defined as

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the learning needed to maintain and improve our quality of life and the quality of life of generations to come. It is about equipping individuals, communities, groups, businesses and government to live and act sustainably, as well as giving them an understanding of the environmental, social and economic issues involved. (Makrakis, 2011b, p. 411)

These definitions were important to panellists in order to generate sample competence items classified as generic (interdisciplinary) and discipline-specific competences. The first may be described as a combination of knowledge, understanding, skills and abilities that all graduates should have and the second related to a specific field of knowledge within a certain academic discipline. The clusters adopted for the generic competences were based on Jacques Delors' UNESCO report *'Learning: the treasure within'* (UNESCO, 1996), which recognizes four pillars for education of 21st Century: 1) learning to know, 2) learning to do, 3) learning to be and 4) learning to live together. We also added the fifth cluster of 'learning to transform oneself and society' that has been later introduced by UNESCO as the 5th pillar. These five pillars were conceptualised and contextualised to address sustainable development issues (Table 1).

Validation of the Sustainability Competences

Cronbach's alpha was computed to examine the internal consistency of the sustainability competence items composed in each of the five clusters that were piloted in one of the partners' institutions. The alpha values for the five clusters ranged from 0.77 (learning to be), to 0.74 (learning to live together), 0.77 (learning to know), 0.79 (learning to do) and 0.76 (learning to transform oneself and society). Reliability tests suggested that screening the data would improve reliability levels. We screened the collected data by discarding items that showed very low corrected item-total correlations, i.e. <0.25. The constructed sustainability competences implemented through a survey in 11 universities that participate in the RUCAS project (Makrakis et al., 2012). The aim of the survey was: 1) to further redefine the items included in each generic competence cluster and discipline-specific competence items and 2) to identify, among other things, the knowledge students get from their courses in relation to sustainable development, the sources of sustainability knowledge, the teaching methods, the attitudes towards learning to live sustainably, the sustainability actions and the perceived functions and roles of universities. The results of this survey would be used for developing the strategy and the capacity-building

Table 1. Clusters defined in the context of education for sustainability

Cluster	Definition
Learning to be	This type of learning concerns all the processes and practices that lead to human self-actualisation, self-regulation and cultivating a sense of being versus having.
Learning to live together	This type of learning concerns all the processes and practices that lead to a peaceful and non-discriminatory society and human co-existence with the natural world.
Learning to know	This type of learning concerns all the processes and practices that lead people to experience, construct and transform knowledge for making sustainability a mode of life and being.
Learning to do	This type of learning concerns all processes and practices that lead to merging knowledge with action for building a sustainable future.
Learning to transform oneself and society	This type of learning concerns all the processes and practices to transform their unsustainable values and behaviours and collectively engaged to change society towards sustainability.

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programme for reorienting university curricula to address sustainability. The study population was set to include all final year students of six academic disciplines, namely: educational sciences, social sciences, applied sciences, business/economics sciences, technical sciences and health sciences. In total, 3757 replies were collected among the 11 university partners: 54% females and 46% males. In terms of student geographic composition, 62% come from the three Middle East countries (Egypt, Jordan and Lebanon) and the remaining 38% from Europe (Greece, France, Ireland, Italy and Sweden). There were variations among the country samples, with the higher response from Jordan (39%) and the lowest from Ireland (1%). The variation is mainly due to the number of disciplines involved in each country and the size of institutions. After several screening attempts, 54 items remained in our final pool of items. Reliability levels for the reduced clusters of sustainability competences came as 0.86 (learning to be), to 0.85 learning to live together), 0.87 (learning to know), 0.88 (learning to do) and 0.86 (learning to transform oneself and society). Table 2 summarizes the correlation matrix along with variables' means and standard deviations. The five clusters of perceived sustainability competences correlated significantly with each other and with the overall index of perceived ESD competence. The highest correlation between the variables comprising the four dimensions perceived ESD competence quality was between learning to know and learning to live together (Pearson's $r= 0.90, p<0.01$), whereas the lowest correlations were those between learning to live together, learning to know, learning to transform oneself and society and learning to be (Pearson's $r= 0.58, p<0.1$). In addition, the five clusters of perceived sustainability competences correlated significantly with the total sustainability competence scale, ranging from $r= 0.80$ *to* $0.88,$ at $p<0.1$. Similarly, Table 3 summarises the correlation between the five generic clusters of education for sustainable development competences with the six discipline-specific competences for applied sciences, economics/business sciences, educational sciences, health sciences, social sciences and technical sciences. The correlations range from 0.45 to 0.71 at p< 0.01 level. The results clearly give further credence to the sound psychometric properties of the sustainability competence instrument.

The RUCAS Approach: The "How" Question

The RUCAS survey revealed that, 30% of the 3.757 students have taken courses directly related to sustainable development, 50% have taken courses including some aspects of sustainable development and 21%

Table 2. Correlation matrix among the clusters and the total competence scale

	Ltobe	Ltlt	Ltknow	Ltodo	Lttrans
Learning to be	1.00				
Learning to live together	0.58**	1.00			
Learning to know	0.58**	0.90**	1.00		
Learning to do	0.64**	0.74**	0.74**	1.00	
Learning to transform	0.58**	0.63**	0.63**	0.72**	1.00
Total	0.81**	0.83**	0.83**	0.88**	0.80**
Mean	4.4	3.9	3.9	4.1	4.2
S.D.	0.80	0.88	0.88	0.85	0.85
N	3519	3570	3570	3450	3410

**p< 0.01(2-tailed)

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Table 3. Correlations between generic ESD competences and discipline-specific ESD competences

Generic Competences for S.D.	Mean (1- 6)	Discipline-specific Competences for Sustainable Development					
		App. Sc.	EconSc.	Edu.Sc.	Health Sc.	Soc. Sc.	Tech Sc.
Learning to Be	4.4	.45**	.38**	.47**	.57**	.57**	.60**
Learning to Live Together	3.9	.46**	.50**	.48**	.56**	.65**	.45**
Learning to Know	3.9	.62**	.56**	.44**	.62**	.66**	.66**
Learning to Do	4.1	.60**	.61**	.56**	.57**	.67**	.70**
Learning to Transform	4.2	.59**	.70**	.60**	.71**	.66**	.67**
Mean		3.7	4.0	4.0	3.9	3.6	3.7
Standard Deviation		1.0	.81	.95	.86	1.0	.83
Number of students		880	611	773	306	594	130

**p< 0.01(2-tailed)

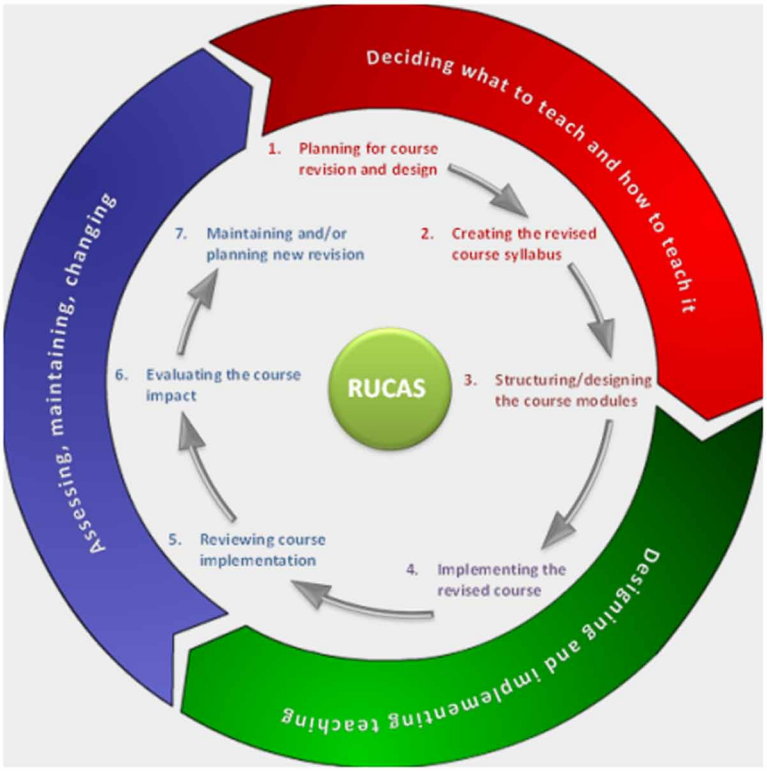
have done a course assignment or project that concerns sustainable development. Comparing European and Arab students, the corresponding results for Arab students are 20%, 48% and 12%, while for European students are 23%, 50% and 19% respectively. In terms of academic disciplines, the survey shows that the most active in embedding sustainable development in their curricula are the disciplines of Business/ economics followed up by Educational Sciences. The least active ones are those of Health Sciences and Technical Sciences. When students were asked to rank the key sources of information about sustainable development, the Internet was ranked first by 37% among EU students and 63% among Arab students and even higher than university courses (20% for EU students and 16% for Arab students). Surprisingly, Radio scored much higher (33%) than university courses (16%) and TV (16%) among Middle Eastern students. The average means of the generic ESD competences as depicted in Table 3 show a range from 3.9 to 4.2 on the six-point scale. Similarly, average means of the discipline-specific competences show a range from 3.6 to 4.0. The fact that some courses related to sustainability have been introduced cannot be seen as an adequate response to the current sustainability crisis. Things cannot be changed by just adding and/or embedding sustainability in one or two courses being taught with conventional pedagogical methods. It has been revealed that most of the students (62%) rated lecturing as the most dominant teaching method, while other teaching and learning methods such as place-based learning (15%), inquiry-based learning (16%), problem-based learning (17%), discovery learning (16%), inter-disciplinary teaching (20%), which are suitable with learning to live together sustainably, are much less evidenced in higher education pedagogies (Makrakis, 2012). These findings suggest there is need for a revised curriculum, not only in terms of content, but also in terms of teaching and learning methodology, including learning processes such as values clarification and critical reflection.

Accordingly, we have made two key decisions: first, to develop a strategy for reorienting university curricula to address sustainability that ended up to the RUCAS Model consisted of seven interactive and cyclical processes to respond to three critical questions: 1) what to teach and how to teach it; 2) how to design and implement a course and 3) how to ensure that students are learning what is being expected (Figure 1). The RUCAS model provided the guiding instrument in the course revision, implementation and evaluation process to address sustainability.

Second, we have adopted Makrakis and Kostoulas-Makrakis (2012a) ExConTra learning model depicted in Figure 2. This model is underpinned by experiential (Kolb & Kolb, 2005), constructivist

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Figure 1. The RUCAS Seven Step Model

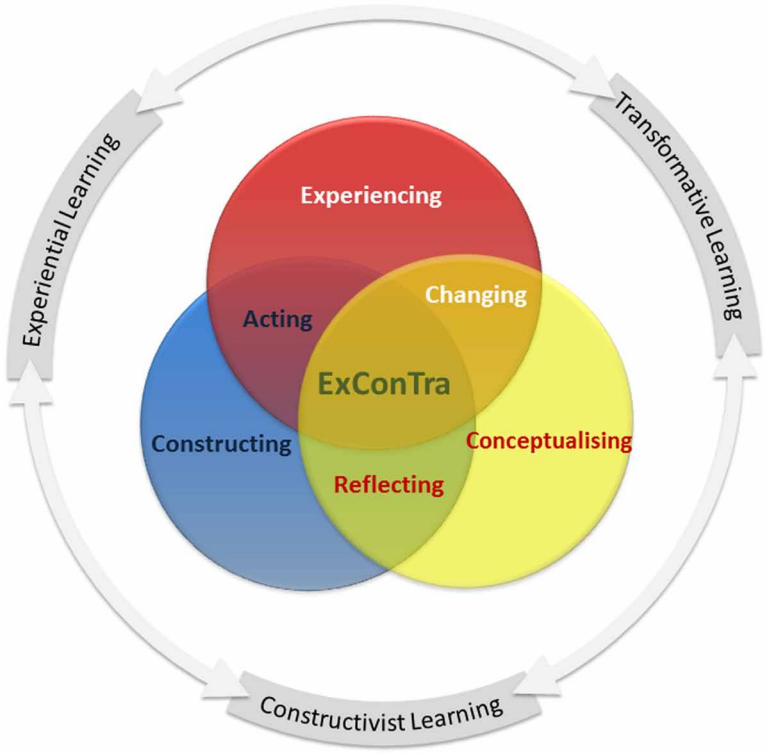


(Jonassen, 1999) and transformative (Mezirow, 2000; Marsick & Mezirow, 2002) theories of learning and is associated with educational approaches such as inquiry and discovery-based learning (Hai-Jew, 2008; Balım, 2009; Alfieri et al. 2011), case-based learning (Carroll & Borge, 2007; Lee et al., 2009), service learning (Shumer & Duckenfield, 2004; Simons & Cleary, 2005), place-based learning (Ault 2008; Gruenewald & Smith, 2008; Smith & Sobel, 2010) and reflective/reflexive learning (Kostoulas-Makrakis, 2010; Tilbury, 2011). All of these methods are based on the principle that students experience, construct and transform their own versions of reality rather than, simply absorbing versions presented by others. From a sustainability perspective, these methods help to transform unsustainable actions and reconnect people to the natural and cultural world of which they are an organic part.

In the following, three examples will be presented, one from Heliopolis University in Egypt, the other from the University of Jordan and the last from Notre Dame University in Lebanon focusing on an assessment of the extent to which the five pillars of sustainability competences were integrated into the revised course curricula to address sustainability. The assessment was based on peer-review carried out by a team of experts from three EU partner universities. More specifically, Dublin City University expert team was assigned to review courses revised in the Egyptian partners, an expert from Heliopolis University was assigned to review the Lebanese partners and another one from University of Padova was assigned to review the Jordanian partner universities. The methodology for peer-reviewing used an open-ended instrument that covered various dimensions of course curriculum revision for sustainable education substantiated by class observation and focus interviewing.

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Figure 2. The ExConTra Learning Paradigm



In the case of Heliopolis University, 34 courses within the disciplines of Business, Engineering and Pharmacognosy were reviewed by the DCU team in April 2013. In general, all revised courses have infused sustainability, some to a greater extent, such as: Living Economics; Money & Accounting; Sustainable Development; and Pharmacognosy I, II. A number of innovative projects have been noticed, such as the 'Water is Life project' that straddles several different disciplines. Results summarised in Figure 3 show that there is an emphasis on sustainability aspects related to preparing learners to know and do, while there is less emphasis on sustainability aspects related to preparing learners to reflect on own values base (Learning to Be), or on how learners can contribute to peaceably "Live Together," or on how learners can act as Agents of Change (Learning to Transform Oneself and Society). It has been also observed that there is creative engagement between lecturers & students, especially through the student engagement in real-world project based learning. Examples of real-world projects are the ones on an Engineering project on hybrid cars and "IT and Sustainable Development". In discussions with management, it was also evident that there is a high degree of commitment to the infusion of sustainability in all aspects of University life. A Summer Internship programme was seen as an excellent initiative, providing practical experience in partner companies within SEKEM, as well as other institutions, factories, farms etc.

In the case of the University of Jordan, 11 courses within the disciplines of Math teaching, International Finance, Finance Analysis and Multimedia Programming, were reviewed by the University of Padova reviewer in June 2013. As Figure 4 shows, there is an emphasis on sustainability competence aspects for preparing learners to know and do, but less emphasis on preparing learners to reflect on own values base (Learning to Be), or on how learners can contribute to "Learning to Live Together," or on how

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Figure 3. Integration of the five pillars of sustainability competences in Heliopolis University

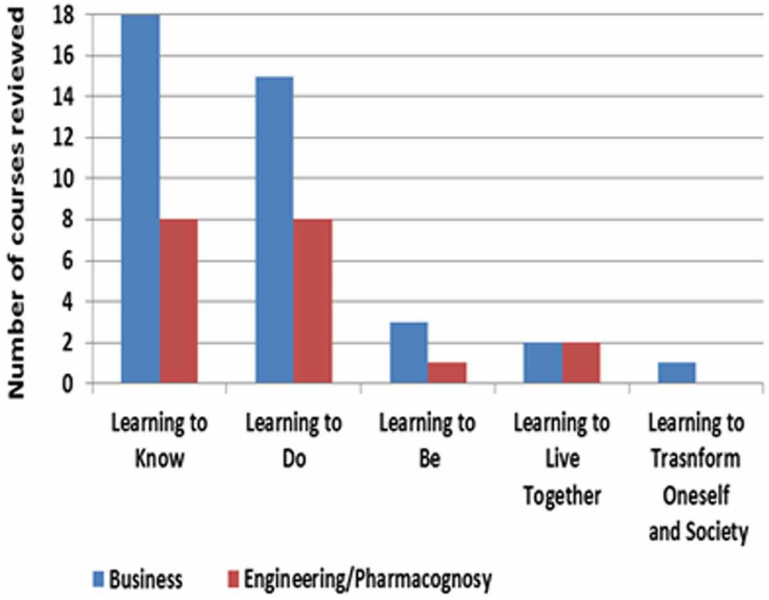
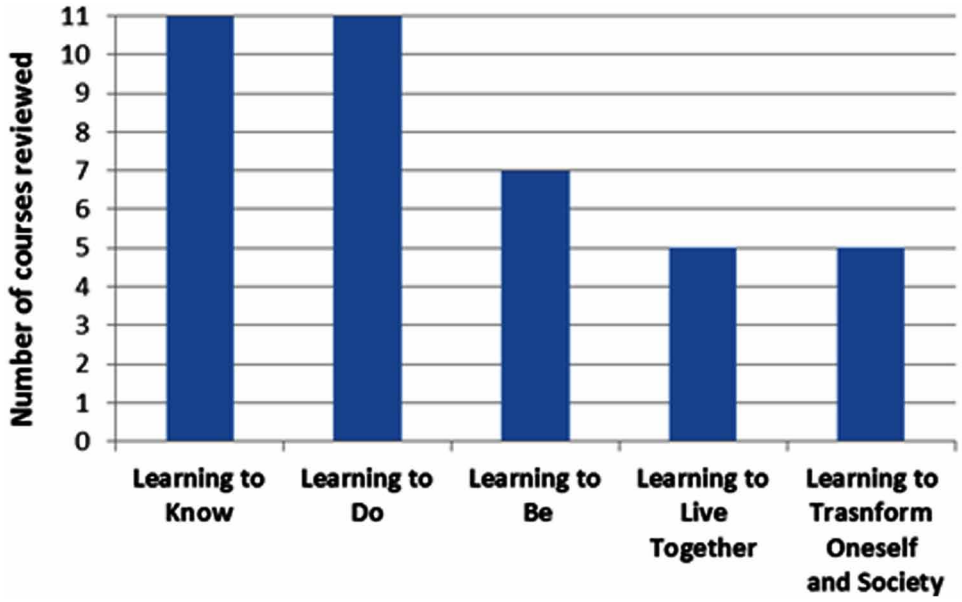


Figure 4. Integration of the five pillars of sustainability competences in University of Jordan



learners can act as "Agents of Change" (Learning to Transform). Various practicum assignments were developed placing students in relevant community sites. For example, a student practicum concerned 'Environmental education for the young child' that aimed to improve the physical environments at the College of Education in the University of Jordan. Another practicum focused on working with community institutions, such as orphanage and home for the elderly. Another practicum involved students in

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working with children and teachers from public and private schools to improve their understanding of their environment, and the importance of sustainable development. Working as volunteers to help poor children by picking olive trees from a farm and taking 1/3 of the crops for poor children was another innovative practicum developed by students at the University of Jordan. Designing a Learning Center at the University of Jordan Kindergarten can be also counted as an innovative practicum assignment. The Learning Center includes: hand made puzzles to improve thinking skills; stories; thinking games and learning materials from recycled items. 'Designing a digital story' and 'Solve problems regarding international finance crisis' are other practicum assignments developed by students participating in the revised courses.

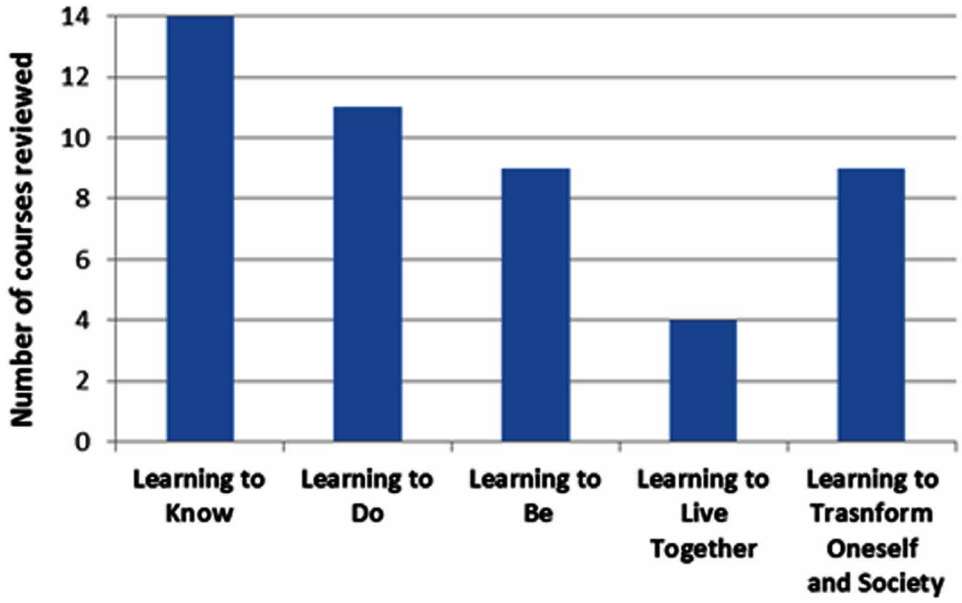
In the case of Notre Dame University-Louaize in Lebanon, a total of 14 revised courses within the Faculties of "Business Administration and Economics," "Engineering" "Nursing and Health Sciences," "Natural and Applied Sciences," "Engineering," and "Political Science, Public Administration and Diplomacy" were reviewed by the Heliopolis University team in May 2013. All of the courses reviewed had sustainability infused in them albeit to greater and lesser degrees. It was found that the courses that were most interesting were, "Economics of developing countries" and "Air Pollution Engineering". Practicum student assignment developed within the first course are 'Groundwater pollution and its impacts on development in Lebanon', involving stakeholders such as the Federal Institute for Geosciences and Natural Resources-Lebanon. Another practicum assignment focused on 'Child labor', involving among others the Ministry of Social Affairs-Lebanon. Other practicum assignments focused on reducing youth unemployment, involving various schools such as Jesus and Mary, Saint Joseph and Champville as well as the Lebanese American University; 'Agricultural development', involving the Ministry of Agriculture-Lebanon and Cenacle Libanais pour la protection de l'environnement; 'The effect of oil extraction on economic development in Lebanon', involving the Ministry of energy and water resources and the Ministry of economy; and 'Sports in Lebanon: A potential tool for development and peace', involving the Ministry of youth and sports and the Federation Libanaise du Basketball (FLB). In the context of the "Air Pollution" course, practicum assignment developed are 'Assessing Particulate Matter Pollution at a Construction Site in Keserwan' and the 'Air Pollution Impact of Private Generators in Sahel Alma and Haret Sakhr, involving the municipalities of Haret Sakhr & Sahel Alma; 'Noise Pollution of a Building Under Construction in Metn on the Surrounding Environment' and the 'Emission of Pollutants from cars at NDU-Louaize' and 'Measuring Indoor Air Pollution at Different Locations in NDU-Louaize. As Figure 5 shows, with the exception of the pillar "Learning to live together," that seemed to be neglected by most of the courses, all others are sufficiently represented in the courses reviewed. In particular, there is an emphasis on preparing learners to know and do, and a bit lower but equal emphasis on preparing learners to reflect on own values base (Learning to be) and on how learners can act as "Agents of Change" (Learning to Transform).

The RUCAS Curriculum Perspective: The "Where" Question

Considering curriculum perspectives, it is of particular importance to examine current curricula to identify where they are focused and to where should be directed in light of current trends and sustainability crises. In terms of academic disciplines, Table 4 shows that the most active in embedding sustainable development in their curricula are the disciplines of Business/economics followed up by Educational Sciences. The least active ones are those of Health Sciences and Technical Sciences. Interpreting the average means of the discipline-specific competences related to sustainability, ranging from 3.6 to 4.0 of

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Figure 5. Integration of the five pillars of sustainability competences in Notre Dame University



the six-point scale together with the overwhelming dominance of lecture-based approaches to teaching, university curricula in the RUCAS participating higher education institutions needed a re-examination of their orientation.

It is often said that education plays a dual role. On the one hand, it reproduces certain aspects of current society and, on the other hand, it prepares students to transform oneself and society. Although, these roles are not necessarily mutually exclusive, curricula tended in the past to reproduce an unsustainable culture rather than empowering citizens to think and work towards a sustainable future (Makrakis & Kostoulas-Makrakis, 2012b). Sterling (2001) sets out what the role of education could/should be:

- To replicate society, culture and citizenship: A socialisation function.
- To train for employment: A vocational function.

Table 4. Sustainable development curriculum experiences by academic disciplines

Disciplines	SD courses taken		Relevant to SD		SD assignments		No
	No	Yes	No	Yes	No	Yes	
Education	65%	**35%**	38%	**62%**	76%	**24%**	800
Sciences	70	30	48	52	84	16	915
Technical Sciences	83	17	70	30	86	14	423
Health Sciences	86	14	62	38	94	6	325
Soc. Sciences	70	30	55	45	73	27	763
Business/Ec.	54	**46**	34	**66**	65	**35**	414
Total	70%	**30%**	50%	**50%**	79%	**21%**	3640

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- To develop the individual: A liberal humanist function.
- To encourage a fairer society and a better world: A transformative function.

The last role is seen by Sterling as central to achieve a more sustainable educational system. The first two roles mirror ideologies adherent to curriculum as product, the third, curriculum as process and the fourth curriculum as praxis. Curriculum as product is principally based upon an objectivist approach – seeing knowledge as something stable that should be replicated in learners' minds, decontextualized from social reality and perceived as existing independently from learners' experiences. A division of knowledge into fields of specialization continues to characterize modern educational systems, including in the RUCAS participating institutions with some variation. Such a curriculum orientation functions as a bottleneck to turning these institutions into sustainable universities. This forces university teaching staff to view knowledge from a compartmentalised perspective that leads to serving and maintaining a culture of unsustainable production and consumption. In decontextualized learning, curricula and teaching methodology are mainly used in the context of instrumental rationality and technical interest in knowledge, which does little to develop human self-realization and critical discourse (Makrakis & Kostoulas-Makrakis, 2005; 2012). A curriculum as process is not a prescribed body of knowledge to be transferred, but rather an active process that links with the practical form of reasoning (Grundy, 1987). In this sense, the curriculum is being considered more open-ended than a prescribed body of knowledge, setting an emphasis on interpretation, judgment and meaning making. Curriculum as praxis moves beyond process, as it integrates in its conception an emancipatory knowledge interest, not just a practical one.

Assessing the students' preferences towards the roles universities can play and the curriculum that these roles support shows what values are dominant and what directions are needed to be taken as well as how to better understand the extent to which sustainability principles drive curriculum development. Taking into consideration the whole sample of the RUCAS survey, it is evidenced a clear trend towards the transformative function, that sees a university as an agent of change towards a fairer society and a better world. More specifically, 42% of students indicated that function compared to 6% that perceived the university's role to replicate society and culture and promote citizenship. When taking into consideration the country of students, perceptions are spread between the liberal and the transformative role. Italian and Irish students indicated a clear preference to the liberal role, in contrast to the Greek (56%) and Jordanian (46%) students who were oriented towards the transformative role. It is interesting to note, that the Egyptian students' preferences are situated between the socialisation (28%) and the transformative (37%) role. A more balanced preference between the liberal and transformative role was revealed among the French, Swedish and Lebanese students. Similarly, a more balanced preference is revealed between the vocational, liberal and transformative role among Lebanese students.

Although, the students' perspectives with respect to the role and function of higher education is directed towards the transformative function, the peer-review on the revised courses shows that the corresponding pillar or cluster of "Learning to transform oneself and society" competence was integrated in less than half of the courses peer-reviewed, with the exception of the Notre Dame University-Louaize. Students must not only acquire new skills and information through transmissive and constructivist approaches, but also critically reflect and radically transform their own perspectives, knowledge and approaches to thinking and learning.

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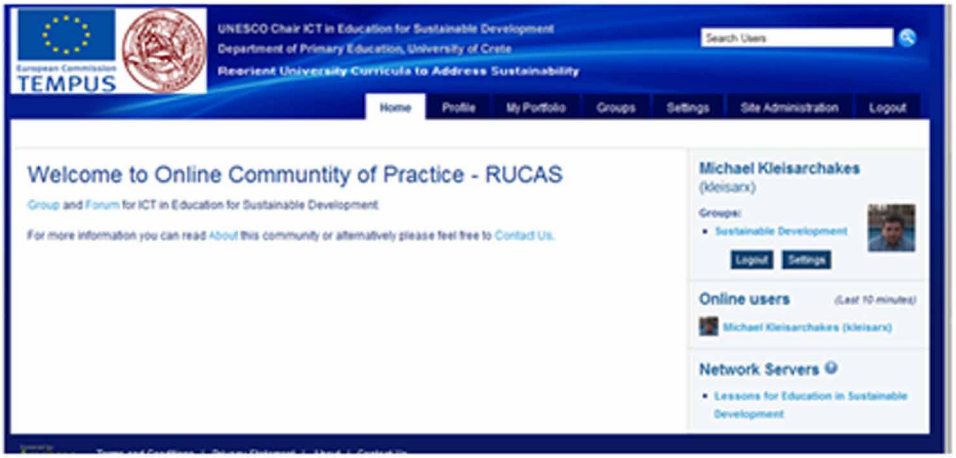
Preparing Academic Staff for Transforming Curricula: The "Whom" Question

The great challenge of the 21st century for institutions of higher learning is to train professionals who are critical of, and capable of acting in transforming their frames of reference to achieve sustainable development goals and objectives. To facilitate and strengthen the transformation of university curricula towards sustainability in the partners' universities, an online community of practice (OCoP) has been developed that gives access to all academic staff in the partner institutions (http://community.cc.uoc.gr). The RUCAS OCoP (Figure 6) considers university instructors as part of a "critical community" of practitioners committed not only to improve the quality of teaching and learning in their institutions, but also to transform those structures, practices and behaviours that provide constraints to turning their universities into sustainable ones. It provides a virtual space in which university staff and other practitioners across its consortium members can come together, share stories and experiences, and solve problems pertaining to the RUCAS tasks and activities. Although, the OCoP is restricted to the academic staff involved in the RUCAS project, it is planned to be open to every interested university that wants to be associated with the RUCAS Sustainable Universities Network.

Two types of participation among members of the OCoP have been identified: 1) active participation and 2) peripheral participation. As depicted in Figure 7, university staff participating in the RUCAS project used the OCoP tool to formulate discussion groups/forums, upload revised course syllabi, use the space provided as a repository for teaching materials, guidelines, publications and so forth. About one third of the more than 100 members of the RUCAS OCoP can be considered as active participants. The rest can be considered as peripheral participators, who read and benefit from its tools and resources without contributing themselves.

The RUCAS OCoP played a critical role in the three regional workshops aimed to get the academic staff ready to transform their courses and pedagogies. The first regional workshop was held at the Notre Dame University-Louaize in Lebanon (October 2011) with the aim to introduce academic staff to the teaching methods, concepts, principles, processes and practices in ESD curriculum design and revision for Higher Education. The specific objectives were to: 1) build capacity amongst university staff in the partner universities of Egypt, Jordan and Lebanon to embed ESD in curricula and pedagogy and 2) review

Figure 6. The RUCAS OCoP



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Figure 7. The RUCAS repository



and revise undergraduate curricula to address ESD in line with Bologna and Lisbon processes. Through this workshop, 52 participants discussed why there was a need to re-orient university curricula to address sustainability and identified ESD themes, teaching methods, goals and competencies to be addressed within their curriculum design and practice. A particular model for ESD curriculum re-orientation was also presented and discussed. The first regional workshop paved the way to the second that was held in Cairo January, 2012. In the second regional workshop 35 academic instructors were to review the produced revised course syllabi and present experiences from their practices. In particular, the emphasis was placed on reviewing existing courses and teaching methods to address issues that are pertinent to education for sustainability through the infusion approach.

All members of the group participated in a rich discussion and provided feedback and suggestions of how to infuse ESD and obstacles that partner universities might face. The keyword that members identified as the means to infusion was 'contextualizing' examples within ESD without undermining the main concepts of the original course. Results of this discussion were evident in the session that followed. In the 3rd Regional Workshop held in Amman April, 2012, 40 participants:

- Examined the implementation process of the revised courses during the spring semester.
- Discussed the process and outcomes of disseminating the ESD-student competence survey results through publications in international journals and conferences as well as the general dissemination activities for the project.
- Prepared suggestions and a catalogue for course revisions and new courses in the disciplines of educational sciences, technical sciences, health sciences, applied sciences, business/economic sciences and social sciences for the next academic year.
- Discussed the strategies for the institutionalisation of ESD in the partner institutions.

A particular emphasis was also placed on the student practicum placements in the community. In this context, community engagement work was perceived as an important dimension of ESD since engagement with communities helps to bridge the gap between theory and practice and between universities and

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the broader community. The opportunities for students to engage in service learning programmes which provide them with 'real-life' experience were emphasised. It was widely shared among the participants that engaging students in situations identical with those they are expected to find after graduating and to equip them with the necessary hands-on experience to confront the real-life issues, is of paramount importance in curriculum transformation. Such activities help students to reflect upon their experiences in the real world and to gain a deeper understanding of their role as active local/global citizens and professionals in their respective academic areas and to develop practical skills to apply in real-life situations. To this end, emphasis was placed upon reflective and reflexive practice through the use of particularly developed self and peer-reviewing instruments that ensure quality and facilitate the monitoring and evaluation process of the RUCAS initiative.

CHALLENGES PAST AND PRESENT FACING THE ORGANIZATION

The great challenge of the 21st century for institutions of higher education in general and the RUCAS partner institutions, in particular is to educate students on learning to live together sustainably. This challenge implies that university curricula and teaching methods should be revised and improved upon in order to infuse sustainable development and translate knowledge and critical consciousness into action. Higher education institutions bear a profound, moral responsibility to increase the awareness, knowledge, skills and values needed to create a just and sustainable future. Indeed, higher education plays a critical but often overlooked role in making this vision a reality. Other challenges faced before the start of the RUCAS project were: 1) lack of staff readiness to address sustainability issues from a transformative perspective; 2) lack of understanding about why an interdisciplinary education for sustainability program is needed and 3) existing administrative and other infrastructures were not ready to respond to and support the transformation of university curricula to address sustainability. To this end, reorienting university curricula to address sustainability (RUCAS) was seen as a very urgent and necessary initiative to equip graduates with knowledge, skills, perspectives and values of sustainability so as to assume responsibility for creating a sustainable future and lifestyle. From experiences of RUCAS interventions in different contexts and situations, there are some specific challenges, which have come across.

Challenge 1: Creating a mechanism by which different stakeholders can work together is complex due to different perceptions, interests, experiences and understandings of what is needed and how issues and problems can be handled.

Challenge 2: Training university staff for course revision, especially from different educational and socio-cultural backgrounds is a real challenge. Some may think that they know best and not give due importance to the opinions or perspectives of the others. Some could also raise conflicting ideas and they may be intimidated by others due to different interests, perceptions, culture, and academic background.

Challenge 3: Develop local ownership and self-reliance. From a managerial perspective, issues identified were related to developing local and regional leadership that could sustain efforts to make major transformations at various domains and levels. Also, appropriate coordination among all the Consortium members and working teams for connected related activities was a critical issue.

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Challenge 4: From an organisational perspective, there was an issue of communication, taking into consideration different perceptions of leadership, time, culture, political problems arising in the region, etc.

Challenge 5: From a technological point, one major challenge concerned the supporting infrastructure in terms of coordination and professional development that would foster the attempted transformative actions to change course content and instructional methodologies.

Challenge 6: Students must recognize the limitations of their current knowledge and perspectives. This means that university teaching staff cannot simply transmit knowledge on students. What is required is a true transformation of students' existing knowledge, especially through learning to clarify own values and critical reflection.

Challenge 7: Identifying important learning goals/objectives and outcomes aligned with appropriate feedback and assessment procedure is of critical importance in this process. Ensuring the alignment of learning outcomes, teaching methods and learning activities and assessment tasks is decisive to the course revision process.

Challenge 8: Embedding sustainability in the university curricula is emerging as a process and praxis in transforming faculty perspectives and increasing their active global competence and sustainable citizenship.

Challenge 9: Building of quality assurance systems supported by new information technologies is seen as a key development process.

Challenge 10: Keeping up to date academic staff with disciplinary and interdisciplinary knowledge and skills, especially through professional development and academic rewards is critical to any transformative change planned.

SOLUTIONS AND RECOMMENDATIONS

Referring to the above cited challenges, our experiences show that establishing a 'platform' where you can have an open and continuous discussion or dialogue with different stakeholders is of paramount importance. A face-to-face communication among participants has been proved difficult and costly. Thus, the use of online and offline discussions with key stakeholders and ensure that they are informed regularly and thoroughly is a decisive strategy to the success of any program. Developing local ownership and self-reliance is a managerial perspective that can generate changes and sustain efforts to make major transformations at various domains and levels. Another issue was the level of willingness to get involved in highly demanding tasks. This was tackled through incentives and rewards such as joint publications, certification and so forth. Development of a shared understanding and acceptance of managerial principles among all participants proved to be a critical driver to achieve expected outcomes. Setting-up an internal and external monitoring and quality assurance system is seen very critical. Indeed, distributed leadership is of critical importance together with encouragement for co-production of and sharing knowledge. The building of a supportive infrastructure in terms of coordination and professional development can foster the attempted transformative actions to change course content and instructional methodologies. The establishment of a Virtual Training Center in each partner university is expected to support the process of reorienting university curricula to address sustainability. Similarly, the online community of practice

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(OCoP) and the development of an ICT-based training Toolkit on ESD curriculum reform and innovation in Higher Education can be considered among the key drivers for transformative change. Development of guidelines for strengthening stakeholders' inputs in the curriculum development and implementation has been considered as a critical solution to the demands for capacity-building.

Indeed, one critical move to support academic staff has been the development of a monitoring and evaluation framework to provide guidance about the core teaching and learning approaches used in transforming their courses and pedagogies towards sustainability. This covers basic pedagogic methods, approaches to curriculum design and various quality assurance instruments used across all stages from developing competences to integrating competences in the course revision process as well as self assessment and peer-reviewing. Through critical reflection of biases and assumptions, academic staff involved in the RUCAS project had the opportunity to critically reflect on their understandings, points of view and habits of mind, worldviews, and create transformative learning experiences to alter their frames of reference, teaching practices and course content. Summing-up, other solutions attempted are: obtaining constructive feedback and strengthening the inputs of the key stakeholders; monitoring visits by internal and external evaluators to verify adoption of quality assurance standards; contextualise sustainability taking into consideration local problems and issues; organize symbolic rewards to the most committed ones (e.g. certification, champion awards); identify the barriers and drivers related to their potential contribution; encourage and support strong distributed leadership and support for the change agenda; provide needed materials and resources in a timely manner and appropriate coordination among all working groups.

Our reflections on the processes and practices during these three years revealed a number of key strategic points that should be taken into consideration when implementing such fundamental change in higher education curricula and pedagogy. These include: a commitment for personal and institutional change; designated leadership at institutional and consortium level; a multi-stakeholder perspective; a risk analysis and a plan for change; development and dissemination of appropriate resources; and engagement in capacity-building. Replication and up-scaling are fundamental objectives of the RUCAS project as it provides the opportunity to build on best practices and lessons learned and expand the reach and impact not only within partner institutions, but within partner countries. The issue of up-scaling is inherent in the project itself as the RUCAS project provides a viable avenue for "whole institution" curriculum reform, research and teaching across all Higher Education Institutions in the Arab region.

FUTURE DIRECTIONS INCLUDING RESEARCH

Our experiences and studies with the participation of more than 3000 undergraduate students in European and Middle Eastern Universities indicate that it is very important to develop undergraduate students' sustainability competences and sustainable development issues than developing specialised post-graduate courses. Such an approach will have a greater impact on society, environment and economy besides the increased employability of graduates and the modernisation of universities. Also, the isolation in the partner countries' higher education institutions from the labour market and stakeholder guidance in course design and content has placed sustainable development courses in a marginal position. A multi-stakeholder-driven model for modernising higher education curricula is needed, taking into con-

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sideration the evidence that current efforts to curricula take place within a framework of limited or not any stakeholder consultation. There is a critical need for Middle East universities in light of the climate change challenges their region is facing to cultivate interdisciplinary expertise among their future leaders across many of the societal sectors. Further research is needed to identify and analyse the barriers and drivers of stakeholders' inputs to interdisciplinary curriculum development. Research questions to be considered include the following: What and how much knowledge about sustainability is required in the course? Does the course already include the examination of and the development of perspectives and values that lead to the transition towards a healthy, just, equitable, secure and environmentally sustainable society? To what extent are students encouraged in this course to be aware of the connections between the environmental, social, cultural, political and economic aspects of sustainability? Are the teaching methods used consistent with the values, ethics and principles of education for sustainability? As most failed attempts to embed sustainability cite a lack of leadership, incentives, knowledge, and/or resources when trying to implement new programs or add them to existing curricula, further research is needed to explore barriers and drivers to embedding sustainability in higher education institutions.

CONCLUSION

The RUCAS Euro-Mediterranean initiative through the development of sustainability competences and capacity-building programs to train university teaching staff for embedding sustainability in their academic disciplines is considered a good example for reorienting university curricula to address sustainability. It provides the opportunity to build on best practices and lessons learned and expand the reach and impact not only within partner institutions, but beyond that. Within the three years of the RUCAS initiative, we have transferred expertise from European universities through the organization of three regional workshops in Beirut, Cairo and Amman, where university staff coming from six disciplines have been trained on revising course curricula to embed sustainability. An Online Community of Practice (OCoP) developed is being used as a resource, repository and forum (http://community.cc.uoc.gr/). Almost 250 university courses have been revised to address sustainability across the six prioritised academic disciplines (educational sciences, social sciences, applied sciences, technical sciences, business/economics sciences and health sciences). A pilot initiative for student placement and practicum has been carried out, through which more than 3000 students have been involved in producing collaborative projects dealing with local sustainability issues. The opportunities for students to engage in service learning programmes provided them with 'real-life' experiences. It was also widely shared among the participants that engaging students in situations identical with those they are expected to find after graduating become more equipped to confront with real-life issues.

The interventions carried out by the RUCAS project have contributed significantly in producing a corpus of university teaching staff in each partner university who in turn initiated course curriculum revisions to address sustainability. It has also resulted in shifting traditional approaches to teaching and learning towards alternative teaching and learning methods such as place-based learning, inquiry-based learning, problem-based learning, discovery learning, inter-disciplinary teaching, which are suitable to education for sustainability. It is of particular importance to note that students participated in a survey for mapping their competences related to education for sustainability. They were also actively involved,

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especially through practicum assignments during the implementation of the revised courses. Teaching staff was also involved in developing the ESD-student competence framework that was applied. They also took part in professional development or capacity building workshops to get the needed readiness and involved in the curriculum revision process, the implementation and the assessment of the revised courses. Administrative staff has also taken part in facilitating the process and the local National Tempus Offices organised external monitoring field visits. The revised student courses and the institutional ESD framework policies and practices that are being developed are also expected to be the drivers of change within and among institutions in the partner countries and region.

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Chapter 36
Transdisciplinary Methodology of an Architectural and Urban Discourse in Higher Education

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ABSTRACT

The chapter includes identification of the need for reconceptualization of architectural and urbanistic discourse in higher education and the definition of the transdisciplinary methodology for a sustainable development of the living environment. Architecture and urbanism as complex disciplines that start from the existential social needs and reach to the most complex challenges and aspirations involve complex approaches and complex relations. Professional educational environment from architecture and urbanism aspect is integral. It includes the study of forms and models of urban space planning to architectural structures, details, materials, environmental challenges, as well as new paradigms of shaping life and work in the community. This requires the involvement of various disciplines and forms of knowledge for forming a competent and productive response to modern challenges of the real world. With the development and adoption of transdisciplinary methodology in environmental higher education, a platform can be developed for sustainable urban development in a sustainable social community. Technological aspect has a central role in that process.

INTRODUCTION

Research in this paper is essentially motivated by a tendency to understand the complexity of an urban system, with an emphasis on architecture and urbanism, that is the built environment as a primarily product of activities of these fields. This paper examines the challenges posed by the diversity of opinions and attitudes in a monodisciplinarry action and also the articulation of the challenges of the integrated knowledge from different perspectives. A comprehensive response to the sustainability of the solution

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cannot be provided by none of the standard, linear theories. This leads to the replacement of opinions with an integrated knowledge that promotes the sustainable development of the urban environment. In this context, the reconceptualization of educational methodology in higher education is essential.

Urban expansion policies, intensive urbanization and technical and technological possibilities have led to cities developing into power centers, which are adopting a global city character. On the other hand, questions of urban poverty, urban health, urban decay, brownfield sites, urban regeneration etc. are coming into focus, demanding a higher level of insight in the development and shaping of urban areas. Global approach to research and urban question-solving is an important part of sustainable development, where universities take central place in the process. In that context, collaborative educational architectural and urbanistic discourses with a high level of collaboration can develop an adequate platform for answers to complex questions of 21st century urbanism. Production of professionals with developed conscience for a comprehensive overview of problems and with transdisciplinary collaborative knowledge can strongly contribute to sustainable upgrading, controlling and managing of urban areas.

The aim of education is the production of competent professional intellectual elite for the specific requirements of space and time. This aim is attainable only if we are committed to continuous and integrated model of studying, for layered understanding of the urban environment and the humane and healthy view of social values. These are also the basis for the development of environment of permanent cultural paradigms.

Cultural environment is the most precious asset of the human society, the culture of spatial management has become an important measure of the cultural level of a society in the 21st Century, which can play a decisive role for the future of civilization (Kurtović-Folić & Perović, 2012). Cities are explicit indicators of knowledge, architectural and cultural strength and overall social development. Knowledge and skills are the pillars of development. United engaging discourse and practice and different professional competencies articulatesproductive management of the urban system, its control and improvement.

Architecture and urbanism as broad areas of action include the complexity of the educational system. Complexity involves multiple dimensions and contents of the study program, many layers and cooperation between all factors and levels of the educational process. Complexity of architecture and urbanism as disciplines, suggests and obliges their layered studying that is customized to dynamic social changes and modern conditions of life and work. An important direction in the professional educational environment is to promote the new forms of urban culture and society development, to promote the development of new forms of urban culture and society, through integral engagement, which has been embedded in strategic methodological framework oriented toward research line. Thereby,the educational process is not only the companion of social change, but its driver, and thisis possible to achieveonly by healthy thinking and acting.

The 21st Century involves flexibility and globalization of knowledge. The complexity of the urban system and the complexification of the needs of users of space, requires a complex analysis of various factors and influences that shape the developed environment and facilitate the process of design of architectural and urbanistic programs.

The aim of this paper is to define a new model-general transdisciplinary methodology of architectural and urbanistic discourse in higher education, which will enable the development of a platform for complex analysis of urban problems in purpose of sustainable development of the physical structure of cities. This methodology could be generally applied in other study programs of higher education.

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BACKGROUND

Higher education in the 21st century, in scientific research, is relying primarily on issues of sustainable development and pervasive emphasizing of the need for abandonment of the dominantly disciplinary methodology of education. The term sustainable development has emerged as a response to environmental degradation and an expressed need for global cooperation in order to achieve joint sustainable solutions. Sustainable development is an integrated economic, social, environmental, technological and cultural development directed towards the protection and improvement of the environment. The most cited definition of sustainable development is the Brundtland definition as follows:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Bruntland, 1987).

Issues and encouragement of sustainable development are a global task with diverse and complex challenges (Baker, 2006). In the context of the necessary changes, a more specific definition of sustainable development is as follows:

In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspiration (Brundtland, 1987).

Research shows the need for a new era of social, economic and environmental development that will be based on integrated knowledge.It is important to note that since 1990 there has been a series of declarations proclaimed on sustainability in higher education, which was investigated by various authors (Grindsted & Holm, 2012; Lozano at al., 2013; Wright, 2002).With the goal of sustainable development, declarations, charters, and other promoted documents, dominantly point to the central role of the universities in addressing the issues faced by the modern civilization, as well as to the need for integrated models and paradigms in the curricula of higher education, from the interdisciplinary to the transdisciplinary level.

The significance of the proclaimed declaration is shown by the fact that more than 440 universities in the world have signed the Talloires Declaration, the first Declaration on Sustainable Development in Higher Education (ULSF, 2012), which was created out of the need for urgent solving of problems in the living environment and articulating the directions of sustainability. In the world with most profound changes, environmental education has a leading role in the control and development of urban systems, and is formalized as a key in this process.

In the *Decade of Education for Sustainable Development* from 2005 to 2014, declared so by the United Nations in 2002, the universities have been recognized as important places for the contribution to sustainable development which implies "Reorienting educational programs" (UNESCO, 2005). Regarding architecture and urbanism education, it is important to consider the context of collaborative environmental education, as sustainable, including interdisciplinary collaboration and articulating new methodological challenges of transdisciplinary orientation. Transdisciplinary environmental education involves the production of integrated knowledge and presents the most realistic but also the most challenging methodological choice that can meet the global challenges of the new century.

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ENVIRONMENTAL EDUCATION AND SUSTAINABLE URBAN DEVELOPMENT

In the Declaration of the United Nations Conference on the Human Environment, held in Stockholm (UN Documents, 1972), there is a set of proclaimed principles and strategies for the conservation and development of a productive and healthy environment. Conference in Stockholm has, for the first time on a global level, pointed out the need to integrate environmental education into existing educational systems.

Research methodologies, paradigms, models of higher education by various authors, as well as a number of proclaimed declarations and charters on sustainable development in higher education, have had a significant impact on the transformation of architectural and urbanistic discourse in the world with the most profound changes in society. These changes have particularly been in the spotlight during the last decade that has officially started of the new millennium, which is quite clear an age of intensive transformations, and they are stimulated by the rapid development of technical and technological capabilities, global challenges, and complex environmental problems. However, there are more theoretical discussions and attitudes, while the practice of higher education takes place predominantly in the disciplinary context.

Modern environmental education includes integrity of architecture, urbanism, landscape and interior architecture, art, design and other disciplines, which is particularly evident in the 21st Century when the issues of environment and sustainable development have become more complex. The very description of the city cannot be displayed without analyzing the economy, public policy, civil engineering, history, literature, religion, art, with each discipline having its own domain of research. Architecture is well positioned to offer an adequate synthetic overview (Allen, 2012). Questions of the relations of humans and the environment, history and theory of architecture and urbanism, art, technology, social sciences, ecology, planning and design, cultural heritage, multiculturalism etc., reflect adequately through the integrated architectural and urbanistic activities.

Development of new domains, such as Ecological Urbanism (Mostafavi, 2010), Landscape Urbanism (Waldheim, 2006), Meteorological Architecture (Rahm, 2009), Transurbanism (Brouwer, Mulder, & Martz, 2002) Transarchitecture, cultural tourism etc. pander the need for integrated science and confirm the previous hypothesis. The revised Charter for Architectural Education, from 2011, which was initially approved in 1996, highlights the connection between architecture and other disciplines, "architecture is a discipline which draws knowledge from the humanities, the social and the physical sciences, technology, environmental sciences, the creative arts and the liberal arts" (UNESCO / UIA, 2011). Architecture and urbanism cannot be treated independently in the context of sustainable development, but there has to be a developed, "Awareness of responsibilities toward human, social, cultural, urban, architectural, and environmental values, as well as architectural heritage" (UNESCO / UIA, 2011). The objectives of the Charter for architectural education are

The creation of a global network of architectural education within which individual achievements can be shared by all and that it will enhance the understanding that architectural education constitutes some of the most significant environmental and professional challenges of the contemporary world (UNESCO / UIA, 2011).

Classification of environments on physical environment (natural and built environment) and non-physical environment (social, cultural, political, economical), indicates the importance of integrity of the disciplines, that the space is next to the physical dimensions also cultural and perceptual and ecological.

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It is not sustainable, in light of the global challenges of ecological crisis and climate changes, to study isolated natural and built environment, which places architecture and urbanism in the context of environmental research. "Eco-development, ecosystem planning, bioregional planning, and green and sustainable design are all new ideologies and concepts that place emphasis on resolving environmental problems caused by human activities" (Salama, 2008, p. 109) Urban sustainability is an essential component for the advancement of civilization. "The promotion of sustainability in the design of the built environment is a key-factor for addressing the challenges that mankind faces in response to finite resource availability, ecological deterioration and climate alteration" (Altomonte, 2009, p.12).

The high degree of responsibility in modern society in economic, social, and ecological sense, particularly issues of urban health, is placed on professionals who plan, design, build, manage the built environment. The impact of sustainability that is truly rooted in the program of higher education (Farren-Bradley, Sarah, & Amanda, 2010) allows the articulation of sustainable professional practice.

In theory and professional research there is increasing emphasizing of the role of architecture and urban planning in the process of sustainable development, through the creation of directives and methods that put green building in the focus in the domain of evaluation of property. The most common and most influential international environmental methods for assessing environmental impact are: Leadership in Energy and Environmental Design (LEED), developed in 2000 by the U.S. Green Building Council (US-GBC) and Building Research Establishment Environmental Assessment Method (BREEAM), founded in 1999 by the Building Research Establishment (BRE).

Architectural and urbanistic works with specific aesthetic and technical values and an environmentally sustainable design are the requirements in contemporary city shaping. Such courses of action cannot be developed without adequate professional training. Students should acquire adequate knowledge on the impact of environmental, structural and technological issues, planning, design and construction of space as well as artistic disciplines (The European Higher Education Area, 2010).

The last decade has significantly changed paradigms and architectural education reforms in Europe and in the world. It has caused the inadequacy of the application of certain directives in the context of rapid economic change and its reflections on the equally rapid changes in society (Spiridonidis, 2011). Architectural and urbanistic curricula include the production of professional elite that is prepared to meet the challenges in planning and shaping of the modern built environment and with a clear vision of sustainable development. Sustainability is a core issue of architecture, which needs to be integrated into the architectural program at the global level (Wright, 2003). Environmental education plays a central role in articulating and promoting of sustainable solutions in a time of intense technological and social changes.

RE-CONCEPTUALIZATION OF DISCIPLINARY METHODOLOGY IN ARCHITECTURAL AND URBANISTIC DISCOURSE

The key initiator of sustainable social development are the universities. Sustainable higher education involves a re-conceptualization of conventional methodology in higher education with study curricula of traditionally linear orientation. In order to develop sustainability in higher education, which is constituted by declarations, increasingly university programs are being directed to review and revise the current curriculum. It is certain that radical transformations are necessary in the methodology of higher education, which is designed, predominantly, on disciplinary grounds. Modern higher education implies sustainable curricula across all levels, which refers to the highest forms of cooperation. Integrated knowledge, that

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involves intensive and integrated collaboration between disciplines and stakeholders, will have a more certain preparedness to face the challenges of sustainability, resilienceand vulnerability that dominate the contemporary study of the modern city. Urban expansion and global processes point to the importance of choosing the methodological approaches to the analysis, research, and specific interventions in urban space. Human activities on the one hand produce wealth in the cities, and in parallel, studies show that poverty and fragmentation occupy a significant position in the urban system. Understanding of architectural and urbanistic discourse as central to collaborative environmental educational process, creates space for the articulation of integrative educational methodological paradigm in the context of sustainable development of the built environment. It is unrealistic to encourage disciplinary methodological transformation and development in modern high education, in the context of the sustainability paradigm. Contemporary architecture and urbanism include planning and design of the built environment in the atmosphere of intense: social, economic, environmental, technical and technological changes, diverse opportunities and challenges. Global influences, environmental conditions, climate change, and global requirements, transportation systems and infrastructure with the technological possibilities point to the new position of architectural and urbanistic work with multidimensionality and multidisciplinarity emerging to the fore. It is getting more difficult to study architectural and urbanistic discourse fragmentary, especially due to a number of disciplines involved in the creation of environmental sustainability. Environmental sustainability requires an integrated system process in the development of the built environment and a high degree of collaboration between different disciplines, which must involve integrated knowledge. Re-conceptualization of conventional methodological paradigms of higher education transforms the disciplinary linearity into a transdisciplinary infrastructure network of innovative, productive learning methodologies. Limitations of conventional and conservative disciplinary educational methodology interpret the articulation of awareness through new challenges based on the principles of connectivity, holistic and collaborative levels of reality. Starting from the physical ambient in which the process of education is being conducted, architecture and urbanism are harder seen as specific and independent units: industrial design, parametric design, management, engineering, urban health, regional and local conditions cannot be partially investigated. The need for an integrated intellectual research has been formalized.

In the conventional framework of higher education, an innovative approach to sustainable education involves joint action learning, with Juisto, McCauley and Stephens (2013) state processes, opportunities and challenges of shared action learning through five stages:

(1) Project impetus, (2) Contextual research and project planning, (3) Community engagement and project refinement, (4) Action, and (5) Reflection and reporting. The key theory of urban sustainability for effective education is a holistic view through collective action, which is "critical thinking; holistic or systemic thinking; long-term orientation; engaged, participative learning (in contrast to passive or spectator sports-like behavior); collaborative learning; timely feedback; and learning in cyberspace-as-classroom. (Banai, 2012)

Out of different levels of reality, Disciplinarity, Multidisciplinarity, Puridisciplinarity, Crossdisciplinarity, Interdisciplinarity, Transdisciplinarity (Max-Neef, 2005; Georgescu & Georgescu, 2012), unlike others, the highest level of integrity - transdisciplinarity works between and beyond disciplines, with a unique methodology aimed to solve common problems. The focus is on the problem, and the autonomous action of disciplines is unacknowledged. Sustainability of autonomous action of disciplines, up to

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interdisciplinary, it is not certain. Global urbanization, economic instability, as well as increased awareness of the environmental crisis has sparked a different way of thinking about the design methodology, one of interdisciplinary orientation (Allen, 2012). Interdisciplinarity, which is increasingly present in the curricula of higher education in the field of architecture and urbanism, has a tendency to develop relationships between social, economic and environmental factors that influence the development and transformation of the contemporary cultural landscapes. The bodies of knowledge originate from different disciplines and are necessary for the successful creation of the built environment, and the importance of awareness of the role of architecture and urban planning in order to improve the quality of life through sustainable cities is primary. Interdisciplinarity contains as an essential feature the identification of certain attitudes and issues that cannot be explained through the disciplinary methods and theories, as well as the diagnosis of complex and systemic problems in practice. Looking at educational engagement in a broader sense, it can be concluded that a productive development of general urban culture requires the integration of education through the convergence of natural and social sciences as well as the inclusion of new ones that have not yet strengthened their position in the current time. This, it seems, is at the same time an important pillar for the sustainability in the global ambient.

There are close-knit relations between interdisciplinarity and sustainability in education, where students are thinking beyond the frameworks of one discipline and effectively collaborate in the process of solving problems. Various approaches are possible in the promotion of interdisciplinarity that arise from the need to transform the standard curriculum. For example, landscape urbanism has appeared in schools in the 1990s, in order to encourage interdisciplinary research in the post-industrial city. It includes a variety of disciplines: architecture, urban planning, landscape architecture, ecology, hydrology, horticulture, construction, infrastructure. Also, climate change requires a review of the conventional paradigms of education. Visual and functional architecture should develop a sensitive relationship towards the context and local conditions. Global impacts in the local context, as well as the need for higher levels of integrity prompted the Graduate School of Architecture, Planning and Preservation-GSAPP, Columbia University, to develop Studio X, "the first truly networked global think-tank devoted to real-time engagement with the future of the world's built environment." Studio X was launched in 2008 (GSAPP, Columbia University, 2013) and is "a global network of advanced research laboratories for exploring the future of cities." StudioX " is a new kind of cultural space in the city" with the mission of "bringing together the worlds of architecture, design, art, planning, preservation, construction, media, business, education, and research" and it develops "a special relationship with local artists: visual, multi-media, installation, performance, music, literature networked truly global think tank devoted to real-time engagement with the future of the world's built environment" (GSAPP, Columbia University, 2013).

Intensive changes of the modern world induce vulnerability of urban systems, which is not easy to track, control and develop in accordance with the requirements and consequences of these changes. Interdisciplinary methodology has proved insufficient in solving complex issues of modern cities. In that sense, development of transdisciplinary methodology and integrated knowledge that involves a combination of research, education, and engagement of different stakeholders, can become a new paradigm in sustainable education. Students in transdisciplinary educative collaboration have the ability to approach the problem differently, to think globally and act locally, and to develop critical and creative thinking (Salama, 2008). Future architects will have the capacity to not only consume knowledge, but to create it as well (Salama, 2008).

The choice of methodology for studying and understanding of the city and its architecture and routing the flows of urban development opens the way towards a sustainable urban system. Research confirms

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that the role of transdiciplinarity in the new century is essential. Modern practice indicates that there are certain levels of knowledge transformation and the tendency towards a collaborative methodology of education, but with insufficiently developed criteria and shows the need for a radical revision of the existing higher education system.

TRANSDISCIPLINARY METHODOLOGY IN ARCHITECTURAL AND URBANISTIC EDUCATION

The educational transdisciplinary action intends to avoid the fragmentation of knowledge for the benefit of communicativeness (Andalécio, 2009). Transdiciplinarity should be the strategy for development of educational engagement, but not exclusively based on the theoretical principles but as a way of thinking and acting. Diverse research and experience from other areas shows that in most universities, and even those who are profiled as the faculties for transdisciplinary studies, where transdisciplinarity, from the name of the faculty to the program itself, has been officially adopted as a model of studying in theory, teaching is carried out in the disciplinary framework (Andalécio, 2009). This confirms the complexity of application of this methodology. Transdisciplinarity as a concept, appeared in the 70s of the 20th Century, and gained in importance only two decades later, when the two streams appeared, treating this term by noting the importance of routing one-dimensional classical thinking towards multidimensional that transdisciplinarity accepts (Klein 2004). Transdisciplinarity is based on complexity, layering, compaction, communicativeness but also specifics that include different perspectives. The importance and actuality of the term indicates a need towards new, more productive studying models that follow the requirements of global time and dynamics of social changes. Transdisciplinarity involves deliberation of methodology in professional education on a higher level. Transdisciplinary metodhology is universal, it is applied in all areas of knowledge and represents a new "revolutionary" model of cogitation in the 21st century.

First World Congress of transdisciplinarity was implemented in 1994, where the statute of transdisciplinarity was adopted. The main goal of the congress was the implementation of transdisciplinarity in education. The greatest impact and the greatest achievement in this direction was achieved by the establishment of The International Center for Transdisciplinary Research CIRET, in 1987 in Paris. This triggered the development of new organizations and programs of transdisciplinary orientation. Transdisciplinarity has in time acquired international impact, particularly in the field of higher education, which became open to various experiments and the development of transdisciplinary curricula, particularly at the post-graduate studies level at universities. Transdisciplinary methodology has become primary in modern research of the development in practices of education for a sustainable future (UNESCO, 1998).

The need for transdisciplinary methodology stems from the global requirements, limitations of the disciplinary methodology, the search for knowledge that goes beyond disciplines and includes a variety of stekeholders. As other authors discuss "transdisciplinarity involves going between, across, and beyond different disciplines. While interdisciplinarity refers to the links between knowledge and models available in different disciplines, transdisciplinarity moves beyond this to develop both a new vision and a new experience of learning" (Morin, 1999). Integrated knowledge can address complex problems of modern urban systems. Sustainable development could initiate transdisciplinary thinking which is of a research, critical and creative nature. Burry (2012) points to the need for new models of practice, emphasizing transdisciplinary approach to the design of the built environment with the concept of ideas and practical applications that articulate the call for the integration of knowledge and research in design.

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The emergence of science is linked to a clear separation between scientific and practical knowledge, which changed over time. "The emergence of transdisciplinary orientations in the knowledge society at the end of the 20th century is the most recent step" (Hirsch Hadorn et al., 2008, p.19).

Adaptive, flexible, creative and integrated architectural-urbanistic design, as well as the transdisciplinary approach in fields of architecture, urbanism and landscape urbanism have resulted in the development of an entirely new understanding of the built environment, and, which are not constructed on traditional paradigms and patterns of planning and design, aesthetic and functional requirements, but is the new guidance as indicated by the developed relations: meteorological architecture, transarchitecture, transurbanism, ecological urbanism and others. Introducing a transdisciplinary understanding of the built environment articulates a whole new philosophy of relation towards space, which was known back in the history of the building of cities.

Notable names in the history of modern urbanism, who represented the integrated study of cities in the context of the living environment are Patrick Geddes, Lewis Mumford, and RadhakamalMukerjee. These 'trans-disciplinary' environmentalists' (Guha, 2000), have treated the city as an organic whole, an active stage for the performance of various philosophies of life, needed to be integrally researched.

Environmental crisis is largely related to the engineering crisis of planning and design of cities, which is why new methodological points are a significant contribution towards the development of sustainable cities. Drawing on previous research and viewpoints of the authors and the developed general methodology of transdisciplinarity, it can be concluded that the methodological basis of architectural and urbanistic discourse in the direction of sustainable development involves training in the context of environmental synthesis of disciplines. Disciplinary methodology of architectural and urbanistic education as multidisciplinary fields is not sustainable. Disciplinary methodology solves the problem in the short term, while interdisciplinary methodology that is selectively applied in practice in higher education, as it appears, is not sufficient to meet the various needs and impacts of the 21st Century, especially if committed to the development of sustainable cities of the future.

Transdisciplinary methodology is an integrated single methodology for different types of knowledge. It integrates different disciplines, theory and practice, universities, academic and non-academic structure, and others. Transdisciplinary methodology over time is reflected in the new language of paradigms and models that can be used as instruments for complex and global problems that are outside the realm of traditional scientific methodology. Research shows that in the transdisciplinary methodology of architectural and urbanistic discourse of higher education, the central place belongs to the environmental study, then communication, creative and critical thinking and technological aspects, in order to articulate the sustainable development of cities. In addition, ecological, socio -economic, political and cultural influences on architectural and urbanistic activities should especially be emphasized, as well as the unity of theoretical and practical experiences. Engineering sciences, as well as the arts are integral elements of architectural and urbanistic education.

Engaging students through critical thinking, decision making in problem solving, consolidation of ideas and skills through feedback information, and implementation of ideas in the implementation of innovative and productive solutions is of primary importance. The effectiveness of communication relations, effective strategic communication platform, communication as a strategic interactive long-term process, scientific research, intellectual, in-depth research practice, are essential in the practice of transdisciplinary methodological education of architects and urban planners. Given the complexity of the implementation of transdisciplinary methodology, Max-Neef (2005) notes two possibilities of transdisciplinarity "a weak and a strong transdisciplinarity" (p.5), in the context of the reorientation

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of higher education. Since there are many challenges and the wider adoption and implementation of transdisciplinary methodology into the curriculum of higher education is a complex process and yet to come, from the aspect of architecture and urban planning every step forward is of great importance for sustainable planning and design of the cities.

TECHOLOGICAL ASPECTS OF THE TRANSDISCIPLINARY COLLABORATION IN EDUCATION

The technological aspect is central in contemporary design of urban space. Planning, research, experiments, alternative, new models of physical structures include adequate modeling and intensification of communication globally. It is no longer enough to be exclusively related to a certain space and intervene in it from the perspective of a particular discipline. The intensity and complexity of information technology and capabilities and their availability have allowed the connection, dialogue and mobility in the broadest sense.

Technological innovations developed in the last decade largely construct a platform for the new technological era, complexity of which will largely determine the complexity of the educational system. Digital technologies such as e.g. the Geographic information system -GIS enable transformation of the rational planning approach towards communicating. The complexity of the space planning involves a high level of professional competence and responsibility in the context of sustainable development. GIS could become an effective tool in planning and designing sustainable cities. Computer technologies such as "computer aided design (CAD), 3D object scanning, rapid prototyping (RP) and industrial rapid manufacturing (RM) technologies such as computer numerically controlled (CNC) cutting / milling technologies," are very incentive to overcoming disciplinary boundaries (Marshall & Pengelly, 2006). By means of appropriate computer technology it is possible to employ new forms of cultural, psychological, sociological, aesthetic, artistic domains in the design process. In this sense, it is necessary to develop also the technologically innovative solutions that cross disciplines and integrate different knowledge. Allen (2012) identifies three stages of digital design, the first stage is metaphorical, created during the 80s in the 20th century, the second phase, which occurred during the 90's is experimental, while the third, current phase, is the age of digital technology, robotics and parametric design.

Education should be developed in line with rapid technological changes, which requires extensive revision of the curriculum, international architectural and urbanistic education, the use of integrated models of technology hardware and software, telecommunications and multimedia technology. The last two decades are characterized by rapid technological and social changes and with it complex challenges in the architectural practice of education (Allen, 2012).

Education in the broadest sense, has a key role in achieving the required profound changes in contemporary society dominated by digital technology patterns. The specificity of disciplinary educational process is no longer a primary strategy, but above all, production of professionals who can respond to the global, ecological, climatic, geographical, regional circumstances in local conditions. Technological capabilities foster collaboration, transprofessionalism as a challenge with new forms of cooperation at all levels can be more dominantly positioned than the conventional differentiated practice of problem solving.

The synthesis of disciplines through modern effective technological models can promote and encourage the more productive processes of architectural and urbanistic education and professional practice in cultural contexts.

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CHALLENGES OF TRANSDISCIPLINARY METHODOLOGY IN HIGHER EDUCATION

Limits to disciplinary thinking (Ramadier, 2004) have resulted in the development of higher levels of integrity, which in realization faces various challenges. Research of Evans and Marvin (2006) showed that interdisciplinary theoretical basis of researching the city as a complex combination of science, technology and society, and complex problems at the beginning of the decade, have not been finally realized in practice. Universities are constantly exposed to various external influences, external influences, and organizational influences (Hyun, 2011). This points to the complexity of the radical transformation of methodologies in higher education. Methodological innovations include a gradual and continuous process of revision of curricula, from interdisciplinary to the transdisciplinary level. On the other hand, the failure to develop educational programs related to sustainability at universities and institutes, present an impact on society as a whole (UNESCO, 1998). Contemporary methodological shift in architectural and urbanistic education shows that there is a strong need for changes, but that often transdisciplinary defined curricula are implemented in practice in an interdisciplinary framework. The main challenge is that the transdisciplinary methodology strongly advocates the development of a single integrated methodology for problem solving. Different disciplines develop their own research methodologies and actions and often with high levels of contradiction, which makes it difficult to create a unified language.

Also, if we talk about sustainable development, collective and individual interests are varied and often conflicting. The development of new paradigms and models of transdisciplinary orientation in pursuing the highest forms of cooperation on different levels, includes certain paradoxes that have to be overcome. "One of the challenges of higher education is to reconceptualize its relationship with the rest of society, both civic and corporate, so it can broaden its role to address the challenges of today's world – the polycrisis (McGregor & Volckmann, 2011, p. 2).

FUTURE TRENDS

We start from the position that the transdisciplinary methodology is a necessity of higher education in the 21st Century. The development of sustainable cities implies sustainable architectural and urbanistic education. It would be useful to direct future research towards the development of new models, paradigms, patterns that would more approximately determine the features and articulate the benefits of transdisciplinary methodology in architectural and urbanistic discourse in the context of environmental higher education. This would help encourage commitment to transdisciplinary methodology of the curricula at universities as primary drivers of sustainable development.

CONCLUSION

The academic environment is a particularly sensitive issue and it implies the inclusion of all forms of institutional infrastructure and researching diagnosing of the key issues and the cross section for its improvement. Academic study programs, personnel policy, transparency, universality and innovative visions of development are the basis of productive knowledge. Acquiring of skills and competence, creativity,

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critical thinking, international cooperation, teamwork in the transcultural contexts contribute to a more complex approach of the problem.

The mission of modern higher education in the 21st Century includes orientation towards the development strategy of integrated knowledge, which, as such, can meet the challenges of the global process of urbanization, cultural and social transformation. Sustainable development of the physical structure of the city is the primary issue in response to the demands of the global time. Integrated urbanistic and architectural knowledge entails the inclusion of more autonomous disciplines in the system of collaborative work, as well as other forms of knowledge that with united action could provide the answers to the questions of the global world in the local context. Transdisciplinary methodology of architectural and urbanistic discourse in higher education can become a paradigm of the sustainable development of cities in the 21st Century.

Global processes are increasingly shaping the local built environments. Unified knowledge can meet the challenges of the third millennium for the goal of sustainable development. University knowledge implies the adoption of transdisciplinary methodology. Studying architecture and urbanism in a transdisciplinary environmental context is of particular importance for a sustainable future.

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KEY TERMS AND DEFINITIONS

Architectural and Urbanistic Sustainable Higher Education: Environmental integrated education with architecture and urbanism as central disciplines.

Architectural and Urbanistic Sustainable Knowledge: Environmental integrated knowledge that includes academic and non-academic knowledge, with a purpose of developing a human-built environment in a dynamic time of technology.

Environmental Sustainable Higher Education: Integrated education of different disciplines and forms of knowledge.

Interdisciplinary Higher Education: Interconnected education of independent disciplinary methodologies.

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Multidisciplinary Higher Education: Education of independent disciplinary methodologies.

Sustainable Higher Education: Education that is the product of integrated knowledge.

Transdisciplinary Higher Education: Education of a single integrated methodology, which is created by the transformation of different disciplinary methodologies.

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Chapter 37
Sustainable Education: A Buzzword of Universiti Teknologi PETRONAS, Malaysia

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ABSTRACT

The sustainable development (hereafter, S.D.) aims a growth that could satisfy the wants and needs of present generation without affecting future generations. Accordingly, this study investigates the role of HEIs in S.D. by selecting the case of Universiti Teknologi PETRONAS, Malaysia. The study adapted the universities sustainable development initiatives checklist/index for qualitative analysis of the main website, operational documents, and practical initiatives of the university for S.D. The findings revealed that the university has good and meaningful contributions towards three dimensions of S.D. i.e. economic, social and environment. The study proposed an improvement in Education for Sustainable Development (ESD) and implementation of S.D. framework for universities. The findings have significance and practical implications for academia, regulatory bodies, policy makers, and HEIs. Also, the findings are significant in association with new economic model (NEM) and vision 2020 of Malaysia.

INTRODUCTION

It is the issue of everybody to concern with society and its welfare. The individuals, larger or smaller groups, formal or informal entities, public or private firms, governmental or non-governmental organizations considered as the key stakeholders of society must always have aspired to champion societal concerns (Amoako, Agbola, Dzogbenuku, & Sokro, 2013). Sustainability has a broad sense and can be viewed as the relationship of organizations with the society as a whole, and the need for organizations to

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align their values with societal expectations (Dowling & Pfeffer, 1975; Elkington, 1997; Roca & Searcy, 2011). In reality, it is a standard that organizations can impact their environment with the potential to build a sustainable development (Helg, 2007). However, it is grave that society educates everyone to be responsible. As concerning to all societal actors, universities are considered are the ones educating the future leaders of a country. What these educational institutes teach and do not teach may make or break the nations' future and well-being (Amoako et al., 2013).

The most accepted definition of sustainable development (S.D.) was firstly coined by the Brundtland Report which claims for a development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The main contribution of this pioneering concept highlighted that the human well-being depends on the health of the environment, in other words, on society, economy and environment are inextricably connected (Delai & Takahashi, 2013). Sustainable development is three nested and interrelated domains where the largest is the environment that provides ecosystem services and natural resources, in the middle is society and the smallest is economy (Baxter, Boisvert, Lindberg, & Mackrael, 2009). Hence, S.D. comprises of three main dimensions: environmental, social, and economic.

S.D. has become a globally accepted concept and become a guide to interacting with nature and society. In order to overcome the challenges of S.D., it calls for a paradigm change at all levels including education sector (Disterheft, Caeiro, & Azeiteiro, 2013). To support this argument universities have been charged with the key roles in promoting and implementing sustainable development (UNESCO, 1992). Moreover, many scholars see the impact of universities on S.D. has vastly greater than any other single sector of society because universities educate the coming generation of decision-makers, influencers, and leaders (Lozano, 2006). Due to societal impact universities are seen as multipliers for distributing S.D. principles with the ethical obligation to systematically integrate S.D. into their institutions (Cortese, 2003). Hence, a number of universities have responded and showing good progress in the implementation of S.D. in universities. "The emerging fields of sustainability in universities is Education for Sustainable Development (ESD) which can be seen as an evolving scientific foundation for the advancement of sustainability, including the transition to sustainable universities" (Disterheft et al., 2013). ESD is being part of the sustainability discourse and policy-making process since very the beginning, it has been influencing the debate on learning objectives, contents, pedagogies, and competencies necessary for the paradigm shift to S.D. (Disterheft et al., 2013). During the last decade, there is an increasing trend in higher education institutes to engage in incorporating and institutionalizing S.D. into their curriculum, operations, research, outreach, assessment and reporting (Lozano & Young, 2013).

However, in spite of many steps and policy making for S.D. number of universities are engaging with S.D., while, most of them are continued to be traditional. Consequently, they are still lagging behind to contribute in a holistic manner for a broad spectrum of stakeholders requirements (Lozano, Lukman, Lozano, & Huisingh, 2013). The current study has an objective to investigate S.D. initiatives of a university with a focus on three dimensions economic, social and environmental. The study will answer the research question that how a university could contribute for S.D. The study selects University Technology PETRONAS (official name as Universiti Teknologi PETRONAS - UTP) Malaysia as a case. The remaining sections of the paper consist of a brief literature review, a Malaysian perspective, a case study of UTP, conclusion and recommendations.

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LITERATURE REVIEW

History

Generally, the literature evidenced that the origin of S.D. is associated with the publication of "Limits to Growth" by the Club of Rome in 1972 (Meadows, Meadows, Randers, & III, 1972) to the United Nations conference on the Human Environment, held in Stockholm in 1972. However, the concept itself can be traced back 300 years in the work of Hans Carl von Carlowitz published about sustainable forestry, and T.R Malthus (1766-1834) who reported the environmental limits to population growth (Mebratu, 1998). So, evidenced from this historical work that the emergence of S.D. concept is a post-industrial era, and it is much older (Disterheft et al., 2013). Nonetheless, there is a general consensus among the scholars that the WCED report "our common future" known as Brundtland Report considered as an evolution of S.D. The report coined the definition of S.D. as "S.D. is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The term S.D. sometimes applied to economic growth or as a development strategy. S.D. is being the process to achieve a growth. While the term sustainability would have more emphasis on the environment, stand for the final goal of human wellbeing (Lozano, 2008; Waas, Hugé, Verbruggen, & Wright, 2011). However, in the common practice and literature, these terms are not using as separate and in the usual approach of using these terms interchangeably.

Additionally, a consensus about the basic principles and ideas of S.D. and sustainability comprises normativity, intra and intergenerational equity, justice, gender equality and participation. These principles have been endorsed by the Rio Declaration at the UN Earth Summit in 1992 and are usually associated with both terms equally (Disterheft et al., 2013). Accordingly, during the 1970s and 1980s, many of educational institutions moved forward in establishing environmental sciences and environmental studies programs (Rowland, 2013). In the meantime, campus staff and administrators working in campus operations have started to address issues like utilization of resources. Moreover, such efforts often driven by economic forces, for example, an increase in energy prices encouraged energy managers to seek means for energy conservation. Water shortages and increased costs led the water conservation both in buildings, offices and landscaping as well. As a result, the introduction of the Talloires Declaration[1] by Jean Mayer of Tufts University in 1990 was an important turning point in the evolution of the campus-based sustainability movement in the USA and Canada. The declaration clearly recognized higher education role in sustainability education, and the signatories are committed to their institutions to ten actions, including fostering environmental literacy for all. This declaration was important because it explicitly linked ESD to campus operations in a section titled, "Practice Institutional Ecology". The signatories committed to setting an example of environmental responsibility. At that time only four US universities were present, however, by 2010, there were 350 total signatories around the world (Rowland, 2013).

Sustainable Universities

Cortese, (2003) identifies four dimensions for sustainable universities: education, research, university operations and external community. Lozano (2006) adds a fifth dimension of assessment and reporting. These dimensions are considered as interconnected and dealt with in a comprehensive, dynamic, horizontal in manner and considered crucial for implementing sustainable development in a holistic way. There are still some issues with less attention like the non-materialistic aspect of sustainability related

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to social, cultural and ethical questions. However, some good progress has been made in curriculum greening, campus operations (environmental issues and their educational dimension) system transitions approach towards a large group of stakeholders, outreach programs and last but not the least assessment and reporting. Universities are also conducting specific conferences with the focus on S.D. implementation in universities (Disterheft et al., 2013; Lozano, 2011).

Education for Sustainable Development (ESD)

As discussed earlier the debate about S.D. has also initiated the concept, ESD which helps to achieve the goals of sustainability. It has been a field for international educational policy-maker since the beginning of the S.D. debate. The ESD concept started being institutionalized in 1992 with the international recognition of Agenda 21 and its specific chapter 36 about education at the UN Earth Summit in Rio de Janeiro (UNDES.D., 2009). ESD can be defined as ''Education for Sustainable Development (ESD) is a learning process (or approach to teaching) based on the ideas and principles that underlie sustainability and is concerned with all levels and types of learning to provide quality education and foster sustainable human development—learning to know, learning to be, learning to live together, learning to do and learning to transform oneself and society'' (UNDES.D., 2009). The UNESCO was assigned as manager for the implementation of Agenda 21's chapter 36, and ESD has received much attention worldwide. Further related achievements were the UNESCO report ''Education for a Sustainable Future'', in which the necessity of a reorientation of education in all sectors and the key principles of ES.D. are stressed, and the launch of the UN Decade on Education for Sustainable Development (2005–2014) that stimulated numerous projects on all educational levels.

Similar to the concept difficulty of S.D., ESD has also no single, uncontested definition, and often terms such as Education for Sustainability (EfS) or Sustainability Education (SE) are used interchangeably. Other terms which are used less frequently such as Earth Education; Environmental and Developmental Education; Environmental Education for Sustainability; Education for a Sustainable Future; Education as Sustainability; and Sustainable Development Education (Filho, Manolas, & Pace, 2009).

Some Milestones and Policy-Making for S.D. in Higher Education

To support the commitments towards sustainable development more than 20 declarations and policy documents are promulgated for education institutions (Disterheft et al., 2013). All of them are based on a moral obligation toward promoting and contributing to S.D. within universities: ''perhaps the unifying theme among all declarations and policies is the ethical and moral responsibility of universities to be leaders in promoting sustainability'' (Wright 2002). In 1972 at Stockholm Conference education was formally known on an international level to play an important role in fostering environmental protection and preservation (Lozano et al., 2014). Afterwards, more HEIs have engaged and embedded in environmental education and education for sustainable development (ESD) into their systems' elements (Lozano, 2006). Similarly, HEIs developed and signed a collection of declarations, charters, and initiatives to provide guidelines or frameworks for HEIs for showing their commitments and better embed sustainability into their system, Table 1 exhibited most widely recognized higher education for sustainable development (HESD) (Lozano et al., 2013).

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Table 1. HEIs developed and signed a collection of declarations, charters

Year	Event/Declaration	Level or Focus
1972	Stockholm Declaration on the Human Environment, United Nations Conference on the Human Environment, Sweden	Society
1975	The Belgrade Charter, Belgrade Conference on Environmental Education, Yugoslavia Tbilisi	Education
1977	Tbilisi Declaration, Intergovernmental Conference on Environmental Education, Georgia	Education
1987	"Our Common Future", The Brundtland Report	Society
1990	Talloires Declaration, Presidents Conference, France	Higher Education
1991	Halifax Declaration, Conference on University Action for Sustainable Development, Canada	Higher Education
1992	Report of the United Nations Conference on Environment and Development (Rio Conference); Agenda 21, Chapter 36: Promoting Education, Public Awareness and Training and Chapter 35; Science for Sustainable Development	Society
1992	Association of University Leaders for a Sustainable Future, founded, USA Kyoto	Higher Education
1993	Kyoto Declaration, International Association of Universities Ninth Round Table, Japan	Higher Education
1993	Swansea Declaration, Association of Commonwealth Universities' Fifteenth Quinquennial Conference, Wales	Higher Education
1993	COPERNICUS University Charter, Conference of European Rectors (CRE)	Higher Education
1996	Ball State University Greening of the Campus conferences were in 1997, 1999, 2001, 2003, 2005, 2007, and 2009	Higher Education
1997	Thessaloniki Declaration, International Conference on Environment and Society: Education and Public Awareness for Sustainability, Greece	Education
1999	Environmental Management for Sustainable Universities (EMSU) conference, first held in Sweden. Following conferences in 2002 (South Africa), 2004 (Mexico), 2006 (U.S.A.), 2008 (Spain), and in 2010 in The Netherlands	Higher Education
2000	Millennium Development Goals The Earth Charter Global Higher Education for Sustainability Partnership (GHESP)	Society Society Higher Education
2001	Lüneburg Declaration on Higher Education for Sustainable Development, Germany	Higher Education
2002	World Summit on Sustainable Development in Johannesburg, South Africa (Type 1 outcome: Decade of Education for Sustainable Development; Civil Society outcome: the Ubuntu Declaration)	Society
2004	Declaration of Barcelona	Higher Education
2005	Start of the UN Decade of Education for Sustainable Development (DES.D.) Graz Declaration on Committing Universities to Sustainable Development, Austria Abuja	Education Higher Education
2009	Abuja Declaration on Sustainable Development in Africa: The role of higher education in S.D., Nigeria Torino (Turin) Declaration on Education and Research for Sustainable and Responsible Development, Italy	Higher Education Higher Education

Nonetheless, signing a declaration has not yet ensured that the signatory institutions will implement S.D. within their systems. As a result, some universities accused of "greenwash" if they fail to implement S.D. thought out their system instead of signing a declaration (Bekessy, Samson, & Clarkson, 2007). Moreover, some universities without signed any declaration or belonging to any charter, are performing well for S.D. (Lozano et al., 2013) such as regional development (Dlouhá, Huisingh, & Barton, 2013), to reduce greenhouse gas emissions, academic leadership, commitment via inclusion of S.D. in their mission and vision statements (Lee, Barker, & Mouasher, 2013).

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Sustainability Reporting in HEIs

Sustainability reporting has gained much importance in the last decade in both profit and non-profit organizations. In the corporate world this trend has increased over the last decade (Daub, 2007). When we see this increase, particularly in the corporate world looking at the world's 250 largest companies; in 1999, only 35% of them reported on their corporate social responsibility activities, in 2013, 93% of these organizations have compiled sustainability reports (KPMG, 2013). From the viewpoint of fairness that the private, public, and non-government sector should have a concern for increased disclosure of organizational activity. However, in the recent literature, only a few research papers (partly) address sustainability reporting by government and non-government organizations (Hahn & Kühnen, 2013). Following the increasing trends of sustainability reporting in the corporate world (Kolk & Perego, 2010; Lozano & Huisingh, 2011), some higher education institutions (HEIs) have started sustainability reporting (Ceulemans, Molderez, & Van Liedekerke, 2014). However, this trend of sustainability reporting is still in its early stages in HEIs, both because of the lack of a substantial number of reporting, and low quality of reporting outcomes (Ceulemans et al., 2014). In the Global Reporting Initiative (GRI) Database [2] the first sustainability report from the university sector was in reported in 2001, and by the end of 2012, this number gradually increased to 33 reports. Similar to the low number of HEIs publishing these reports, only a low number of research studies have been conducted to addressing the issues of sustainability reporting in HEIs, and in spite of the slowly progress of trend sustainability reporting in higher education, it is still unclear for certain players in this field what sustainability reports contain.

S.D. and Malaysia

The awareness towards the sustainable development in Malaysia was highlighted for the first time in the Third Malaysian Plan (1976-1980) published by the Economic Planning Unit (EPU)[3] from the Prime Minister's Department. The Plan designed a blueprint for the Government of Malaysia (GOM) for five years as a development strategy. From the fourth to presently the Tenth Malaysian Plan (2011-2015), the concept of sustainability gained much importance in line with global initiatives on sustainable development (Samuel, Agamuthu, & Hashim, 2013). The Eighth Malaysian Plan (2001-2005) focused on the incorporation of environmental considerations into development was intensified, which result in the integrated and holistic management of the environmental and natural resources. During these periods institutional capacity and regulatory frameworks were reinforced, new approaches and planning tools were established for environmental protections. As an end product, the National Environmental Policy (NEP) was formulated in 2002.

Under the ninth Malaysian Plan (2006-2010) environmental stewardship was promoted to ensure the balancing of development and environment. The Plan has strongly emphasized the need for R&D to enable the achievement of enhanced environmental quality in the century. Moreover, the efforts towards sustainability are further established under the Tenth Malaysian Plan (2011-2015) with the introduction of the AFFIRM (Framework for Awareness, Faculty, Finance, Infrastructure, Research and Marketing) to develop a complete ecosystem for environmental sustainability. Through this period, institutional capacity and regulatory frameworks were reinforced, new approaches and planning tools were established for environmental protection. Two focus areas have been identified for the next five years first developing a roadmap for climate resilient growth, and second, enhancing conservation of the nations' ecological assets. During 2010 the Government of Malaysia has taken several steps towards implementation of sus-

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tainability e.g. Government announced an RM 100 million CSR fund, creating of a federal level ministry dedicated to Green Technology, and also allocated funds for RM 1.5 billion towards the development of environmental sustainability. The Malaysian government has also announced a commitment to reduce carbon emissions up to 40 percent by 2020. Sustainability declared as one of the three goals of New Economic Model 2010 (NEM, 2010).

Through National Key Economic Areas (NKEA) in the Tenth Malaysian Plan, the government would improve the quality of public higher learning institutions through performance-based funding by escalating the rating system for Malaysian Higher Education Institution (SETARA) in order to cover private universities and college universities, and its faculty level. It also introduced the central enrollment system for all students including international students with flexible credit accumulation framework. A conducive educational system would be provided to attract students and world leading faculties in niche areas to set up branches in Malaysia (NEM, 2010).

METHODOLOGY

The current study uses University Technology PETRONAS (official name as Universiti Teknologi PETRONAS - UTP) Malaysia as a case study by adapting universities sustainable development initiatives checklist/index from the previous literature (Lozano et al., 2014). For the grounding of S.D. initiatives the study uses qualitative content analysis procedure for the years 2011 to 2015 of UTP main website (http://www.utp.edu.my/), embedded website links, internal university operational documents and departmental initiatives those are directly linked to S.D.

Universiti Teknologi PETRONAS (UTP)

Universiti Teknologi PETRONAS (UTP) established as a university in the private sector of Malaysia in 1997. In the start university offered a variety of programs related to engineering and technology at graduate and post graduate level. Currently, UTP offers five (5) engineering programs namely Chemical, Civil, Electrical & Electronics, Mechanical and Petroleum, and three (3) technological programs namely Petroleum Geoscience, Information & Communication Technology and Business Information System, Applied Physics, and Applied Chemistry. However, the university later introduced the programs in management and humanities as well in order to produce graduates with excellent skills of leadership and communication. The University has a current strength of 6000 students from more than 50 countries around the world. It has produced more than 10000 graduates till date since its inception in 1997.

The Quacquarelli Symonds (QS) ranked UTP as 4-star institution (out of five-star rating) in five areas of employability, internationalization, innovation, facilities and access among eight. The UTP is the only university with this honor in the private sector of Malaysia. The university has also ranked in top 200 universities of the QS World University Ranking by subject for Chemical Engineering in 2015. Moreover, the departments of Electrical & Electronic Engineering, Mechanical Engineering and Computer Science & Information Systems of the university have also included in the world ranking. In addition, the university has a distinction to be the only university in the private sector of Malaysia ranked in the top 200 universities in QS rankings for Asia in 2014. The university stood 335 in the QS World University Rankings for Engineering and Technology Faculty. The University is a Tier 5 (Excellent) University

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for SETARA (Rating System for the Malaysian Higher Education Institutions). It has also achieved the status of Tier 5 for D-SETARA (Discipline-Based Rating System) in engineering.

UTP has the vision to become A Leader in the education of engineering and Technology and recognized as a Centre of creativity and innovation.

The mission of the university is to produce well-rounded graduates who are creative and innovative with the potential to become leaders of the industry and the nation. Moreover, the university also aims to encourage creativity and innovativeness for the welfare of the society.

UTP Endeavors for Sustainable Growth

UTP focuses Research and Development activities in order to earn the name of a research university within and outside Malaysia. The university carries out extensive research projects in collaboration with PETRONAS (which is the parent company of the university) and other national and international institutions. Subsequently, the university focuses nine areas namely Enhanced Oil Recovery, Carbon Dioxide Management, Deepwater Technology, Nanotechnology, Green Technology, Biomedical Technology, Hybrid Energy Systems, Intelligent Cities and Sustainable Resources. This focus is considered to strengthen all the three dimensions of sustainability not only in university but in society and country as well. The university was, therefore, awarded a 5-star rating by Malaysian Research Assessment Instrument for research, development, and commercialization in the recent past.

The Centre of Excellence (COE) and Centre for Intelligent Signal and Imaging Research of the university focus biomedical image analysis with neurochemical imaging. Subsequently, these were recognized as the National Higher Institutions by the Ministry of Education in October 2014 to focus. Moreover, the Centre of Innovative Nanostructures and Nano devices were also recognized as a national COE by the Ministry of Science, Technology and Innovation, Malaysia in 2011.

Economic Sustainability

Department of Mission Oriented Research (MOR)

The R&D Master Plan of UTP focused on developing technological platforms in the Oil & Gas, Transportation and Intelligent System in the start. However, the university, later on, turned its attention on "Mission Oriented Research" in "Oil and Gas Industry" of the country. This shift triggered much by the current capabilities of the university and importance of the sector which have a great contribution in the GDP of the country. In addition, the university aimed to assist the core businesses of its parent company (PETRONAS) which enjoys the status of "leader" in the sector. Subsequently, a department of Mission Oriented Research established to focus Enhance Oil Recovery (EOR). EOR is a technique that increases oil production by injecting stored carbon into the mature oil fields. The department focusing research areas in the field of enhancement of Reservoir Rock and Fluid Characterization, EOR screening and modeling, New and Novel Technologies like Nano-enhanced EOR and EOR Agent Injection. The department prioritizes the enhancement of WAG applications by implementing modified chemicals synthesized from local sources and Nanomaterials developed by UTP researchers. The department undertakes research activities spanning from Geology through drilling and finally on EOR recovery methods as the method has a higher success rate. Following are mission and vision statements of the department. The department aims to develop and improve reservoir characterization and recovery methods in EOR to enhance

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recovery. The department has the vision to be known as a leading R&D institution on advanced EOR Fluids and acknowledged as an expert in Reservoir Modeling and Characterization in EOR.

Following are the details of various projects carried out by the department.

1. Simulation of Injecting Characteristics During WAG Process.
2. Mathematical Modeling of Steam-Alkaline-Gas (SAG) Injection.
3. Synthesis and characterization of a polymeric smart surfactant for enhanced oil recovery purposes.
4. Development of a new alkaline smart surfactant acid flooding formulation for enhanced oil recovery.
5. Development of a graft polymer for enhanced oil recovery.
6. Development of biopolymers for enhanced oil recovery.
7. Development of new EOR methods with the application of EM waves and Nano particles.
8. Understanding the effects of Asphalting presence on multi-phase relative permeability characteristics.
9. Understanding the effects of different injection schemes and displacement efficiency during WAG injection.

Intelligent Cities

Undoubtedly, Good quality of living is the right of every human being on the earth. However, most of the human are deprived of it due to a number of reasons in developed as well as developing countries. Good living quality includes the basic necessities like food, air, water, shelter, electricity, transport, roads, sewerage, health care facilities and security with a reasonable cost and without tempering environment much. In a nutshell, good quality of life demands a well establish the infrastructure to efficiently deliver. The efficient infrastructure not only contributes to the good quality of life but also increase economic prosperity which further improves the quality of life. The issue of quality living is more highlighted in urban areas where the population density is higher than that of rural areas. Thus, the city governments, whether in developed or developing countries, face a number of problems to cope with in providing good quality of life. The MOR for Intelligent Cities of the UTP focuses these challenges to convert into opportunities so that to improve the quality of life in cities, local economy, and the environment. The MOR specifically focuses the following areas for developing and promoting intelligent cities.

To focus these areas, the MOR provides following facilities for improving the attainment of objectives. The MOR for intelligent cities has the vision to be known for social and technological innovation in modern cities by identifying and developing core research agenda and capabilities in the fundamental and advanced domains related to intelligent cities.

Figure 1. MOR specifically focuses areas for developing and promoting intelligent cities



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Commercialized Product: Math Quest

UTP by collaborating with Hezmedia Interactive S.D.n Bhd and MDeC has developed Math Quest. The idea behind developing this Math Quest was to help the students of primary school aged between 9 to 12 years. The quest has been developed for learning numbers by combining the learning and role playing game theories. The Eight mini games developed for the quest include Mailbox Mania, Nail the Jackpot, Rock in Room, Chaos Store, Sword Force, Chop the Chunk, Pearl Voyage and Baa… Baa Bad Sheep. Each of these games is different with a common objective of learning numbers. Due to the difference in nature, tutorials have been provided at the start of each educational game.

The achievements of this product are as follows:

1. Won Gold Award for Engineering Design Exhibition 24 (EDX24).
2. Silver award - Malaysia Technology Expo (MTE) 2011.
3. 1st Runner Up in the INTEL DST Asia Pacific Challenge 2011.
4. Gold Award – ITEX 2012.
5. Gold Award- INPEX 2012.

Environmental Sustainability

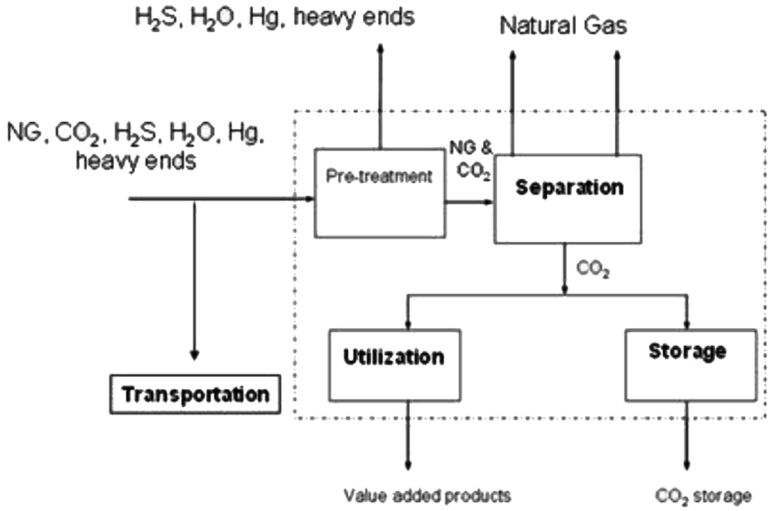
Carbon Dioxide Management

About 40% of the world gas reservoir which is approximately 2500 trillion cubic feet has a high volume of CO2 and H2S. Malaysia accounts for undeveloped CO2 –NG gas fields having a capacity of 13 trillion cubic feet of these two cases. The processing of high CO2 -NG requires an advanced technology in pretreatment, separation, utilization, transportation, and storage. The MOR of the university focuses on projects like CO2 which ensures the safety of the environment. The department currently focuses the technologies which separate CO2 particularly on adsorption, absorption, membrane, cryogenic, high gravitational separation and hybrid system including corrosion. The department is focusing selective removal of CO2 (Solvent Absorbent, Membrane, Adsorbent) in material handling activities. Moreover, the quality of NG pipeline (Absorption, Adsorption, Membrane, Cryogenic, and Supersonic Gas Separation) is focused in the separation and modeling activities. In addition, the management of material towards high CO2 handling (improved alloy steel and corrosion inhibitor are prioritized in corrosion. The separation technologies of CO2 –NG gas of the department will enable monetization of high CO2-NG gas fields in Malaysia. Moreover, the technology is expected to grant a competitive edged to PETRONAS which will help its penetration in domestic as well as international market. The following model explains this technological process.

The department has a mission to become a center of excellence in CO2-NG separation technology for oil and gas industries by expanding the frontiers of the technology for the betterment of society. The department has the vision to acquire a status of leader in Technology Research and Development of Separating High CO2- NG.

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Figure 2. Carbon Dioxide Management Technological Process



Hybrid Energy Systems

The depletion of fossil fuels, global warming and focus on renewable energies has grabbed much of the attention these days. The MOR has a Hybrid Energy System which can be broadly categorized into three groups namely Alternative Energy, Power Systems, and Novel & Hybrid Systems. The Hybrid Energy System of MOR currently focuses hybrid energy systems by considering all the available local resources for renewable energy.

The Hybrid Energy System MOR is committed to enhancing its capabilities by equipping various labs. Currently, the department has the following facilities to support research.

1. Centre for Automotive Research and Electric Mobility (CAREM): It is a state of the art laboratory equipped with optical research engines, high-speed imaging, planar laser induced fluorescence, particle image velocimetry, laser Doppler anemometry, phase Doppler anemometry, single and multi-cylinder test beds.
2. Gas District Cooling Plant: The plant is the ownership of the university where various projects are undertaken mainly in cogeneration systems.

Biomass Gasification Lab for Power Generation: This lab is equipped with custom built gasifiers which facilitate studies and research on how to convert the local biomass resources into gas. The lab is also equipped with diesel and petrol engines which are connected with dyno meters and emission measurement systems.

3. Solar Research Site (SRS): SRS facilitates five experimental research models to strengthen integrated techniques for improving the performance of the thermal solar systems.

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The department aims to earn a name in energy efficient technologies and integrated alternative energy systems so that sustainable energy solutions could be found for the welfare and betterment of the society. It concentrates on Electrical Power Generation Systems, Thermal Energy Systems, and Energy Management Systems to develop such Centers of Excellence that could fulfill the energy needs of the nation.

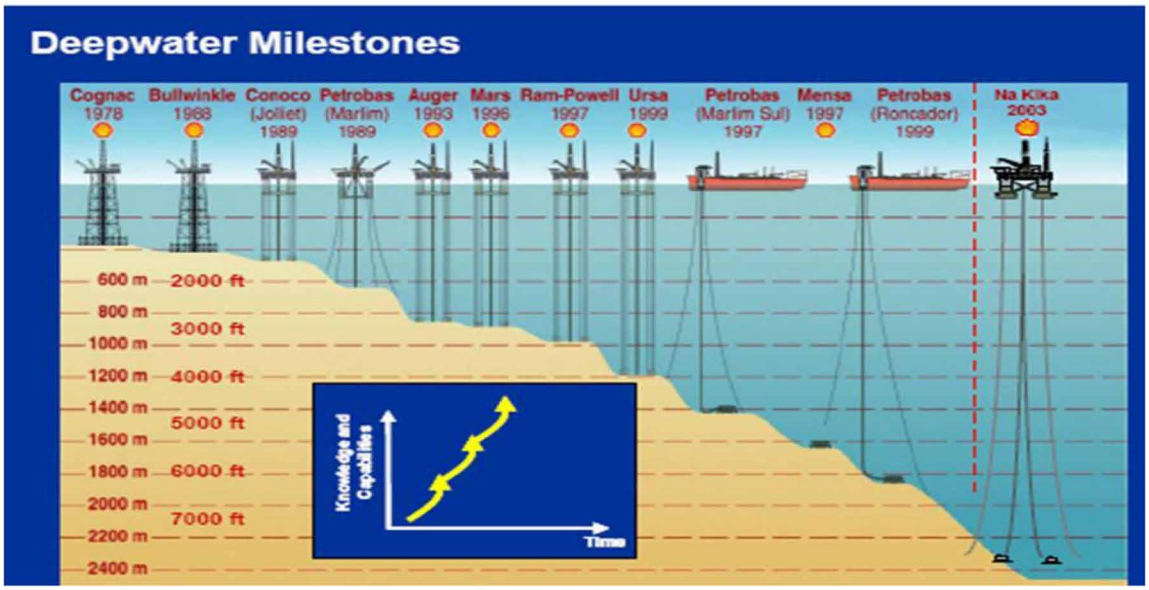
Deep-Water Technology

The term "deep water" means the water that has a depth between 500 to 1,499 meters. The water that has a depth more than 1500 meters is known as ultra-deep water. After a successful and easy access to offshore hydrocarbon deposits during last five decades, the industry is eager to explore more inaccessible locations for searching oil and gas reserves. Subsequently, the deep water technologies focused for the past ten years. The industry has been also focused much by the increasing price of the commodity and issues of energy crunch and shortages in future. It is expected that more and more research and investment will improve the technology, understanding and economic viability of the industry.

The department has the vision to be a preferred choice and deep water R&D center of excellence in Asia-Pacific by 2017. The department has the following deep-water technology projects:

1. Deep water structure integrity and reliability.
2. Pipeline flow assurance.
3. Sub-sea systems.
4. Geohazards and Geotechnic.
5. Knowledge management.

Figure 3. Deep water technology models



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Nanotechnology

Nanomaterials have potentials to produce such new products which could energize the economy, overcome societal issues, rejuvenate existing industries, and create entirely new businesses. These opportunities arise as a result of the unique properties (physical, magnetic, optical, chemical, mechanical, electronic, and biological) of materials when they are at Nanoscale (< 100 nm). It is considered that a novel solution-oriented approach to materials and nanomaterials development should be carried out to realize its complete economic benefits. This approach requires a robust understanding of the fundamental scientific principles operated at the nanoscale, including interdependent structure-property relationships. This will enable cost-effective design, synthesis, and scale-up of materials that deliver selected properties, allowing for the focus on the requirements for specific applications as the primary drivers of the design process. These, in turn, will accelerate the development of nanomaterial which will result in a large number of diverse products to penetrate in markets so that solve the long awaited issues and stimulate economic growth. The MOR for nanotechnology has the vision to be the nation's premier center of excellence and provider of Nanotechnology. (See Figure 5).

Green Technology

The Green Technology of MOR concentrates on sustainable technologies in order to decrease environmental issues pertain to greenhouse gas emissions, water contamination, chemicals, toxic waste and heavy metals management. The mission deals these issues through channelizing activities to the main themes like wastage of wealth, clean technology, and cost effective solutions. The mission has two

Figure 4. Nanotechnology mission



Figure 5. Nanotechnology mission



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research centers namely Center for Biofuel and Biochemical Research (CBBR) and PETRONAS Ionic Liquid Center (PILC). These centers focus the following areas:

1. **Bio-Fuel and Bio-Chemical:** This area covers the conversion of biomass to solid, liquid, gas, fuels and biochemical products.
2. **Ionic Liquid:** This area deals in developing new potential ionic liquid which supports oil & gas industries.
3. **Green Process System Engineering:** This area focuses green process modeling, simulation, integration and optimization in order to boost the efficiency of material and energy management in green processes.

It has a mission to develop such novel, sustainable and competitive technologies which could reduce environmental pollution and greenhouse emissions. The current projects are shown as follows:

1. Fatty acid alkyl ester from ceibapentandra, using the microwave-assisted technique.
2. Development of Agro-based activated carbon and modified carbon nanotubes (CNTs) for CO2 Capture.
3. Prototype development of integrated biodiesel blending system for mixtures of rubbers seed oil and crude palm oil.
4. Conversion of waste polyethylene and liqnocellosic materials to syngas using catalytic gasification process.
5. Conversion of paddy husk into silica ash, bio-gasoline, bio-char syngas using high-temperature microwave heating.
6. Synthesis, characterization and rheological study of novel biodegradable drilling polyol esters of jatropha.
7. Exploration of novel feedstock for the production of biodiesel.
8. Development of biomass catalytic gasification systems for sustainable bio hydrogen production.
9. Development of graphitic nano fiber and carbon nanotubes for hydrogen storage.
10. Thermodynamics of phase and chemical equilibria in the transesterification of triolein to methyloleate.
11. Investigation of the kinetics of carbon dioxide adsorption on amine functionalized MCM-41.
12. Synthesis and characterization of novel ionic liquids for toxic metal ions extraction.

Biomedical Technology

One of the MOR also works for Biomedical Technology (BMT) in UTP. It has a Centre for Intelligent Signal and Imaging Research (CISIR) which is one of the leading missions in Biomedical Engineering and Technology in Malaysia, which has more than 20 faculty members and 80 postgraduate students. It can broadly categorize into five main research groups of Intelligent Medical Imaging (IMI), Neuro-Signal Processing (NSP), Pervasive Computing & Embedded Systems (PCES), Health Informatics & Modeling (HIM) and Adaptive & Assistive Bio-Engineering (AABE).The five groups cover the topics of dermatology, ophthalmology, neuroscience, orthopedics, rehabilitation and disease modeling. The mission facilitate researchers with cutting-edge and state-of-the-art equipment like multispectral cameras, thermal cameras, 3D laser scanner, 3D optical scanner, 128-channel EEG machine (compatible with fMRI for simultaneous data acquisition), eye tracker, fNIR system, wireless EMG system, ECG

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machine, 20 channel wireless EEG machine and customized sodium knee coil for FMRI. The MOR BMT has the vision to be a National Center of Excellence in Health Diagnostic Tools. The MOR BMT has a mission to provide solutions to different problems in the field of biomedical science and engineering by exploring the frontiers of knowledge.

Social Sustainability

University Internship Programs

Universiti Teknologi PETRONAS (UTP) established with the aim to produce graduates who are not only technically sound but also strong in critical thinking, communication, behavioral skills, business acumen, practical attitude and solution synthesis ability. UTP has a compulsory practical training for undergraduate students in the form of two internships. The internships namely Student Industrial Training (SIT) and Student Industrial Project (SIP) both have a duration of 14 weeks. This experience is considered to enhance the knowledge and understanding of students. The university keeps contact with different industries to facilitate students in placing them for internships. The Student Industrial Internship Programme (SIIP) is one of the examples of the University –Industry collaboration.

Sustainable Development

The Sustainable Resources Mission Oriented Research (SUREMOR) focuses the emerging discipline of "sustainability". The SUREMOR include the economic and environmental dimensions of sustainable development. It also focuses human capital development for a sustainable environment. SUREMOR in collaboration with university conducts activities of social responsibility and sustainability in the fields related to engineering, technology, and humanities.

The SUREMOR has the vision to be a Leading Regional Centre for Sustainable Resources in low carbon materials and environmental Engineering.

SUREMOR concentrates on THREE (3) areas relevant to global sustainability (see Figure 6).

Charity/Donation

UTP established Yayasan UTP (UTP Foundation) to further promote education in the country in 2007. Yayasan UTP has a key role in seeking donations and searching new partnerships with individuals and organizations to support university UTP its growth for becoming a leading educational institution for creativity and innovation. Yayasan grant scholarships for research and innovation in the field of arts, sports and culture. It also aims to extend philanthropic activities and financial support for the welfare of the society. Yayasan has also an important role in achieving the vision of the university to become a role model and leader in technology, education, innovation, and technology. In October 2013, UTP had organized a successful Golf tournament at Kelab Golf Sultan Abdul Aziz Shah (KGSAAS), Shah Alam Selangor. The tournament raised a fund of almost RM 0.5 million for Yayasan UTP fund (see Box 1).

Yayasan UTP (YUTP) provides non-repayable financial aid to deserving Malaysian students studying in UTP on a need basis. An amount of RM6, 000 granted to a successful applicant for assistance in tuition fee. Yayasan UTP provides 3 types of scholarship.

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Figure 6.

1. LOW CARBON DESIGN AND CONSTRUCTION
   - ✓ High Performance Binders
   - ✓ High Performance Aggregates
   - ✓ Sustainable Structure (Repair, Maintenance & Durability)
2. RESOURCE EFFICIENCY
   - ✓ Formulation of 3R's and Waste Water Formulation
   - ✓ Recovery of Energy
   - ✓ Water Resources & Basin Management
3. WATER UTILISATION AND WASTEWATER MANAGEMENT
   - ✓ Pollution Management & Policy
   - ✓ New Treatment Materials
   - ✓ Novel Treatment Systems

Box 1.



Cultural Activities

Yayasan, Alumni UTP and Dewan Filharmonik PETRONAS (DFP) have jointly organized a Tapestry of Colours 2015 – a concert in 2015. The concert aimed to raise funds for Yayasan UTP (YUTP) and thus the revenue collected from tickets given to the foundation. The Yayasan grants scholarships to the deserving students of UTP to support research, creativity, and innovation in the fields of arts, sports, and culture. The foundation has granted total scholarship worth RM 3.5 million to more than 400 students till date, since its inception in 2010 (see Box 2).

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Box 2.



UTP Performing Arts Group (UPAG) Shines at World Dance Festival

The university has a Performing Arts Group (UPAG) comprised of 19 members from the UTP Performing Arts Group (dancers) and 6 members from UTP Gamelan Group Sanggar Kirana (musicians). The UPAG has recently represented Malaysia for the third time in 10th Cheonan World Dance Festival at Cheonan Samgeori Park, Cheonan, Korea. The group achieved 3 awards namely Best Costume Award, Best International Street Parade Award and First Prize Award for Cheonan Folk Dance Competition International Category in this festival (see Box 3).

Box 3.



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International Culture Night

The International Student Council (ISC) of Universiti Teknologi PETRONAS (UTP) has organizing 'International Culture Night (ICN) since, 2011.The first program in this connection was successfully organized on 1 April 2011 which aimed to showcase different cultures, dances, and costumes of different countries. It is one of the colorful events of the university which is liked much by the students as well as outside local community. The event is now supported by the State of Perak and Jabatan Kebudayaan Kesenian Negara Malaysia (JKKN) Negeri Perak. The event has following main objectives.

1. To introduce and promote the cultures of enrolled students from different countries of the world (around 60 countries).
2. To improve communication, coordination, integration and familiarity among the students from different cultures and between local and international students.
3. To promote respect, peace, understanding and harmony among different cultures.
4. To provide a platform for students in other universities to come and perform at the event for the sake of establishing good relations.

Meet UTP@F1 Showcase

The UTP has an event "Meet UTP@F1 Showcase" where an institution of higher learning with the collaboration of well-known Formula 1 PETRONAS Grand Prix exhibit different educational opportunities and renowned F1 grand prix events. The event promotes Universiti Teknologi PETRONAS (UTP) and this time Formula 1 PETRONAS Grand Prix 2015 as well. Visitors can see race cars on display along with educational opportunities in UTP. The prospect students and their parents can seek guidance for admission and career development from the staff, students, and alumni of the university. Students are also encouraged to walk in along with their educational credential to get admission and sponsorships on the spot. The university also organizes an exhibition to show its inventions and accomplishments which enhance the morale of students, faculty, and staff. The Computer and Science department of the university exhibit their robots in these exhibitions.

Other Initiatives

Consultancy

The university is also committed to becoming a preferred choice in providing multi-discipline consultancy services and products. The University has about 300 active in-house consultants in the various fields of specialization and they are well prepared to undertake any sectors from the consultancy services. The University has also established a knowledge-based partnership with other parties from within and outside of the country to undertake consultancy services according to market demand. Recently, the university has completed a feasibility study of deep water sea port in Lumut. This consultancy team also looked into the possible impact of the proposed project on the demand for labor and supply. In addition, the report analyzed the possible impact of the project on all other sectors (including the feasibility of electronic vehicles manufacturing plant) and the consequent.

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Professional Chairs

UTP provides opportunity to industries to sponsor different Professorial Chairs for establishing a relation between academia and industry. This collaboration enables the university to gain knowledge and experience from its partners in the industry which ultimately contributes to students' development. At present, the university has following 4 professorial chairs namely:

1. Schlumberger Chair in Petroleum Engineering.
2. Shell Chair in Petroleum Geoscience.
3. Transocean Chair in Drilling Technology.
4. Mitsubishi Chair in Green Technology.

Academic and Research Conferences

Research provides a solution to the modern age problems which benefits society. UTP focuses research activities and innovation for sustainable knowledge. In conjunction, the university arranges a congress by the name Engineering, Science and Technology Congress (ESTCON) after every two years. The congress includes a number of conferences from different fields of engineering, technology, information technology along with humanities and management.

UTP Corporate Social Responsibility

Recently in Aug 2015, on the hands of Tun Dr. Mahathir launched UTP Corporate Social Responsibility (CSR) book "A Gift of Hope". "A Gift of Hope", is a book launched in conjunction with UTP's CSR approach, aligned with the university's overall vision and goals. The purpose of the book is to highlight the relationship between the university and the local society in which it resides.

CONCLUSION AND RECOMMENDATIONS

HEIs could become sustainability leaders and change drivers; they can ensure the needs of present and future generations by contributing through their institutional role, and they can educate future generations to make sustainable societies. In this regard, HEIs are required to empower and aware their employees to implement the S.D. paradigm in order to ensure S.D. throughout the university system including education research, campus operations, community outreach, assessment and reporting (Lozano et al., 2013). The debate of S.D. in HEIs has expanded over the past decades. It has been recognized that HEIs play a pivotal role in promoting S.D., sustainability principles, contributing to the paradigm shift for the better future of current and future generations. HEIs covers S.D. gamut by adopting two mainly focusing practices: on-campus and off-campus sustainability practices. These two are commonly considered as the best practices for S.D. adoption within universities. Campus sustainability covers inside the campus operations directly or indirectly link to S.D. including ES.D., sustainability research projects, S.D. related conferences, inside environmental and social contributions, while off campus covers all the outside contributions of HEIs for the S.D. domain. The current study finds that Universiti Teknologi PETRONAS, Malaysia has good and meaningful contributions for S.D. as shown in the above discussions.

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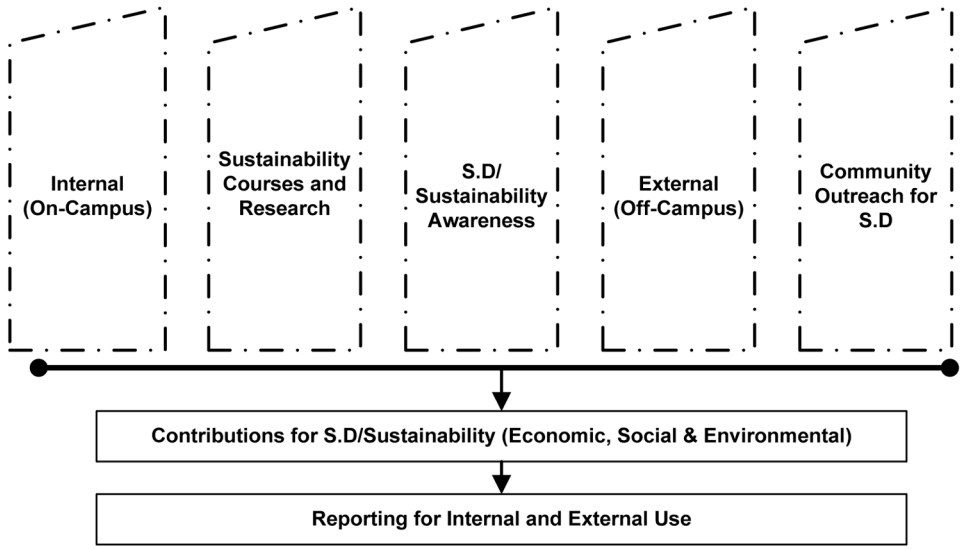
However, despite some progress and good examples, only a few HEIs are engaged and follow an S.D. implementation process holistically. They just follow the one-sided trend of "going green" only for the purpose to fulfill market requirements, somehow marketing advantages, and economic benefits. As a result, it increases greenwashing and may lead to losing the original meaning and credibility of S.D. Despite the progress made and signs of transition, there is still a long way to go to mainstream sustainability in HEIs, and a paradigm shift from unsustainability to sustainability is still difficult to identify. Even institutions having many years of experiences in the field of campus sustainability are wedged in situations that hinder a full sustainability implementation.

Keep in view the case study of UTP we conclude the findings and proposed Table 2 and Figure 7 for avoiding the implementation barriers. Table 2 provides rigorous steps for S.D. implementation within the culture of any organization particularly a university. The study proposed these steps in following catego-

Table 2. Education for sustainable development priority areas

Commitment to S.D. and E.S.D.	Priority
1. Top Management Commitment	High
2. Vision and Strategy	High
3. Targets & Benchmarking	High
4. Stakeholders Identification	High
5. Stakeholder's Awareness & Empowerment	High
6. Research & Development for S.D.	High
7. Focus on Social, Environmental and Economic Sustainability	High
8. Reporting for Internal & External Use	High
9. Adhere National and International Policy(ies) (where applicable)	High

Figure 7. Proposed sustainability implementation framework for university



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rization i.e. top management commitment, vision and strategy, targets and benchmarking, stakeholders identification, awareness and empowerment, R&D for S.D., focus on economic social and economic sustainability, reporting for internal and external usage and last but not the least follow a national and international policy where applicable. In Figure 7 the study proposed sustainability management system (SMS) for HEIs. The purpose behind the SMS for HEIs is to ensure the implementation of S.D. in line with the 9 priority area as defined earlier.

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2 http://database.globalreporting.org/
3 http://www.epu.gov.my/en/home

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APPENDIX

Table 2.

Initiative for Sustainable Development	Reporting
S.D. included in the vision and mission, goals & objectives	Yes
Policy for implementing S.D.	Yes
Strategic plan for implementing sustainability	Yes
Staff dedicated to S.D.	Yes
S.D. working group	Yes
S.D. office	Yes
University leaders provide an S.D. budget or in-kind support	Yes
Plans to improve energy efficiency	Yes
Energy efficient equipment	Yes
Renewable energy usage	Yes
Plans to reduce GHG emission	Yes
Efforts to reduce GHG	Yes
Plans to improve prevention and management of waste	Yes
Waste bins to separate and recycle waste	Yes
Policies and activities to reduce paper consumption	Yes
Plans for water and wastewater management	Yes
Course on S.D. for all students	Yes
Optional courses on S.D. in the curriculum	Yes
Integrated sustainability courses throughout all curricula	Yes
Invited lecturers/professors on S.D.	Yes
Teaching across the natural sciences and social sciences faculties	Yes
Continuing education to the public on S.D.	Yes
S.D. institute research center	Yes
Funding for S.D. research	Yes
Promotion of holistic thinking in research	Yes
Use of research generated in S.D. teaching	Yes
A number of publications on S.D.	Yes
Patents in the field of S.D.	Yes
Creation of S.D. new knowledge and technologies	Yes
Research between the natural sciences and social sciences faculties	Yes
Exchange programs in S.D.	Yes
Joint S.D. degrees with other universities	Yes
Joint S.D. research with other universities	Yes
Collaboration in S.D. research projects with other universities	Yes
S.D. partnerships with other society stakeholders	Yes
Part of interdisciplinary S.D. expert networks	Yes
Academic staff involved in voluntary advisory activities in S.D.	Yes
S.D. events that are open to the public/community	Yes
S.D. working for group with members from different departments	Yes
Policies that promote S.D. for all students and staff	Yes
Sustainable practices for students	Yes
Student participation in S.D. activities	Yes
Employees and other stakeholders act sustainably	Yes
S.D. efforts are visible throughout the campus	Yes
Staff and researchers are aware of S.D.	Yes
Staff and researchers are engaged in S.D. research	Yes

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Table 2. Continued

Initiative for Sustainable Development	Reporting
Assessment of S.D. issues	Yes
Communication of S.D. activities	Yes
Environmental reports	No
Sustainability reports	Not Reported
National environmental universities' rankings	Not Reported
National S.D. universities rankings'	Yes
International environmental universities' rankings	Not Reported
International S.D. universities' rankings	Not Reported
Campus Operations	Yes
Education	Yes
Research	Yes
Outreach	Yes
On-campus experiences	Yes
Assessment and reports	Not Reported
Cultural Development	Yes

Sources Adapted: (Lozano et al., 2014)

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Chapter 38
Integration of Education for Sustainable Development Into Formal Secondary Curricula of East Timor

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ABSTRACT

This chapter explores the relevance of Education for Sustainable Development (ESD) in formal education reform in East Timor. This chapter relied on relevant published documents and information published by various national and international agencies concerning East-Timor. It firstly reflects on the organization background of development of new secondary curriculum in East Timor; then it focuses on what protocols and principles form the basis of these new curricula. There is further description of the development and implementation of the new curricula inclusive of subject selection in consideration of ESD and Millennium Development Goals (MGDs) as illustrated with some examples of ESD integration in new textbooks for 10th year. Lastly, it highlights the challenges that team developers faced at the completion of curricular development and presents some solutions to overcome difficulties related to restructuring and implementation. Thus this chapter aims to provide an example of sustainable development integration into secondary curricula of a young country - East Timor – while illustrating the extent of curricular materials could contribute to developing skills, values and attitudes aligned with sustainable development perspectives.

ORGANIZATION BACKGROUND

Education for sustainable development (ESD) concerns educational processes to help achieve sustainable development (SD), based on three premises: environmental protection, economic development and social development, integrated in an inclusive and equitable manner (UNESCO, 2011a). Therefore, ESD is important for improving the living conditions of all citizens, promoting SD and achieving the

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Millennium Development Goals (MDG), especially in young countries like East Timor. The government of East Timor has recognized the importance of secondary school curricula restructuring, including disciplinary programmes, along with the production of resources required for the various disciplines, as a priority (RDTL, 2011). In these circumstances, the Government, within the project *"Restructuring of secondary school curriculum of East Timor,"* together with Portuguese institutions (e.g. IPAD, 2010), has been developing new secondary curricular materials, with the general purpose to contribute to local MDGs (UNMIT, 2010) and sustainable development, (Capelo, 2013). Also, teacher-training courses were implemented (IPAD, 2010.

Many young countries that have undergone a post-war political transition present common patterns of development. Such a political transition may include internal conflicts, divergence over environmental and economic priorities, and a diverse ethno-cultural heritage. East Timor is no exception and presents many problems of resource degradation and deterioration, as well as local and regional diversity in the social, economic, cultural and environmental domains, reinforcing the need to respect and preserve national identity (Presidency of the Ministers' Office, 2007). All these concerns underscore the need to improve education in order to promote respect and a sense of responsibility for the sustainable development of the country. In other words, educational practices (formal, non-formal and informal) should be adjusted to local needs in order to encourage students to explore questions, issues and problems, especially in contexts relevant to SD (GC-UNESCO, 2009).

A main role of formal institutions is strengthening the preparation of students to face emerging local, national and global problems in an appropriate way, and to understand these problems and constructively participate in solving them. Moreover, the holistic perspective present in any educational program guided by ESD principles will help students develop multiple competences, e.g., technical, cognitive and emotional (UNESCO, 2011a, b).

East Timor is a country in Southeast Asia, comprising the eastern half of the island of Timor. During 400 years it was a Portuguese colony. In 1975, East Timor declared its independence but soon after it was invaded and occupied by Indonesia. In 1999, following the United Nations-sponsored act of self-determination, Indonesia relinquished control of the territory, and East Timor became the first new sovereign state of the 21st century on May 20, 2002. After independence, East Timor became a member of the United Nations and the Community of Portuguese Language Countries (Earnest, 2003). Since independence, Timor-Leste's social and economic policies have focused on alleviating poverty to address the immediate needs of our people, consolidating security and stability, and providing a foundation for nation through building institutions of State. As most education infrastructure in Timor-Leste was destroyed during the Indonesian period. East Timor's Government had invested in building and rehabilitating schools across the country, training teachers and innovating curriculum (RDTL, 2011).

Since this time, the government has invested in building and rehabilitating schools across the country, with modern and adequate classrooms, water and electricity. Also, the government invested in reform of education system, including development of a new curriculum that focused on "developing relevant knowledge, useful capacities and critical intellectual and social skills, and on promoting creativity and problem-solving skills, communication skills and critical thinking" (RDTL, 2011, p. 23). To achieve these goals, the Timorese Ministry of education has relied on the support of international experience of higher education institutions, many of which Portuguese. Portuguese institutions emerge not only because Portuguese is one of the two official languages, but also because it is the language selected for education (Albergaria-Almeida et al., 2012).

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Actually, reform in at all levels of education is ongoing. Secondary school reform, in particular, is supported by the cooperation between East Timor and Portugal for the period of 2009 and 2012. The new secondary curriculum replaced the old curriculum and the respective curricular textbooks from Indonesia and Brazil. These old textbooks still exist, with extensive programs, written in a condensed form and with little diversified strategies. Though the introduction of the new textbooks reduced the shortage of textbooks, there were still not enough textbooks to teach and all the students – some students had to rely on copying notes from the board. Furthermore, most of the old textbooks did not focus on East Timor, and were not relevant to the East Timor context or case (Earnest, 2003). Their language is difficult for teachers because they have textbooks in Indonesian but the level of proficiency of Indonesian by the students is less than satisfactory so sometimes they had to explain in Tetum. Concerning the Portuguese language, the Government had made Portuguese the official language and in most schools there were teachers from Portugal that were teaching the students and East Timorese teachers Portuguese (Earnest, 2003).

In short, the work presented here, focuses on the process of design, acceptance and implementation of new secondary school curriculum materials developed during the course of specific protocol cooperation between East Timor and Portugal. Additionally, it focuses on some aspects guiding the new general curriculum which were behind its design, in particular ESD and MDGs approaches (IPAD, 2010), and its acceptance by government authorities, such as the Ministry of education, as well as, by the teachers.

SETTING THE STAGE

The Ministry of Education of East Timor within the framework of a Cooperation Protocol with Portuguese Institutions, specifically, *Portuguese Institute of Development* and *Calouste Gulbenkian Foundation*, followed by a Cooperation Agreement between *Calouste Gulbenkian Foundation* and one of Portuguese Universities, namely Aveiro University (AU) (Martins & Ferreira, 2012), prepared new secondary curriculum such as, *Programmes*, *Textbooks for Students* and the corresponding *Teacher's Guides* (IPAD, 2010). Specifically, a multidisciplinary team of approximately 60 specialists from AU supervised by two coordinators (Prof. Isabel Martins and Angelo Ferreira) are structured to produce new curricular materials for 14 disciplines, for the three years of schooling, 11th/10th/12th, respectively. In total, the team produced 42 *Textbooks for Students* (150-160 pages each), 42 *Teacher's Guides* (75-90 pages each) and 14 disciplinary *Programmes* (approx. 60-80 pages each) (Martins & Ferreira, 2012).

The need for suitable curricular materials is of particular importance, as the minister of presidency of East Timor highlighted in the official launch of the 'Education First Initiative': *"It is not good enough that many have to walk hours each day, to an overcrowded classroom, without appropriate books and curriculum"* (Prime Minister RDTL, 2012).

CASE DESCRIPTION

As is already well documented in numerous studies (e.g. Albergaria-Almeida et al., 2012; Shah, 2012), and official documents of the Government (RDTL, 2011), most schools and virtually all teaching equipment and materials in East Timor were destroyed or had disappeared (MECYS/SSLS, 2005), after the independence referendum in 1999. Most of remaining items were Indonesian and/or Brazilian textbooks.

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The recent protocol between East Timor and institutions in Portugal came to bridge the lack of specific secondary curriculum materials for East Timor.

Developmental of General Secondary Curriculum in East Timor

For the development of a general secondary curriculum, the Portuguese team took into consideration the necessity to overcome: "low enrollment ratios in secondary education;" "the large number of out-of-school secondary-school-aged youth;" difficulties in "adjustment of secondary education structures to accommodate ever increasing cohorts of students and their diversified learning needs and interests;" "low relevance, quality and efficiency in last secondary education programmes;" due to "out-dated information;" "discipline-based, college-bound curriculum;" "inadequate qualifications of many teachers and education managers and school principals;" "over-centralized administration of secondary education and lack of school autonomy, essential for improved efficiency;" and "inadequate and inappropriate use of new technology as subject, education resource and tool of delivery" among others problems [(Nan-zhao & Haw, 2002), p. 426-427]. Some of these purposes were still recognized by technical missions for monitoring the secondary curriculum restructuring in East Timor, e.g. Ferreira et al. (2011). These technical missions was performed during 2009 and 2011, five in total, where a Portuguese team is developing contacts with Timorese authorities in order to meet and work with educational leaders, schools and teachers, and with other entities that could provide relevant issues to curriculum development.

In addition to these contacts, the team consulted documents and reports from national and international agencies for the Asia-Pacific context, official documents of the East Timor Government, the recommendations of UNESCO and other UN organizations concerning ESD priorities for the second half of the Decade of Education for Sustainable Development (UNESCO, 2005), recommendations given by international bodies dedicated to ESD promotion and implementation (e.g. SEAMEO INNOTECH, 2010), as well as the East Timor work developed by researchers and educators that are important to link up (e.g. Jones, 2010; Leach, 2010; Nicolai, 2004, Taylor-Leech, 2008). IN consideration of all of these, the team designed a curriculum with a combination of content and competency-based approaches, where topics and contents were selected according to the:

1. Opinions and suggestions from local citizens about some issues that should be present in new curriculum (NIER, 1999),
2. Necessity of including new disciplines in secondary curriculum, such as, "Geology," "Citizenship and Social Development," "Themes of literature and culture" and "Multimedia technologies" (NIER, 1999),
3. Inclusion of thematic contents that reflected local characteristics, i.e. adaptation to cultural context (NIER, 1999),
4. Inclusion of MDGs-related issues (e.g. poverty, hunger health) (ESCAP/ADB/UNDP, 2007),
5. Inclusion of SD or ESD-related issues (SEAMEO INNOTECH, 2010),
6. Integration and promotion of learning goals and activities that take into account actual literature about science education (e.g. activities that encourage creative thinking, problem solving and promote greater autonomy) (e.g., NIER, 1999; Nan-Zhao & Haw, 2002), and
7. Awareness of Timorese Ministry of Education and AU for monitoring and evaluating the process of new curricular materials implementation (NIER, 1999).

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The intentions of the team are explicitly to develop secondary curriculum in an ESD perspective, in terms of specific learning characteristics and resources (see Table 1), as well as, of ESD subjects (see Table 2). The Timorese Government itself had already stated the interest of promoting a quality education towards sustainable development of the country (Capelo et al., in press).

Review of ESD experiences in the first half of the DESD (Wals, 2009) confirms that ESD can help mobilize people's participation in SD and their problem-solving capacity through processes which enable different learning contexts to flourish (e.g., collaboration, dialogue and participation). The term "process" used in this context refers to methodologies or pedagogical approaches, or teaching and learning styles adopted to implement ESD at different educational levels (Tilbury, 2011), while the term "learning context" comprises the use of different learning approaches and resources.

In science classrooms, these are linked to the concept of "Learning to Change" (UNESCO, 2011a, p. 101), which advocates "teaching science through interactive pedagogy, such as project-based learning, experiential learning and cooperative learning" (UNESCO, 2011a, p. 92). Taking this into account, Table 1 aims to suggest appropriate ESD learning approaches and resources (UNESCO, 2011a) for secondary school programmes in East Timor, whether in science or social disciplines.

The learning approaches mentioned above are based on a set of "learning characteristics" defined by UNESCO (2011a), some of which are "participatory" and others are "collaborative." According to Tilbury (2011), an internationally renowned researcher in the area of sustainability leadership, these characteristics are the most appropriate for supporting ESD learning. This researcher refers to them as, respectively, "processes of active and participatory learning" and "processes of collaboration and dialogue" (2011, p. 7). Also, states that the first, especially, encourage pupils to:

- *ask critical reflective questions;*
- *clarify values;*
- *envision more positive futures;*
- *think systemically;*
- *respond through applied learning; and*
- *explore the dialectic between tradition and innovation (p. 29)*

Concerning the set of specific ESD key themes that should be addressed in the curricula (see Table 2) the team took into consideration the specific literature concerning ESD-related issues (UNESCO, 2011a; Wals, 2009) and specific key themes recommended for the second half of the DESD for the Asia-Pacific region (UNESCO, 2010). These key these included "preventing the loss of biodiversity," "water management," "climate change adaptation," "disaster prevention," "rural development," and "cultural diversity" (UNESCO, 2011a, p. 94). Cultural diversity is relevant since respect and preservation of indigenous knowledge and traditional languages (e.g. Jones, 2010; Leach, 2010; Nicolai, 2004; Taylor-Leech, 2008) are paramount o true sustainability.

The team had also count some priority areas stated by ESD strategy for the Southeast Asia region (UNESCO, 2005a, p. 2) such as "natural resources" and "environmental education" and relevant targets from among the eight MDGs that have not been achieved in East Timor (UNMIT, 2010), such as "environmentally sustainable development" (see Table 2).

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Table 1. Suggested appropriate ESD learning approaches and resources for secondary school programmes in East Timor

ESD learning approaches which could be addressed in secondary curriculum of East Timor
Cooperative and collaborative
Participatory
Student-centered
Experiential
Evidence or research based
Project and activity based
Interdisciplinary (inter-relationships across disciplines in dealing with problems)
Borderless (can take place regardless of time and location, and regardless of age)
Esd learning resources which could be addressed in secondary curriculum of East Timor
Science kits
Games
Research documentation
Information and communication technologies (ICT) articulation

Table 2. Appropriate ESD key subjects for secondary school curriculum East Timor

ESD key subjects which could be addressed in secondary school curriculum of East Timor
Health promotion, namely: HIV/AIDS Malaria Tuberculosis Others
Environmentally sustainable development, namely: Preventing the loss of biodiversity Water management Climate change adaptation Food security Disaster prevention Natural resources management and consumption Rural development
Environmental education
Cultural diversity (promotion of indigenous knowledge, recognition of traditional languages)

Examples of ESD Integration in New Curriculum

The following examples of ESD issues are related to the themes of *International Year of Water Cooperation* (WWAP, 2012) and the *International Year of Sustainable Energy for All* (UN, 2011; UNDP, 2011) as integrated into the new secondary textbooks of 10th schooling year. In consideration of the International Year of Water Cooperation, the new Biology and Chemistry textbooks integrate in an implicit way, subjects that help Timorese to become aware about the access, distribution and consumption of water (see Table 3).

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Table 3. Examples of the integration of issues related with international year of water cooperation in East Timor secondary Chemistry and Biology textbooks

Chemistry	Biology
Unit A. Materials, Waste and Risk Management	Unit 1. Biodiversity and Dynamic Unit of Life
"Water is the most precious resource of the Earth, being a duty of each of us to preserve it and look after it. It serves for drinking, bathing, (....) and suspensions in medicines" (p.55) "How do I purify water in an emergency situation?" (p. 55)	"In East Timor, there are more than 100 rivers (...). Many of these rivers are not permanent, drying in the dry season. (…) the island of Timor is drier than the surrounding islands" (p.13) "In the Millennium development goals Report of, (...) (forecast of sanitation improvement and providing better water supply to the population in Timor-Leste" (p. 52)
"Off-shore platforms» petroleum exploration using desalination processes for drinking water" (p. 70)	"The solid remains (...). These remains can still release metals and ions that will contaminate water and soil" (p.48)
	"Reduce the use of natural resources will be a first step to consider. We can, for example, think about reducing the use of potable water to what is strictly necessary. "For example, we can reuse the water to wash the food to water" (p. 49)

Concerning the integration of subject issues or practices related to the *International Year of Sustainable Energy for All*, the analysis of new Biology and Chemistry curriculum materials of 10th school year, in particular, do not explicitly address matters relating to sustainable energy for all, which does not mean that they are not useful for teachers and students. From these books, Timorese acknowledged problems related to energy, were able to develop respect and values for energy resources and adopt attitudes and behaviors according to ESD perspective (Capelo et al., 2012).

Some practical activities suggested in these materials (e.g. Biology Programme, p. 18; Chemical Programme p. 24) can stimulate students to study matters relating with the *International Year of Sustainable Energy For All* (Mendes el al., 2012; Ferreira et al., 2012). Besides, regarding Chemistry, the *Programme* does not refer to matters that relate to Sustainable Energy for everyone, but refer to environmental consequences of waste disposal practices such as burning and incineration (p. 21). In the Chemistry *Textbook*, natural resources appear in the definition of sustainability in the *glossary* (Ferreira et al., 2012, p. 164) and in the *introduction* (p. 6), while the *Teacher's Guide* has the definition of environmental protection, in the *glossary* (p. 76), as well as a reference to energy utilization (p. 50). The term still arises in the context of integrated energy resources, oil exploration platforms and on issues proposed at the end of a subtopic (Ferreira et al., 2012, p. 70). Similarly, fossil fuels and alternative energy sources are integrated into a personal and socially relevant content, like desalination platforms, as well as issues proposed at the end of the same subthemes (Ferreira et al., 2012, p. 70).

In this perspective, the current curriculum gives relevance to certain aspects that the old curriculum did not give such as: i) contextualization to the reality of East Timor, ii) interdisciplinarity, iii) teaching centered on students, iv) promotion of practical activities, and v) promotion of ESD learning approaches and subjects. Overall, the *Programmes*, *Textbooks for Students* and *Teacher's Guides* of all disciplines under the responsibility of AU have been defined and prepared for specific curricular areas and for three years as mentioned earlier, namely, 4 for General Component (Portuguese; English; Citizenship and Social Development; Multimedia Technologies); 5 for Science – Physics (Technologies &; Chemistry; Biology; Geology; Mathematics); and 5 for Social Sciences Humanities (History; Geography; Sociology; Themes of literature and culture; Economics and Quantitative methods) (Capelo, 2013).

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Approval of New Curriculum and Its Impact

The new general secondary curriculum has already been approved by National Parliament resolution No. 20/2011 and Government resolution No. 24/2011; Decree-Law No. 47/October 19, 2011 (published in Journal of Republic, series I, no. 38, pp. 5308-5314, October 19, 2011) (Capelo, 2013). The *Programmes* have been delivered to the Timorese Minister of Education. Moreover, *Textbooks for Students* and *Teacher's Guides* for all disciplines of 10th grade have already been edited and are actually being used in schools since 2012. On the other hand, *Textbooks for Students* and *Teacher's Guides* for 11th and 12th grades and for all disciplines have been prepared and delivered to the Timorese Minister of Education, for editing and use from 2013.

In consideration of the curricular reformation and development, the Timorese government always showed receptiveness with respect to the work performed by the Portuguese team. The Timorese government recognized the educational value of ESD promotion and MDG achievement in the curricula (information obtained in informal conversations between elements of Portuguese technical mission and Minister of Education, not published). Timorese teachers in conversations with the Portuguese team, revealed a huge motivation for using the new curriculum. However they recognized their own limitations and difficulties, such as:

1. resistance to change their traditional teaching habits, as well as, to change the curricular subjects, identified by the fear of the unknown,
2. discrepancy in learning opportunities between "urban" and "rural" teachers and between "genders,"
3. awareness of the relevance of new curriculum for achieving ESD purposes and then contributing to MDGs,
4. lack of pedagogical resources in classrooms,
5. high miscommunication risk due to language difficulties, and
6. risk of "educational culture shock" between trainees.

CURRENT CHALLENGES

To contribute to better performance by Timorese teachers, the Timorese Government approved an intensive course held in Portugal for Timorese teachers. Thus, the AU held an intensive six week course in October and November 2011 for 24 general secondary school Timorese teachers. These teachers were selected by the Timorese Ministry of Education, who come to Portugal to improve their training for teaching in the 10th year of schooling. This opportunity was later extended to their colleagues in East Timor. Specialists of disciplinary teams, trainers and guests teachers of secondary schools participated in the training, which allowed the Timorese teachers to experience aspirational functioning schools, and in some cases, participate in secondary school classrooms.

Also, the Timorese government supported a bachelor's course carried out in East Timor, designed and implemented with the collaboration between Portuguese teachers and the Timorese Ministry of Education. This bachelor´s course includes several modules that correspond to different subjects with an enrollment of 301 Timorese teachers. This course was held at the *National Institute for Teacher Training* (INFORDEPE), located in Díli, East Timor. During this course Timorese teachers revealed a great motivation and sense of responsibility for using the new curriculum. The implementation of

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teaching strategies (e.g. formulation of thinking questions, collaborative construction of concepts maps, construction and presentation of posters, daily plans about ESD subjects) to replace the old strategies were welcomed (Albergaria Almeida et al., 2012).

The Timorese teachers also demonstrated awareness of their own limitations and difficulties, showing solidarity among each other in order to minimize and overcome obstacles related to the interpretation of new themes (e.g. ESD or MDGs issues), new methodologies implementation, e.g. laboratory activities; language difficulties and cultural shock between trainees, among others.

The bachelor's course does not explicitly address matters relating to ESD/MDGs issues integration in the new curriculum (which does not mean that they were not useful for teachers, in a collaborative way). It did assist to develop (i) awareness about issues or problems related with MDGs, (ii) respect and value of national heritage, and (iii) attitudes and behaviors towards sustainable development (Capelo et al., 2012). Future revisions or adjustments of new secondary school curriculum mean that every aspect of the process of curriculum implementation should be monitored and evaluated regularly.

SOLUTIONS AND RECOMMENDATIONS

In general terms and with regard to curricular implementation, it was recognized that there are some difficulties. The East Timor Government identified and made efforts to overcome them. For instance, the Government is aware of the poor training of teachers and stresses the importance of continuous teacher training (e.g. Ferreira et al., 2011; Afonso et al., 2011). Also, the East Timor Government now pays particular attention to the process of monitoring and evaluation of curricular implementation (ME-RDTL, 2012).

For contributing to this, the Portuguese team is developing contacts with Timorese authorities in order to meet and work with educational leaders, schools and teachers, and other entities that could provide relevant issues to monitor and evaluate curricular implementation. Several authors (e.g. Baker, 2000; Horton & MacKay, 1999) state that monitoring and evaluation should be prioritized in cases like this one, i.e., when the reform could benefit from the results of an evaluation, to provide feedback to policy-makers, for instance, providing guidelines about teacher training.

This training and follow-up should be provided by the teams that produced curricular materials. It is obvious that the need for a significant effort to provide the school park with the minimum conditions for a teaching quality and dignity that the Timorese deserve and need (properly equipped classrooms, laboratories, computer rooms, libraries, etc.). It is clear, however, that financial investment is not all that is needed. Improving the schools' organization and commitment of everyone in the creation and maintenance of a good working environment, especially with regard to maintenance and cleaning, is vitally important (Ferreira et al., 2011).

Other countries in Asia also followed guidelines towards the alignment of secondary school curriculum by ESD purposes (e.g. Malaysia, Laos, Cambodia), considering the priorities of an equitable education for all, and improving the quality of life for all. However, these countries are also going through the processes of monitoring and evaluation of the new curriculum to readjust some aspects to the necessities of each one. Last but not least, the proposed new curricular materials aligned with ESD key subjects and practices will enable students to develop relevant skills in terms of a better understanding of science subjects, for instances, climate change, loss of biodiversity, food security and rural development required for SD (UNESCO, 2011a).

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However, even though the selected subjects in each discipline may indicate that secondary school curricula are aligned with ESD principles, it is also important to assess if they then contribute effectively to SD. As Tilbury (2011) highlighted in a very clear way:

One critical question remains […], which relates to the extent and the depth of connection between the choice of processes in ESD initiatives and actual contributions to sustainable development. In other words, is there a direct relationship between processes and outcomes in ESD? (p. 8)

Thus, the complexity of a system-wide reform requires changes that imply various stakeholders' intervention, training and the monitoring and evaluating of the new curriculum in order to build a better future. Moreover, it is important not to underestimate the timeframe for a system-wide change to give time and to prevent the capacity to resist to centrally mandated changes (Hallinger, 2012).

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Chapter 39
A Paradigm Shift: Empowering Farmers to Eliminate the Waste in the Form of Fresh Water and Energy Through the Implementation of 4R+T

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ABSTRACT

The growing population in Turkey as well as in the rest of world is focusing their attention on the availability of main resources for now and for future generations. As the clock ticks by, this focus is intensifying at an exponential rate. Depleting resources, dependency on fossil fuels, high costs of energy, water quality, food cultivation and food safety present themselves as expected issues of our generation. Waste in the form of electricity and fresh water in agricultural practices can be reduced by using Reduction, Recovery, Reuse, Recycle and efficient Technologies in order to come to a sustainable management of waste starting with small-scale farming implementations. This generation must act to implement these changes, and they must act now.

INTRODUCTION

The growing necessity of adequate waste management measures is an important area of sustainability. Waste management of not only solid and liquid wastes but also the wastes in the form of electricity, water and soil (through erosion) which complement the multidisciplinary approach of (4R+T) 4 R's consisting of Reduction, Reuse, Recycling, and Recovery with (T) the efficient Technologies in the rural development and agricultural practices.

The growing population and increasing demand of food bring more emphasis on the agricultural production and dairy industry. The current irrigation practices urgently need a shift from the massive flood irrigation in thousands of hectares to more environmental friendly, sustainable irrigation methods such as drip irrigation with renewable energy powered pumping systems. This shift in the irrigation method

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would meet with the waste management pyramid at the Source Reduction & Reuse which is the most preferred action as a result; save the natural resources, conserve energy both water and electricity, save money for consumers and for governments as well as making farming more profitable.

Economically, the agricultural areas in Turkey are around 8.5 million hectares in total of which 69% is currently irrigated by all types of irrigation methods, although generally flood irrigation is the primary method. The development of the infrastructure of the remaining 31% in the coming years will not only increase the agricultural yield and create new jobs but will however put pressure on both the water resources and electrical infrastructures.

Because of the unreliability of the resource due to the effects of the climate change it is even more prudent to manage our resources more carefully.

This is where the importance of Technology wrapped around in the 4R's comes into play and creates the ability to make major shifts in farming methodologies against conventional practices.

Reduction in the consumption of water and the energy to provide this resource is the focus of this chapter.

BACKGROUND

The population of Turkey is estimated to be 100 million in 2030 by TUIK (Currently 75 million - Turkish Administration for Statistics). Turkey with its current water resources and changing water demand needs to sustain its water resources at least at current usage levels to be able to meet the demand in 2030 with 100 million people.

State Hydraulic Works (DSI) states the current yearly usable water quantity per capita is 1.519 m^3 approximately. With the growth rates provided by Turkish Statistic Administration (TUIK), only by conserving the water sources as they are at the moment, the usable water quantity per capita will decrease to 1.120 m^3 per year, which is very close to the definition of 'water poor' being less than 1.000m^3. This creates another pressure and importance at the same time for sustainable water and resultant energy management practices.

With the growing world population toward 2050, there is a challenge to produce 50% more food up to 2030 and to double the production by 2050. The conditions will make the world achieve these targets by using less water due to the growing industrialization, urbanization and climate change. Water efficiency, water management, especially in agriculture, being the major water user, reaching about 70% of the fresh water withdrawals and over 40% of OECD countries' total water withdrawals (OECD, 2010).

In Turkey, 75% of the total water consumption comes from the irrigation sector. As a result of a fast growing industrialization with the growing rate of population the availability of water per capita is decreasing. Most of the investments realized were on the irrigation infrastructure by transferring the water natural resources to the fields. Large capital investments are necessary in order to expand the irrigated area which results in difficulties in the allocation of the capital investment while putting pressure on the consumptive use of water resources (Cakmak, 2010).

The Turkish Government transferred the irrigation schemes to water user organizations and is one of the world leaders. However, the water price in these organizations is still based on operation and maintenance costs, and is charged per hectare depending on the crop. It does not include the Economic and Opportunity costs associated (Cakmak, 2010).

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State Hydraulic Works (DSI) declares new prices on a yearly basis. In 2015, depending on the irrigation type (free flow or pumping), the irrigation prices varies between 7.50 TL/da (1da=0.10 ha) to 103.50 TL/da. (DSI) In addition to these costs, operation and maintenance costs are also charged by the users, which are also declared annually. In comparison, urban water pricing differs between 3.93 TL/m^3 – 0.47 TL /m^3 excluding environmental tax and solid waste management fees (ISKI, 2015).

In some regions of Turkey, open irrigation canals from the dam to the field is causing inefficient irrigation, resulting in loss of water through evaporation (50%) and damages to the canals along the way (Adana TAYEM, 2013).

Electricity prices for pumping the water for irrigation are also resulting in very high expenses for the users in addition to their current water prices. Most of the water unions and farmers cannot pay and are in debt for their irrigation.

In addition to this price structure, all wells will have metering installed which will monitor the quantity of the water consumed by 2nd April 2016. This is actually a postponed date; the scheme was meant to be implemented by April 2013. (Official Gazette dated 4th April 2014, law no.167).

State Hydraulic Works (DSI), declares that the ground water reserves of Turkey is 21.54 billion m^3 (2013) of which the safe reserves are 16.95 billion m^3 (2013) of water. The irrigation consumption from ground water is up to 13.55 billion m^3 of which 25% is taken by registered well users, 45% is used for domestic use, and 30% is done by irrigation Cooperatives and by State. The number of registered wells in 2012 is recorded by DSI as 206.451, and it is estimated that the number of unregistered wells is approaching 200.000.

Therefore, it is very important for consumers to understand the value of water, prior to the irrigation, usage and processes. It is also very important that the costs associated with these processes is understood well by the users and that the introduction of sustainable water management systems can be easily offset against those costs.

MAIN FOCUS

In the year 2015, it is possible to have sustainable water and energy management in agricultural practice through the use of 4R's and efficient technologies. This will overcome the issues relating to waste creation from excess fresh water usage and the associated high costs of energy consumed in both the recovery and the reticulation.

By reducing the volumes of water consumed and eliminating electricity power bills, we improve the overall profitability of the farm. This then gives the farmer the opportunity to use these additional funds to focus on the balance of 4R's+T. This holistic approach to the waste management and operation of the farm complex will create a much more sustainable and profitable environment.

The field studies that we have carried out show that the majority of the farmers who have their own wells are either not aware of the quantity of water they consume to irrigate or the capacity of their submersible/surface pumps used to reticulate. Generally they are uninformed. Thus, they are unaware how much water they use for their crops. It is declared that 70% of natural water resource is consumed by agriculture. However if we could realign the unknown with the known parameters this percentage could be dramatically reduced. Through simple education methods, these unknown parameters could be monitored and reduced very easily.

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The groundwater law no.167 published in 2013, took measures on the metering systems for both electricity and water consumption in the wells, which caused a lot of controversies among the farmers. The implementation of the law was thus, postponed by the Board of the Ministers of Turkey stating that there was a short supply of equipment to implement the infrastructure required. This was a big setback for the proponents of the introduction of water consumption metering and control.

Decreasing water sources per capita in the coming years, increasing cost of electricity, importance of growing food to meet the demand of an increasing population, oblige the Government to initiate measures such as the water metering systems. Also, different methods of support mechanisms such as grants, low interest financing of renewable solutions to solve water management, all support the use of the resources focusing on the reduction, reuse, recycling and recovery in a sustainable and Technology smart way by the Government.

Typically flood irrigation is used to irrigate in most regions using large electrical pumps through canals and pipelines to provide mass volumes of water over short periods of time. Against this backdrop of flood irrigation, there is little research and even less knowledge of the amount of actual water particular crops do require and so this lack of knowledge results in over compensation of the amount of water that is used.

Therefore, if farmers could be educated to recover their water by pumping it in the storage tanks and using gravity to drip irrigate we not only reduce both volumes of water and energy consumption but create control over the volumes of water and the erosion of the soil. With a 'closed loop' drip irrigation, the water not used in the system can be returned to the storage for Reuse. Also, grey water from the farm domestic use can be Recycled and used for irrigation or farm domestic use further reducing the fresh water demand at the source. Furthermore, the recycling of washed down/cleaning water used in animal husbandry within farm complex can be used to break down manures to create fertilizer for the crops.

Then, by introducing either solar or wind power to run irrigation pumps off the electrical grid (off-grid) from either underground water tables to surface or from canals, dams and ponds to the fields, we not only reduce the energy consumption but we remove the enormous cost of bringing the electrical network to the area that requires irrigation and the dependency on the network utilities to provide a reliable electrical service. These irrigation pumps are often installed in 'end of line' situation, which results in not only voltage issues but high costs for the farmers. By using renewable resources, which are naturally available and are for free all day, every day of the year in varying volumes, we remove both these high infrastructure and operating costs, making the farm more profitable.

Through case studies, it is acknowledged that solar or wind powered pumps with half of the rating of conventional mains power pumps, can provide the volumes of the water required and are equal or even greater than the conventional methods (based on standard variables). As a result, the introduction of renewable energy powered pumps; farmers can have the independence of owning and controlling their own irrigation and even taking away the dependence on shared cooperative pumping systems.

It is a well-documented fact that flood irrigation loses 50% of the water flooded to evaporation. Spray irrigation (Sprinklers) loses 30% and drip irrigation loses only 10% to evaporation. Therefore it is implicit and imperative that farmers be educated in proper irrigation methods to reduce fresh water consumption.

One of the key focuses needs to be that the price of water charged by the relevant authorities needs to be based on actual kiloliter consumption rather than by the hectare depending on the crop, as is currently the case.

In this context, the use of good technological equipment comes into perspective when implementing such changes. The difficulty is that there is no one system that does all. Each farm has to be designed

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specifically to the individual farm requirements. That is water tables can differ in depth, distances that the water needs to be pumped vary and the area to be irrigated is always different. The biggest challenge in this step is the introduction of good quality, environmental friendly, long lasting and efficient technologies to design the farms of the 21st century.

In an everyday developing world, certain measures can be taken on sight by Reduction, Reuse, Recycling, and Recovery with the efficient Technologies in the rural development and agricultural practices. This would not require very high investment costs but would be necessary to implement sound management and better understanding of nature, water, agriculture, environment and human beings.

SOLUTIONS AND RECOMMENDATIONS

There is not a single solution to tackle in addressing the water and energy wasted in the agricultural practices, animal husbandry, generally in farming. The solutions are multiple, combinable depending on the place that is going to be applied. The government, State Agencies, Universities, Research Centers and Companies who are already aware of this issue can play an important and big role.

The Government has already set the law on renewable energy, defined the feed-in-tariffs and enabled the citizens to implement renewable energy. However, as the bureaucratic layers of this implementation process is quite costly and lengthy especially for small capacity users, the growth of residential and/or agriculture sector small-scale business have not widely used yet. A further solution for this case would be the enhancement of the policies for agriculture, more precisely a wider policy comprising sustainable development, by providing the opportunity for future generations to have fresh water resources and good quality grown food etc.

Sustainable management of water resources in agriculture can be achieved through several solution implementations.

1. Educating the farmers, providing training on how valuable their environment is and how best to utilize their water and their energy needs to grow their crops.
2. Publishing new laws, regulations, communiqué and their implementation countrywide will broaden the sustainable development approaches in the farming.
3. Installing monitoring systems to better understand the actual usage and requirements.
4. Implementing the correct water pricing to stop wasting the fresh water.
5. Bringing subsidies, grants for the installation of renewable energy water pumping systems, smart equipment for reuse and recycle the water.
6. Structuring regional/crop-based sustainable farming models as guidelines to be implemented not only in Turkey but in different parts of the world as well.
7. Bridging agriculture with engineering designs and technology.
8. Supporting and subsidizing Public – Private – University Project applications for small scale projects and create competitions all around the country to promote these models as well as to raise awareness in every corner of Turkey.

Farming in Turkey has been carried out using traditional methods, which date back hundreds of years. This shift from traditional or conventional to sustainable farming can be implemented through both education and field trainings of individual farmers in an in-situ application which would involve all

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stakeholders / interest groups in the end-to-end process. Eventually, a positive impact on both the quality of the products grown and the health of the consumers who consume them will be greatly enhanced.

FUTURE RESEARCH DIRECTIONS

There needs to be a paradigm shift from traditional farming methods towards proper business management practices in agriculture, the implementation of consumption control methods and the use of renewable energy resources.

New farming methods with the inclusion of renewable energy, environmentally friendly smart technologies can be implemented with joint projects between companies, universities and public represented by local authorities in the region of the projects. Implementation models of such partnerships can be further investigated.

There also needs to be a deeper understanding, through field-testing of the actual water requirements for each type of crop grown, monitoring the behavior of nature, the tendencies of the climate, the impact of the climate change, water tables and their forecast.

It would also be challenging to study the impact of small-scale sustainable farming into the rural economy as well as projecting it to the economic development of the country by bringing a green approach to the fossil fuel driven, waste intensive agriculture.

CONCLUSION

It is still possible to prevent 'water poor' status being labeled on Turkey. If action is taken now through the reeducation of farmers, our water resources can be preserved and managed well into the middle of this Century. The implementation of new methods, models of renewable energy technologies in the recovery, reduction, reuse, and recycling of water through efficient technologies would bring a breath of fresh air to both the farmers' side as well as the governments' side when both water and energy are putting a lot of pressure.

The education of farmers in Turkey is crucial in reaching 4R + T in sustainable agriculture practices but not limited to.

The holistic approach that comes with the paradigm shift of traditional farming will eventually bring better results starting from the family to the village, to the society and to the country as a whole.

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KEY TERMS AND DEFINITIONS

4R + T: Reduction, Reuse, Recycling, Recovery and Technology.
Drip Irrigation: Controlled quantity and timing of the irrigation.
Flood Irrigation: Literally covering the surface of the ground with water to varying depths.
Off-Grid: Not connected to any local or national electrical power network.
Recovery: Extraction of water from water table (ground water), dam, rivers and canals.
Recycling: Collection of waste water, treatment and redistribution.
Reduction: To reduce the volume of water and energy consumed.
Registered Well: Wells that are identified and permitted by Turkish government.
Reuse: To capture excess or remaining volumes for redistribution.
Unregistered Well: Wells that are unknown to any authority.
Water Poor: Water consumption amounting less than 1000 m^3 per capita.

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Chapter 40
Employment Aspect of Energy Performance Practices in Buildings and Fiscal Policy Proposals for Turkey

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ABSTRACT

Energy efficiency practices in buildings can be an important tool in fighting unemployment by creating many new jobs, besides increasing the economic, social and environmental levels of welfare. Therefore, energy-saving measures in buildings constitute a major aspect of energy policies in many developed countries. This study focuses on two main issues. The first of these is the evaluation of the increase in employment resulting from energy efficiency in building measures, and the second is the development of fiscal policy proposals for Turkey by comparing practices applied in Sweden and Greece.

INTRODUCTION

Increase in population, rapid growth, income increase and changes in consumption habits have resulted in the rapid growth of world's energy demand and the reserves in existing energy sources have approached critical levels. In the face of this increase in energy demand, the environmental and economic sustainability of fossil energy sources that have a large share in energy production and consumption have begun to be questioned. According to the 2015 report of the International Energy Agency-IEA (IEA, 2015, p. 25), more than 80% of primary energy consumption is derived from fossil fuels. More than 90% of the CO2 emissions that cause global warming stems from fossil fuel consumption. According to the predictions[1] that IEA has made based on three different scenarios, it seems possible to reduce the share of fossil fuels in energy consumption in the case of improving new energy efficiency policies and increasing

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renewable energy investments. If the current policies are maintained, the security of countries' energy supply will be jeopardized and environmental degradation will increase. In this regard, as an alternative to fossil fuels energy production based on renewable sources such as solar, wind, hydro, biological and geothermal resources and one without risks unlike nuclear energy has been a significant current issue. Although the policies aimed at increasing renewable energy sources constitute a major step of measures to be taken with regards to energy supply, the use of these sources is yet limited. As for the efficient use of existing energy sources, it constitutes the demand aspect of measures. By increasing the efficiency of energy consumption it would be possible to reduce the environmental damage of fossil fuels[2] and to meet without interruption the energy needs of societies. In addition to this, energy saving would provide many economic and social benefits at the macro and micro levels such as the increase of countries' capacity for international competitiveness, the improvement of balance of payments for countries that import a large part of their energy since their external dependency would decrease and the reduction of energy costs for individuals as well as businesses. Besides, energy saving measures have the potential to generate a major employment. New jobs would be created by means of direct, indirect and induced effects. Direct effects would be triggered in the production, application and marketing processes of technologies that are to improve energy efficiency, indirect effects would be triggered in other sectors associated with the energy efficient sectors and induced effects would be triggered by spending the revenues obtained from energy expenses. Countries frequently bring up against global economic crises. The impact of these crises on individuals and social welfare often becomes destructive especially due to its unemployment outcomes. Governments' support for the implementation of renewable energy resources and energy efficiency through a sustainable development perspective will result in success in the struggle for both global economic crisis and global warming (Erdoğdu, 2012).

32% of total energy consumption worldwide takes place in buildings according to the IPCC's 5th evaluation report (IPCC, 2014, p. 675). On the other hand, in Turkey, 32.3% of the energy gets consumed in the industrial sector, 25.0% in the transportation sector and 37.5% in the housing and services sector (Eurostat), and energy saving in housing might be provided to a large extent only by simple measures and low-cost techniques. When this potential is taken into consideration, it is of great importance to develop strategies and policies that will ensure energy efficiency in buildings.

Factors such as the use of renewable energy sources in buildings, recycling of waste, arrangements in heating/cooling, electricity/lighting systems, adjustments made in consumption habits to use energy more efficiently, will minimize energy consumption in buildings. Moreover, buildings called passive, green or sustainable will minimize the damage to the environment in the construction process. They can also be designed to consume nearly almost zero energy during their lifetime.

According to TUİK data, the construction sector in Turkey accounts for 6% of GDP as of 2013 and the growth rate of the construction sector is 11%. 7% of the total labor force is employed in the construction sector. 121,049 new buildings were constructed in 2013 and nearly 85% of these buildings are residential buildings (TÜİK, 2014, p.134,135,395,404,676,678.). In Turkey there is a great opportunity for structuring to have a green transformation in the long term when the "Law of Transformation of Areas under Disaster Risks", that prescribes within the framework of urban transformation improvements and renovations in buildings under risk, is taken into account. Energy efficiency measures that would be taken in existing buildings include simple procedures that could be implemented and have effective return in a very short term. Returns created by these measures to be taken, are capable of quickly meeting their costs in terms of both the public sector, at the individual level and the business environment. In the long-term, social, economic and environmental welfare will increase.

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Energy efficiency measures in buildings provide many benefits and by emphasizing their impact on employment, fiscal policies that could be implemented in order to increase energy efficiency are evaluated in this study.

This study is grounded on two main issues. The first of these is the evaluation, at the theoretical and empirical levels, of the potential increase in employment generating from energy efficiency measures in buildings. The development of appropriate public policies taking into account the job opportunities that the energy efficient investments would generate in addition to their other advantages, is important for Turkey that is faced with high unemployment rates. Energy efficiency measures are considered to be among major possible solutions to the problem of unemployment in Turkey whose production is based on labor-intensive technology. The other issue on which this study is grounded is to develop policy recommendations with regards to the fiscal measures that may be taken in this direction considering all the benefits of these activities.

In this context, the second part of the study features theoretical and empirical literature that analyzes the impact of energy efficient projects on employment. There exists an extensive literature on how renewable and energy efficient projects would lead to new jobs in many sectors of the economy. The summary of the literature is limited to the studies that examine the effects on employment of energy efficiency measures in buildings.

Political measures developed to increase energy efficiency in buildings will be discussed in the third section. Financial and fiscal support for increasing energy efficiency in buildings offered in Greece, that has a financial setting similar to that of Turkey, and in Sweden, that is quite advanced in this matter, is being compared with the fiscal legislation and incentives in Turkey. In the fourth section, fiscal policy proposals for Turkey are developed by also evaluating fiscal practices offered worldwide but particularly in EU countries and in the United States in order to increase energy efficiency in buildings such as tax reductions and exemptions.

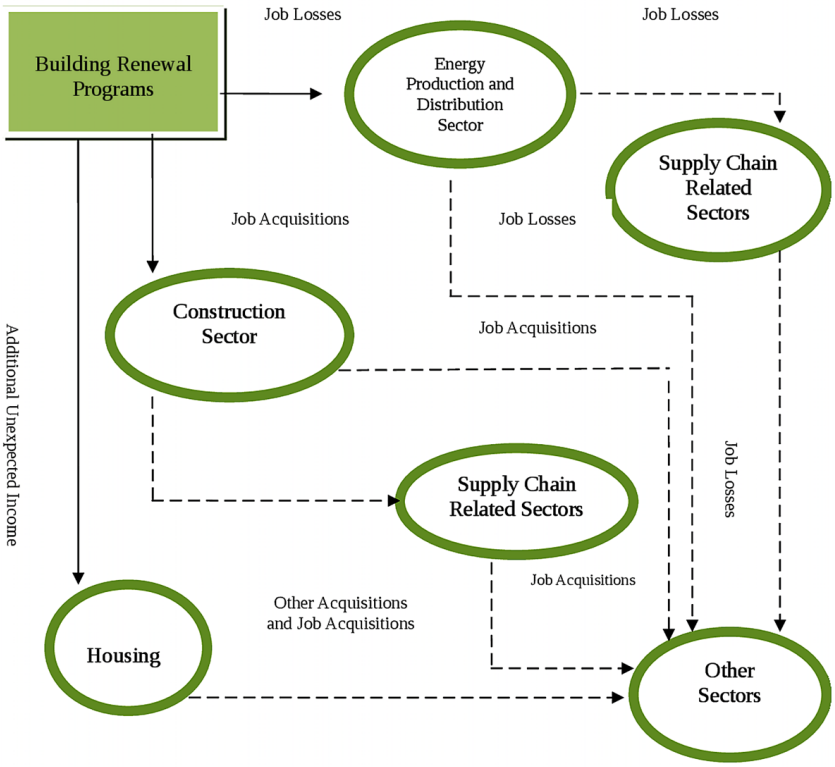
The fifth part consists of the conclusion.

THE EFFECT ON EMPLOYMENT OF ENERGY EFFICIENCY IN BUILDINGS: LITERATURE SUMMARY

Although there is no precise definition in literature on the energy efficiency measurement, energy efficiency is generally defined as the ability to produce with less energy without any decrease in the output or service quantity.[3] There exists a variety of methods for the improvement of energy efficiency in buildings. Technologies and procedures such as improving the old systems to prevent dissipation and unnecessary usage of energy, adapting new systems and making designs that would partially produce the energy need of buildings would save energy. The modification or renewal of lighting, heating, cooling, air conditioning and water heating systems, replacement of energy operated appliances with energy-efficient ones, making window, roof, floor and exterior insulations, improving the energy systems of buildings by new engines and mechanisms, and active energy management measures stand out among these. Changing consumer behavior is also among important factors in preventing energy waste. Many new jobs called clean or green jobs will emerge in the stages of energy efficient technique and technology production, their marketing, application and maintenance.

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Figure 1. Chain effect of increasing energy efficiency in buildings on jobs
Source: Keskin, http:www.solar-academy.com/menuis/Yesil-Isler-ve-Istihdam.193310.pdf



Implementation of energy efficiency in buildings has four main effects on employment. These include the effects of investment, of operation and maintenance, of reducing activity and of increasing consumption (Mirasgedis et al., 2014, p.277-278).

- **Investment Effects:** Many new jobs will emerge in the stages of producing energy efficient measures, their marketing, implementation, pre-investment feasibility, design and etc. However, these jobs are periodic. After implementation these jobs will expire.
- **Operation and Maintenance Effects:** Processes related to maintenance and repair required to sustain energy efficient procedures also create new jobs. This kind of employment is permanent.
- **Reduced Activity Effects:** It will lead to job losses in the traditional energy sector since energy demand will decrease. This impact is permanent.
- **Increased Consumption Effects:** Energy expenses will decrease after energy efficiency investments and the revenues saved on this will be directed to the purchase of goods and services, previously not done, in other sectors. This increase in demand will lead to employment increase throughout the economy. This impact is permanent.

These impacts will affect the level of employment by generating direct, indirect and induced effects. Direct impacts on employment emerge as a result of expenses made to improve equipment or to install energy efficiency technologies and procedures. For example, expenses to be made for the transformation

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of lighting systems into energy efficient ones, for the production and implementation of heat insulation materials, the production and modification of energy efficient tools and equipment directly affect employment.

Jobs related to energy efficiency in buildings are classified in Table 1.

New jobs will emerge in the areas listed above and have direct contribution to employment growth. Job losses will arise in the traditional energy sector though. Indirect effects occur in other sectors related with these equipment and services. For example, volume of work and employment will increase in sectors that provide intermediate goods to the energy efficient sectors. The fact that the supply chain of these goods and services are domestically available will increase the number of jobs created by bringing about a multiplier effect. There will be job losses in the sectors related to traditional energy sectors though. Induced effects emerge as a result of energy efficiency investments reducing the energy costs in the long term. Revenues obtained from energy savings will be redirected to the goods and services not consumed before. National employment will increase on the assumption that this demand will be directed to domestically produced goods and services in general.

Table 2 shows the direct, indirect and induced effects of energy efficiency procedures on employment according to investment, savings and the use of funds in economy.

Table 1. Energy efficiency jobs in the buildings sector

Appliances
Battery Technologies
Energy-Saving Building Materials
Energy-Saving Consumer Products
Green Architecture and Construction Services
HVAC and Building Control Systems
Lighting
Professional Energy Saving
Smart Grid
Water Efficient Products

Source: Muro et al., (2011), p.16.

Table 2. Energy efficiency employment impacts

Economic Effect	Direct	Indirect	Induced
Initial Investment in Energy Efficiency	"Energy Efficiency" jobs added as efficiency measures are implemented	Supply chain jobs added to support the investment	New jobs added as a result of spending from new incomes
Redirection of bill savings	Jobs added in the general economy from the spending of energy bill savings	Supply chain jobs added	New jobs added as a result of spending from direct and indirect impacts
Financing the initial and continued investment	Jobs offset in the general economy	Supply chain jobs ofset	Jobs offset by the offsetting income impacts

Source: Anderson et al., (2014), p.3.

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Since energy efficiency procedures also cause job losses in other areas while creating new jobs, their gross effect on employment is more visible than their net effect. Although there are some difficulties in calculating the net effect, according to many empirical studies the net positive effect on employment is quite high despite the job losses in the traditional energy sectors.

Studies that analyze the effects on employment of energy efficiency procedures in buildings generally focus on the effects of energy efficiency investments on employment, on the employment effects created by the re-spending of revenues obtained from energy expenses and on the effects of the decreasing demand for traditional energy sectors on employment. The examples given are usually selected from the USA since the majority of the studies on this subject are conducted there.

Mirasgedis et al. (2014), have investigated the effects on employment, in Greece, of widespread measures taken in the building sector by making use of the input-output analysis and the adjusted earnings gain approach. These measures include the exterior and roof insulation of buildings constructed before 1980, installation of double or triple-glazed new window frames and the replacement of old diesel boilers used for heating by gas-fired boilers. According to the assumption that these measures are independently taken in 1000 households, direct, indirect and induced employment effects create gross 414 new jobs yearly. Exterior and roof insulation creates 155 new jobs, double or triple glazing of windows 88 new jobs and replacing old boilers 171 new jobs. But the net effect decreases due to the reduction of the activity in the traditional energy sector and net 275 new jobs are created.

Brookings Institution (2012), has emphasized some results of a study that shows the effects of PACE[4] program on the economic output level and on jobs in the USA. According to the results, 4 million dollar PACE fund can create a gross economic output of 10 million dollars on average. With this amount of fund, tax revenues can also increase by 1 million dollars at the federal, state and local levels and 60 new jobs can be created on average. Brookings Institution has made some calculations according to these results. Assuming that one percent of the 75 million owner-occupied homes in the U.S. are to invest in a PACE project that cost an average of 20,000 dollars each, it has been calculated that there will be a 15 billion dollar increase in the gross economic output, 4 million dollars tax revenue and 226,000 new jobs created.

Burr et al. (2012), have analyzed the results, in residential and commercial buildings in the USA, of national building energy ratings and disclosures that would reduce the potential energy costs and create employment, using the input-output model. Building energy ratings and disclosures include the annual energy rating of commercial buildings that are 25,000 feet square or bigger, the annual energy rating of residential buildings that have 20 or more units and the public disclosure of the building energy ratings. There are similar policy requirements in many cities and states in the USA. According to the results of the study, the amount of private investment will be more than 7.8 billion dollars until 2020 with this program and procedures that will ensure energy transparency in buildings and the energy cost saving for each 1 dollar invested would be 3 to 4 dollars. This program and procedures by causing direct, indirect and induced effects will create 23,713 net new jobs in total in 2015 and 59,620 in 2020. The energy costs of building owners, consumers and companies will be reduced by approximately 3.8 billion dollars through 2015 and by more than 18 billion dollars through 2020. More than 60% of the net jobs created will be generated by the effects induced due to the reduction of consumers' and companies' energy costs.

Garret-Peltier (2011), have analyzed, using the input-output model, the effect on employment and expenditures of incentives provided within the scope of Better Buildings Initiative[5] for retrofits in com-

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mercial buildings in the USA such as improvement of energy efficiency-enhancing heating/cooling, electricity/lighting systems, insulation, new building energy systems and improvement of office equipment. According to their findings, the weighted average employment multiplier for each investment of a million dollars spent for the manufacture and installation of energy efficient technologies is 5.7 for direct effects, 4.1 for indirect effects and 3.9 for induced effects totaling up to 13.6. In addition to the energy efficient investments, new staff needs to be employed in order to monitor and operate the new energy systems in the buildings. The employment multiplier of such expenditures is 8.0 for direct effects, 4.4 for indirect effects and 5.0 for induced effects totaling up to 17.4. Energy efficient practices in buildings will reduce energy costs and contribute to employment by creating demand in other sectors. Employment multipliers created by the re-spending of the revenue saved from energy costs are 6.5 for direct effects, 3.4 for indirect effects and 4.0 for induced effects totaling up to 13.9. The contribution of 8, 692 million dollars of federal and private investments after the incentives provided by this program is 48, 633 direct full-time job years, 32, 969 indirect full-time job years and 32, 699 induced full-time job years totaling up to 114, 302 full-time job years.

Gold et al. (2011), have estimated the effect on the US economy and employment of many standards and legal regulations developed since 1987 until 2010 in order to improve the energy efficiency of lighting systems and equipment used in the commercial sector and the housing in the USA. 340,000 new jobs have been created in 2010 thanks to these standards and legal regulations. This figure corresponds to the 0.2% of USA's total employment. It is estimated that by improving these standards the number of jobs will rise to 387,000 annually in 2020 and to 380,000 annually in 2030. A savings of 34 billion dollars have been provided by the energy bills in 2010. It has been estimated that the level of savings will be 64 billion dollars annually in 2020 and 68 billion dollars annually in 2030.

Rhodium Group (2013) has estimated the amount of required investment in the event that the goals defined by Alliance Commission on National Energy Efficiency Policy[6]'s report, in order to improve energy efficiency in the USA, is realized and their effect on employment. The report aims at the reduction of energy efficiency in the USA by 18% until 2030. 166 billion dollars of annual investment is required for providing energy saving in the transportation sector, energy efficient industrial equipment and vehicles and the technology and design of buildings in line with these objectives. 48% of investments will be made in transportation, 43% for residential and commercial buildings, while the rest will be made in the industrial sector. It has been estimated that the net energy saving in 2030 will be 327 billion dollars. These investments will create net 1.3 million new jobs. It has been foreseen that the most significant increase will be in the service sector. The other sectors showing significant increase will be manufacturing and construction sectors, respectively.

The Rockefeller Foundation (2012), has calculated that taking the necessary measures[7] for providing energy saving in buildings in the US provides a 279 billion dollars of investment opportunity. It has been estimated that 3.30 million direct and indirect new jobs in total would be created by energy efficiency retrofits. Approximately 2.20 million of these jobs will be created by retrofits in residential buildings, 0.86 million by retrofits in commercial buildings and 0.30 million by retrofits in institutional buildings.

Anderson et al. (2014), have made estimations on the economic and employment effects of the application of Department of Energy's (DOE) energy efficiency programs in buildings in the US, according to the Energy Information Administration's (EIA) 2014 reference scenario. As a result of the actualization

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of investments encouraging a reduction of electricity consumption by %15, 131,000 new jobs in 2020, 300,000 in 2025 and 320,000 new jobs in 2030 will be created including direct, indirect and induced ones.[8] If the electricity conservation is 10% then it is estimated that 70,000 new jobs in 2020, 198,000 in 2025 and 213,000 new jobs in 2030 will be created (according to %3 discount rate).

Markaki et al. (2013), have calculated the investments that Greece needs to make until 2020 in accordance with the energy and climate change package legislated by the European Commission in 2008 and the effects of these investments on employment. In order to achieve its renewable energy and energy efficiency goals, Greece needs to make, in the 2010-2020 period, a total investment of 47.9 billion Euros including 21.4 billion Euros in the power sector, 14.5 billion Euros in buildings, 10.9 billion Euros in the transportation sector and 1.1 billion Euros in the industry. The measures that need to be taken in the buildings are in general oriented to provide energy efficiency. 6800 million Euros need to be spent for the insulation of buildings cell in 1 million households, and 1257 million Euros for the replacement of old boilers in 700,000 households. In addition to this, 920 million Euros need to be spent for the installation of 7,500,000 smart metering systems, 360 million Euros for co-generation-district heating, 1179 million Euros for research in energy conservation, 459 million Euros for various pilot actions, 1493 million Euros for the installation of solar collectors for hot water and central heating in an area of 3,700,000 m2. 19,300 new direct jobs, 10,300 new indirect jobs and 5,100 induced new jobs totaling up to net 34,600 new jobs will be created annually during the period when expenditures for providing energy efficiency in buildings are made.

Young et al (2013), have analyzed the effects on energy saving and employment of the legalization and implementation of the Energy Savings and Industrial Competitiveness Act (S.1392)[9] that was submitted to the US Congress in 2013. Accordingly 66,000 net new jobs in 2020 and 164,000 in 2030 will be created and 2.1 billion dollars of net annual energy savings in 2020 and 13.7 billion dollars in 2030 will be achieved.[10]

Roland-Holst (2008), has examined, in terms of innovation and employment, the economic effects of energy efficiency policies practiced in the state of California. The study consists of two parts. The first part focuses on the economic effects of California's current energy efficiency policies. He concludes that the energy efficiency measures have provided $ 56 billion of household energy savings and that they have created approximately 1.5 million FTE (full-time equivalent) jobs with a payroll of $ 45 billion in total, between 1972 and 2006. He states that as a result of energy efficiency, California's dependence on importing energy has been reduced. It emphasizes that California has directed a larger share of its consumption to goods and services oriented at employment within the state, and that the supply chain of these goods and services are present within the state. He states that this creates a multiplier effect in job generation. The second part examines the economic effects that the implementation of "Draft Scoping Plan" issued in June 2006 by California Air Resources Board (CARB) would create. In order to evaluate the future economic effects of the policies proposed in the Draft Plan, Berkeley Energy and Resources (BEAR) model that is a statewide economic model developed by the Center for Energy, Resources, and Economic Sustainability (CERES) at the University of California Berkeley has been used. Roland-Holst concludes, by including the innovation potential, that the policies proposed by the Draft Scoping Plan will increase the Gross State Product up to approximately $76 billion and the real household incomes up to $48 billion and that it will create 403,000 efficiency and climate action driven jobs. He argues that the existing energy efficiency programs and standards will create 181,000 additional jobs until 2020 and that 22,000 more jobs will be created when innovation is taken into account.

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ENERGY EFFICIENCY REGULATIONS IN BUILDINGS: SWEDEN, GREECE, AND TURKEY

This section examines the legal legislation and practices in Sweden, Greece and Turkey. Sweden and Greece have been selected as case studies, former for being one of the leading countries in energy efficiency and latter for having similar economic characteristics with Turkey.

To improve energy performance in buildings, legal regulations have been made since the 1950's in Sweden and since the 1970's in Greece. In addition, two EU member countries regulate their legal legislation in order to adapt to the directives of the European Commission. As well as defining legal obligations, they use financial and fiscal instruments such as subsidies, financial incentives, tax reductions and grants to increase energy efficiency and use of renewable energy sources in buildings. In Turkey relevant regulations have been made in the framework of Energy Efficiency Law issued in 2007 and Energy Performance of Buildings Directive issued in 2008 and some legal obligations especially for new buildings have been defined. However, there is no fiscal measures applied for energy efficiency in buildings except small financial incentives.

Regulations in Sweden

Total energy used per unit of heated area in residential and business buildings in Sweden is intended to be reduced by 20% in 2020 and 50% in 2050 compared to the usage in 1995. In addition, the increase of renewable energy's ratio displaying continuity and the disappearance of the dependence on fossil fuels for energy use in the building sector by 2020 is anticipated (2005/06:145 bill) (Sweden's Second National Energy Efficiency Action Plan, 2011, p.11).

Regulations related to energy efficiency in buildings have begun in the 1970's (Cialani & Perman, 2014, p.2). Various grants and tax reductions have been available for energy efficiency measures since the late 1970's. In the years 1985-1986 and 1986-1987 10% rated grant for thermal insulation in buildings has been given (Kiss et al., 2010). Although the first building regulations might be observed in 1956, requirements for energy efficiency have taken place in building regulations from 1975 (McCormick and Neij, 2009, p. 5). Accordingly, some k-values have been determined concerning building components. Various changes have been made about energy efficiency in code in 1984, 1988, 2002, 2006, and in 2008. The average U-Value requirements of buildings have been introduced in 1988. The building code in 2006 has set the energy demand levels for residences according to two climate zones. By adopting three climate zones in 2008, maximum power levels have been set (McCormick & Neij, 2009, p.6.).

Various laws have been issued in the 2000s to comply with EU directives and to transfer them into national law. At the same time, new regulations about energy efficiency measures have been made by issuing new laws and regulations about buildings and by making changes in the existing legislation, and various financial supports[11] have been offered.

Between the years 2000-2007 a grant program targeting investments in heating by solar energy was implemented in order to encourage the use of solar heating technology in residences and certain business buildings (Sweden's Second National Energy Efficiency Action Plan 2011, p. 31).

Energy incentives as grants between the dates of 2007-2009, and as tax deduction (in the 30% ratio of material and labor costs) between the dates of 2004-2006 have been given to single-dwelling residence owners for the installation of energy efficient windows and biofuel plants (Sweden's Second National Energy efficiency Action Plan 2011, p. 29).

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An incentive that covers the labor, material and planning costs for the installation of solar cells in public buildings has been given between 2005 and 2008 within the scope of the support whose abbreviation in Swedish is "OFFrot" (Sweden's Second National Energy Efficiency Action Plan 2011, p. 30, p. 32). A new grant program has been launched on July 1 2009 for the installation of solar cells. The grant program from which individuals, businesses and public organizations could benefit has supported installations that began and was completed between the dates of July 1 2009 and December 31 2011. Grants support at maximum 60% of investment costs with the exception of large companies (maximum 55%). In addition, the upper limit per solar cell is SEK 2 million and peak electric power installation per kilowatt is SEK 75000 plus VAT at maximum. During 2009-2011, a total of SEK 212 million has been allocated to support the installation of solar cells, within the scope of this grant program (Sweden's Second National Energy Efficiency Action Plan 2011, p. 30-31).

In accordance with the 2002/91 / EC Directive, an Act (2006: 985) has been issued on energy certification for buildings (Sweden's Second National Energy Efficiency Action Plan 2011, p. 28). This Act has made it mandatory since 2009 for rental buildings, cooperative buildings and some non-residential buildings to have energy performance certificates issued by certified experts (Wahlström and Hårsman, 2015, p.58).

A grant has been given, between 2006 and 2010, to single-dwelling and multiple-dwelling home owners and to owners of business premises with associated residences so that they convert from direct electricity heating to district/central heating or to individual heating with biofuels, heat pumps or solar energy (Sweden's Second National Energy Efficiency Action Plan, 2011, p. 30).

In accordance with the 2006/32/EC Directive and with the 93/76/EEC (Energy Services Directive) that has been legislated away, the Bill 2008/09:163 (A coherent energy and climate policy - Energy) has been drafted (Sweden's Second National Energy Efficiency Action Plan 2011, p. 5). It has set the targets of 6.5% energy saving by 2010 and of 9% by 2016 in comparison to the average final energy consumption of the period 2001-2005 (Sweden's Second National Energy Efficiency Action Plan 2011, p. 1). In the 3rd National Energy Efficiency Action Plan (2014, p. 1), it has been emphasized that Sweden has by far met its savings target under Sweden's Energy Services Directive.

The Swedish Government has initiated, in 8 December 2008, a tax reduction for repair, maintenance or conversion and extension works, whose abbreviation in Swedish is "ROT," in order to promote labor supply and to reduce black market labour. According to this regulation, a tax reduction is applied to the 50% of building work costs in residences or holiday houses. Maximum amount of reduction per person per year is SEK 50000 while new builds are excluded from it (Sweden's Second National Energy Efficiency Action Plan 2011, p. 29; Sweden's Third National Energy Efficiency Action Plan 2014, p. 39).

Since 2009, incentives for the installation of solar panels have been available to individuals, enterprises and organizations. Support meets 35% of investment costs. The amount of support is a maximum of SEK 1.2 million. SEK 210 million has been allocated for the period of 2013-2016 within this scope (Sweden's Third National Energy Efficiency Action Plan 2014, p. 39).

More strict requirements have been applicable as of February 2009 for new buildings that use electricity for heating or air conditioning (Sweden's Second National Energy Efficiency Action Plan, 2011, p. 27). Energy requirements have also been made stricter on January 1, 2012 for new buildings that are not electrically heated. Energy requirements have been hardened by 20% more on average (Sweden's Third National Energy Efficiency Action Plan, 2011, p. 86).

In 2014, the Swedish Government has given authority and responsibility to the Swedish National Board of Housing, Building and Planning for proposing, no later than June 15, 2015, quantitative guidelines

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for energy management requirements in nearly-zero energy buildings (Sweden's Third National Energy Efficiency Action Plan 2014, p. 39).

Swedish Construction Federation has received a five year help for promoting energy-efficient new buildings and conversions. (Low Energy Buildings Program (LÅGAN)) In order to get support within this context, new buildings must achieve at least 50% better energy performance than Building Code (BBR). The conditions for conversions are 40% less energy consumption than the BBR requirement and that the energy consumption reduces by at least 50% (Sweden's Third National Energy Efficiency Action Plan, 2014, p. 40).

A new Planning and Construction Act has gone in effect as of 2 May 2011 replacing the Act (1994:847) about technical functional requirements for structural works, etc. and the 1987 Planning and Construction Act (1987:10) (Sweden's Second National Energy Efficiency Action Plan, 2011, p. 27). The Act determines the minimum requirements about energy management. Energy requirements have been made stricter by 20% on average (Sweden's Third National Energy Efficiency Action Plan, 2014, p. 38).

The new version of the Energy Performance of Buildings Directive 2002/91/EC has entered into force on 18 June 2010 (2010/31/EU) (Sweden's Second National Energy Efficiency Action Plan, 2011, p.7, 28). A bill has been presented in the spring of 2012 for transferring this directive into Swedish law. When the Energy Performance of Buildings Directive has been transferred to Swedish law in 2012, a new Act has also been agreed upon on Energy Declaration (Sweden's Third National Energy Efficiency Action Plan, 2014, p. 37).

The 2012/27 / EU Energy Efficiency Directive (EED) on energy efficiency must be applied as of June 2014 (Sweden's Third National Energy Efficiency Action Plan, 2014, p. 4). The Bill 2013/14: 174 (Implementation of the Energy Efficiency Directive) prepared for the implementation of the 2012/27/EU Directive in Sweden was passed in the Parliament on April 2014. Along with it, new laws on energy efficiency and changes in the existing law have come to the fore (Sweden's National Reform Programme 2015, p.41): the Act on Energy Measurement in Buildings (2014: 367), the Act on Energy Surveys in Large Companies (2014: 266), the Act on Certain Energy Cost-Benefit Analyses (2014: 268), the Ordinance on the Purchase of Energy Efficient Goods, Services and Buildings by Government Agencies (2014: 480).

2013/14: 174 Bill proposes regulations related to energy audits and energy management systems in accordance with the Article 8 (4) - Article 8 (7) of 2012/27/EU Directive. Accordingly, energy audits must be fulfilled by December 5, 2015 by major enterprises. Afterwards, the audits must be repeated at least once in four years (Sweden's Third National Energy Efficiency Action Plan 2014, p. 22).

Regulations in Greece

In Greece 25.5% of total energy is consumed in the residential sector, %41.4 in the transportation sector, 18.5% in industry, 1.9% in agriculture, 11.9% in the service sector and 1.7% in other sectors. The building sector in Greece is energy intensive and approximately 36.4% of total energy consumption takes place in the buildings as of 2015 (Eurostat). Since the 1970's, Greece has been making legal regulations for improving energy performance in buildings. The 1st Thermal Insulation Regulation (Hellenic Ministry of Environment, Planning and Public Works, 1979) in 1979 has attempted to reduce the redundant energy consumption of buildings. The use of solar thermal systems in buildings was among the measures taken for the promotion of Renewable Energy Sources (RES) in the 1990s. Until 2002, tax deductions have been applied to 75% of the taxable income obtained from RES systems in heating and cooling with the act L2364/1995 (Hellenic National Renewable Energy Action Plan, 2010, p. 69, 80). Regulations on

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energy efficiency in buildings known as KOXEE have been introduced in 1998 with the 21475/4707 Ministerial Decision. Energy labeling of buildings has been initiated with this act. In 2005, KOXEE has been renamed to KENAK (Dascalaki et al., 2012, p.470). In general, the legal regulations have been issued in order to adapt to the Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. The act of L3661/2008 "Measures to reduce energy consumption in buildings and other provisions" has been issued and liabilities for improving the energy efficiency of buildings, providing energy saving and for protecting the environment have been determined within this context. This act focuses on energy efficiency in the building sector with the implementation of the Regulation on the energy performance of buildings (KENAK). (Hellenic 2nd National Energy Efficiency Action Plan 2008-2016, 2011, p.14-15).

KENAK sets two key requirements (Hellenic 2nd National Energy Efficiency Action Plan 2008-2016, 2011, p. 29-30):

- Submission of a study on the energy performance of buildings for issue of a building permit,
- Performance of energy inspections to buildings, boilers, heating and air conditioning systems.

5825/2010 "Endorsement of Energy Performance Buildings Regulation"" (M. D. D6/B/OIK, 09.04.2010) has been issued in April 2010. This Ministerial Decision has included measures such as issuing certificates for public and private buildings, improving the minimum energy standards in new buildings and existing buildings exceeding 1000 m^2 undergoing major renovation and making regular inspections of hot water and heating systems. Determining procedures such as the classification of buildings according to energy performance, the scope of energy performance certificates and their format, the improvement of energy performance measurement methods, etc. have been aimed at (IEA, 17.07.2012, http://www.iea.org/policiesandmeasures/pams/greece/name-22966-en.php).

2009/28/EC Directive has been issued in order to generalize the use of renewable energy sources (RES) EU-wide. Greece has issued L3851/2010 "Acceleration of the development of renewable energy sources for the confrontation of climate change" act in order to comply with this Directive. Article 13 of the Directive contains measures about buildings. Greece has expanded Article 10 of the act L3851/2010 according to the scope of L3661/2008. Reduction of VAT rates in natural gas and electricity markets, giving low interest-rate loans, financial incentives and grants for energy efficiency measures have been agreed upon. After the date of 01.01.2011, in order to issue building license for buildings 60% of their annual hot water needs must be met by solar thermal systems. All new buildings, latest by 31.12.2019, need to use renewable energy sources, electricity and heat cogeneration, district or block heating systems, and heat pumps with seasonal performance factor in their primary energy consumption. The deadline for new public buildings is 31.12.2014 (Hellenic 2nd National Energy Efficiency Action Plan 2008-2016, 2011, p.30,71; Hellenic National Renewable Energy Action Plan, 2010, p. 44, 46).

EU 2006/32/EC directive was adapted to the Greek legislation by means of the Law L3855/2010. "L3855/2010 on the improvement of the energy end-use efficiency have set the grounds for the transition to low energy consumption in buildings and identify a set of measures and mechanisms for this transition". Energy saving of 9% has been intended by the end of 2016 within the scope of this Law, compared with the period 2001-2005. (Hellenic 2nd National Energy Efficiency Action Plan 2008-2016, 2011, p.4, 29). The EU Energy Performance Building Directive has been recast in 2010 and Greece has issued L4122/2013 in order to adapt its legislation to this directive. The Law "updates the minimum energy performance requirements for buildings adopted by KENAK and provides that from 1of January 2021

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all new buildings shall be nearly zero-energy buildings, whereas with regard to new buildings owned by the public and the wider public sector this obligation shall be implemented from 1 January 2019" (Kokkaliaris, Maria, 2015, p.63).

Many financial incentives have been defined within the scope of KENAK to provide energy saving in homes. Subsidies up to 35% have been applied on the marketing price of air conditioners in 2009 with the purpose of replacing old air conditioners. 141,323 air conditioners have been replaced within its extent. (Three times the target figure of 45,000). Financial incentives have been available since 2012 for the replacement of electricity or traditional heating systems with solar systems either by 50% or 100% depending on the climatic conditions of regions. With the "Energy Saving at Home" program that targets all housing built before 1990 in Greece, various supports are available to the households that have taken the measures of thermal insulation of roofs and exteriors, improvement of heating and hot water systems. 100% interest-free loans and 35% grants are offered to the people with an annual income of less than 40,000 or 60,000 Euros. 100% interest-free loans and 15% grants are offered to the people whose incomes range between 40,000-60,000 or 60,000-80,000 Euros. The program is financed by the EU European Regional Development Fund (ERDF) and national resources. A budget of 396 million Euros has been allocated. (Hellenic 2nd National Energy Efficiency Action Plan 2008-2016, 2011, p. 60, 69,70, 71, 74). With the incentives granted within the scope of this program, 40,000 buildings have been included within the program's scope until the end of 2013 and 400 million Euros have been fund-raised (Papamanolis, 2015, p4).

Regulations in Turkey

Turkey is number 21 in the world rankings in primary energy consumption and its share of world energy consumption is 1% (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, 2015, p. 7-8). Approximately 32.3% of the consumed energy is consumed in the industry sector, 37.5% in the residential and services sector, 25.0% in the transportation sector (Eurostat). Turkey that has limited natural gas and oil reserves imports a large part of its energy. According to the foreign trade data in 2013, 49.2 billion of the 99.9 billion dollar foreign trade deficit in Turkey is originated from net energy imports (T.C. Gümrük ve Ticaret Bakanlığı RYKGM-Ekonomik Analiz ve Değerlendirme Dairesi, 2015, p.21). The amount of total primary energy supply in 2013 is 120,290 thousand toe. While 96,001 thousand toe is imported, domestic production meets 26.6% of energy supply with 31,944 thousand toe (T.C. Enerji ve Tabii Kaynaklar Bakanlığı, EİGM, 2013).

Legal regulations and practices for efficient use of energy and for benefiting from renewable energy sources are very limited. The most important initiative in this regard has been issuing of the 2007 L5627 (OG, 02.05.2007) "Energy Efficiency" law. This law includes procedures about increasing the efficiency of energy in production, transmission and distribution stages, in industrial enterprises, buildings, power generation facilities and transportation as well as principles and procedures for the utilization of renewable energy sources. Based on this law "Energy Performance of Buildings Directive" (OG, 05.12.2008) has been issued in 2008. This directive specifies the principles and procedures related to energy performance of buildings including control procedures, information gathering, and minimum performance criteria, standards and norms about architectural design, heating, cooling, insulation, hot water, electrical installation and lighting in buildings. Additionally, this directive regulates the measures of issuing energy identification certificate in existing and new buildings, meeting energy needs by renewable energy sources (RES), creating a nationwide building inventory, conducting activities in order

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to increase awareness of energy culture and efficiency. The directive has decreed that new buildings built after 2011[12] must get an energy identification certificate that includes information on buildings' minimum energy needs and energy consumption classification, on their insulation properties and/or the efficiency of their cooling systems. In addition to this, the directive has made it mandatory that newly constructed buildings meet the improved standards in their thermal insulation, mechanical facilities, ventilation/air conditioning systems, hot water systems, electrical and lighting systems.[13] In the case that there are major renovations in existing buildings that include project changes about energy efficiency (in the case that the renovation cost exceeds the 25% of the property tax value of the building), the provisions of this directive are implemented.

"Energy Efficiency Strategy Paper 2012-2023" (http://www.eie.gov.tr/verimlilik/document/Energy_Efficiency_Strategy_Paper.pdf) has been published in 2012. It targets the reduction of Turkey's energy density (amount) consumed per GDP capita in 2011 by 20% in 2023.One of the strategic objectives set for the realization of this goal is to reduce energy demand and carbon emissions of buildings and to promote sustainable environmentally friendly buildings that use renewable energy sources. "In year 2023 the heat insulation and energy efficient heating systems providing current standards shall exist in all commercial and service buildings having total usage area of more than 10,000 m2 with the dwellings having building group class 3 or more from the defined building groups in the Communiqué About Approximate Unit Costs of the Buildings, which put into force annually, in metropolis contiguous areas from the buildings having usable attribute in the scope of Urban Transformation Law and Earthquake Regulation". The reduction by 10% of annual energy consumption in public buildings by 2015 and by 20% by 2023 has been targeted (Energy Efficient Strategy paper, 2012).

Measures to be taken in the buildings are also included among the strategic objectives of the 2011-2023 Climate Change Action Plan. Objectives have been identified for increasing energy efficiency and the use of renewable energy in buildings. These objectives are; the creation of thermal insulation and energy efficiency systems that meet the standards in commercial and public buildings that have a total area of use larger than 10 thousand square meters and in at least 1 million homes by 2023, effective implementation of Energy Performance of Buildings (BEP) Directive and of other energy efficiency directives in all buildings by 2017, development of means that will provide the necessary financial support for energy efficiency, renewable energy and BEP in buildings until the end of 2013, giving "Energy Performance Certificate" to all buildings by 2017, reduction of annual energy consumption of public institutions' buildings and facilities by 10% until 2015 and by 20% until 2023, providing at least 20% of the annual energy needs of new buildings by renewable energy sources as of 2017 (T.C. Çevre ve Şehircilik Bakanlığı, 2012, p. 11).

In addition to these, "The Directive on Certification of Sustainable Settlements and Sustainable Green Buildings" (OG, 08.12.2014) has been issued. The Directive regulates the principles and procedures for creating assessment and certification systems of sustainable settlements and sustainable green buildings in order to reduce a building's environmental impact by using its natural resources and energy efficiently, and it also regulates the principles and procedures for identifying the mission, qualifications and responsibilities of those who will take part in the certification process.

Besides these, communiqués and directives have been issued since 2002 for increasing the efficiency of central heating boilers and energy labeling the white appliances.[14] In addition to the legal regulations, credit and grant mechanisms have been developed to support high cost, high energy yield projects especially in industrial enterprises.[15] Most of this support is funded by international organizations. "Turkey Sustainable Energy Financing Program" (TurSEFF, n.d.) can also provide loans to homeowners for

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efficiency-enhancing projects in addition to the credits it provides to industrial and commercial companies by means of partner banks. Projects need to provide energy savings of more than 30% in order to get support. However, most of the banks partnering in the program, keep the term for loan repayment short.

FISCAL POLICY PROPOSALS FOR TURKEY

The most important legal regulation in order to increase the energy performance of buildings in Turkey has been the issuing of "Energy Performance of Buildings Directive" in 2008. With this directive, issuing energy identification certificates for new buildings, that is a regulation practiced in many EU countries, has been introduced. The energy performance criteria for buildings during their construction have been determined by relevant Turkish Standards. However, it is not possible to talk about an important legislation aimed at improving the energy performance of existing buildings. There exists no incentive mechanism for this such as tax reductions and grants. Compared to the EU member states, Turkey has fallen fairly behind in this regard. According to the survey conducted by Building Performance Institute Europe (BPIE) (Maio et al., 2012) in 2011, grants and subsidies, preferential loans and fiscal instruments are widely used in energy-efficiency improving activities of EU member states.

Table 3[16] shows tax reduction supports used in some EU member states for energy efficiency activities in buildings. In Bulgaria a 100% tax reduction from the property tax is practiced both for Class A

Table 3. Level of support for tax reduction

	Level of Support	On Individual/ Households Income	On Property Tax	On Taxable Profit
Austria	25% (envelope, equipment)	X		
Belgium (Federal)	40% (envelope, equipment, other)	X		
Belgium	• 20% (new) E-level of E60 • 40% (new) E-level of E40 or less		X	
Bulgaria	• 100% for 7/10 year Class A • 3/5 y Class B • Building commissioned after January 1st 2005		X	
Spain	Up to 10% (envelope, equipment)	X		
Finland	60% of labour costs (envelope, equipment)	X		
Greece	Up to €700 (equipment)	X		
Ireland	Write off 100% of the purchase value in the year of purchase (equipment)			X
The Netherlands	41.5% (of annual investment costs) (equipment)			X
Portugal	• 25/50% property tax (Class A/A+)(equipment) • 10% increase in the deduction related to house loans in the individual tax (Class A/A+) • 30% (investment in RES)	X	X	
Sweden	€5 000 /y/building (labour costs)	X		
United Kingdom	n/a (equipment) n/a (envelope)		X	X

Source: Maio et al., 2012, p. 22.

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buildings that are 7/10 years old and for Class B buildings that are 3/5 years old. 60% of the labor costs of measures related envelope and equipment of buildings in Finland are subject to tax reduction deducted from the individual/household income. In Ireland 100% of the purchase value of equipment measures is written off in the year of purchase from the taxable profit. Some examples of tax credits and reduced VAT rates for energy efficiency activities in buildings are shown in the Table 4[16] and Table 5[16], respectively.

The public sector in Turkey needs also to make fiscal arrangements in this regard taking into account the social, economic and environmental benefits that improving energy efficiency in existing buildings will provide. Energy consumption has many externalities ranging from the health of living beings to their quality of life, to agricultural production and economic crisis risks. These externalities cannot be priced. Since positive externalities generated by energy efficiency measures cannot be measured it is deviated from the social optimum in the allocation of resources. Neither end consumers nor enterprises are willing to do by themselves the necessary renovation work for improving the energy efficiency of buildings. The failure of the market mechanism in this matter necessitates the intervention of the government (Erdoğdu et al., 2015). It is important that, besides legal regulations for the improvement of energy efficiency standards of buildings, activities that will motivate the households and enterprises about this begin. It is not well known by enterprises that energy efficient businesses offer profitable investment opportunities or by households that energy efficiency-enhancing activities meet their costs in a short time and that they provide significant energy savings in the long run. According to Sardinaou (2008), in general, there are two main obstacles to energy-saving investments: financial market obstacles and human factor obstacles. The fact that the future of energy prices is unclear (likely to fall), result in, in particular, low

Table 4. Level of support for tax credit

	Level of Support
France	40% on the interest of the home for 7 years (complements the zero interest rate loan) (envelope, equipment)
Italy	36/55% (envelope, equipment)
United Kingdom	• 100% tax relief on the cost (equipment) • €1 860 /y (£1 500/y) (envelope, equipment)

Source: Maio et al., 2012, p. 23.

Table 5. Level of support for reduced VAT rate

	Level of Ambition
Belgium	6% (envelope, equipment) instead of normal rate of 21%
Spain	8% (envelope, equipment) instead of normal rate of 18%
France	5.5% (7% from 1°of January) (envelope, equipment) instead of normal rate of 19.60%
Italy	10% (envelope, equipment) instead of normal rate of 21%
Netherlands	6% (envelope) instead of normal rate of 19%
Poland	8% (envelope, other) instead of normal rate of 23%
Portugal	13% (equipment) instead of normal rate of 23%
United Kingdom	5% (envelope, equipment) instead of normal rate of 20%

Source: Maio et al., 2012, p. 23.

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returns in energy-saving investments in the short term and the perception of these investments as risky. Even if the company managers have enough information about the profitability of energy saving, they are faced with capital rationing (Sardianou, 2008). Therefore, if governments accelerate their informing activities in this matter, facilitate access to financial markets, create demand by informing consumers, this will increase the private sector's motivation.

The results of the survey carried by YEGM (n.d.) in 2010 also point at the consumers' lack of motivation about activities to increase energy efficiency. 2531 people selected from 26 provinces of Turkey's seven geographical regions have been surveyed for this poll. It has researched how aware the public is of activities taking place within the framework of Energy and Natural Resources Ministry's energy efficiency project (ENVER) and how much they implement these activities. According to the survey, households are majorly (82.2%) not aware of the energy efficiency practices carried out by the Ministry. However, when the answers given to the report's questions on energy efficiency measures are considered, one can conclude that the households are willing to implement energy-efficient practices as they are better informed about these. For example, almost half of the refrigerator (51.5%) and washing machine (47.4%) preferences mentioned in the survey are energy-efficient (class A) ones. Ads by white appliance manufacturers ensure that households are informed on this to a great extent. More and better information provides a shift of consumption preferences for energy efficient ones. However, preferences for energy efficient ones in other white appliances such as dishwasher (27.5%) and air conditioning (9.2%) is quite low. Most of those who do not prefer Class A white appliances are not informed about the energy class of such goods. It can be argued that as the level of knowledge on lighting and thermal insulation increases so does energy-efficient practices. According to the answers given in the survey to questions about thermal insulation, 74.8% of the buildings do not have thermal insulation. However, according to the other findings individuals are informed about thermal insulation and are willing to get it done. For example, 47.2% of respondents' energy efficiency priority is to make thermal insulation. However, 55.7% of households (who have not insulated their homes) think that the cost of thermal insulation is high. Window glass insulation is better than the level of exterior and roof insulation. 60% of the windows are double-glazed, 0.9% have coated glass, while 39.2% are single glazed. Only 44.4% of lamps used for lighting in houses are energy efficient. The percentage of using both normal and energy-saving lamps is 42.1%.

Supporting the energy efficiency-enhancing projects of companies producing energy-powered equipment such as home appliances, lighting equipment etc. with low interest loans, grants and profit tax reductions, by increasing investments in energy efficient sectors, would both provide employment growth and increase demand as energy efficient products get cheaper. Since discounts made in VAT rates of these products would directly affect the end consumers, consumer preferences will shift towards energy efficient ones.

The majority of energy consumption in buildings is used for heating. Insulating the exteriors, roofing, flooring and windows of buildings would create a huge energy savings. According to a study conducted by IZODER (Garanti Bankası), an insulated building provides an average of 50% savings in heating costs. This study calculates the fuel costs of an exemplary 5-storey building with 4 apartments and a total living area of 500 square meters in Antalya, Istanbul, Ankara and Erzurum, respectively from warm to cold, with no insulation and insulated according to the insulation standard, and it concludes that insulation provides more than 60 per cent energy saving. Since thermal insulation procedures will significantly reduce household energy costs, households' motivations can easily be triggered. The share of a family's average energy consumption costs within the minimum wage is 30.8% as of 2014 (T.C. Enerji ve Tabii

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Kaynaklar Bakanlığı, 2015, p.30-33). Households spend a large portion of their income on heating costs. But many people, as also proven by the research of YEGM, think that the cost of thermal insulation is high. Therefore, offering financial and fiscal supports such as grants, low interest loans, subsidies and tax reductions, would encourage these practices. Given the that the income per capita in Turkey is quite low, subsidies and grants on thermal insulation for low income people should be applied, and local governments should take financial responsibility for it. According to the modern theory of public finance, public goods that benefit the local area should be provided by local governments. Energy efficiency practices in buildings are also a kind of local public service. However, the budgets of local governments may not be enough. The central government's support for local authorities by unconditional transfer payments would be an effective policy (Dongyan, 2009). In addition to this, the central government might encourage the private sector for the establishment of energy efficiency programs, and these programs might work in cooperation with local authorities.

For example, the PACE program (Brookings Institution, 2012) that supports practices that will provide energy efficiency in buildings in the United States might be taken as an example. PACE program supports renewable energy and energy efficiency practices such as solar panels and thermal insulation. PACE mechanism establishes a link between the homeowners and local governments. Local governments give specific loans to households that will make such investments and these loans are paid in up to 20 years through annual property taxes (PACE, http://www.pacenow.org/). A pilot program in Turkey under the leadership of companies that carry out energy efficiency activities might be launched and this program's cooperation with local governments might be facilitated. Property taxes might be determined based on the energy performance of buildings.

Additionally, fiscal policies such as pre-tax reductions for companies that carry out insulation practices and produce energy-efficient boilers, accelerated depreciation for energy efficiency equipment, tax refunds, tax concessions and abolition of tax exemptions for businesses that do not fulfill the energy saving criteria (Dongyan, 2009) might be launched. Making VAT reductions in energy efficient products would also help to reduce the cost of the final consumer. The tax reduction practice initiated in Sweden in late 2008 called ROT, aimed at maintenance or conversion and extension works in buildings might be taken as an example. With reference to ROT, the cost of maintenance and conversion works to be done in buildings for energy efficiency might be deducted from tax. In addition, grants might be given to individuals converting their heating systems to a system of biofuels, heat pumps or solar energy. Low-energy building projects might be supported as in the example of LAGAN.

Environmental taxes might be used by local governments. While high environmental taxes might have a deterrent effect for buildings that have high pollution impact and low energy efficiency, the other way around, implementing of low environmental taxes for buildings that have high energy efficiency with less environmental waste, would have an incentive effect (Erdoğdu et al., 2015).

Establishing appropriate financial support for low-income households is important both in terms of social justice and the effectiveness of the measures. In most cases, individuals from low-income groups live in buildings with low energy efficiency. The buildings inhabited by these income groups do not have thermal insulation measures as well as renewable energy sources like solar systems. The white appliances and other electrical equipment used in the homes as well lighting systems are old-tech products. Grants and low-interest loans for low income groups might be implemented modeled on the "Energy Saving at Home" program in Greece.

In order to take all these fiscal measures, it is necessary to make a building inventory in Turkey. The latest building count by TÜİK was done in 2000 (DIE, 2000). The updating of these data and to determine

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the energy performance of existing buildings will give information about needed investments. Different practices should be recommended and developed considering that.

Turkey with its large surface area has a different climate and geographical structure. For example, while in the Mediterranean region one should focus on system and equipment adjustments that will improve energy efficiency of air conditioning systems, policies that will support thermal insulation practices in the regions of Eastern Anatolia and Central Anatolia should be implemented.

As a result of the fiscal measures that governments will take, energy efficiency investments will increase and new jobs will be created since there will be direct, indirect and induced effects on all the sectors of the economy. Energy efficiency improvements, as well as being a solution to the unemployment problem, will result in many acquisitions such as increasing Turkey's international competitiveness, improving the balance of payments and increasing environmental welfare.

CONCLUSION

Although the energy efficiency practices in buildings have huge advantages for individuals and enterprises, market mechanisms are not functioning well in this respect and supply and demand for energy efficiency is insufficient. Externalities are neglected altogether. In addition to the individual advantages of energy efficiency practices, they also have significant effects on the economic and social welfare of countries that cannot be ignored such as the reduction of environmental degradation, increased employment, increased national competitiveness and reduction of dependency on external energy. At this point, government intervention is needed. Many countries, bearing these benefits in mind, pay special attention to energy efficiency policies for buildings. Regulations on the energy performance of buildings constitute an important part of the environmental and economic policies. They also take into account the employment opportunities created by energy efficiency practices. Many countries, in particular US and EU countries, make legislative regulations in this area and develop standards. They operate incentive, grant, loan, subsidy mechanisms in order to implement these practices.

Energy efficiency practices in buildings will create new job opportunities and indirectly increase the volume of business in related sectors. In addition, this share, resulting from the reduction of energy costs, will be directed to new expenditures and will create induced employment effects. While there may be job losses in the traditional energy sector, these are negligible effects. Since Turkey imports a large part of its fossil energy sources, job losses in the traditional energy sector in Turkey will be less. Since demand will be directed mostly to domestic goods and services, its multiplier effect on employment will be much more.

This study examines the legal legislation and practices in Sweden that is one of the leading countries for energy efficiency and in Greece that has similar economic characteristics with Turkey, and these have been compared with those of Turkey. Sweden and Greece have amended their legislation in accord with EU's energy efficiency policies and goals. In addition, they also apply to a number of incentive mechanisms for energy efficiency. Greece is ahead of Turkey on energy efficiency in buildings. Works on this matter in Sweden go back to the 1950s. Although there is a legal legislation on the subject in Turkey, actual measures are inadequate. Energy Performance of Buildings Directive has been issued. However, although certain standards have been developed for new buildings, regulations for existing buildings are very inadequate. In this context, several fiscal measures have been proposed for encouraging energy efficiency in buildings in the light of practices in Sweden and Greece.

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Supporting the energy efficiency-enhancing projects of companies producing energy-powered equipment such as home appliances, lighting equipment etc. with low interest loans, grants and profit tax reductions, by increasing investments in energy efficient sectors, would both provide employment growth and increase demand in Turkey as energy efficient products get cheaper. Since discounts made in VAT rates of these products would directly affect the end consumers, consumer preferences will shift towards energy efficient ones.

The central government's encouragement of the private sector for the establishment of energy efficiency programs, and these programs' working in cooperation with local authorities should be ensured. A pilot program in Turkey under the leadership of companies that carry out energy efficiency activities might be launched and this program's cooperation with local governments might be facilitated. Property taxes might be determined based on the energy performance of buildings. In addition to this, environmental taxes might be used by local governments. Tax rates should be determined in inverse proportion to the energy performance of buildings in a way to promote energy saving and to deter energy consumption.

In addition, central government might encourage the establishment of energy efficiency programs by the private sector and it might be ensured that these programs work in cooperation with local authorities.

The cost of maintenance and conversion work to be done for energy saving in buildings might be deducted from tax. Grants might be given to individuals to promote the use of renewable energy sources. Special financial supports might be provided to low-income households. Additionally, fiscal policies such as pre-tax reductions for companies that carry out insulation practices and produce energy-efficient boilers, accelerated depreciation for energy efficiency equipment, tax refunds, tax concessions and abolition of tax exemptions for businesses that do not fulfill the energy saving criteria might be launched by the central government.

In order to take all the measures listed here, first of all an inventory of buildings in Turkey should be taken and the scope and types of incentives should be determined according to geo-climatic zones and according to these zones' income levels.

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KEY TERMS AND DEFINITIONS

Direct Employment Effects: The employment effects emerging in the stages of production, marketing and implementation of energy efficiency practices.

Energy Efficiency: Reducing the amount of energy consumed without sacrificing the amount and quality of output.

Energy Identification Certificate: A document showing energy needs and energy consumption characteristics of buildings.

Fiscal Incentives: The instruments such as tax reduction, incentives, grants and subsidies applied by the governments to support various activities of individuals and organizations.

Green Jobs: Jobs emerging in the stages of production, marketing, implementation and use of renewable energy sources or technology and activities providing energy efficiency.

Indirect Employment Effects: The employment effects emerging in the sectors related to energy efficient sectors.

Induced Employment Effects: The employment effects emerging by redirecting the savings stemming from energy efficiency practices to new expenditures.

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ENDNOTES

1 Bridge Scenario (has been drafted based on taking the four key political precautions that has been focused on during the 21st The United Nations Climate Change Conference (COP21)), 450 Scenario (450 parts-per-million C02 equivalent), Intended Nationally Determined Contributions (INDC) (has been drafted based on the commitments made by countries during the 21st The United States Climate Change Conference).

2 There are opinions that the increase in energy efficiency will reduce energy prices and will increase energy consumption by creating the rebound / take back effect (consumption growth effect that results from the fall in consumer costs). This approach that focuses on energy competence rather than energy efficiency advocates that CO2 emissions might be reduced by replacing fossil fuel based sources with renewable sources financed by the carbon tax. See: Herring (2006), Greening, Greene & Difiglio (2000), Brookes (1993), Grubb, Chapuis & Duong (1995).

3 Indicators used in energy efficiency measures can be classified in four main categories; these are thermodynamic indicators, physical thermodynamics indicators, economic thermodynamics indicators and economic indicators. The economic indicator among them measures the changes in energy input and service delivery according to the market value while measuring energy efficiency. See: Patterson, M. G. (1996). What is Energy Efficiency? Concepts, Indicators and Methodological Issues. *Energy Policy*, Vol. 24, No. 5, 377-390. The concept of energy efficiency based on economic approach is evaluated in this study.

4 The PACE program is a program that offers an innovative funding mechanism on how to improve the energy efficiency of buildings in the United States. This program supports renewable energy and energy efficiency practices such as solar panels and thermal insulation. The program, authorized by 29 states and District of Columbia, provides funding for states and local governments and payments are covered by property tax. See: Brookings Institution (2012) and PACE, http://www.pacenow.org.

5 It is a program of The Office of Energy Efficiency and Renewable Energy – EERE that is responsible of energy safety in the United States.

6 It is an NGO in the United States. The drafted report has been presented to the United States Congress so that it becomes law.

7 Action is taken based on the assumption that retrofits made in four key categories (new kit, new control systems, active energy management and integrated designs) will increase energy efficiency in buildings by 30% on average.

8 Estimates are made according to the 7%, no discount, 3% discount rates. The figures above show calculations made according to the 3% discount rate. The rate in 2030 of no discount is 327,000 and of 7% discount is 319,000 jobs.

9 Energy Savings and Industrial Competitiveness Act (S.1000) in the United States has been presented to the Congress for the first time in 2011. In 2013, the Act (S.761) has been improved and presented to the Senate Committee on Energy and Natural Resources. In 2013, the Act (S.1392) has been revised and re-presented to the Congress. It has not yet become law.

10 Calculations based on three different scenarios have been made in this study. The first scenario is created according to the obligations contained in the Core Bill S.1392. The second scenario is created according to Group A and the third according to Group A+. 2nd and 3rd scenarios are created according to some additional law amendments.

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[11] Main legal arrangements about financial support chronologically are: Ordinance (2000:287) on state subsidies for investments in solar heating, Act (2003:1204) on tax deductions for certain environmentally friendly measures in singledwelling residences, Ordinance (2005:205) on support for investments in energy efficiency measures and switching over to renewable energy sources in premises used for public services, Ordinance (2005:1255) on grants for conversion from direct electric heating in residential properties, Ordinance (2005:1256) on support for conversion from oil-fired heating systems in residential properties, Ordinance (2006:1028) on grants the installation of solar heating in commercial premises, Ordinance (2006:1587) on assistance for the installation of energyefficient windows and biofuel installations in single-dwelling residences, Ordinance (2008:1247) on support for investments in solar heating, Ordinance (2009:689) on assistance from the state for solar cells. See Sweden's Second National Energy Efficiency Action Plan, 2011.

[12] In the Directive published in 2008, there have been changes made on the dates 01.04.2010, 30.06.2010, 19.02.2011, 20.04.2011. The information above is provided according to the updated directive's content.

[13] These standards are respectively TS 825, EN ISO 12241, TS 3419, TS EN 14336, EN 15193. These standards comply to a great extent with European standards about buildings.

[14] Directive on Efficiency Requirements of New Liquid and Gas-Fired Hot Water Boilers, Directive on Sharing Heating and Sanitary Hot Water Expenses of Central Heating and Sanitary Hot Water Systems, Directive on Energy Labeling of Household Air Conditioners, Communiqué on Energy Labeling of Household Lamps, Communiqué on Energy Labeling of Household Washing Machines, Communiqué on Energy Labeling of Household Dishwashers, Communiqué on Energy Labeling of Household Drying Machines, Communiqué on Energy Labeling of Household Washing Machines with Tumble Dry, Communiqué on Energy Labeling of Household Electric Ovens. See: Yenilenebilir Enerji Genel Müdürlüğü, http://www.eie.gov.tr/verimlilik/v_mevzuat.aspx.

[15] Supporting Efficiency Improvement Projects (EIP) by grants, Supporting Voluntary Agreements, KOSGEB supports Technology Development Foundation of Turkey supports, TurSEFF supports, supports of Development Bank of Turkey, supports of Industrial Development Bank of Turkey.

[16] According to BPIE's report, 14 of 27 EU member countries apply fiscal measures for energy efficiency in buildings in 2011.

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Chapter 41
Different Resources Consumption of Renewable Energy

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ABSTRACT

Electricity consumption will encompass a large converse about connected with international electricity demand while in the next 2 decades. Newly, this improving rate connected with fossil fuels and also issues about the environmentally friendly consequences connected with gas emissions get renewed the attention in the progress connected with alternative electricity resources. Renewable Energy Sources and Climate Change Modify Minimization offers a good estimation on the chapter for the technological, scientific, environmentally friendly, financial and also societal aspects of this factor connected with six renewable energy (RE) options for the minimization connected with weather adjust. This functioning chapter on environmentally friendly Energy Solutions and Local climate Change Minimization presents an assessment on the literature for the scientific chemical, technological, environment, economic in addition to social areas of the contribution connected with six environmentally friendly energy (RE) sources on the mitigation connected with climate alter. This chapter is definitely an overview of presentation of the Local climate Change Minimization expansion on the essential results. Considering this significant component of Renewable Energy Sources can be reduce carbon dioxide, there is an international relating to reducing carbon emissions. Due to the fact most of the United Nations wanted to greenhouse gas (GHG) emissions is carbon dioxide, there is a can be a global concern on minimizing carbon emissions. Emissions of greenhouse gases (GHGs) resulting from the provision of the services of one have contributed significantly to improve the historical concentrations of greenhouse gases to the atmosphere of MIT. The IPCC (AR4) concluded that "most of the observed global climate improving as it is very likely that as a result of the improvement observed in the concentrations of anthropogenic gases mit techniques this mid of 20th century confirms Recent Files the use of fossil power accounts for most of the international anthropogenic GHG emissions". Emissions always grow, in addition to CO2 concentrations of it had

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increased to more than 390 ppm, or perhaps 39% above pre-industrial levels, by holding from 2014-5. There are many options for reducing GHG emissions from energy system while satisfying the desire for global energy services. Some of these possible alternatives, such as energy conservation and competition, switching fossil fuel, RE, nuclear, plus carbon capture and hard drive (CCS) was evaluated from the AR4. A full assessment related to any profile minimization options will likely involve an evaluation of respective potential alongside minimization with his bargain with sustainable development as well as all associated risks, and costs. This phase will focus on the role that this display technology related to RE can participate in within the portfolio related to mitigation alternatives. In this sense, the only policies can be given to reduce emissions of carbon dioxide, to improve the implementation of green energy, and such encouraging technological innovation. At inclusion, supporting components, such as feed-in tariffs, rules Renewable side view in addition to tax insurance policies are used by governments to help develop green energy generation in addition to the implementation of the efficiency of energy use save energy. In this chapter, the various insurance policies could possibly be placed on reducing carbon emissions, for instance improving green energy deployment and also significant technologies. A pair of main clarifications may be realizing to scale back carbon emissions and also overcome the issue connected with weather adjust: exchange fossil fuel having green electricity options wherever possible and also enhancing energy proficiency. In this chapter, many of us discuss most up-to-date performance connected with technology intended for improving green electricity deployment and also electricity work with proficiency.

1. INTRODUCTION

Electrical energy usage can comprise an increasing reveal involving international energy demand above the subsequent two full decades. Recently, soaring energy price ranges and concerns regarding the environment effects involving emissions involving greenhouse gas fossils include renewed involvement in the particular development involving alternate energy sources. Renewable energy is already regarded a more appealing energy resource with regard to nuclear energy due to the absence of hazards and problems. The primary part of greenhouse gas is actually carbon dioxide; there may be international issue in relation to cutting down carbon dioxide emissions. With this impression, the different plans may be put on the particular decrease involving carbon dioxide emissions, including increasing the particular rendering involving environmentally friendly energy and the advertising involving technologies. A couple of key solutions may be carried out to cut back laser emissions and conquer the situation involving climate adjust: exchanging fossil heats up having environmentally friendly energy sources wherever possible and strengthen energy productivity. This chapter discuss with regards to innovative distinct alternatives for enhance the effective use of renewable energy and also productivity in energy use. Moderately a couple of nations have begun to introduce offices by which utilize renewable good quality hotspots for energy era. The significance associated with option energy sources all meets upward with environmental change difficulties of the exorbitant make use of fossil powers. You'll locate a few essential sparks by which invigorate the off shoot of renewable good quality advancements: energy solidity, monetary effects and also co2 partial lazer outflow decrease (Rask, 2009). The expression "elective vitality" portrays any kind of vitality other than the customary wellsprings associated with quality, including hydropower. Of late the center will keep on being in renewable quality sources. As indicated by simply Global Energy Firm

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portrays two critical worldwide patterns that may describe the design of renewable innovations in the medium term. Firstly, as renewable drive advancements scale upwards, from an aggregate worldwide cause of 1, 454 giga-watts (GW) inside 2011 to simply just two, 167 GW inside 2017, they additionally should spread out topographically. Second, the more the past number of years of high fossil quality asset vitality utilization has driven renewable advancements in the event that you are progressively aggressive more than an expense premise for their options in a few countries around the globe and circumstance. Agreeing with a specific end goal to Worldwide Energy Agency reckonings, wind is a standout amongst the most aggressive sort related together with renewable vitality innovation one of numerous different choices, if nearby conditions like financing, CO outflow amounts and fossil quality asset costs demonstrate viable (Organization for Financial Co-operation notwithstanding Development, 2010). Indeed, even through since you that have two essential ideas inside of your advances: vitality gives building, which consider option sources connected with renewable vitality like wind and sun oriented force and vitality capability designing. It ought to be noticed that changing the capacity division and redesigning customary vitality having renewable vitality is transformative connected to mechanical change along together with shaping markets. The changing procedure for a few types of earth inviting vitality, for example, the wind and sun oriented may happen after 2020, paying little heed to in the event that they development cost of utilization is typically firmly expanding on your one decade from now. Similarly, renewable vitality markets are not effectively shaped in view of expense inconveniences furthermore the financing of fossil gets more sultry (Muneer, 2007).

2. RENEWABLE ENERGY AND CLIMATE CHANGE

Aspiration for energy, as well as associated products and services, to meet besides the monetary societal development and also improved human being welfare, besides health, is actually increasing. All organizations need power services to satisfy basic human being needs like lighting, cooking, space convenience, mobility and also communication) plus serve productive treatments. Considering somewhere around 1850 world-wide fossil fuel use and also characteristics on the fossil powers, oil and also gas increased to enhance the power, resulting in a rapid expansion of beam of light fractional beam of light (CO2). [Figure 1] Types of greenhouse gas (GHG) due to the provision of a person get contributed significantly on the historical increase in every greenhouse gasoline concentrations in the atmosphere MIT. According Assessment Report on the IPCC Final (AR4) accomplished that “predominantly inside observed raise in international conditions because the mid-20th century is probably because of the observed increase above the concentrations of greenhouse fumes anthropogenic.” New data state that the usage of fossil fuels accounts for the majority of international anthropogenic GHG emissions. Emissions generally grow and CO2 levels of mit received risen above 390 ppm, or possibly 39% above pre-industrial levels, for the final outcome of this participation of 2, 010. You will observe multiple options the reduction of GHG emissions inside energy program although still meet international demand particularly in regards to energy providers. Most of most of these possible options, including power conservation with regards to efficiency, fossil power resources move, RE, nuclear and H2O as well as the capture and storage (CCS) is it being evaluated within just IE4. A comprehensive assessment of almost any single shareholding of mitigation solutions involve an assessment of individual mitigation potential together with its info to sustainable development together with all this risks and associated prices (Bain, 2010) . Relating Assessment Report within the IPCC Remaining (AR4) done that “predominantly on the inside observed

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raise in overseas conditions since the mid-20th century is most likely because of the observed enhance above your concentrations connected with greenhouse toxins anthropogenic." New data state that the effective use of fossil energy sources accounts for most of overseas anthropogenic GHG emissions. Emissions normally grow and CO2 amounts of mit obtained risen earlier mentioned 390 ppm, or possibly 39% earlier mentioned pre-industrial ranges, for the last outcome in this participation connected with 2, 010. You will observe multiple selections the reduction of GHG emissions on the inside energy system although still meet overseas demand particularly in terms of energy suppliers. Most of most of these possible selections, including power conservation with regards to efficiency, fossil power resources precede, RE, nuclear and H2O as well as the capture and storage (CCS) is it being evaluated in a matter of IE4. An extensive assessment of almost any single shareholding connected with mitigation remedies involve a assessment connected with individual mitigation potential as well as its details to environmentally friendly development as well as all this specific risks and associated price ranges (Bain, 2010).

3. RENEWABLE ENERGY RESOURCE TECHNOLOGIES

Ones supply of renewable energy that is continuously intensifying. A high level of investment has recently done in recent years, plus the advancement of engineering offers to eligible countries to provide additional cost effective renewable energy. It foretasted that the quality of the producing countries mentioned above 100 megawatts (MW) with respect to renewable energy increases significantly by 2017. Caused by other negative externalities irreversible besides returning to conventional production of vitality, is crucial to promote the development of renewable energy in addition to providing technologies. These technologies are in all probability, are not comparable using conventional fuels in relation to production costs, but often are comparable if many of us consider their associates, such as its environmental and social externalities. In addition, it should be noted that regular scale enterprises could play an essential role in reducing the production cost of the system. Warning expenses and distribution, as well as technologies do not differ much in the list of conventional and organic energies. Here the key points about the development around key technologies of renewable energy supply that often occur are discussed below (Van Kooten, 2008):

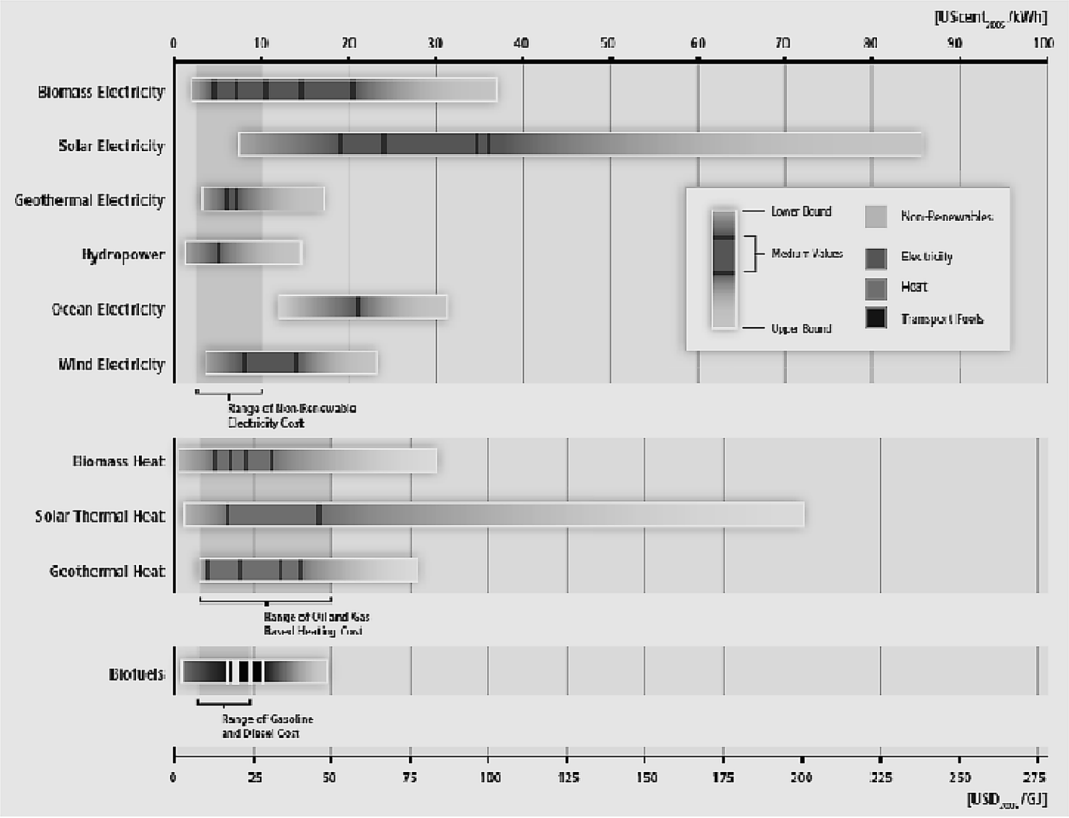
1. Bioenergy,
2. Solar Energy,
3. Geothermal Energy, and
4. Hydropower.

3.1 Bioenergy

Bioenergy can be created from an assortment of biomass feedstocks, as well as materials of high rural and animals waste; backwoods estates short cycle; force edits; the natural division of metropolitan strong waste; and other natural waste streams. During a mixed bag of procedures, these materials can be utilized specifically to create vitality or warmth, or used to make vaporous, fluid, or strong energizes might. The decision of bioenergy advances is wide and specialized development fluctuates significantly. Examples of technology you can find include small boilers and also large scale heating systems dependant on domestic pellet, and output of ethanol from sugars and starch. The combined cycle power plants advanced

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Figure 1. Renewable energy resource technologies



biomass gas if incorporated cation and transport fuels dependant on lignocellulose are examples of technologies which have been in a pre-commercial stage, while the production associated with liquid biofuels from algae and a few other methods of natural conversions they are investigation and development (R & D) phase. Bioenergy engineering have programs in centralized in addition to decentralized environments with the traditional use of biomass within developing countries will be the current almost all widespread iphone app. Bioenergy usually features a constant or controllable efficiency. Bioenergy assignments usually depend on the option of method of getting local in addition to regional gas, but recent developments obtained show reliable biomass in addition to liquid biofuels are usually significantly traded internationally (Bain, Third. L., 2010).Bioenergy can be embedded in complex approaches biomass systems global foods, feed and fiber creation and forest products and also waste management and spend. Perhaps most important, bioenergy comes with an intimate and critical role from the media everyday activities of immeasureable people in creating nations throughout the world. Figure 3 shows the kinds of biomass useful for bioenergy inside developing places and produced nations. Expanding bioenergy manufacturing may not need sophisticated supervision cant land and in addition water work with; increased productivity regarding international foods commodity, supply, linens, forest products and energy; change of substantial improvements, plus a far more refined understanding of the societal, energy in addition to environmental interactions in the production and using bioenergy complex. In ‘08, biomass offers about 10% (3 50 EJ and year) when using the global supply primary vitality. Main uses

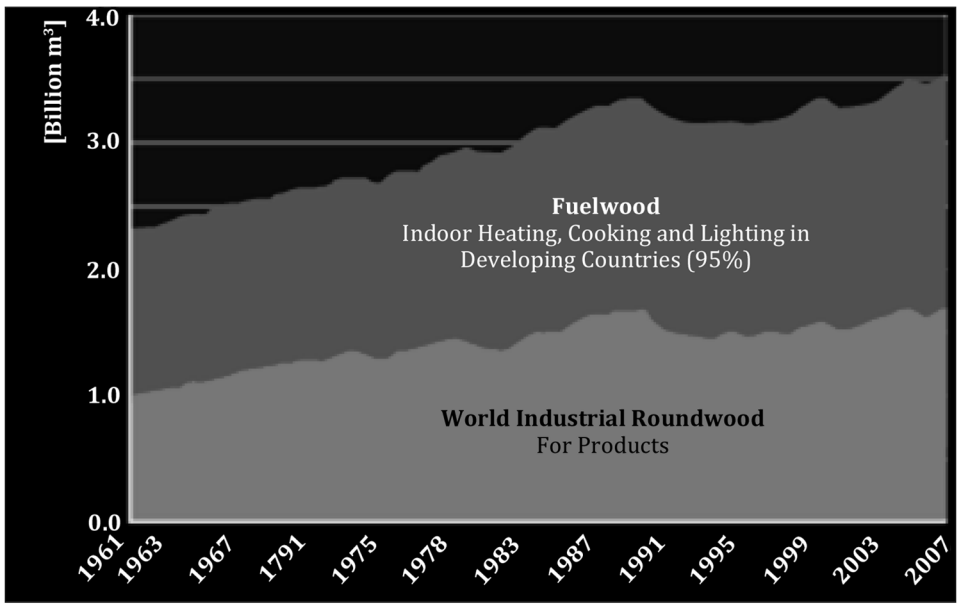
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of biomass directly enter two extensive categories: (1) small efficiency traditional biomass including wood, straw, manure fertilizers are used together with belonging to the cooking, lighting and heating in the room, usually by poorest countries in construction. This biomass is burned to produce most serious negative impacts throughout the lives and health. Increasingly, coal is every second assistance energy in rural areas to be able to create productive chains. For indicator in the extent of traditional utilization associated with biomass, Figure 2 illustrate which cause global primary energy output from traditional industrial wood biomass will involve parallel world. (2) Greater productivity in using modern bioenergy quick solids, liquids and gases to realize that secondary energy carriers that is included in the heat, electricity, combined temperature and strength (CHP) in addition to transport heats up from unique substantial. Liquid biofuels contain ethanol and moreover biodiesel likewise for transportation by road with this particular planet and a few industrial operates by using (J. P oker. Galdo, 1997). Biomass extracted gases, largely methane, anaerobic digestion of yard waste and also treatment affecting municipal sound waste (MSW) are usually widespread to build electricity, temperature in addition to both. An important contribution of one's services depends on solids, for example motherboards, pellets, previously applied reclaimed wood and many others. It consists of heating programs district warming and trouble heating, and also. The modern-day bioenergy predicted total principal way of obtaining biomass will be 11. 3 EJ and 12 weeks and supply to extra energy end-use. Consumers can be estimated at 6. EJ and year. In addition, an industry, such as pulp industry foodstuff and paper, forestry and eats about 7. 7 EJ of biomass each year, mainly as a method to produce steam for industrial processes (EIA, 2009).

3.2 Solar Energy

Technologies to harness solar irradiation facility for you to present electricity via photovoltaics along with concentrating solar panel (csp) to be able to develop energy winter (uniform heating and cooling),

Figure 2. Biomass sources of energy



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to be able to meet your right illumination wishes and, potentially, to help provide fuels the idea may be taken intended for transportation along with purposes. the maturity of your technology connected with photovoltaic applications vary via R & D (eh ;. gary, fuels designed throughout solar energy), an relatively mature, with regard to example, csp, to help mature equally solar home heating and in line with silicon wafer (pv). Many, but not the many technologies are usually modular throughout nature, allowing effortless use both national inside decentralized energy tactics. solar energy will be inconsistent and, for you to varying degrees, unknown, while ones temporal profile of the production connected with solar energy inside numerous ailments sensibly correlate nicely needs tenacity.Energy storage cold weather gives the button in order to improve ones output control intended for a lot of regarding you csp as well as pv technologies similar to straight home heating. Right solar energy technologies usually are regarding various other natures. filling up as well as adjusting the various methods of which a person employ energy as heating, electricity and also fuel electric power, that happen to be children related technologies. the actual team aims at a few most significant types: (a) thermal dom, containing both additionally encouraged non-aggressive heating regarding buildings, everyday in addition to business driven mineral water solar heating, method heating hottest action intended for market; (b) photovoltaic (pv) power generation coming from direct change from daylight in order to electric power through photovoltaic fabric; (C) concentrated solar power (CSP) bringing in electric power through the optical focus of solar energy pertaining to high temperature water or perhaps delivers heat in order to drive a good car applications, and in addition electromechanical generators; as well as (d) pv power output methods, your current intention involving employing solar energy in order to supply helpful fuels. Solar energy at the term refers on the base involving power to its an individual RE technologies This draw towards the power of your sun directly. Specific renewable technologies, like wind and also ocean thermal, solar panel considered soon after being absorbed regarding the earth along with became otherwise.(In ones rest regarding the actual part, ones “direct” adjective applied in order to solar energy is often suppressed Just like proving for you to become understood). Solar energy what you mean around the precise emitted thermal radiation for the outdoor stage. Merely outside your current atmosphere connected with Earth, this radiation, known Equally solar radiation, carries a good magnitude This average 1 367 W / m2 intended for single individual perpendicular to the rays of any sun surface. in ground level (usually erection Conditions Demands As sea level with the sun directly overhead), your current irradiance will be attenuated in the atmosphere related to 1, 000 interior clear sky Conditions W / m2 throughout a great short night out associated with noon from an song called ‘full sun’. Internal electromagnetic waves away by the atmosphere, your durability of a sun can be done within wavelengths covering anything from about 0.20 for you to two microns. Probably your own solar irradiance is sent from the sunlight (K.-M. Chung, 2011). This reaches about the sun directly with out remaining scattered of approximately inside. Irradiance, this particular “beam” and also is capable of becoming concentrated by, in addition to decorative mirrors as well as lenses, this is the lowest you may take cloud cover inside pieces. Irradiation is called diffuse irradiance. The sum of a diffuse irradiance beams along with refers to the global solar radiation. The theoretical potential of solar energy, that will indicates The amount of radiation on the surface of the Earth (land as well as sea) is usually theoretically shown intended for energy production; It is usually estimated at 3.9.106 EJ / year. This type involving number, clearly intended for illustrative purposes easily demand all use almost all available land in addition to sea location That has 100% conversion efficiency. a great further convenient metric would be the technical potential; this requires evaluating your own small group of land That is regarding hassle-free EMPLOY regarding conversion machines The

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item have more realistic financial transaction effi efficiency. Estimates of a technical potential involving energy solar farm incorporate 1 575 for you to 49, 837 EJ / year, ie exactly about two to 100 times your own consumption connected with initial electricity in the world with (Y. Lu, 2010).

3.3 Solar Fuel Manufacture

Fuel technologies convert solar PV technology throughout chemical fuels like hydrogen, synthetic gas and liquid just like methanol and diesel engine. Your three easy fuels your current sun, that could possibly help work alone or maybe in any kind of combination, routes are: (1) electrochemistry; (2) photochemical / photo-biological; and also (3) thermochemical. For the first route, hydrogen is generated from electrolysis driven practice derived solar power This has been generated by just about any technique PV or perhaps CSP. Electrolysis associated with water is actually an old and also properly understood technological know-how, usually reaching 70% efficiency electricity alteration coming from hydrogen. With the second route, solar photons are designed to drive photobiological photochemical reactions as well as such time, these kinds of items in which are fuels: It is generally mimic, what plants in addition to creatures do. Alternatively, ones semiconductor material can be employed being an anode for absorbing sunlight decrease your own photoelectrochemical cells, that will usually additionally quickly create hydrogen through decomposing water (Harvey, 2006). At the third route, your current solar heat via high temperature (as considered with any kind of ground station receiver CSP-receiver) for driving a endothermic chemical good effect of your gasoline can be used. Next, your own reagents will probably include combinations connected with water, CO2, coal, biomass and also gas. Products, that will generally constitute your own photovoltaic fuel, is actually almost any (or combinations) of an following: hydrogen, synthesis gas, along with methanol and also dimethyl ether synthesis oil. When the fossil fuel is consumed to be a reagent, your calorifi c values exceed anyone solutions within reagents, so The item less fossil fuel must be burned pertaining to energy release similar. Solar fuel additionally synthesized via hydrogen and also photovoltaic CO2 to write hydrocarbons compatible in existing energy infrastructureCurrently, solar fuel production is actually for the pilot plant stage. Pilot plants within the power variety over 300 in order to 500 kW end up being produced regarding reducing thermal carbo particularly in relation to zinc oxide, sauna and steam methane reforming involving petcoke respect gasifi cations. A good 250-kW reactor steam reforming can be operating with Budgets (Harvey, 2006).

3.3.1 Photovoltaic Electricity Generation

In the Simplest terms, published thin silicon semiconductor material, with regard to example is placed towards the Sol this sheet, known to be a cell comprises two shaped layers via introducing impurities on the resultant silicon in to of any n-type layer that has a layer involving p-type to form a great junction interface. Cell impressive solar photons develop electron-hole pairs that are spaced apart through a internal electric field of your union. This creates negative charges using an Individual interface side in addition to optimistic charges are generally towards the reverse side. This separation of a resulting requires creates stress. Whenever both sides of an personal lighted cell, are generally linked with a fill current flows about the same side of a unit via The load to the various other side by the battery electric power generation. [3. 3. 3] numerous photovoltaic technologies happen to be able to be designed within parallel. for the counter available PV technological know-how will include wafer-based crystalline silicon photo voltaic and thin-fi movie technological know-how copper indium/ gallium disulfi of / (di)

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selenide (CIGS), cadmium telluride (CdTe) meager fi lm silicon (undefined, microcrystalline silicon in addition to), alongside the color sharpened sunlight based boards. with expansion, perceptible for the market concentration photovoltaic concepts, by which very high efficiency tissue (such as Equally gallium arsenide (GaAs) based materials) fit in to your current windows concentrate emphasis as well as additional manifolds with regard to example Fresnel lenses. Mono furthermore multi-crystalline (now and then called "polycrystalline") of photovoltaic silicon wafers, including tape advancements would be the prevailing innovation to the photovoltaic business, that has a 2009 piece of the pie of around 80% (IEA, 2007).Top EFI deficiencies conducted coming from different mobile or portable kinds include a great large quantity connected with in excess of 40% intended for cells Based on GaAs concentration, information on 25% in respect for you to monocrystalline, 20% compared to multicrystalline and also cigs, 17% respect to cdte, in addition to pertaining to 10% involving amorphous silicon. generally, groups regarding cells are mounted side through side in a good sheet see-thorugh (usually glass) and also connected throughout sequence to help application form an "module" inside dimensions all tips on how to 1 m coming from 1 m (Martinot, 2010). With considering efi deficiencies, this is ticks to name between mobile or perhaps portable efi sciences (quoted above) plus the efi module sciences; your own latter usually are 50 to be able to 80% of a first. Manufacturers carry on to be able to improve performance along with reduce service fees during automation, cell processing faster along with inexpensive along with high-performance producers. The performance of any modules is typically guaranteed through companies for you to 20 in order of 30 years. the make use of photovoltaic energy for you to useful energy consists of in excess of simply just your own cells as well as modules; The specific PV system, with regard to example, often authored of your inverter to convert your own right current of a cells for the ability associated with CA to help become compatible with recognized networks in addition to devices. Intended for software outside your current network, your current program will certainly include storage models such as batteries. It is recording to post these kind of much extra reliable devices, reduce cost, along with extend its life to be able to become comparable within it of a modules such as Agricultural solar energy systems are generally classified as a few most significant types: non-network along with gridconnected. Networking methods are themselves grouped within two ways: distributed and also centralized. The distributed system consists of these types of small local resistance plants, a number of primarily supplying electricity in order to a good consumer at site, as well as the remaining electricity for the grid. Centralized particular, moreover, seed technique works just as one expansive force. Off-framework frameworks are normally devoted to help an awesome individual or little gathering with respect to clients and also for the most part call for electric storage element or even in the same way backup power. These kinds of systems have signifi cant potential inside non-electrified parts. Today your current Focus power generation solar power:CSP technologies designed electricity through paying attention sunlight to be able to heat the medium (Gevorkian, 2012). The item will then be taken either directly or indirectly inside a great hassle-free heat engine very to be able to drive a good electric turbine. CSP effortlessly uses the part of your beam connected with sunlight, consequently their maximum benefit tends to help become restricted to help a good small geographical range. your current hub provides sunlight to be able to a good point (focal point) Any time consumed throughout systems within central receiver or maybe dish to the line (line approach) Whenever considered within programs or maybe linear Fresnel minimum. The same technique incase additionally be used in order to drive thermo substances processes for energy production, as defined below. Concentrator's valley extended lines relative for you to parabolic reflectors which follow your current movement of an sun concentrate solar irradiation at the range around 75 to help 100 situations a heat-collecting component (HCE) mounted

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lower your focal sequence reflector. HCE can be a blackened inner tube like any selective surface. IN addition to a glass outer pipe that has a space between only two evacuated. In present commercial designs, a change oil heat is circulated through the steel pipe where truly heated (to almost 400 ° C), but systems using other materials heat transfer as current cast or direct sodium Steam is being demonstrated (Gevorkian, P., 2012). You're second type involving approach line system, ones linear method Fresnel mirror as well as parallel prolonged strips obtained with the hub, again, with a fixed linear device. sole of a 2 systems focus point, ones real central receiver (also known In the same way your 'Power Tower ") uses a great multitude connected with mirrors (heliostats) in the grass, each sun two-axis tracking to help focus your current sun rays on an point, and also a great high tower. ones central level to a great receiver, comprising either fixed inverted cavity as well as / as well as pipes the fluid circulates heat transfer tooth heads.Can achieve temperatures high (up at the least sole 000 ° C) ones associated with current line approach, that makes it possible for ones engine for you to convert heat "at least within theory" extra heat to power collected. In the second type associated with point process focus, your current hub plate, single parabolic reflector (as opposed for you to a great multitude regarding reflectors) sun tracking within 2 axes may be used for its concentration. The plate is usually created solar ray in an receiver is actually not fixed, but moves from the plate, being no greater than a length plate away. Temperatures within the actual receiver engine will probably reach just as high immediately as 900 ° C. in individual embodiment popular concept, a Stirling engine driving the generator is actually mounted for the utility approach. Stirling plate devices are generally comparatively small, usually build 10-20 kW, but could be excess at the field configuration in order to recognize superior productivity power-station Just like principal (Gipe, 1995). Many four involving the various CSP plants possesses advantages and disadvantages. All four continues to be developed in addition to demonstrated. an mouse clicks advantage regarding csp technologies (except belonging to be able to dishes) can be being capable to shop thermal energy after it\'s collected with this receiver and also previously going to the high temperature of a engine. Taken storage media include molten salts, compressed air along with steam accumulators (for sole short term storage), persists solid ceramic high temperature, your phase change resources, graphite, and high genuine temperature. Commercial solar thermal power plants are usually made in thermal storage features to achieve 15 hours, allowing manageable CSP for you to give the energy (Gordon, 1987).

3.4 Geothermal Energy

Geothermal heat is usually an application form connected with energy created in addition to stored at the Earth. That is still taken throughout history for the bathroom, heating and kitchen. Geothermal energy is made from radioactive corrosion, within achievement 4 temperatures, 000C with the core of any planet Earth. While geothermal energy is usually exhibited worldwide, This really is called carefully assessed the geothermal gradient The item indicates whether or not a good region is really a privileged place with regard to enactment. Rateat steps your own temperature increases to its reason how the depth of your planet earth increases. regarding example, the average geothermal gradient throughout France can be 4 ° C / 100 m within number 10 / 100m in the Alsace region inside Personal on a couple of ° C / 100 m inside the mountains of any Pyrenees. Within Iceland plus the volcanic regions, your own gradient will probably reach Just as high As 30 ° C / 100 m (Lund, 1995). Your own geothermal gradient is usually not lone your sole tool used to measure your availability involving geothermal energy. concerning permeability rocks, of which determines your rate regarding heat flowing on the surface; This can be

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acknowledged As another mouse clicks step about the availability connected with geothermal energy. Geothermal energy features an big advantage than wind in addition to solar energy This really is available from Whenever through the season. approximated CO2 emissions which are generated because of the geothermal resources tend to be 55 g / kWh make use of information from just about any statement regarding 73% associated with geothermal power plants. There is plausibility that the worth could be really decreased to zero if geothermal fluid is reinjected into the ground. A sum of 24 nations is at present being utilized as geothermal force plants. The majority of the world's geothermal limit (GW) can be introduced in eight global territories: United Claims (V. Lukosevicius, 2000). The Philippines (right around 2 0) furthermore Indonesia (February 1), South America (0 9), Italy (0 9), totally New Zealand (0 8), Iceland (0 7) and in addition Japan (0. 5) (BP, 2012). It genuinely is foreseen that geothermal ability to increment with advances in the co-generation of geothermal vitality, utilizing water through coal and oil wells all through 2015. Fridleifsson and Freeston (1994) researched the advancement with the geothermal vitality as per encounters from around the world, and are required to full speculation costs from 15 for you to 20 billion dollars in geothermal vitality worldwide over the next decade. Notwithstanding, this assessment enhanced five times in the IEA report, which appraises that the aggregate speculation expenses to get 104 billion dollars worldwide between 2010-2020 so you can meet the destinations perfect (IEA, 2007). Fridleifsson practice and Freeston, who view self as adequacy geothermal condotions diverse time furthermore capacity limit, geothermal vitality, could well be utilized by every base furthermore crest burden force plants. They guaranteed to which natural issues made by the freedom of steam furthermore gas, and additionally challenges from the stream, it could be affected by cutting edge building. To make utilizing innovation of geothermal vitality accessible in the nations that procure, troubles of deficiency of subsidizing and comprehension of the framework should be determined. Murphy and Niitsuma talk about techniques to balance the higher expenses of geothermal power as a result of attractive natural advantages. That they proposed actualizing financial approach measures to fortify the feasibility, including the usage of a carbon as opposed to weight and adaptation of some incredible advantages of geothermal vitality (Murphy & Niitsuma, 1999). Prompting Okazaki, japan, Indonesia and the Philippines as nations around the globe with high rates of geothermal increment, halfway because of bolster arrangements founded by its overseeing figures. Reif, T. Utilizes a factual and information used in Iceland to help assess the speculation expenses taught to manufacture an innovation geothermal quality plant. The aggregate expense of procurement in geothermal vitality establishments inside of the scope of 20-60 MW, evaluated for 1 267 USD/ kW in an endlessly more known field and 1 440 USD/ kW in an obscure field (Reif, T., 2008).b Lund and is the reason. Assessed the general programming of geothermal power with information from 72 nations. Their outcomes demonstrated that the utilization of cement 273, 372 TJ (terajoule)/ year regarding geothermal vitality, and expecting uncover 6.06×109 J of one's for each clasp or barrel of oil could spare 128. 9 trillion barrels of oil or 19. 2 million tons for every year. They additionally contended that extra staff may be a sparing of 2 million barrels (41. 6. 2 million tons) contrasted and fuel oil and 7, 000, 000 heaps of carbon outflows if the utilization of geothermal warmth pumps is alluded to as amid the cooling mode. Frick connected a specialized examination in the life cycle for enhanced geothermal quality era (EGS) having low temperature stores that will evaluate the impact of the land conditions inside of nature framework (Frick, & Schröder, G., 2010). The outcomes demonstrate the way that life cycle of a double geothermal force plant is subordinate upon the materials and vitality inputs. Consequently, the effective access in your base store boring is overweight to have minimal ecological effect. There is confirmation that maybe less positive geothermal warmth and power can bring about a procedure of vitality alongside enhance solidness. In a comparable study and Saner

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examined the essentialness utilization and outflows of nursery gasses after which you can connected an existence cycle appraisal to take a gander at the ecological effects as a result of area source savings introduced contrasted all together with traditional warming strategies. Purkus furthermore Barth (2011) explored the German dialect geothermal segment, with expand exposure from the significance associated with political assist, in addition to the general conditions from the electricity market (Purkus and also Barth, 2011). They argued that despite the disadvantages associated with high investment costs almost no risk of heat from geothermal engineering, the advantage associated with flash could not allow him to become reliable base-load power. Kaya et is the reason. (2011) investigated the reinjection in geothermal fields with data via 91 plants (worldwide) found which geothermal and reinjection plan should reduce the possibility of contamination of groundwater. Results showed the response of different strategies for geothermal reservoirs reinjection determined through geothermal technology. In the most recent study, now the status from the (global) geothermal energy and found the high temperature technologies (Flash, plus dry steam) generation technologies incorporate most developed geothermal energy. These folks grow define four models, as well as 1FMP (single flash) 2FMP (double flash), 3FMP (triple flash) plus DSMP (dry steam), to manage various geothermal techniques. The results showed the DSMP model receives the best amount NPV (1 013 united states dollar 6, 000) and the difficulty TIR (22. 8%). In addition, it is estimated that the expenses associated with electricity to turn into a model (Nawaz, & Tiwari, 2006).

3.5 Hydropower

Hydropower makes use of energy which involves far more water to reduce elevations, especially to reach electricity. Pursuits include hydroelectric dams together with reservoirs river management, in addition to current jobs, as well as protecting a procession in the dimensions of the project. This assortment gives hydropower to meet up with urban desires large centralized in addition to decentralized non-urban desires. Hydro technologies are generally mature. Hydroelectric things to do ranging manipulate a company temporarily. By comparison, the controllable output given by hydroelectric facilities that may have reservoirs allows you to meet maximum power demands and turn into a help to balance the particular electrical systems that may have large portions relative age group RE variable. The function on hydroelectric reservoirs commonly reflects its many works by using, for illustration, water, irrigation in addition to Drought flood control and navigation, as well as thoroughly clean energy present (IEA (2010).

3.6 Ocean Energy

Water power leads to the potential, kinetic, chemical energy along with power involving sea water, along with this really is transformed to provide the electricity, heat, or perhaps drinking bottled water (Charlier, 2003). A great wide variety of technologies will be achieved, like dams respect tidal range, sub turbines for you to ocean currents as well as tides in addition heat exchangers for its conversion of thermal energy associated with water, and also a great menu of models to help harness ones vitality involving waves as well as salinity gradients. Water technology, from the exception of the genuine tidal dams is actually near your own phases of an pilot in addition to demonstration project, and also requires quite a few additional research in addition to development. A number of any technologies have changed profi energy production l'ensemble des within some other degrees of predictability (e.g., waves, tides and also the current selection), whilst others can give almost constant operation or maybe possibly controllable for such as ocean thermal as well as salinity gradient (ETSAP, 2010).

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3.7 Wind Energy

Wind power uses the specific kinetic energy in the stirring air. The main request of significance to help climate change mitigation ought to be to create electricity from large wind generators located on the property (land) or perhaps fresh seasonal or perhaps (offshore) water. Onshore wind technology was being made and deployed a huge scale. Offshore wind power technologies will probably continued technical progress. Wind power will be variable along both equally, to some quantity, unpredictable, but experience with comprehensive studies as of many provinces has demonstrated that the incorporation connected with wind energy normally involves not pose insurmountable barriers approach (Blanco, 2009).

3.8 Mutual Heat and Power

Consolidated warmth or maybe joined with force (CHP) is the system of warmth and power together. It is required to get an extensive pick up in effectiveness for every source independently. All force dispersion organizations novel power easily to manage or sauna. For right around 30-40% of the aggregate vitality heap of any nation pays for warming, cogeneration is a proficient utilization of fuel every time a piece of the imperativeness is removed, while the residual heat. Capture some or all residual energy as a byproduct involving heating. In Reykjavik end users can easily invest in both branches, together with the thermal energy into energy (Tester, 2005). Undoubtedly one of cogeneration can be particularly cogeneration unit Avedore, Denmark multifuel grow (NGOs and Natowitz, 2009). Shipley ET age. (2008) estimated the increase in cogeneration capacity America and 20% in 2030 simply cause a reduction 5. 3Quads (quadrillion British temperate units) and the use of only one of 848 MMT fractional laser laserlight. Depending on the results, America more than 1. 9 Quads of energy resource consumption and emissions of 248 million metric numerous CO2 by using Generation Company saves. Based around the WEO (2012) Registration, the average efficiency of the vegetation of energy will be a 41% worldwide, with practically 60% of the primary energy is converted to heat loss (IEA, 2012E). CHP could extensively alter the residual heat standard in a positive financial significance for professional technical or business waste and heating constructions. It is anticipated that the new elements of cogeneration could help the energy efficiency of its highest and not 85%. (Madiment and Tozer, 2002) investigated the effective use of the combined temperature and cooling power (CCHP) for supermarkets in England and directly compared with the energy content saving price label / capital while using conventional engineering. The results suggest that CCHP provides a significant level of primary energy despite the reduction of CO2 released compared to conservative schemes, but also intended to compete with the most useful technologies regarding long help. They argued that innovative technologies such as fuel cells can deliver updates over the efficiency of the CCHP force belonging to refrigeration. Hawkes and Leach looked profitable trading strategies associated with three alternative micro-cogeneration engineering such as Sterling engine, gas engine with the fuel system of solar panels dependent solid oxide (SOFC) for residential use in the United together. They assessed the financial and ecological attributes of the technologies mentioned above led by the heat, electricity brought with techniques minimum load operation (Leach, 2007). The effects showed the greatest reduction in CO2 emissions following approach cheap operating costs were good high SOFC cost computer, the same. An individual considered this export volume in relation to electricity aggregates reveal the micro-cogeneration unit as a virtual power plant (VPP) through participation in the energy of low-cost sector. They found that the export capacity connected with micro-cogeneration systems depends largely around the technical parameters, energy prices along with

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affiliate demand profile. Based on the real model applied, the marginal price was conjectured with just a small cogeneration system is above the placement price of high season. Kiviluoma and Meibom (2010) studied the impact associated with variable power generation through wind turbines and electricity stored in electric vehicles the opportunity to improve the elasticity of its influence grating. Using the results, cogeneration units could actually be viable to produce more elastic in terms of invention techniques and using heat energy options. Is investigated this contribution Christidiset high temperature storage to boost cogeneration units in liberalized areas of energy, the implementation of particular design which measures the ability of custody of probable heat and optimal tax. They concluded that the separation of electricity production and heat stipulate could make available a stretch of cost recovery time for storage devices within the proposed program of energy (Tsatsaronis, 2012).

CONCLUSION

The actual improvement regarding climate change will be simply just regarding the main challenges of the last century. Transition to help the single end user exactly who supports the higher power green global energy program incase be a great integral section of a reply involving humanity to live. Your chapter offers a great tick's basis for these types of chapters generally transition. The particular a complete in addition to reliable contribution to the debate at whether or not renewable energy can easily solve your climate problem with a financially attractive method. That is a model intended for further development of the renewable energy sector, as well as absolutely establishes the role within minimizing climate change everything. Ongoing queries about climate change have intended renewable energy a switch towards the overall collection of world energy consumption component. Technology regarding renewable energy might reduce CO2 emissions from replacing fossil fuels fractional power generation industry and the transport sector. Because of its negative in addition tO irreparable externalities at the production associated with conventional energy, which is to be vital regarding development, along with promote renewable energy technologies provide. power generation while in friendly energy sources on the environment must end up being updated to reduce the unit cost associated with energy and also make sure these are generally compatible using a competitive substitute regarding conventional energy sources. A couple main solutions might be implemented to lessen CO2 emissions and to overcome the particular dilemma involving climate alter: the substitution of fossil heating system by alternative energy sources regularly and strengthen energy performance, no matter what kind. In this specific chapter, we should instead be, wind flow, geothermal along with hydroelectric sun places, due to important contribution in the energy generated through the production involving renewable energy and gives sources. Renewable is increasing on the global level. Following extreme increase in oil prices as well as effects about the prices involving coal along with propane, the lots of investment it has recently been made in the recent past on alternative energy. These advancements in technologies have permitted countries to generate renewable power in larger plus more profitable levels.

Due to the negative along with irretrievable externalities linked to conventional energy taking out along with consumption, you will need to promote along with develop option vitality produce and usage. The IEA expects developing a positive growth involving alternative power means. They become substitutes related to fossil stimulates and decrease emissions. At any time, some option technologies might not be comparable that you can conventional stimulates, the area of manufacturing costs along with transmission, but may very well be comparable in the case we look at the many beneficial externalities, for

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example the environment along with social effects. Also, understand that should turn out to be financial regions of degree can play an essential role in reducing the cost of manufacturing program. Costs along with transmission technology and presentation will not differ considerably from typical and alternative energy options. We have at the moment presented detailed home elevators key technology of option development energy supply, such as hydro, the wind, solar, geothermal as well as length. The emphasis may be on latest production potential, in addition on the estimated, along with development expenses sink potential. Hydropower may be the largest source of renewable energy for energy generation throughout the world. Despite its important factor of energy generation, its growth is difficult on account of high expense costs as well as relocation in the initial set cost in the environment and the population. Hydro power is attractive as a result of combined way to obtain water with regard to agriculture, people, and recreation along with industrial employ. Moreover, you will keep water along with energy that can be used for inserts electrical power generation basic and high two. Having access to financial, politics and market risks, the focus with the allocation connected with resources along with ecological neighborhood concerns are viewed as obstacles to the development connected with hydropower potential. The capacity with the installed blowing wind power in addition has been growing, especially in countries just like China, the USA all, Germany and Denmark. Advantages connected with wind electrical power plants including contracts along with turnkey installing within a short period of period, lower when compared with nuclear along with hydropower investment decision, economies connected with production in lean muscle, lack connected with fuel prices and low operation along with maintenance prices. The issues connected with the aid of intermittent blowing wind energy contain wind electricity and added cost for that transmission of energy to buyers. Generation cost is determined by the location, viability about the minimum speed required for wind generators. China is promoting a volume of only solar panel technology, decreased era load as a result of availability connected with cheap labour and the general public subsidies. Geothermal energy has been used to be able to record more than bathroom, home heating and cooking food. The geothermal gradient, as well as the rock permeability app determines their particular financial viability. Unlike wind along with solar, geothermal solar panel is consistently available over the year, despite the technological know-how has some adverse environment effects. Improving electricity efficiency is surely an important method to reduce electricity use and as a consequence CO2 emissions, so that you can overcome neighborhood problem rescheduling. We outlined the state of the art methods connected with technical along with financial viability within the usage of green electricity, plus to be able to use along with combined replacement inside the first part of this evaluation. In the particular latter part of energy efficiency technologies are discussed. The efficiency connected with electricity networks is seen at distinct levels, including power creation, transmission, demonstration and consumption. To do this, different engineering are Energy Efficiency, as well as electric vehicles, combined temperature and electrical power, virtual electrical influence plants. Each one of the technologies discussed in depth and when compared their activities. This technological innovation was critical of green energy and efficiency provided complete and useful information which they can use in doing the determination from the different actors in the present rapid current market development. Each technological innovation has its advantages and disadvantages vary through location, availability, ease connected with technology suppliers, financial restrictions and environmental items to consider. Each metropolis, region or even nation has different first conditions in which conclude the mixture of action that may produce less costly costs, while minimizing the damage a result of the atmosphere. Therefore, there is absolutely no single solution for all energy must have and the situation but a remedy of ideal location between some achievable renewable options.

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Chapter 42
Using Successful Cases to Promote Environmental Sustainability:
A Social Marketing Approach

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ABSTRACT

The success of encouraging environmental sustainability by means of social marketing programs is partially determined by identifying certain actions that can favourably influence people's behaviours towards a more ecologically benign lifestyle. In this chapter, such actions (remodelling businesses and the economy by means of non-market capitals, social enterprises, and economic democracy; transforming food systems; renewable energy and energy reductions and simplifying lifestyles) are gleaned from a description of Cuba's transition period, the Findhorn Ecovillage and the BedZED development where greater levels of environmental sustainability have been attained. Associating the actions to social marketing theory reveals that they are well positioned to influence behaviours towards improved levels of environmental sustainability.

INTRODUCTION

As has been uncovered in Beachcroft-Shaw and Ellis's chapter on social marketing and it's application to sustainability, social marketing is theoretically speaking a useful mechanism that, by means of collaboration and creative thinking, has the capacity to influence individual and societal behaviours towards increased levels of environmental sustainability. It is defined as an instrument to influence behaviours that is steeped in traditional marketing's theory, tools and techniques (Kotler & Lee, 2011). Based on the underlying factor that behaviours are difficult to influence (Jackson, 2005; Kilbourne, McDonagh

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& Prothero, 1997), the applicability of social marketing to the essence of collective creativity and collaboration is summed up well by Domegan (2008: 137): [s]ocial marketing is "the co-creation of complex social and economic benefits and value 'with' customers among/throughout an entire community network of relationships". In other words, to begin with behaviours are tricky to influence and because of this require multiple and integrated ways of thinking. So, if benefits are created together with customers by developing relationships and networks of relationships with them (Eagle, Dahl, Hill, Bird, Spotswood & Tapp, 2013; Hastings & Saren, 2003; Marques & Domegan, 2011), then the complex and relationship- and behaviour-driven nature of social marketing deeply favours multiple and integrated ways to solve problems i.e. collective creativity and collaboration across several stakeholders. For example, when attempting to influence people's behaviours towards a healthier lifestyle, social marketers would likely need to involve multiple influential bodies. These could include medical practitioners such as dieticians and doctors, local businesses such as gyms, sports facilities and supermarkets, local or national government to for example pave more bicycle paths for people to cycle more frequently, groups of people who have successfully adopted a healthier lifestyle who can reflect on their changes to the broader population. Within this network of relationships, a creative and collaborative environment would be a factor of a social marketing program's success (Marques & Domegan, 2011).

In reality, some social marketing campaigns have not succeeded in the past due to the complexity of people's behaviours and the factors influencing it (Jackson, 2005; Kilbourne *et al.*, 1997). However, there have also been some cases where collaboration and creative thinking has led to successful social marketing interventions that improved environmental sustainability (e.g. Frame & Newton, 2007; French, Merritt & Reynolds, 2011; Kotler, Roberto & Lee, 2002; McKenzie-Mohr, 2000; The NSMC, 2010). Successes can be attributable to several factors, one of which is uncovering a specific set of actions[1] that can influence behaviours in the right direction (Kotler *et al.*, 2002). More specifically, actions that can act as a foundation for social marketing programs (those that dovetail well with social marketing theory) targeting people to behave in more environmentally sustainable ways are vital for social marketers. One area that social marketers can turn to for actions that could underpin social marketing interventions aimed at increasing environmental sustainability are successful cases where improvements in environmental sustainability exist in the real world.

To derive such actions that could be useful for social marketers, the chapter is divided into two sections. The main purpose of the first section is twofold: firstly, it describes three instances (Cuba, Findhorn Ecovillage & BedZED) where increases in environmental sustainability have been attained and; secondly it isolates actions common to at least two cases that can be used in social marketing programs to influence behaviours towards a more environmentally sustainable society. After drawing out actions from the three cases, the section thereafter takes these actions and collectively relates them to social marketing theory, which intrinsically represents collaboration and creativity due to its multiple-stakeholder nature.

Successful Cases of Environmental Sustainability

By examining cases in which shifts in behaviours led to a more environmentally sustainable lifestyle, social marketers can extract useful actions that could form the foundation of social marketing programs, which will likely require collaboration and creativity across multiple stakeholders such as consumers, businesses, international organisations, national governments etc. The forthcoming cases were chosen because they represent such shifts in behaviours that resulted in a greater potential of environmental sustainability. One national-level case (Cuba) discusses how an entire country shifted to more envi-

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ronmentally sustainable lifestyle culminating in being the only country in 2003 to be environmentally sustainable (i.e. infinitely extendable into the future) with a very high development index (Moran, Wackernagel, Kitzesa, Goldfinger & Boutaud, 2008). In the 21st century no other country has achieved this status. Reviewing one of the most successful ecovillages, the case of Findhorn Ecovillage shows how certain actions largely improved environmental sustainability at the local level that resulted in the lowest ecological footprint of the developed world (Dawson, 2009). The last case of The Beddington Zero (Fossil) Enery Development (BedZED), a planned development initiated by a non-profit organisation and developed in coordination with several organisations, exhibits how organisation-led initiatives can also lead to improvements in environmental sustainability.

Cuba's Transition Period

Perhaps the only real-life evidence of a national-scale shift to a more environmentally sustainable socio-economic system exists in Cuba's transition period. Up until Cuba's economic crisis in 1989, the country had "reached the developed world standards in life expectancy, education and social development indexes" (Boillat, Gerber & Fune-Monzote, 2012: 603). Until this point in time the country also relied heavily on imports and exports derived from monocultures: more specifically, it represented an unsustainable socio-economic system using resources in excess of local supply (Borowy, 2013; Dawn King, 2012). After the crisis, and a consequent 35% drop in Gross Domestic Product (GDP), caps on imports and exports enforced through a trade embargo compelled government to transform its policies and ordinary Cubans to change their lifestyles in order to curtail unnecessary consumption (Borowy, 2013; Dawn King, 2012). To survive, Cuba's socio-economic system had to become more environmentally (and socially) sustainable at the national level (Borowy, 2013; Dawn King, 2012). Several key factors that influenced this transformation are examined forthwith.

Since Cuba had obtained agro-chemicals and fuels through imports, the import caps on fossil fuels, fertilisers and pesticides was the catalyst for policy changes that included a shift to organic and semi-organic agricultural systems (Boillat *et al.*, 2012; Borowy, 2013; Cabello, Garcia, Sagastume, Priego, Hens and Vandecasteele, 2012). These changes equated to a smaller ecological footprint through locally produced food and the use of fewer fossil fuels and ecologically harmful substances (Boillat *et al.*, 2012; Borowy, 2013; Cabello *et al.*, 2012). Additionally, government promoted non-mechanical means of transport and farming, which also decreased the amount of fossil fuels burned (Borowy, 2013; Dawn King, 2012). For example, the government issued over 1 million bicycles, transformed vehicles to transport large amounts of people and locally manufactured buses. In the case of farming, traditional methods including animals and fewer artificial stimulants were promoted (Boillat *et al.*, 2012).

Structural changes in the agricultural sector of the economy paved the way for an increase in co-operative farming practices characterised by direct farmer-to-public trade at farmer's markets (Boillat *et al.*, 2012). Individual farmers with relatively small plots of arable land bound together to form co-operative farms, which were state owned but not state controlled i.e. farmers still maintained the means of production (Boillat *et al.*, 2012). Organic urban agriculture, which was initially a grassroots movement, was in the end also promoted and urban gardening became the norm with the aid of government laws and policies (Cabello *et al.*, 2012, Murphy and Morgan, 2013). Both structural changes (co-operative farms and urban agriculture) shortened the distance between production and consumption and therefore reduced the negative environmental effects of lengthy food distribution networks (Boillat *et al.*, 2012; Cabello *et al.*, 2012). Since these were organic and low-input operations, the ecological footprint of

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these agricultural methods farms was lower than conventional farming (Boillat *et al.*, 2012; Cabello *et al.*, 2012; Jawtusch, Oehen & Niggli, 2011) and increased the food production capacity of the nation (Murphy and Morgan, 2013).

A decline in oil imports from the Soviet Union also prompted government to introduce widespread measures to localise energy production and focus on energy efficiency and saving and producing renewable and decentralised energy (Cabello *et al.*, 2012; Murphy and Morgan, 2013). Large thermoelectric power plants gave way to smaller, locally distributed gas plants, which resulted in reducing greenhouse gas (GHG) emissions by 69% (Cabello *et al.*, 2012). Inefficient appliances such as old refrigerators, light bulbs, air conditioners, televisions, fans, cooking stoves and water pumps were substituted for more energy efficient appliances (Cabello *et al.*, 2012). Renewable energies such as wind energy, solar panels, small hydropower and biomass facilities were introduced (Cabello *et al.*, 2012; Morgan & Murphy, 2013). These government-led activities did not go unnoticed as in 2009 Cubans "use[d] 43 percent less energy than people in the rest of the world" (Murphy & Morgan, 2013).

On the whole, Cuba, albeit from an external resource cap, realised a shift to a more environmentally sustainable society while ensuring high levels of well-being (Boillat *et al.*, 2012: Borowy, 2013; Cabello *et al.*, 2012; Murphy and Morgan, 2013). From 1990 to 2009 the country witnessed a 25 per cent reduction in carbon dioxide (CO2) emissions (Murphy & Morgan, 2013), which in 2009 was 44 per cent less compared to the world average (Murphy & Morgan, 2013). In 2003 Cuba had "a consumption pattern that could be extended globally without entering overshoot" coupled with a very high development index – the only one of 93 countries surveyed (Moran *et al.*, 2008). As of 2006, Cuba used the equivalent resources of 1.4 planets (GFN, 2015a).

To summarise the Cuban case, it has been demonstrated that the shift to a more environmentally sustainable society was the result of changes in the broad areas of agriculture, energy production and consumption and government laws and policies. The combination of the changes influenced the everyday behaviours of people (primarily on an involuntary basis) and are thus relevant for social marketers seeking to realise environmental sustainability. This is discussed in the section that relates social marketing to certain actions.

Now that the Cuban case has been discussed, the next case looks at environmental sustainability at the local level with the similar goal to extricate actions to form the foundations of social marketing programs targeting environmental sustainability.

Findhorn Ecovillage

One of the most successful ecovillages is Findhorn Ecovillage in Scotland. The Findhorn Ecovillage began in 1985 (Findhorn Ecovillage, 2015) and "grows much of its own produce, has several renewable energy sources on site (windmills, biomass electric, passive solar), green homes, a community grocery store, a car share and community laundry facilities, and many connections to businesses in nearby towns" (Calegar, 2013, para: 2). Being a grassroots initiative, the ecovillage is governed by the resident-elected council (Findhorn Ecovillage, 2015). The ecovillage maintains an ecological footprint less than half of the United Kingdom average – "the lowest ever measured for any settlement in the industriali[s]ed world" (Dawson, 2009: 26). It is therefore seen as a highly successful means of attaining environmental sustainability. Several factors assist to achieve this status, the major ones being discussed below in no particular order.

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The first factor is energy. The community's energy needs are met with a mixture of on-site renewable energies that include wind, passive solar and biomass. Energy production, on average, exceeds the community's needs by 23% with the surplus being sold back to the national grid (Tinsley and George, 2006). On-site renewable energy production and consumption represents an ecological footprint 22% of the national average (Dawson, 2009), which equates to the resources of roughly 0.7 planets. Not only is energy produced on site, primarily attributed to the four community-owned wind turbines, there is also a high degree of energy efficiency with buildings being designed and constructed with efficiency in mind (Findhorn Ecovillage, 2015). For example buildings are highly insulated, fitted with solar panels (to heat water) and are designed to be naturally heated by the sun (Findhorn Ecovillage, 2015). Additionally, residents also tend not to use much energy i.e. only when it is necessary for their well-being (Dawson, 2009).

Secondly, three local Community-Supported Agriculture (CSA^2) farms cater to the community's local, organic, seasonal and low meat and high fruit and vegetable diets (Daswon, 2009; The Findhorn Ecovillage, 2015). A CSA farm allows the ecovillage's community to secure a portion of the farm's produce (USDA, 2016). The CSA scheme is the oldest in the United Kingdom (UK) and eliminates the long distances between production and consumption and packaging needs common to large UK retailers (The Findhorn Ecovillage, 2015). All farms combine organic techniques with the latest technology and produce a wide variety of vegetables, fruits and animal products (Findhorn Ecovillage, 2015). Harvests are sold at the ecovillage's grocery store to which all residents have access (The Findhorn Ecovillage, 2015). The ecological footprint of the ecovillage's environmentally friendly diet is 33% of the UK's median (Daswon, 2009), which equates to the resources of approximately 1 planet.

The fact that Findhorn's community consumes goods at half the rate of the average Briton (therefore equating to the resources of about 1.7 planets) is the third major reason contributing to its low ecological footprint (Dawson, 2009, Tinsley and George, 2006). Not only does the community consume less in general (Tinsley and George, 2006), they also share goods amongst themselves where possible such as televisions, washing machines and cars (Dawson, 2009). Moreover, the community does not consume many items that do not directly satisfy their needs since cultural activities and community entertainment provide them with most of their personal needs (Dawson, 2009).

When compared to the one-planet level required for environmental sustainability, Findhorn nevertheless consumed at a rate equivalent to 1.5 planets (Ewing, Goldfinger, Oursler, Reed, Moore, and Wackernagel, 2009; Tinsley and George, 2006). This is however a vast improvement from the UK's average of 3.3 planets (GFN, 2015b).

To sum up the Findhorn Ecovillage case, the presentation of literature about the community shows that it is possible to reduce the ecological footprint of those living in the developed world to one that is more sustainable. Through a combination of renewable energy, agricultural methods and consumption patterns, Findhorn Ecovillage's residents behave in a way that is more environmentally sustainable that is primarily voluntary i.e. behaviours are self-initiated. Therefore this is an important case for social marketers to take note of when targeting society to shift behaviours voluntarily to a more environmentally sustainable lifestyle.

BedZED Urban Development

Located in Hackbridge in London's Borough of Sutton, BedZED is a council-facilitated commercial development sporting a mixture of offices and living spaces (Chance, 2009; Schoon, 2016). The project

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is managed by several organisations including Bioregional (non-profit organisation), a housing association focusing on social housing (Peabody Trust) and architects from Bioregional and ZEDFactory (Schoon, 2016). All of these organisations focus their efforts on the benefit of the population through social or environmental means (Schoon, 2016). Construction was completed in 2002 and it is designed to encourage more sustainable lifestyles (Chance, 2009; Hodge & Haltrecht, 2009). Until 2005 it generated zero carbon emissions (Hyde, Watson, Cheshire & Thomson, 2007) – after which it's renewable energy provider closed down – and features communal gardens and car sharing options (Forrest and Wiek, 2015). The project's ecological footprint is the equivalent to 2.6 planets, which is less than the 3 planets the Borough of Sutton required in 2009 (Chance, 2009). Chance (2009) goes on to state that if residents were to further adjust their lifestyles the development could reach an average resource use of the equivalent to 1.7 planets. The factors that increase the potential for environmental sustainability at BedZED are elaborated on below.

The major aspect that offers increases in environmental sustainability is design and construction. The development is designed using passive architecture rather than technical fittings (Chance, 2009; Schoon, 2016). It is fitted with solar panels on the roof and energy efficient appliances are installed in every home (BDG, no date; Schoon, 2016). Highly insulating materials prevent large temperature fluctuations and the building's south side floor-to-ceiling windows promote natural (sun) heating (BDG, no date). Smart-energy meters are visible in the kitchens and display how much energy is being used, their total consumption and a high-use alert (Chance, 2009). Situated close to public transportation options and boasting many bicycle parking spaces, BedZED residents need not necessarily own a car (Schoon, 2016). The development's car club has an online booking system to use the hybrid car parked on site (Chance, 2009). From 2012 to 2015, these (and some other) measures reduced consumption by "53% in travel carbon footprint…36% in gas consumption…32% in CO_2 from home heating and electricity…27% in electricity consumption…[and] 23% in total carbon footprint" when compared to a conventional housing development in Sutton, London (Schoon, 2016).

Other smaller measures that were present at BedZED, for example gardening allotments and a promoted vegetable delivery scheme, have not been effectively used and therefore their impact has been minimal (Hodge & Haltrecht, 2009). It should be noted that from 2002 to 2005 BedZED was carbon neutral as a renewable distributor provided energy for all spaces (Chance, 2009). Thereafter, non-renewable sources were the predominant form of energy used to heat and power the development (Chance, 2009).

On the whole, BedZED is a reasonably successful development as it managed to maintain an ecological footprint lower than the borough's average. This achievement is primarily realised through the design and construction of the project and the direct impact it has on people's behaviours such as reduced energy use and the method of transportation used. It is therefore seen as an involuntary method of coercing people to behave in certain ways rather than promoting the voluntary adoption of behaviours.

In conclusion, from these three success stories in which improvements in environmental sustainability exist, several particular actions that could make up the foundations of social marketing programs targeted at influencing behaviours towards environmentally sustainable outcomes emerge. Two of the three cases represent one end of the social marketing spectrum with Cuba and BedZED attaining success predominantly through involuntary measures (facilitating conditions) whereas the Findhorn Ecovillage, on the other end of the spectrum, has been successful with voluntary (self-initiated) measures. Before continuing to the next section, it must be noted that these actions need not be explicitly stated in the

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cases. This is because they can be associated with broader/similar actions that encompass their content. In no particular order they are remodelling businesses and the economy, transforming food systems, renewable energy and simplifying lifestyles.

Actions as Foundations for Social Marketing Programs

The following sections connect the specific actions that emerged from the previous sections to broader actions that could act as the foundations for social marketing programs seeking to achieve sustainability. Thereafter social marketing theory is brought to the forefront to which these actions are associated.

Remodelling Businesses and the Economy: Non-Market Capitals, Social Enterprises, and Economic Democracy

Non-market capitals can be seen as items (land, housing or equipment) that are controlled not by the market but by local democracies (Bruyn 1992 cited in Johanisova, Crabtree & Fraňková, 2013). Social enterprises are organisations "involved at least to some extent in the market, with a clear social, cultural and/or environmental purpose, rooted in and serving primarily the local community and ideally having a local and/or democratic ownership structure (one-member-one-vote rather than one-euro-one-vote)" (Johanisova *et al.*, 2013: 11). Economic democracy is "a system of checks and balances on economic power and support for the right of citizens to actively participate in the economy regardless of social status, race, gender, etc." (Johanisova & Wolf, 2012: 562).

A linear relationship exists between these. Non-market capitals provide the platform for social enterprises to endure (Johanisova *et al.*, 2013), which consequently provide the means for economic democracy to exist (Boillat *et al.*, 2012; Johanisova & Wolf, 2012). More specifically, democratic control of capital could enable communities to decide for themselves what best to do with such capital and could pave the way for enterprises and a type of democracy that benefits the community and environment (Deriu, 2012; Johanisova & Wolf, 2012; Johanisova *et al.*, 2013). As Boillat *et al.* (2012: 606) put it: "a voluntary reduction in material and energy consumption is only possible in an economic democracy that makes people responsible, as a community, for the environmental consequences of their own production and consumption pattern". Therefore, it is proposed that giving local democracies control of their resources such as land will in turn enable enterprises that exist to benefit and serve the local community, which will consequently bring about an active participation in the economy.

In Cuba's case, the government allowed local communities and individual farmers to take control of land to be farmed (Boillat *et al.*, 2012) thereby exhibiting non-market capitals. Seeing as non-market capitals are a prerequisite for social enterprises to exist, non-market capitals may have been the cause for social enterprises, in the form of farmer's co-operatives, to become a contributing factor in the country's transition to an environmentally sustainable period (Boillat *et al.*, 2012). Consequently, this regulated economic power because as a result farmers were allowed to sell their produce on the free market and power and economic freedom were no longer controlled by the state. At Findhorn Ecovillage, non-market capitals are controlled by the Ecovillage's democratically and member-elected council (Findhorn Ecovillage, 2015). This enables the establishment and continuation of local businesses and CSA farms as social enterprises that consequently benefit the community (Findhorn Ecovillage, 2015).

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This ensures that there is a balance of economic power and that local the ecovillage's residents can participate in economic activities i.e. there exists an economic democracy. At BedZED it can be argued that the land that was used for the development was handed to a form of local democracy consisting of the several organisations that spearheaded the project. Because these organisations were interested in providing positive social, cultural and environmental benefits for a community (Schoon, 2016), the organisations involved in the development can be considered similar to that of a social enterprise. An economic democracy was then partially ensured as the organisations that orchestrated the development promoted a range of population groups to be involved including low-income groups (Schoon, 2016).

Therefore, because the three case studies maintained an improvement in environmental sustainability and exhibit non-market capitals, social enterprises and economic democracy, social marketers could use this as an action to influence behaviours towards a more environmentally sustainable society. Additionally, because it will involve numerous stakeholders such as businesses, national government, consumers etc., collective creativity and collaboration will be inherently required.

Transforming Food Systems

A food system represents the complete range of variables in an entire food chain from production to consumption, including inputs and outputs at each link (FAO, 2013; Infante Amate & Gonzalez de Molina, 2013). In order to increase environmental sustainability, the way food is produced and consumed needs to be revamped.

This action is made up of more specific actions:

Localising/Regionalising Food Systems

Within food systems, large amounts of resources are exhausted by the transportation of food via lengthy national and international distribution networks (Infante Amate and Gonzalez de Molina, 2013). Localising food systems could thus shorten the distance between production and consumption (Andreoni & Galmarini, 2013), which could minimise the environmental impact of transportation, imports and packaging, and subsidiary processes thereof (Andreoni & Galmarini, 2013; EEA, 2012; Infante Amate & Gonzalez de Molina, 2013; Scherr, Uphoff & Herren, 2012; UN, 1992). Furthermore, localising/regionalising food systems would mean more seasonal and small-scale production (Infante Amate & Gonzalez de Molina, 2013; Latouche, 2010), which also maintains positive environmental outcomes (Barling, Lang & Lele, 2012).

Organic Food

"We think that only a shift towards organic farming (and corresponding changes in consumption patterns) can contribute to substantial reductions of resource use in the food system" (Infante Amate & Gonzalez de Molina, 2013: 32). Not only does organic farming promote biodiversity, provide environmental benefits and use less toxic compounds and energy (Infante Amate & Gonzalez de Molina, 2013; Jawtusch *et al.*, 2011), it can also sequester huge amounts of carbon (from fossil fuels and GHG emissions) – about 4,118 kilograms per hectare per year according to Hepperly (2003 cited in Bates & Hemenway, 2010: 51). Per acre, carbon sequestering of this magnitude equates to the GHG emissions of driving 16,000 km (EPA, 2015).

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Low Meat and Dairy, High Vegetable and Fruit Diet

Due to its ecological burden, it has been said that the consumption patterns of developed nations should shift to a more vegetarian diet constituting less meat and dairy products and more vegetables and fruit – a diet that is better for the environment because it is less resource intense (Barling *et al*., 2012; EEA, 2012; Infante Amate & Gonzalez de Molina, 2013). To illustrate this, studies from Finland and Switzerland present data indicating that households eating less meat and more (organic) vegetables have an overall lower environmental impact (EEA, 2012). This comes as no surprise considering that within the food sector meat and meat products have the highest environmental impact (Tukker, Huppes, Guinée, Heijungs, de Koning, van Oers, Suh, Geerken, Van Holderbeke, Jansen & Nielson, 2006). Additionally, according to Infante Amate and Gonzalez de Molina (2013), cooking vegetables uses up to 70 times less energy than cooking meat products.

Highlighted in the previous section, empirical evidence from research done in Cuba and at the Findhorn Ecovillage demonstrate that organic and localised food systems had a direct impact on increases in environmental sustainability. In Cuba's case, localising food production reduced imports and exports, large-scale monocultures and the extensive distribution networks previously used to transport food around the country, all of which placed a strain on natural resources (Boillat *et al.*, 2012; Borowy, 2013, Murphy and Morgan, 2013). Furthermore, the organic and semi-organic farming techniques that were used throughout the country required fewer ecologically harmful inputs (Boillat *et al.*, 2012; Borowy, 2013; Cabello *et al.*, 2012) and in return offered better yields (Murphy and Morgan, 2013). Looking at Findhorn Ecovillage, the combination of a local and organic food system and low meat and dairy and high vegetable and fruit diet directly contributed to the very low ecological footprint the ecovillage maintained (33% of national average, roughly 1 planet), and in general the ecovillage's high level of environmental sustainability (Dawson, 2009). Such a food system virtually eliminates the distance between production and consumption and reduces the amount of resources required to produce food. At the BedZED project, although gardening beds were made available and a vegetable delivery box scheme was promoted, most residents did not make use of either. Instead most residents sourced their groceries from conventional shops in the area.

Thus, because localising/regionalising food systems has in two of three cases been connected to improvements in environmental sustainability, social marketers could use this action in interventions targeting behaviours that reduce environmental harm. Special attention needs to be paid to BedZED where changes to the food system did not work. Forrest and Wiek (2015) propose the core problem was that the actual residents did not introduce organise the gardening and organic box scheme, or any other changes to the food system for that matter, and therefore the motivation to take up this initiative was difficult to create and sustain once certain driving forces had been eliminated. Keeping all three cases in mind, social marketers will need to collaborate across several territories (production, retail, consumption etc.) and creatively deliver value with customers throughout a network of relationships in order for their interventions to succeed.

Renewable Energy and Energy Reduction

Renewable energy is defined as sources of energy that quickly regenerate and do not diminish over time (EPA, 2014). "Such fuel sources include the sun, wind, moving water, organic plant and waste material (eligible biomass), and the earth's heat (geothermal)" (EPA, 2014). Non-renewable energy sources

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possess many negative side effects (Andreoni & Galmarini, 2013; Jackson, 2009; Moriarty & Honnery, 2012; WWF, 2014). Therefore, shifting to renewable energy sources will likely improve the chance of realising an environmentally sustainable method of energy production (Demaria, Schneider, Sekulova & Martínez-Alier, 2013; Latouche, 2010; UN, 1992). Additionally, while phasing in renewable energies, further positive effects for the environment could be obtained if (developed) nations reduce their energy consumption to only what is needed to maintain a high standard of living (R&D, 2010). This is because such actions would produce a double dividend in which both increasing renewable energy and reducing energy consumption as a whole would benefit the environment.

In all three instances described above, increasing renewable energy and decreasing energy use in general was a positive contributor to increases in environmental sustainability. Through a mixture of methods such as wind energy, solar panels, small hydropower and biomass facilities (Cabello *et al.*, 2012; Morgan & Murphy, 2013), renewable energy production in Cuba resulted in decreased fossil fuel use and thus enabled a higher level of environmental sustainability (Murphy and Morgan, 2013). Albeit out of necessity, further environmental benefits came from reducing electricity consumption as a whole (Boillat *et al.*, 2012) and exchanging inefficient appliances (televisions, refrigerators, etc.) for more efficient ones (Cabello *et al.*, 2012). Moreover, larger, inefficient plants were replaced with smaller, more efficient plants culminating in a gas reduction of 69% (Cabello *et al.*, 2012). At Findhorn Ecovillage all of the energy used is 100% renewable (predominantly wind) and comes from their community-owned wind farm (Findhorn Ecovillage, 2015). Buildings are designed and constructed to minimise energy use and are therefore oriented to make use of passive solar heating, fixed with solar panels to heat water and use extremely insulating materials. Furthermore, the district heating system is designed to be highly efficient (Findhorn Ecovillage, 2015). These were seen as essential reasons why the ecovillage preserved a high level of environmental sustainability (Dawson, 2009). The community's frugal use of energy is also seen as a contributing factor to the low level of energy use (Dawson, 2009). At BedZED, zero carbon emissions were recorded during the three years when the development's energy needs were met with renewable energy (Chance, 2009). In terms of reducing energy consumption at BedZED, its design and construction played a large role in reducing tenants' energy use, resulting in a decrease of 36% and 27% for gas and electricity consumption respectively (Schoon, 2016). Interestingly for social marketers, the installation of built-in smart-energy meters that are visible in the kitchens and display how much energy is being used, their total consumption and a high-use alert seemingly caused a 22% decrease in energy use (Chance, 2009).

Since renewable energy and reducing energy consumption will require collaboration and creative thinking across various sectors (national governments, businesses etc.) and it can increase environmental sustainability, it is seen as a promising action for social marketers to make use of when the intention is to improve environmental sustainability by influencing people's behaviours. Although wind energy was the largest producer of renewable energy at Findhorn Ecovillage, primary research will eventually determine the most appropriate renewable energy form.

Simplifying Lifestyles

Simplifying lifestyles is seen as a means to decrease material consumption by shifting away from high-consumption lifestyles (Alexander, 2011; Andrews & Urbanska, 2010). Since lower consumption means less resources used (Demaria *et al.*, 2013; Hamilton and Mail, 2003), simplifying lifestyles could benefit

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the environment and help achieve environmental sustainability (Videira, Schneider, Sekulova & Kallis, 2014). The three cases are discussed in relation to this action.

In Cuba's case, the lifestyle shift to a simpler one the population had to endure was not voluntary but involuntary, as the shift was forcefully imposed. The state distributed bicycles and transformed the transportation sector to reduce fuel consumption and resource use (Borowy, 2013). High-consumption lifestyles were not even possible, for example, when electricity was available only 8 hours a day, incomes were low and consumer goods were not readily available (Murphy & Morgan, 2013). In general, Cubans have smaller living spaces and as much as 90% of the population don't own a car (Morgan & Murphy, 2013). Therefore, because the ecological footprint of the country was largely reduced, Cubans make it obvious that a simpler lifestyle, albeit involuntarily, has a positive impact on environmental sustainability (Borowy, 2013; Dawn King, 2012, Morgan & Murphy, 2013). Findhorn's population decreased resource use to half the amount of the average British person (Dawson, 2009, Tinsley and George, 2006) by simplifying their lifestyle (on a voluntary basis) through purchasing less consumer goods and living a simpler life disconnected to high-consumption lifestyle (Dawson, 2009). Instead of participating in high-consumption activities the community is involved in different social and cultural activities (Dawson, 2009). Additionally, because many of the residents work on site, car travel is just 6% of the national average and is said to be even less after the introduced car pool (Dawson, 2009). Thus, without being prompted by an external source, the community at Findhorn Ecovillage demonstrates the potentially positive environmental impact of simplifying lifestyles on a voluntary basis. One feature of the BedZED development – inherent in its design – is to encourage residents to reduce the carbon dioxide emissions from personal transport (Chance, 2009; School, 2016). Its car club, close proximity to public transportation and many bicycle parking spaces, for example, are ways that BedZED's design promotes a simplified lifestyle by not having to own a car (School, 2016). Such a method to simplify lifestyles plays a large role in the 53% decrease in resident's travel carbon footprint (Schoon, 2016). Compared to Sutton's residents of which 49% travel by car to work, only 17% of BedZED residents travel to work by car (Schoon, 2016).

To promote simplifying lifestyles as an action, social marketers will likely need to collaborate with different stakeholders (e.g. businesses, consumers, etc.) and creatively attend to delivering value to all stakeholders involved with the ultimate outcome resting on decreasing consumption as it can provide environmental benefits.

The previous section has insofar described three societies that have exhibited improvements in environmental sustainability and from these extracted specific actions that could provide the means to increase environmental sustainability via creativity and collaboration fostered through social marketing programs. The forthcoming section relates these actions to elements of social marketing theory, after which the chapter is concluded.

RECOMMENDATIONS

Utilising the important theories underlying social marketing (described in more depth in Chapter 16), the actions identified and outlined above should adhere to the basic social marketing theory. In short these are that in social marketing exchanges benefits should outweigh costs, benefits and costs should be exchanged within networks of relationships and the actions should operate within a critical marketing framework. The following sections elaborate on these three important tenets of social marketing theory.

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Naturally, all of these theoretical insights will need to be justified by primary research to uncover the types of benefits and costs useful in exchanges, the kinds of relationships and networks the social marketer should use the way programs should be promoted to safeguard society (Eagle *et al*., 2013; French *et al.*, 2011; Grier and Bryant, 2005; Weinreich, 2011).

Actions as Exchanges

Exchange theory refers to the basic human trait that people behave to acquire the largest benefit in exchange for the lowest cost (Grier and Bryant, 2005; Hastings and Domegan, 2014). Therefore, because social marketing programs seek to influence people's behaviours, successful programs are underwritten by exchanges that offer greater benefits than costs that fulfil real needs and wants (Hastings & Domegan, 2014; Hastings and Saren, 2003; Kotler and Lee, 2008; MacFadyen, Stead & Hastings, 2003). From a social marketing perspective, environmental sustainability is a major benefit because it has been linked to human well-being since humans depend on the planet for their prosperity (Andreoni & Galmarini, 2013; Bonaiuti, 2011; Common & Stagl, 2005; Constanza, Alperovitz, Daly, Farley, Franco, Jackson, Kubiszewski, Schor & Victor, 2013). Any costs that compete against the basic necessity humans require to exist would be seen as inferior to the benefit that would ensue. Therefore, because the actions discussed above maintain the ability to improve the chances of attaining environmental sustainability, each action maintains, as a basic premise, greater benefits than costs. Social marketers would nevertheless need to translate the benefit of environmental sustainability into target audience related benefits. For example, instead of exchanging the environmental benefits with a target audience, it might be more relevant to the target audience if exchanges focused on saving them money or their children or grandchildren's well-being.

Actions within Networks of Relationships

"Social marketing is the co-creation of complex social and economic benefits and value 'with' customers among/throughout an entire community network of relationships" (Domegan, 2008: 137). Therefore, because relationships and networks are where social marketing exchanges take place, exchanges and relationships and networks are highly interrelated. To this end, social marketers design programs to facilitate exchanges that occur within certain relationships and networks that benefit individuals, groups and/or society (Marques & Domegan, 2011). Successful social marketing interventions should thus understand how exchanges could be incorporated into different relationships and networks (Marques & Domegan, 2011). Concerning relationships and networks in which exchanges of benefits and costs occur, all actions have the capacity to be promoted via upstream and downstream measures. This is because all actions can influence behaviours via voluntary and involuntary methods respectively. For example, social marketers could target policy developers, law-makers etc. at the macro level (upstream) and the voluntary behaviours of target audiences at the micro level (downstream) when promoting simplified lifestyles for instance. When influencing behaviours at different levels using the identified actions, social marketers should develop benefits and costs for each target audience.

Actions and a Critical Marketing Framework

State of the World reports (2010, 2012, 2013) indicate that the earth's population is living at unsustainable levels and suggest that large-scale shifts are necessary. The lack of sustainability can be seen as

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the broad reason for actions to right the environmental degradation the world currently faces. Thus, actions that can in theory maintain large-scale environmental benefits, and therefore benefits to society, are crucial for building a critical marketing framework within which social marketing programs can successfully operate. All of the abovementioned actions could offer widespread environmental benefits and can therefore be used as the basic foundation for a critical marketing framework. Social marketers would need to explore each action in more depth to obtain a more precise critical marketing perspective i.e. to ensure that the specific action contributes positively to the population's prosperity (Andreasen, 1994; Hastings & Saren, 2003; Marques & Domegan, 2011) keeping in mind that society's well-being includes the well-being of the planet as society is dependent on the planet's well-being (Andreoni & Galmarini, 2013; Bonaiuti, 2011; Common and Stagl, 2005; Constanza *et al.*, 2013). For example, the relationship between social marketers and a network of government departments that are in charge of laws and policies to influence behaviours towards producing renewable energy should ensure that these laws and policies do not, for example, marginalise certain sections of society or provide exorbitant profits for a few companies.

To summarise this section, successful social marketing programs firstly require a set of actions that could influence behaviours towards the intended outcome (Kotler *et al.*, 2002). Secondly, successful interventions are underwritten by exchanges of benefits and costs that occur within networks of relationships that should safeguard society's well-being. Using the cases that were previously discussed, the section showed how actions could be used to establish exchanges of benefits and costs that are facilitated by networks of relationships and operate within a boundary that safeguards society. And since social marketing programs can operate at many levels i.e. between national governments, NGOs, individuals, businesses etc. and require innovative ways to address issued, it is a well-poised mechanism that intrinsically requires collective creativity and collaboration between stakeholders.

FUTURE RESEARCH DIRECTIONS

Ecovillages contain within it all the actions identified in this chapter such as renewable energy and energy reduction, transforming food systems, remodelling business and economy and simplifying lifestyles and, when combined, can have a powerful effect on environmental sustainability as witnessed in the case above. Thus, because ecovillages are a prominent candidate for realising a more environmentally sustainable future, social marketers should place emphasis on researching ecovillages and how to use them to influence behaviours to achieve more promising levels of environmental sustainability.

CONCLUSION

Behaviours are complex and therefore social marketing as a tool for influencing behaviours towards environmental sustainability demands collective creativity and collaboration across multiple sectors. Based on the idea that social marketing programs require a set of actions that can influence behaviours towards a more environmentally sustainable society, Cuba's transition period, Findhorn Ecovillage and the BedZED development, where increases in environmental sustainability have taken place, were analysed with the aim of unearthing such actions. Specific actions that could increase the chances of realising environmental sustainability indeed surfaced: relocalising businesses and the economy, transforming

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food systems, renewable energy and energy reduction and simplifying lifestyles. To check whether these actions could be useful for social marketers to influence behaviours towards environmental sustainability, they were related to important theories underlying social marketing. Since the actions could be applied to social marketing theory, all actions emerged as highly favourable possibilities for social marketers targeting adherence to the resources of one planet earth. In particular, ecovillages transpired as being a highly opportune method to engender environmental sustainability as it contained within it all of the actions identified in the chapter.

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KEY TERMS AND DEFINITIONS

Economic Democracy: An economic system in which citizens are supported to actively participate regardless of their characteristics.

Food System: A food system represents the complete range of variables in an entire food chain from production to consumption, including inputs and outputs at each link (FAO, 2013; Infante Amate & Gonzalez de Molina, 2013).

Non-Market Capitals: Non-market capitals can be seen as items (land, housing or equipment) that are controlled not by the market but by local democracies (Bruyn 1992 cited in Johanisova, Crabtree & Fraňková, 2013).

Renewable Energy: Renewable energy is defined as sources of energy that quickly regenerate and do not diminish over time (EPA, 2014).

Simplifying Lifestyles: Simplifying lifestyles is seen as a means to decrease material consumption by shifting away from high-consumption lifestyles (Alexander, 2011; Andrews & Urbanska, 2010).

Social Enterprises: Social enterprises are organisations that maintain a democratic structure and aim to benefit the local community and its relationship to the environment (Johanisova *et al.*, 2013: 11).

Social Marketing: Using traditional marketing techniques and practices, social marketing is basically a means to influence a target audience's behaviours in order to benefit them and/or society (Andreasen, 1994: 111; Kotler & Lee, 2011: 26).

Social Marketing Actions: These are actions that refer to proposed activities to achieve environmental sustainability.

ENDNOTES

1 Actions refer to proposed activities to achieve environmental sustainability.

2 CSA is defined as a relationship between a farmer and a community of shareholders who invest in the farm in return produce for a share of the farm's produce (USDA, 2016).

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Chapter 43
Sustainable Development and the Sustainability of Socioeconomic Systems:
Some Reflections on Crises and Corporate Systemogenesis

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ABSTRACT

In the current global scenario, it is essential to ensure the stability and sustainable development of the socioeconomic system. The literature shows that there is so far no clear understanding of the nature of the sustainability and development of socioeconomic system. Systems thinking may be the right approach for the transition to sustainable development, supplying a way to understand the universality of the laws of development. This theoretical paper shows how the management of firms can be based on the universal laws of evolution and development

INTRODUCTION

This theoretical paper shows how the management of firms can be based on the universal laws of evolution and development. It aims to discuss and create a framework for better understanding the theory of development, sustainability, and the sustainable development of socioeconomic system, with a particular reference to business systems.

To this end, the paper will:

1. Study the main theories of development.
2. Discuss the essence of evolution and the development of the socioeconomic system.

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3. Describe the main structural transformations over the last 100 years, considering the evolutionary change of socioeconomic systems on the global scale (highly complex nonlinear systems), structural transformations, and their implications in the global context.
4. Construct a holistic model of evolutionary dynamics of socioeconomic systems, allowing a better understanding of the systems as a whole, in interaction and interdependence with their elements over time. This model will be based on the coherent interaction and coevolution of the system's elements and subsystems.
5. Show how holism (systems thinking) in management and in corporate government can be an effective approach to sustainable development.

This study refers to several theoretical approaches from which we alter the terminology and some relevant methodological aspects: *General Theory of System* (Bertalanffy, 1968); *Synergetics* (Buckminster Fuller, 1975), Schumpeter's entrepreneurship theory (1949); the theory of social dynamics (Sorokin, 1937); the theory of social action (Parsons, 1949); Durkheim's theories of sociology and labor (1983 and 1900); Spengler's theory; the theories of economic cycles by Kuznets, Mensch and Elliott (1971–1973); theories of development of nonlinear system by Haken (2000) and Prigogine (1989–1994); and chaos theory as popularized by Gleick (1987). Furthermore, this study is based on a postulate concerning the transition of socioeconomic systems from unorganized to self-organizing systems.

We can find a similar direction and approach to management in the works of Beck & Cowan (2006) and of Warnecke (1993).

The paper provides an analytical overview of the financial and economic crises from 1900 to 2013. The data was analyzed using the system-synergetic approach of Kindleberger and Aliber (2005).

The contribution and implications of this research are to expand the existing theories of development in order to create the scientific basis for future studies. The study demonstrates the laws and tendencies of development and attempts to define the stage of development, shedding light on a new way to manage systems more effectively, helping to foresee future scenarios, and to prevent the negative circumstances the result from crises. Moreover, the proposed approach may facilitate focusing on the future and on innovation, instead of on vain attempts to preserve an imaginary stability. To this end, we consider the financial, economic, social, and technical elements of the enterprise as a connected holistic system.

ON THE UNDERSTANDING OF THE UNIVERSAL LAWS OF EVOLUTION

First, we consider the dialectical theories of the classical German philosophers (Hegel, 1807; Marx, 1894; Fichte, 1792–1810; Kant, 1770–1780s). Friedrich Engels systematized the three laws of dialectics: the transformation of quantity into quality; the negation of the negation (thesis, antithesis, synthesis); and the unity of opposites. According to the first law, within any period of development of society, changes gradually accumulate until further change cannot be accepted, triggering the leap of revolutionary transformation. According to the second law, within any stage of development, mutually antagonistic forces interact as a system. The third law states that any stage of development is the result of the negation and synthesis of the previous stage; development thus has the character of a spiral, and could be characterized as a three-step process.

Auguste Comte's "social physics" divides society into two components: social statics and social dynamics. The social system requires a more "intimate harmony of the component elements and more

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complete subordination to the external world" (Comte, 1856, p. 353). According to Comte, "Humanity cannot herself act otherwise than by her separable members; but the efficiency of these members depends upon their working in co-operation" (Comte, 1856, pp. 354–355). In other words, social progress (that is, development) depends on the cooperation of the separate system elements (individuals). Social progress and development are the quintessence of positive knowledge. Comte states that "systematic study of the Past is necessary in order to determine the future" (Comte, 1856 p. 357).

Herbert Spenser's theory postulates the unity of the decomposition and creation of the system: "evolution is the transition from an incoherent undefined state to determined organized state; complex systems are formed from a combination of simple ones" (Spenser, 1852, p. 237). Evolution is the transition from an unconnected homogeneous number of elements to interconnected heterogeneous elements (the system). So, the process of social evolution is the process of social differentiation and the emergence of social strata: "at that time as parts of mass are integrated, they are differentiated" (Spencer, 1897, p.277).

The social evolution of Émile Durkheim depicts the evolution of societies from the mechanical solidarity of preindustrial society to the organic solidarity of industrial society. In simpler societies, people are associated by personal charisma and traditions, but in complex industrial societies, they are united due to interdependence, diversification, more specialized tasks, and the division of labor. The organic society is considered democratic, because it is based on freedom of choice and diversification of elements. On the contrary, the mechanical society tends towards totalitarianism (Durkheim, 1893, 1900).

Pitirim Sorokin's "Social dynamic" defines the dynamics of social systems as "any kind of motion, modification, conversion, alteration or 'evolution', in short, any change this logical entity in time, whether it changes its place in space, or are we talking about the modification of its quantitative or qualitative aspects" (Sorokin, 1937–41, p. 98). The most important element of the development is the "unit", which undergoes changes while concurrently maintaining its identity. The system may "change itself without losing its identity" (Sorokin, 1937–41, p. 99). Sorokin believed that the main causes of social change are immanent factors: "systems' changes are the result of their own resources and properties". External factors may have an influence on the system, up to the destruction of the system, but they do not have any impact on the preset path of development. The system has a built-in mechanism of development: "socio-cultural systems choose the way of existence by itself" (Sorokin, 1937–41, p. 807).

The *structural functionalism* of Talcott Parsons (along with his Structure of Social Action) and Robert Merton states that the social system is made up of the actions of individuals (Parsons, Shills, 1976). In the process of interaction, individuals are faced with a variety of choices about how they might act, given that their choices are limited by a set of physical and social constraints.

Oswald Spengler (1918) considered evolution as a changing of cultural–historical types. He distinguished the concepts of *culture* and *civilization*: culture is focused inward and on development, while civilization is focused outward and on mere expansion. Yet civilization is the destiny of every culture. Whereas culture is "things-becoming", civilization is the "thing-become"—that is, the transition from culture to civilization is the transition from dynamics (development) to stagnation (Spengler, 1918, 1922).

Another important theory of evolution in terms of economic dynamics was proposed by Joseph Schumpeter. The basis of Schumpeter's theory is "creative destruction", which indicated that development ("economic mutation") destroys the old and creates the new. "This process of 'creative destruction' is the very essence of capitalism" (Schumpeter, 1942). Thus, we must destroy our present to gain the future, and ordinary things to gain innovation; we must create chaos from order, in order to develop.

Other relevant theories of development in this period are the theory of long waves of Kondratiev (1935), the wave theory of Elliott (1938), and, more recently, the theory of spiral dynamics of Beck and

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Cowan (2006). These theories are based on the cyclical dynamic—on repeatability, the return to the past—where cycles can be determined and predicted.

These traditional paradigms are carried out by the need to avoid the nonequilibrium state and instability. The positivist sciences are based on laws that are limited in their possibility of explaining and describing reality: for example, it is impossible to find an appropriate geometrical function to describe mountains, rivers, trees.

In the 1970s, scientists began to examine the causes and patterns behind the chaotic behavior of various systems, finding that the apparent disorder has a logic and organization—that this "organization" differs from the traditional positivist understanding of order.

Questions of nonlinear dynamics and the development of nonlinear systems were investigated by various new theories, such as synergetics, chaos theory, and dissipative systems (Haken, 1996; Prigogine & Nicolis, 1989; Prigogine & Stengers, 1994; Gleick, 1987).

A relevant contribution was given by synergetics, which holds that:

- evolution is a process of formation of order from chaos;
- development occurs through self-organization;
- instability—the nonequilibrium state of the system—is the basic, initial state of every system; the state of equilibrium and orderliness is the stage of evolution;
- the development of the system is carried out through the sequence of nonequilibrium and equilibrium states (chaos and order);
- chaos is the creative force, not the destructive force;
- a complex system has a number of possible alternative ways of development;
- the creation of a whole by simple addition of initial structures is impossible.

Thus, according to the synergetics theory, the development process requires an increased complexity in space (e.g., geographic expansion, regional expansion, acquisition of material assets) and an expanding of areas of influence and interests. At the same time, development requires the differentiation of elements and parts of system and transitions from a state of disorder and homogeneity to a state of order and diversity. Development could follow two paths: the smooth evolutionary path or the revolutionary leap. Therefore, development can be considered as movement: through time (the transition from the past to the future); through space (the creation of new structures); and in terms of qualitative changes (innovations).

Considering all these theories of development, we can conceptually classify them into two groups:

1. *The cyclic-wave theories*, where cyclical development is reversible:
    - The theory of economic cycles (Kondratiev waves; the Grand Supercycle theory of Ralph Elliott (Elliott, 1938, 1946; The "Kuznets swing" of Simon Kuznets, 1930; and others);
    - The theory of cycles of innovation (e.g., of Joseph Schumpeter (Schumpeter, 1942), and spiral dynamics (Beck, Cowan, 2006)).
2. *The theories of the dialectical evolution of the system and self-organization*,

where dialectical development is irreversible. These theories are based on the well-defined dialectics of development, competition, and competitive evolution: Hegelian dialectic; Karl Popper (the competitive development of scientific knowledge); Comte's "social physics"; Ilya Prigogine (competition of the tra-

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jectories of the development ("attractors") and the elements themselves (the process of self-organization); the systems approach and others.

DEVELOPMENT AND TRANSFORMATION OF THE GLOBAL SOCIOECONOMIC SYSTEM

In this section, we analyze the transformation and structural changes in business systems from the 1900s to the present.

By *structural transformation*, we refer to the various actions of businesses that lead to changes in size, ownership, assets, activities, etc. It includes investments, mergers and acquisitions, and diversification of business. Table 1 summarizes the transformations of business regimes.

Table 1. Summary of the organizational and structural transformation of business regimes

Period	Main characteristic of the business context	Priority of industry sectors	Priority of energy resource	Main factors which caused the crisis
End of the 18th century to the 1830s	Separate enterprises in developed countries were scattered	Textile industry	Water (the water mill and engines)	1790s, the beginning of the 19th century: terror in France, the Napoleonic wars, the boom in canal company shares, prices of raw materials in the US and Europe; the rapid development of construction and railways
Second half of the 18th century			Coal for melting cast iron (coke)	The rapid development in the construction of canals and railways, which became objects of speculation
19th century	The spread of the steam engine	Railways, the production of steam locomotives, shipping, the production of steam ships. steam engineering and technology	Coal begun to be used in transport	Heavy industry became an object of speculation
End of the 19th to the beginning of the 20th century	Horizontal mergers, the emergence of monopolies, cartels, trusts, and syndicates. The production of material-intensive products and services	Heavy industry, steel, chemistry, transport (railway, water), concentration of financial markets,	Coal, oil	1856–1857 crisis: end of the Crimean campaign, speculation in heavy industries, agricultural economic society, railway construction
1848		The gradual shift to the electrical power industry and electrical technology	The first production of oil from a drilling hole	
1920–1950	Vertical integration, businesses united within a single production process	Heavy industry, steel, chemistry, transport, electric power industry and electrical technology	Coal, oil. The role of coal was reduced gradually	1929–1933: overproduction and financial crisis. Crises of the 1950s and 1960s: the currency and financial crises.
1960–1970	The creation of conglomerates	Oil and oil products, oil refining, communications, transport	Oil	Energy crisis of 1974–1975.

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Table 1. Continued

Period	Main characteristic of the business context	Priority of industry sectors	Priority of energy resource	Main factors which caused the crisis
1980s	Sectoral concentration of the businesses, the reshuffling of assets			Crisis of 1979–1982: oil prices increase, speculation on real estate and agricultural lands in the USA
1990s	Horizontal megamergers, creation of transnational corporations and global companies		Oil, the search for alternative energy sources. The share of coal in the energy sector was about 20%	Crisis of 1997–1998: a wave of bankruptcies of the world's largest companies, speculation on the capital market
2000s – present	Megamergers, the involvement of the developing markets in M&A. Production of innovation.	Microelectronics, computer science, biotechnology, genetic engineering	Oil, the intensification of the search for new environmentally friendly energy (natural, bio-fuels, etc.) and shale gas.	2008–2009: the global economic recession, financial crisis
The future	Business as innovation networks is based on information and knowledge. Clusters – the most effective form of business because of synergy.	Biotechnology, robotics nanotechnology, the global informational network	Ecofriendly, renewable sources of energy	?

Source: official, business and historical information; analysis and calculations by the author

Table 1 shows that the development of businesses and of entrepreneurship involved:

1. Only two human-invented production technologies: the steam engine and the electrical engine.
2. Only three types of energy source: water, coal, and oil (natural gas).
3. Innovations that changed the world include steam engines, electric motors, aircraft, computers, and microelectronics.

We now consider the statistical data on investment and on mergers and acquisitions for the largest deals of the second half of the twentieth century. We being with FDI and M&A (see Figures 1 and 2).

We can see that, as FDI as M&A are steadily increasing, the result of these transactions is a high concentration of assets and the creation of monopolies and oligopolies. We can also see that the activity of M&A increases just before and immediately after the years of a crisis.

Hence, economic and financial crises show drastic fluctuations of parameters and violations of the equilibrium state. If we compare the development of businesses with the evolution of biological systems, we find that, in periods of crisis, most systems increase their size (this recalls the giants of biological evolution). In business, these processes are equivalent to mergers and acquisitions—business consolidation as an attempt to survive the crisis situation. However, we find that the opposite process is also true: the size of systems can decrease in order to take the low competitive niche (e.g., the market niche) and to get rid of noncore assets. Statistics regarding the worldwide transactions of mergers and acquisitions and foreign direct investment shows stable growth, especially over the past decades.

We can thus point out that evolutionary processes are irreversible. Indeed, we believe that the increasing consolidation of businesses, and the interdependence and reliance on industrial production,

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Figure 1. FDI worldwide, 1970–2012
Source: OECD, UNCTAD (different years)

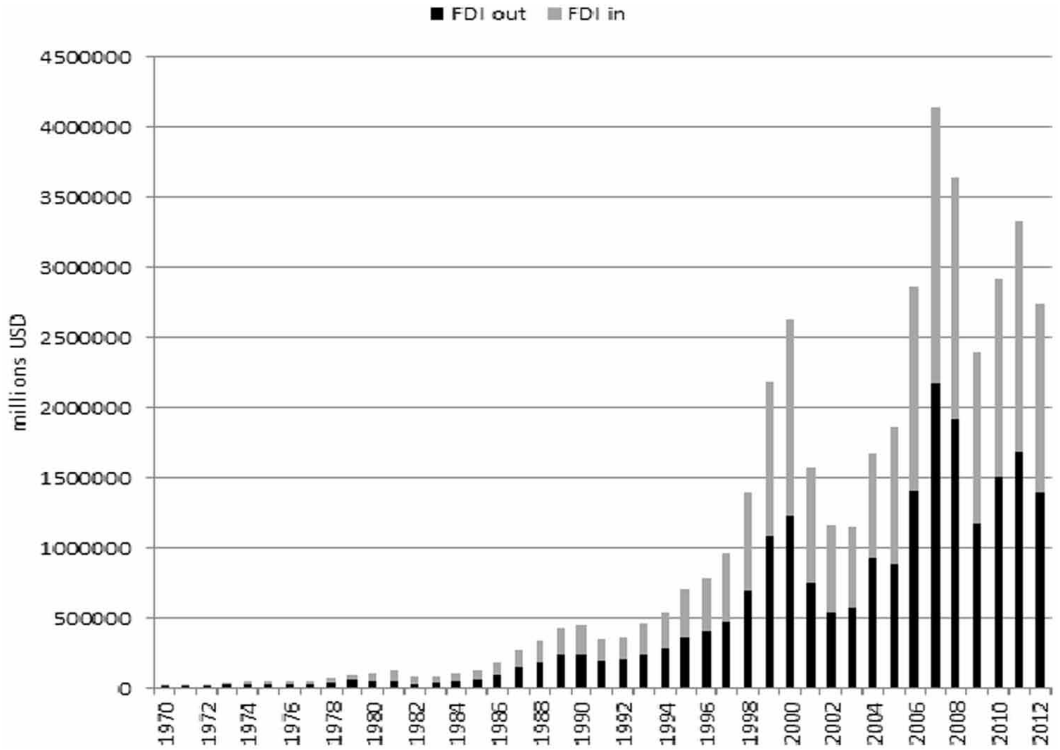
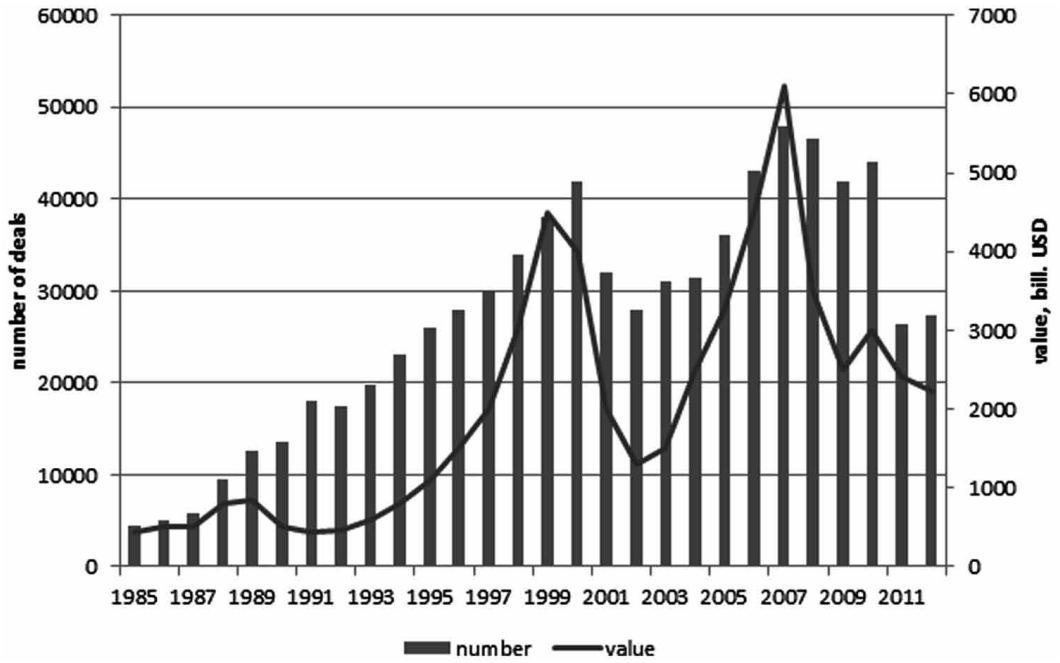


Figure 2. M&A worldwide, 1985–2012
Source: OECD, UNCTAD (different years)



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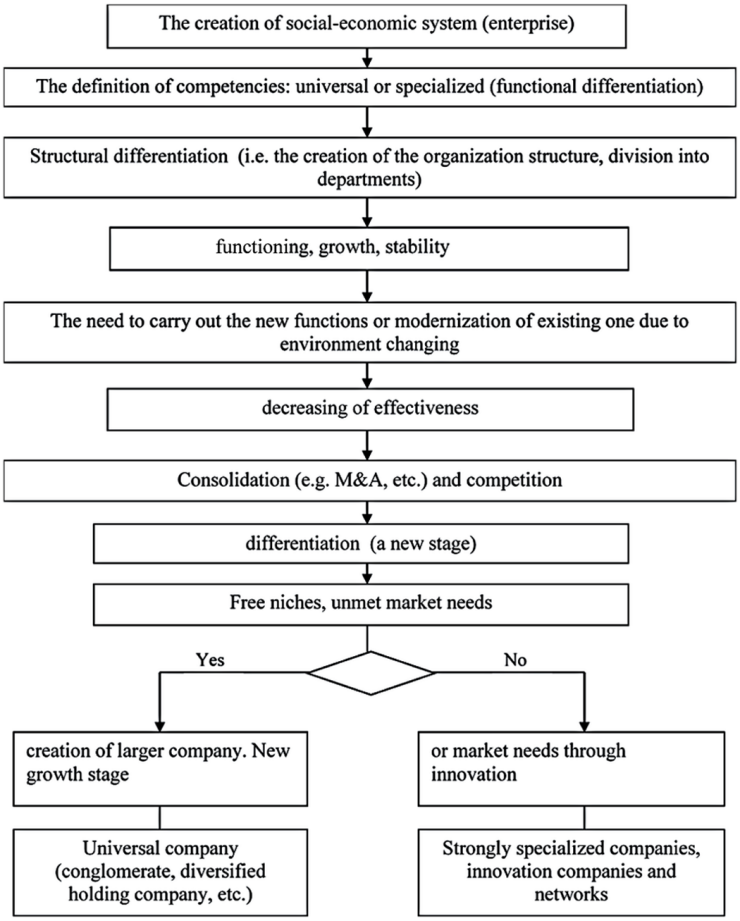
will inevitably lead to a deep crisis. This is because the process will persist so long as businesses do not change to a new business model of functioning and development. We judge that, to avoid this future crisis, firms should consider a new business model based on innovative energy saving or the adoption of alternative energy technologies; the international division of labor; and the cooperation and synergy of knowledge, not based only on production synergies.

A HOLISTIC MODEL OF CORPORATE SYSTEMOGENESIS

In this section we define our idea of a universal algorithm for the development of socioeconomic systems: the *algorithm of corporate systemogenesis*, presented in Figure 3. By *systemogenesis* we mean the sustainable development of socioeconomic systems as nonlinear systems in accordance with evolutionary laws.

We consider this development as an irreversible wave, where the complex system grows by itself and absorbs its own properties, which already existed on a lower level.

Figure 3. The proposed algorithm for corporate systemogenesis
Source: Author's work



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The whole process of evolution is illustrated in Figure 4.

The development of socioeconomic systems is accompanied by the growth of interactions between its elements (people or departments). Interaction takes shape in various forms of cooperation, such as different unions, strategic alliances and partnerships, joint ventures, mergers and acquisitions, and clusters.

Evolutionary processes are accompanied by synergistic effects (Baker & Sinkula, 1999). This is because it is not possible to create the integrity of the system by simple additions to the original elements, which would inevitably lead to interference of their localization and functions.

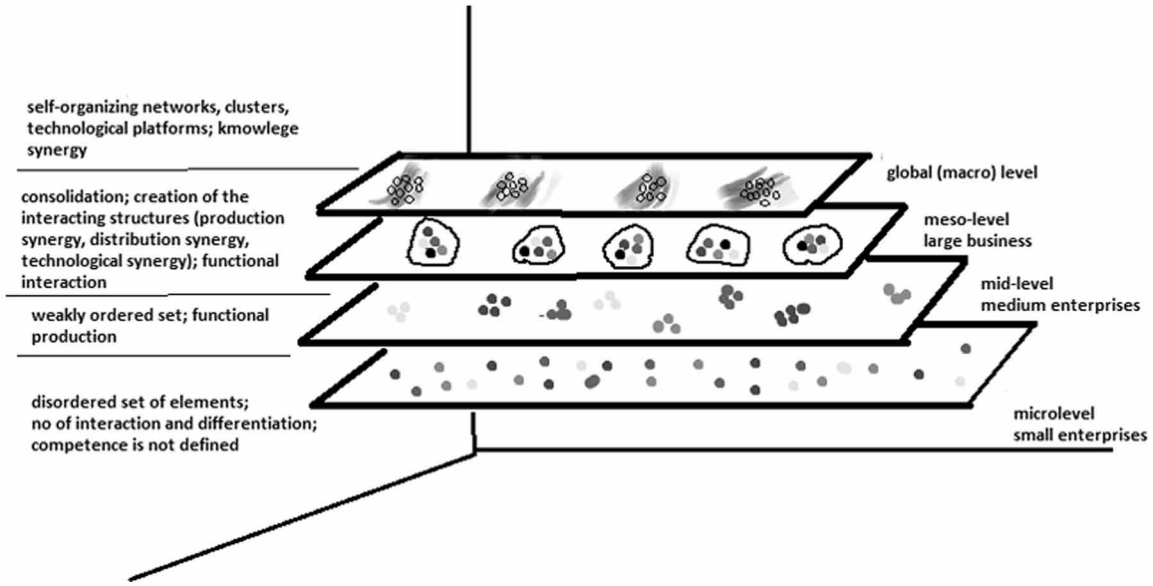
All of the above mentioned stages of development can coexist and coevolve. In other words, we can simultaneously observe microenterprises at the unorganized spontaneous level of development, mesoenterprises with higher level of organization, and self-organizing business systems. We consider all the levels of development not to be mutually exclusive, but to be complementary; the development is a transition from one stage—micro, meso, or macro—to the next. Even if we can provide effectiveness at each stage of development, we consider the real essence of development to be the sequential change of states of the system.

But what happens within socioeconomic systems? How does the process of development occur?

The complex behavior of the socioeconomic system is formed by the interaction of a number of simple behaviors between its main elements—such as its people and workers. These elements of social groups operate independently right up to point of instability and crisis. At that moment, they begin to interact and cooperate (a similar behavior is observed in physical systems by Prigogine & Nicolis 1989, pp. 15–18).

The transition from one state to another and the leap forward to the new level of development are the results of the competition between two processes of interaction and random action. These processes have different directions of impact: interaction between the elements makes the system ordered, while the chaotic random actions of the elements lead to disorder.

Figure 4. The scheme of the model of corporate systemogenesis
Source: Author's work



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Figure 5 shows an example of the elements of a system in a certain spatial localization.

The elements are uniformly distributed in space, with no interaction among them. The state of the system is characterized by complete disorder, with each element behaving randomly and chaotically. Examples of such a system include small enterprises that do not interact. Figure 6 shows a different situation.

In Figure 6, we can see the process of clustering. The elements of the system are spatially closer to other similar elements (e.g., the typical industry clusters). We can observe interactions between the elements within each cluster, while there is no interaction among the clusters.

Changes in the external environment cause two different reactions: if the elements interact, this can lead to the creation of clusters, or to a contrary reaction where they move away from each other, leading to a broader geographical distribution, as in the search for new market niches, or the expansion throughout regions.

Furthermore, the formation of clusters requires a change in the external environment, with favorable conditions that force businesses to unite and cooperate.

The development of socioeconomic systems is initiated by the actual or expected global regime shifts (systemic transformations)—namely, by functional and structural changes in the global system. These regime shifts include abrupt and irreversible transformations (e.g., changes in state regulation of an industry, fundamental technological changes, financial, economic, and sectorial crises, the development of new high-tech products, and the development of new sectors of the economy or business diversification). Thus, the impetus for development may counterbalance a crisis, forming a protection from its consequences, and even the expectation of increased profits in some industries.

The path towards development depends on the location of businesses, both in industry and in the global business system. If similar companies prevail in the industry, they will try to preserve their integrity, independence, and efficiency growth. A problem can be represented by managers trying to maintain the independence of the managed company, in order to protect their salaries. They are then not interested in cooperating or coordinating with other enterprises or competitors to create of unions, alliances, joint ventures, mergers, acquisitions, or other forms of interaction, as this may cost them their working place and salaries, or reduce their level of management control. For this reason, managers will be interested in increasing the value and size of their firms in order to protect it, following the logic that the larger

Figure 5. Spatial localization of a system's elements
Source: Author's work

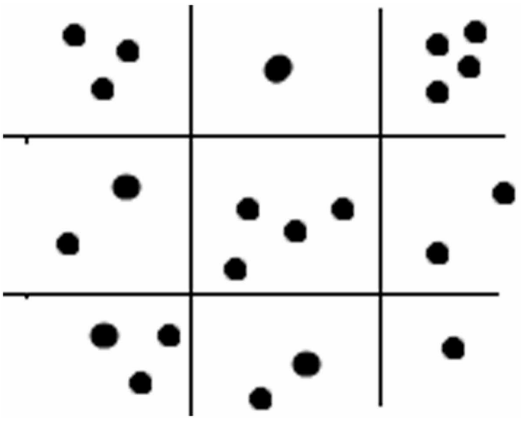
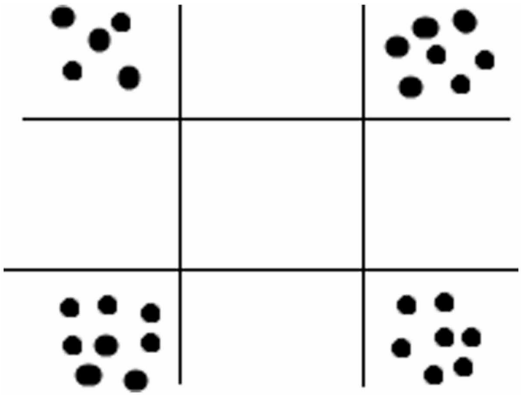


Figure 6. The well-ordered totality of the system's elements
Source: Author's work



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and more expensive the firm is, the less attractive it will look for acquisitions or other forms of external attack. However, the effect of such managerial behavior could be the opposite: buying larger companies leads to a more profitable synergy effect, and this makes the enterprise more attractive for acquisition.

SUSTAINABILITY AND THE SUSTAINABLE DEVELOPMENT OF THE BUSINESS SYSTEM: CONCEPT AND NATURE

In this section, we attempt to explain the concepts of sustainable development and sustainability, according to general systems theory and synergetic theory.

According to general systems theory, sustainability is the ability of the system to keep its movement on the given trajectory, or the ability of the systems to support the given mode of functioning, in spite of external and internal disturbances (Gigch, 1978). The main types of sustainability are equilibrium, homeostasis, and the stationary mode.

Equilibrium is the condition of a system in which all competing forces are balanced. The balance of a business system is not always the optimum from the social justice point of view. The equilibrium should be considered in two aspects: the static (point of equilibrium, such as equilibrium prices, or the equilibrium of supply and demand) and the dynamic, or growth, which means the balanced process of development.

Homeostasis is the stable state of a system in its interaction with the external environment.

The stationary mode is the mode of functioning of the system in which the basic system parameters remain unchanged. The opposite form of functioning of the system is the period of transformation. We can see the transition from one state of the system to a qualitatively new state. In the transition period, transformational effects are observed—structural shifts and transition recession.

The generalized scheme of the concept of sustainability is showed in Figure 7.

What, so, is sustainable development and sustainability of a system? The question is whether we will be able to achieve sustainability of the system, increasing its effectiveness and sustainability.

The UN's concept of sustainable development involves a balancing of economic growth, environmental protection, and inexhaustible resources. In the Report of the International Commission for the United Nations Environment and Development Program, sustainable development is considered as development that meets the needs of the present generation, but without threatening the rights of future generations to such opportunities. Sustainable development means building an effective One-Planet Economy, a new understanding of the "good life" (a higher quality of life), and environment protection, and all this requires cultural changes. Much of the progress in sustainable development is being achieved by the business sector and local governments (Adams W.M., Jeanrenaud S.J., 2008).

Generally, all concepts of sustainable development are based on three hazy terms: economic growth, environmental protection, and inexhaustible resources.

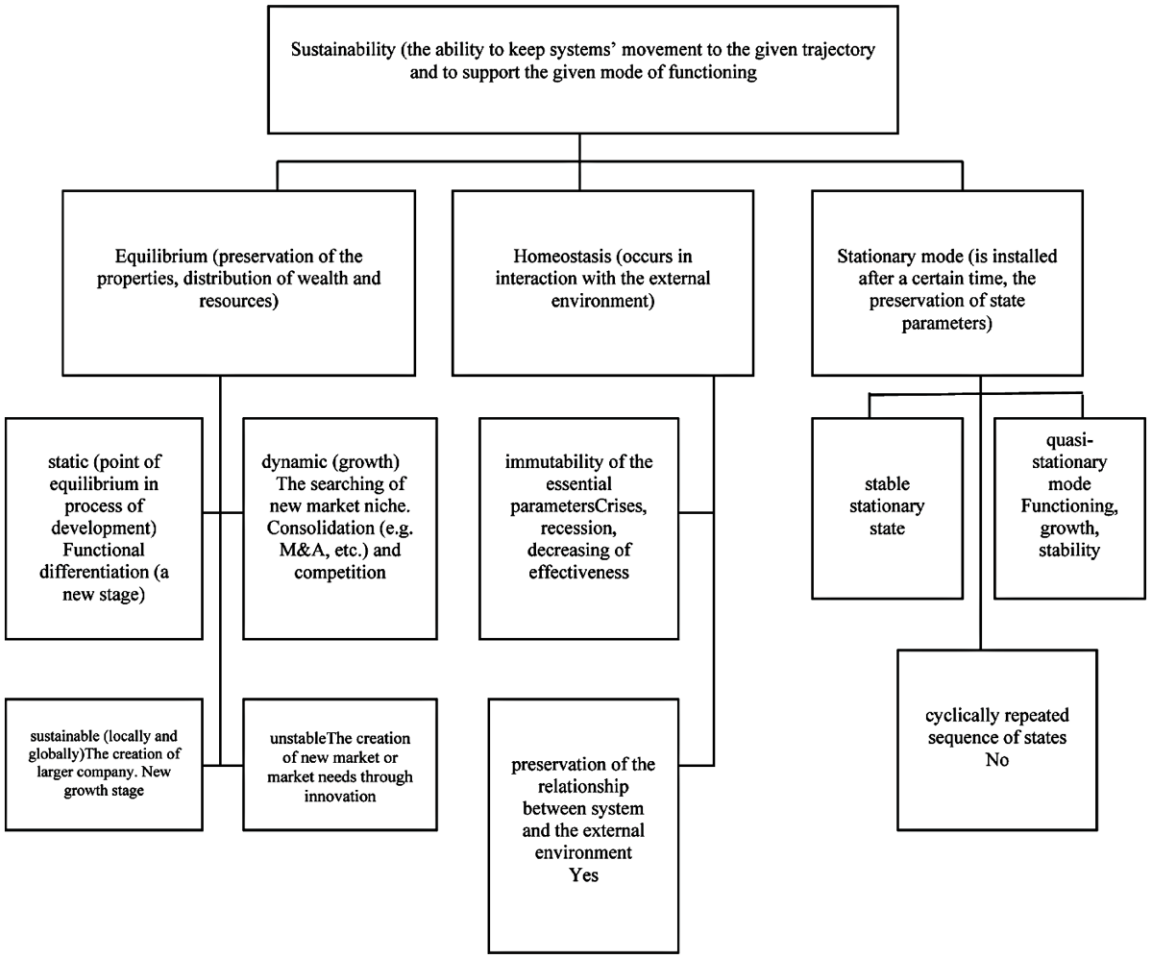
But what do we have to do? How should we manage our businesses for sustainable development?

Sustainable development and sustainability are different concepts: sustainability refers to the state of the system, whereas sustainable development is a dynamic concept referring to movement, change, evolution, and innovative development. Thus, it is not easy to achieve sustainability and development at the same time.

However, in this case, it raises the question of whether the nature of sustainable development and sustainability is compatible with the UN declaration. Sustainability is achievable on the local level

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Figure 7. The generalized scheme of the concept of sustainability of business systems
Source: Author's work



(financial, economic, social stability). But on the global level, the social systems could only achieve a state of dynamic equilibrium, which is not sustainability in a long term.

However, we must also understand that sustainable development and economic growth are different. Growth is just one of the stages of development; hence, we need to restrain growth and seek development. Because the main goal of economic growth is increase of effectiveness and income, it does not consider the natural environment. In contrast, the main goal of development is to create innovations to cope with the natural system's integrity and to save energy. Economic growth is therefore just one stage of the development towards the more advanced concept of sustainable development. For sustainable development, we have to learn how to manage all the stages of development, including the stages of growth, stability (dynamic equilibrium), transition, recession, and crisis. If we try to safeguard a single stage of development, we will not be able to move on to the next stage.

In this framework, crises are inevitable, and they give an opportunity to update and to produce further development. This is connected with the nature of development: development is carried out by transformation, but transformation means unsustainability. Sustainability is possible within some stages, but

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not at every stage of development. Sustainable development is the understanding the whole process of development. We must achieve development, but not every aspect (economic, ecological, social) of it separately. Only by acting in this way can the consequences of the crises be creative, rather than destructive; crises will then provide growth, environmental protection, and human well-being.

A NEW APPROACH TO ECONOMIC EVOLUTION AND CRISIS: CRISIS AND INNOVATION

In this section, we analyze the relationship between development and economic crises. As we stated above, development means movement and change, while sustainability means the state of the system. We thus need unsustainability for development. What is unsustainability in social and economic systems? We consider unsustainability to be *crisis*. Table 2 shows the most important economic crises and the impact they had on the development of business.

As Table 2 points out, during the second half of the nineteenth century, and during the whole twentieth century, the global socioeconomic system experienced several major crises (1847–1848; 1857; in the 1950s and 1960s; 1974–1975; 1979–1980; 1997–1998; 2008–2009). Each of these had its own causes and its own consequences. However, each crisis led to a significant regime shift on the global level: the transition to new technologies (the steam engine was replaced by the electrical engine), or to new energy (water, coal, oil), etc. So, we can assume that the crises are not only an objective reality, but also constitute the need for a search for new opportunities. Crisis (or chaos) is a constructive beginning that provides new opportunities and conditions for innovation and sustainable development. Therefore, we can assume that crises are not only an objective reality, but precisely the need to search for new opportunities.

How exactly does a crisis offer new opportunities for business?

During a crisis, we have to find the most effective methods for working, to optimize the business processes, to reduce the production costs, and to search for new market niches and opportunities. Production needs to become more flexible and effective. In the period of stability, managers try to save the results that have been achieved and to ensure the growth of profitability, while in the period of crises, they are forced to invest in development and innovation. Stability often becomes stagnation, and stability must be disrupted if progress is to be achieved.

If we look at the most important innovations of the second half of the nineteenth century and of the whole 20th century, it becomes evident that the most important inventions and advances in science and technology were the driving forces for economic and social development only if they were accepted and propagated in a global environment (cf. the "institutionalization" of J. Schumpeter). But how do innovations become an engine of economic progress?

As an example, the steam engine was invented in 1780s. The global industrialization and boom in the railroad, metallurgical, and construction sectors led to the crisis of 1847–1848 in the industrialized countries of Europe and the United States. In 1834, the electric engine was invented, and this innovation started to work up the market. In 1903, the first airplane laid the foundations of a new era. The increased demand for oil as a fuel source caused price increases. And in 1970s and 1980s we faced an oil crisis.

The invention of atomic weapons during the Second World War, and the distribution of nuclear energy, including the environmental disaster in Japan in 2011, set us the task of reducing our energy dependence and energy use and searching for alternatives to oil. Next, from the invention of the computer to col-

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Table 2. The most important economic crises and their impact on the development of business

Period	Changes that led to the development of business systems
1900s	Increasing concentration of businesses, mergers and acquisitions, monopolization and consolidation of companies
1929–1933 (The Great Depression)	A gradual abandonment of the concept of the free market as a self-regulating system. Transition to a partial state intervention in the market relations (USA, UK, France, Sweden, Denmark, Norway), as well as full centralization and the direct intervention of the state as far as nationalization; the creation of close relationships between state and large private corporations (Germany, Italy, Spain)
Crisis after II World War	A third scientific and technical revolution, with radical changes in technology and production in developed countries. Development and intensification of the international division of labor, international expansion. The growth of international interdependence and the concentration of businesses. The consumption of energy resources increased; the transition from coal to oil could be observed in developed countries. State support of the modernization of production capacity and investment in the technical development of businesses. Rapid development and growth of production and economy in Japan, Germany, and Italy. Obtaining of independence of former colonies and the "decolonization" of economy.
Economic crisis 1974–1975	A deep economic crisis in all sectors of the US economy, which spread to all developed countries. The growth of energy dependence and, as a result, the intensification of the search for alternative energy sources. The share of own production and processing in developed countries increased, intensifying scientific research into energy and resource-saving approaches. Development and introduction of innovative technologies and equipment. Liberalization of the market, the opening of the customs borders in the EU countries in the post-crisis period; the intensification of consolidation of businesses. Business activity was restored at the expense of stimulation of demand. Communication technologies and computers were developed. Globalization and the active expansion of businesses from developed to developing countries.
1979–1982	The creation of favorable conditions for the development of production (the reduction of taxes, the increased availability of credit resources). The focus was shifted from the demand to the supply. The activation and rapid development of information technologies, telecommunications, and communication technologies. Globalization spreads around the world.
1990s	A new industrialization and restructuring of the economy, accompanied by the growth of the financial sector in most developed countries (e.g., the economic policy of Margaret Thatcher in the UK). The growing consolidation of the western European countries leads to a restructuring of industry and a strengthening of the need for a single currency in the European area.
2005	The rapid development of China and the transfer of production to developing markets (Russia, China, India, etc.) lead to the deindustrialization of the USA and western Europe.
Crisis 2008–2009	Transfer to innovative processes and technologies. The search for alternatives to oil and traditional energy resources. Real changes in the economy and business do not occur, but there is a global understanding of the need for a change in management and development.
2010–2013	A process of reindustrialization, restructuring, and diversification of the economy from the nonproduction and financial sectors to real production industry with high added value and knowledge (aircraft industry, pharmaceuticals, machine building, power engineering). There is a process of deglobalization, a crisis of the euro and the focus on the domestic market. We can observe increasing problems of European identity, unity, and economic interdependence between developed and developing countries.

Source: Author's work

lapse of the so-called dot-com bubble, only about 70 years passed. But social networks have seized the initiative, so that the boom of the computer company has not yet fully come.

Hence, we can assert that many years pass from an idea to its commercialization and wide distribution; the boom takes place cyclically—on average, every 70 years.

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The last crisis of 2008–2009 did not lead to any structural or ideological changes in management, development or functioning of businesses. It did not become the cause of innovation and did not force us to search for radically new solutions. Therefore, we believe that a new wave of deterioration is inevitable in the near future, until the coming of a quality change and the development of business and the world economy as a whole. The crisis is an opportunity of which no one has yet taken advantage.

In addition, an invention itself does not guarantee development—for example, the steam engine itself did not have such a large-scale impact on the markets as did the construction of railways and steam vehicles. Innovations, therefore, accumulate: each innovation absorbs previous ones and is based on them.

We believe that the basis of development of socioeconomic systems is the sequential change of states from chaos to order, from instability to sustainability. Evolution is like a snowball: it starts at an original point (an idea or invention), and as the evolution progresses, it covers more and more systems: companies, industries, markets and countries.

CONCLUSION

The analysis of some theories of development allowed us to describe our view of the universal laws of development, such the increase in complexity, the differentiation, the transition from instability to sustainability, the accumulation of changes and the transition from quality to quantity, and abrupt character of development.

The twentieth century socioeconomic systems experienced several abrupt regime shifts. Each period of transformation was connected with global changes, innovations, and economic crises. We could see that inventions gradually spread, becoming object of speculation that cause other crisis. The threat of crisis forces businesses to interact and to unite with each other, in the belief that a larger company is more sustainable. Our analysis of the statistical data on FDI and M&A showed the dynamics of the processes of concentration of assets and consolidation of businesses.

On these, assumptions we constructed a holistic model of the development of socioeconomic systems, based on holism and the systems approach. The algorithm of development is based on the gradual transition from an unorganized set of small and medium enterprises to self-organized clusters and unions.

Through the analysis of the theories of sustainability and sustainable development, we pointed out how sustainability and sustainable development are different concepts.

The synergetic methodology helped us to draw the conclusion that the crisis has a constructive essence and that development is possible through refusal from past, transition from stagnation to innovation.

Systems and holistic management thinking are necessary if the concept of competition is to be changed. The purpose of competition should not be to a win a war with competitors, but to co-create a unique product.

We should change our attitude to crises, considering them as creative instead of destructive. Life without crises is no utopia, as crises are necessary to focus on constant innovation as new opportunities for the firms.

The right kind of development on the global level is possible only by creating a win–win scenario.

In further research, we will make use of Herbert Spenser's theory, Sorokin's "social dynamic", the theory of Schumpeter, the three laws of the dialectic, and synergetic methodology.

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Chapter 44
Renewable Energy Technologies, Sustainable Development, and Environment

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ABSTRACT

The move towards a low-carbon world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilisation level of atmospheric carbon dioxide is to be achieved. This chapter presents a comprehensive review of energy sources, and the development of sustainable technologies to explore these energy sources. It also includes potential renewable energy technologies, efficient energy systems, energy savings techniques and other mitigation measures necessary to reduce climate changes. The chapter concludes with the technical status of the ground source heat pumps (GSHP) technologies. The purpose of this study, however, is to examine the means of reduction of energy consumption in buildings, identify GSHPs as an environmental friendly technology able to provide efficient utilisation of energy in the buildings sector.

INTRODUCTION

Over millions of years ago, plants have covered the earth converting the energy of sunlight into living plants and animals, some of which was buried in the depths of the earth to produce deposits of coal, oil and natural gas (Lin & Chang, 2013; Glaas & Juhola, 2013; Gerald, 2012). The past few decades, however, have experienced many valuable uses for these complex chemical substances and manufacturing from them plastics, textiles, fertiliser and the various end products of the petrochemical industry. Indeed, each decade sees increasing uses for these products. Coal, oil and gas, which will certainly be of great value to future generations, as they are to ours, are however non-renewable natural resources. The rapid depletion of these non-renewable fossil resources need not continue. This is particularly true now as it is, or soon will be, technically and economically feasible to supply all of man's needs from the most abundant energy source of all, the sun. The sunlight is not only inexhaustible, but, moreover, it is

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the only energy source, which is completely non-polluting (Bendewald & Zhai, 2013). This requires the harnessing and use of natural resources that produce no air pollution or greenhouse gases and provides comfortable coexistence of human, livestock, and plants.

Industry's use of fossil fuels has been largely blamed for warming the climate. When coal, gas and oil are burnt, they release harmful gases, which trap heat in the atmosphere and cause global warming. However, there had been an ongoing debate on this subject, as scientists have struggled to distinguish between changes, which are human induced, and those, which could be put down to natural climate variability. Notably, human activities that emit carbon dioxide (CO_2), the most significant contributor to potential climate change, occur primarily from fossil fuel production. Consequently, efforts to control CO_2 emissions could have serious, negative consequences for economic growth, employment, investment, trade and the standard of living of individuals everywhere.

ENERGY SOURCES AND USE

Scientifically, it is difficult to predict the relationship between global temperature and greenhouse gas (GHG) concentrations. The climate system contains many processes that will change if warming occurs. Critical processes include heat transfer by winds and tides, the hydrological cycle involving evaporation, precipitation, runoff and groundwater and the formation of clouds, snow, and ice, all of which display enormous natural variability. The equipment and infrastructure for energy supply and use are designed with long lifetimes, and the premature turnover of capital stock involves significant costs. Economic benefits occur if capital stock is replaced with more efficient equipment in step with its normal replacement cycle. Likewise, if opportunities to reduce future emissions are taken in a timely manner, they should be less costly. Such a flexible approach would allow society to take account of evolving scientific and technological knowledge, while gaining experience in designing policies to address climate change (Morrow, 2012).

The World Summit on Sustainable Development in Johannesburg in 2002 (Morrow, 2012) committed itself to ''encourage and promote the development of renewable energy sources to accelerate the shift towards sustainable consumption and production''. Accordingly, it aimed at breaking the link between resource use and productivity. This can be achieved by the following:

- Trying to ensure economic growth does not cause environmental pollution.
- Improving resource efficiency.
- Examining the whole life-cycle of a product.
- Enabling consumers to receive more information on products and services.
- Examining how taxes, voluntary agreements, subsidies, regulation and information campaigns, can best stimulate innovation and investment to provide cleaner technology.

The energy conservation scenarios include rational use of energy policies in all economy sectors and the use of combined heat and power systems, which are able to add to energy savings from the autonomous power plants. Electricity from renewable energy sources is by definition the environmental green product. Hence, a renewable energy certificate system, as recommended by the World Summit,

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is an essential basis for all policy systems, independent of the renewable energy support scheme. It is, therefore, important that all parties involved support the renewable energy certificate system in place if it is to work as planned. Moreover, existing renewable energy technologies (RETs) could play a significant mitigating role, but the economic and political climate will have to change first. It is now universally accepted that climate change is real. It is happening now, and GHGs produced by human activities are significantly contributing to it. The predicted global temperature increase of between 1.5 and 4.5°C could lead to potentially catastrophic environmental impacts (Cantrell & Wepfer, 1984). These include sea level rise, increased frequency of extreme weather events, floods, droughts, disease migration from various places and possible stalling of the Gulf Stream. This has led scientists to argue that climate change issues are not ones that politicians can afford to ignore, and policy makers tend to agree (ASHRAE, 2005). However, reaching international agreements on climate change policies is no trivial task as the difficulty in ratifying the Kyoto Protocol and reaching agreement at Copenhagen have proved.

Therefore, the use of renewable energy sources and the rational use of energy, in general, are the fundamental inputs for any responsible energy policy. However, the energy sector is encountering difficulties because increased production and consumption levels entail higher levels of pollution and eventually climate change, with possibly disastrous consequences. At the same time, it is important to secure energy at an acceptable cost in order to avoid negative impacts on economic growth. To date, renewable energy contributes only as much as 20% of the global energy supplies worldwide (ASHRAE, 2005). Over two thirds of this comes from biomass use, mostly in developing countries, and some of this is unsustainable. However, the potential for energy from sustainable technologies is huge. On the technological side, renewables have an obvious role to play. In general, there is no problem in terms of the technical potential of renewables to deliver energy. Moreover, there are very good opportunities for the RETs to play an important role in reducing emissions of the GHGs into the atmosphere, certainly far more than have been exploited so far. However, there are still some technical issues to address in order to cope with the intermittency of some renewables, particularly wind and solar. Nevertheless, the biggest problem with relying on renewables to deliver the necessary cuts in the GHG emissions is more to do with politics and policy issues than with technical ones (Kavanaugh & Rafferty, 1997). For example, the single most important step governments could take to promote and increase the use of renewables is to improve access for renewables to the energy market. This access to the market needs to be under favourable conditions and, possibly, under favourable economic rates as well. One move that could help, or at least justify, better market access would be to acknowledge that there are environmental costs associated with other energy supply options and that these costs are not currently internalised within the market price of electricity or fuels. This could make a significant difference, particularly if appropriate subsidies were applied to renewable energy in recognition of the environmental benefits it offers. Similarly, cutting energy consumption through end-use efficiency is absolutely essential. This suggests that issues of end-use consumption of energy will have to come into the discussion in the foreseeable future (UN, 2003).

However, the RETs have the benefit of being environmentally benign when developed in a sensitive and appropriate way with the full involvement of local communities. In addition, they are diverse, secure, locally based and abundant. In spite of the enormous potential and the multiple benefits, the contribution from renewable energy still lags behind the ambitious claims for it due to the initially high development costs, concerns about local impacts, lack of research funding and poor institutional and economic arrangements (UNFCCC, 2009). Hence, an approach is needed to integrate renewable energies in a way that meets the rising demand in a cost-effective way.

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ROLE OF ENERGY EFFICIENCY SYSTEM

The prospects for development in power engineering are, at present, closely related to ecological problems. Power engineering has harmful effects on the environment, as it discharges toxic gases into atmosphere and also oil-contaminated and saline waters into rivers, as well as polluting the soil with ash and slag and having adverse effects on living things on account of electromagnetic fields and so on. Thus there is an urgent need for new approaches to provide an ecologically safe strategy. Substantial economic and ecological effects for thermal power projects (TPPs) can be achieved by improvement, upgrading the efficiency of the existing equipment, reduction of electricity loss, saving of fuel, and optimisation of its operating conditions and service life leading to improved access for rural and urban low-income areas in developing countries through energy efficiency and renewable energies.

Sustainable energy is a prerequisite for development. Energy-based living standards in developing countries, however, are clearly below standards in developed countries. Low levels of access to affordable and environmentally sound energy in both rural and urban low-income areas are therefore a predominant issue in developing countries. In recent years many programmes for development aid or technical assistance have been focusing on improving access to sustainable energy, many of them with impressive results. Apart from success stories, however, experience also shows that positive appraisals of many projects evaporate after completion and vanishing of the implementation expert team. Altogether, the diffusion of sustainable technologies such as energy efficiency and renewable energy for cooking, heating, lighting, electrical appliances and building insulation in developing countries has been slow. Energy efficiency and renewable energy programmes could be more sustainable and pilot studies more effective and pulse releasing if the entire policy and implementation process was considered and redesigned from the outset (Rees, 1999). New financing and implementation processes, which allow reallocating financial resources and thus enabling countries themselves to achieve a sustainable energy infrastructure, are also needed. The links between the energy policy framework, financing and implementation of renewable energy and energy efficiency projects have to be strengthened and as well as efforts made to increase people's knowledge through training. . The purpose of this study, however, is to examine the means of reduction of energy consumption in buildings, identify GSHPs as an environmental friendly technology able to provide efficient utilisation of energy in the buildings sector, promote using GSHPs applications as an optimum means of heating and cooling, and to present typical applications and recent advances of the DX GSHPs.

Energy Use in Buildings

Buildings consume energy mainly for cooling, heating and lighting. The energy consumption was based on the assumption that the building operates within ASHRAE-thermal comfort zone during the cooling and heating periods (Bos, My, Vu, & Bulatao, 1994). Most of the buildings incorporate energy efficient passive cooling, solar control, photovoltaic, lighting and day lighting, and integrated energy systems. It is well known that thermal mass with night ventilation can reduce the maximum indoor temperature in buildings in summer (Duchin, 1995). Hence, comfort temperatures may be achieved by proper application of passive cooling systems. However, energy can also be saved if an air conditioning unit is used (Givoni, 1998). The reason for this is that in summer, heavy external walls delay the heat transfer from the outside into the inside spaces. Moreover, if the building has a lot of internal mass the increase in the air temperature is slow. This is because the penetrating heat raises the air temperature as well as

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the temperature of the heavy thermal mass. The result is a slow heating of the building in summer as the maximal inside temperature is reached only during the late hours when the outside air temperature is already low. The heat flowing from the inside heavy walls could be reduced with good ventilation in the evening and night. The capacity to store energy also helps in winter, since energy can be stored in walls from one sunny winter day to the next cloudy one. However, the admission of daylight into buildings alone does not guarantee that the design will be energy efficient in terms of lighting. In fact, the design for increased daylight can often raise concerns relating to visual comfort (glare) and thermal comfort (increased solar gain in the summer and heat losses in the winter from larger apertures). Such issues will clearly need to be addressed in the design of the window openings, blinds, shading devices, heating system, etc. In order for a building to benefit from daylight energy terms, it is a prerequisite that lights are switched off when sufficient daylight is available. The nature of the switching regime; manual or automated, centralised or local, switched, stepped or dimmed, will determine the energy performance. Simple techniques can be implemented to increase the probability that lights are switched off (ASHRAE, 2003). These include:

- Making switches conspicuous and switching banks of lights independently.
- Loading switches appropriately in relation to the lights.
- Switching banks of lights parallel to the main window wall.

There are also a number of methods, which help reduce the lighting energy use, which, in turn, relate to the type of occupancy pattern of the building (UN, 2003). The light switching options include:

- Centralised timed off (or stepped)/manual on;
- Photoelectric off (or stepped)/manual on;
- Photoelectric and on (or stepped), photoelectric dimming; or
- Occupant sensor (stepped) on/off (movement or noise sensor).

Energy Conservation

Likewise, energy savings from the avoidance of air conditioning can be very substantial. Whilst day-lighting strategies need to be integrated with artificial lighting systems in order to become beneficial in terms of energy use, reductions in overall energy consumption levels by employment of a sustained programme of energy consumption strategies and measures would have considerable benefits within the buildings sector. It would perhaps be better to support a climate sensitive design approach that encompasses some elements of the pure conservation strategy together with strategies, which work with the local ambient conditions making use of energy technology systems, such as solar energy, where feasible. In practice, low energy environments are achieved through a combination of measures that include:

- The application of environmental regulations and policy;
- The application of environmental science and best practice;
- Mathematical modelling and simulation;
- Environmental design and engineering;
- Construction and commissioning; and
- Management and modifications of environments in use.

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While the overriding intention of passive solar energy design of buildings is to achieve a reduction in purchased energy consumption, the attainment of significant savings is in doubt. The non-realisation of potential energy benefits is mainly due to the neglect of the consideration of post-occupancy user and management behaviour by energy scientists and designers alike. Calculating energy inputs in agricultural production is more difficult in comparison to the industry sector due to the high number of factors affecting agricultural production, as Table 1 shows. However, considerable studies have been conducted in different countries on energy use in agriculture (Kammerud, Ceballos, Curtis, Place, & Anderson, 1984; Shaviv, 1989; Singh, 2000; CAEEDAC, 2000; Yaldiz, Ozturk, & Zeren, 1995; Dutt, 1982) in order to quantify the influence of these factors.

RENEWABLE ENERGY TECHNOLOGIES

Sustainable energy is the energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment (Baruah, 1995). It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years. Increasing environmental interest, as well as economic consideration of fossil fuel consumption and high emphasis of sustainable development for the future helped to bring the great potential of renewable energy into focus. Nearly a fifth of all global power is generated by renewable energy sources, according to a book published by the OECD/IEA (Baruah, 1995). "Renewables for power generation: status and prospects" claims that, at approximately 20%, renewables are the second largest power source after coal (39%) and ahead of nuclear (17%), natural gas (17%) and oil (8%) respectively. From 1973-2000 renewables grew at 9.3% a year and it is predicted that this will increase by 10.4% a year to 2010. Wind power grew fastest at 52% and will multiply seven times by 2020, overtaking biopower and hence help reducing greenhouse gases, GHGs, emissions to the environment.

Table 2 shows some applications of different renewable energy sources. The challenge is to match leadership in the GHG reduction and production of renewable energy with developing a major research and manufacturing capacity in environmental technologies (wind, solar, fuel cells, etc.). More than 50% of the world's area is classified as arid, representing the rural and desert part, which lack electricity and water networks. The inhabitants of such areas obtain water from borehole wells by means of water pumps, which are mostly driven by diesel engines. The diesel motors are associated with maintenance problems, high running cost, and environmental pollution. Alternative methods are pumping by photovoltaic (PV) or wind systems. At present, renewable sources of energy are regional and site specific. It has to be integrated in the regional development plans.

Solar Energy

The availability of data on solar radiation is a critical problem. Even in developed countries, very few weather stations have been recording detailed solar radiation data for a period of time long enough to have statistical significance. Solar radiation arriving on earth is the most fundamental renewable energy source in nature. It powers the bio-system, the ocean and atmospheric current system and affects the global climate. Reliable radiation information is needed to provide input data in modelling solar energy devices and a good database is required in the work of energy planners, engineers, and agricultural scientists. In general, it is not easy to design solar energy conversion systems when they have to

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be installed in remote locations. First, in most cases, solar radiation measurements are not available for these sites. Second, the radiation nature of solar radiation makes the computation of the size of such systems difficult. While solar energy data are recognised as very important, their acquisition is by no means straightforward. The measurement of solar radiation requires the use of costly equipment such as pyrheliometers and pyranometers. Consequently, adequate facilities are often not available in developing countries to mount viable monitoring programmes. This is partly due to the equipment cost as well as the cost of technical manpower. Several attempts have, however, been made to estimate solar radiation through the use of meteorological and other physical parameter in order to avoid the use of expensive network of measuring instruments (Thakur & Mistra, 1993; Wu & Boggess, 1999; OECD/IEA, 2004; Duffie & Beckman, 1980; Sivkov, 1964).

Two of the most essential natural resources for all life on the earth and for man's survival are sunlight and water. Sunlight is the driving force behind many of the RETs. The worldwide potential for utilising this resource, both directly by means of the solar technologies and indirectly by means of biofuels, wind and hydro technologies, is vast. During the last decade interest has been refocused on renewable energy sources due to the increasing prices and fore-seeable exhaustion of presently used commercial energy sources. The most promising solar energy technology are related to thermal systems; industrial solar water heaters, solar cookers, solar dryers for peanut crops, solar stills, solar driven cold stores to store fruits and vegetables, solar collectors, solar water desalination, solar ovens, and solar commercial bakers. Solar PV system: solar PV for lighting, solar refrigeration to store vaccines for human and animal use, solar PV for water pumping, solar PV for battery chargers, solar PV for communication network, microwave, receiver stations, radio systems in airports, VHF and beacon radio systems in airports, and educational solar TV posts in villages. Solar pumps are most cost effective for low power requirement (up to 5 kW) in remote places. Applications include domestic and livestock drinking water supplies, for which the demand is constant throughout the year, and irrigation. However, the suitability of solar pumping for irrigation, though possible, is uncertain because the demand may vary greatly with seasons. Solar systems may be able to provide trickle irrigation for fruit farming, but not usually the large volumes of water needed for wheat growing.

The hydraulic energy required to deliver a volume of water is given by the formula:

$$E_w = \rho_w g V H \tag{1}$$

where E_w is the required hydraulic energy (kWh day^{-1}); ρ_w is the water density (kg m^{-3}); g is the gravitational acceleration (ms^{-2}); V is the required volume of water (m^3 day^{-1}); and H is the head of water (m).

The solar array power required is given by:

$$P_{sa} = \frac{E_w}{E_{sr}\eta F} \tag{2}$$

where: P_{sa} is the solar array power (kW_p); E_{sr} is the average daily solar radiation (kWhm^{-2} day^{-1}); F is the array mismatch factor; and η is the daily subsystem efficiency.

Substituting Equation 1 in Equation 2, the following equation is obtained for the amount of water that can be pumped:

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Table 1. Energy equivalent of inputs and outputs

Energy Source	Unit	Equivalent Energy (MJ)
Input		
Human Labor	h	2.3
Animal Labor		
Horse	h	10.10
Mule	h	4.04
Donkey	h	4.04
Cattle	h	5.05
Water Buffalo	h	7.58
Electricity	kwh	11.93
Diesel	Litre	56.31
Chemicals Fertilisers		
Nitrogen	kg	64.4
P_2O_5	kg	11.96
K_2O	kg	6.7
Seed		
Cereals and Pulses	kg	25
Oil Seed	kg	3.6
Tuber	kg	14.7
Total Input	kg	43.3
Output		
Major Products		
Cereals and Pulses	kg	14.7
Sugar Beet	kg	5.04
Tobacco	kg	0.8
Cotton	kg	11.8
Oil Seed	kg	25
Fruits	kg	1.9
Vegetables	kg	0.8
Watermelon	kg	1.9
Onion	kg	1.6
Potatoes	kg	3.6
Olive	kg	11.8
Tea	kg	0.8
Byproducts		
Husk	kg	13.8
Straw	kg	12.5
Cob	kg	18.0
Seed Cotton	kg	25.0
Total Output	kg	149.04

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Table 2. Sources of renewable energy

Energy Source	Technology	Size
Solar energy	Domestic solar water heaters Solar water heating for large demands PV roofs: grid connected systems generating electric energy	Small Medium-large Medium-large
Wind energy	Wind turbines (grid connected)	Medium-large
Hydraulic energy	Hydro plants in derivation schemes Hydro plants in existing water distribution networks	Medium-small Medium-small
Biomass	High efficiency wood boilers CHP plants fed by agricultural wastes or energy crops	Small Medium
Animal manure	CHP plants fed by biogas	Small
CHP	High efficiency lighting High efficiency electric Householders appliances High efficiency boilers Plants coupled with refrigerating absorption machines	Wide Wide Wide Small-medium Medium-large

$$V = \frac{P_{sa} E_{sr} \eta F}{\rho_w g H} \tag{3}$$

$P_{sa} = 1.6\ kW_p$, $F = 0.85$, $\eta = 40\%$.

A further increase of *PV* depends on the ability to improve the durability, performance and the local manufacturing capabilities of *PV*.

Biomass Utilisation

The data required to perform the trade-off analysis simulation of bio-energy resources can be classified according to the divisions given in Table 3, namely the overall system or individual plants, and the existing situation or future development. The effective economical utilisations of these resources are shown in Table 4, but their use is hindered by many problems such as those related to harvesting, collection, and transportation, besides the photo-sanitary control regulations. Biomass energy is experiencing a surge in interest stemming from a combination of factors, e.g., greater recognition of its current role and future potential contribution as a modern fuel, global environmental benefits, its development and entrepreneurial opportunities, etc. Possible routes of biomass energy development are shown in Table 5. However, biomass usage and application can generally be divided into the following three categories.

1. Biomass energy for petroleum substitution driven by the following factors:
    a. Oil price increase.
    b. Balance of payment problems, and economic crisis.
    c. Fuel-wood plantations and residue utilisation.
    d. Wood based heat and electricity.
    e. Liquid fuels from biomass.
    f. Producer gas technology.

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Table 3. Classifications of data requirements

Criteria	Plant Data	System Data
Existing data	Size Life Cost (fixed and variation operation and maintenance) Forced outage Maintenance Efficiency Fuel Emissions	Peak load Load shape Capital costs Fuel costs Depreciation Rate of return Taxes
Future data	All of above, plus Capital costs Construction trajectory Date in service	System lead growth Fuel price growth Fuel import limits Inflation

Table 4. Effective biomass resource utilisation

Subject	Tools	Constraints
Utilisation and land clearance for agriculture expansion	• Stumpage fees • Control • Extension • Conversion • Technology	• Policy • Fuel-wood planning • Lack of extension • Institutional
Utilisation of agricultural residues	• Briquetting • Carbonisation • Carbonisation and briquetting • Fermentation • Gasification	• Capital • Pricing • Policy and legislation • Social acceptability

Table 5. Agricultural residues routes for development

Source	Process	Product	End Use
Agricultural residues	Direct Processing Processing Carbonisation Fermentation	Combustion Briquettes Carbonisation (small scale) Briquettes Carbonised Biogas	Rural poor Urban household Industrial use Industrial use Limited household use Rural household (self sufficiency) Urban fuel Energy services Household, and industry
Agricultural, and animal residues	Direct Briquettes Carbonisation Carbonisation Fermentation	Combustion Direct combustion Carbonised Briquettes Biogas	(Save or less efficiency as wood) (Similar end use devices or improved) Use Briquettes use Use

2. Biomass energy for domestic needs driven by:
   a. Population increase.
   b. Urbanisation.
   c. Agricultural expansion.

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   d. Fuel-wood crisis.
   e. Ecological crisis.
   f. Fuel-wood plantations, agro-forestry.
   g. Community forestry, and residue utilisation.
   h. Improved stoves, and improved charcoal production.
3. Biomass energy for development driven by:
   a. Electrification.
   b. Irrigation and water supply.
   c. Economic and social development.
   d. Fuel-wood plantations.
   e. Community forestry.
   f. Agro-forestry.
   g. Briquettes.
   h. Producer gas technology.

The use of biomass through direct combustion has long been, and still is, the most common mode of biomass utilisation (Table 5). Examples for dry (thermo-chemical) conversion processes are charcoal making from wood (slow pyrolysis), gasification of forest and agricultural residues (fast pyrolysis – this is still in demonstration phase), and of course, direct combustion in stoves, furnaces, etc. Wet processes require substantial amount of water to be mixed with the biomass. Biomass technologies include:

- Carbonisation and briquetting.
- Improved stoves.
- Biogas.
- Improved charcoal.
- Gasification.

Briquetting and Carbonisation

Briquetting is the formation of a charcoal (an energy-dense solid fuel source) from otherwise wasted agricultural and forestry residues. One of the disadvantages of wood fuel is that it is bulky with a low energy density and therefore requires transport. Briquette formation allows for a more energy-dense fuel to be delivered, thus reducing the transportation cost and making the resource more competitive. It also adds some uniformity, which makes the fuel more compatible with systems that are sensitive to the specific fuel input. Charcoal stoves are very familiar to African societies. As for the stove technology, the present charcoal stove can be used, and can be improved upon for better efficiency. This energy term will be of particular interest to both urban and rural households and all the income groups due to its simplicity, convenience, and lower air polluting characteristics. However, the market price of the fuel together with that of its end-use technology may not enhance its early high market penetration especially in the urban low income and rural households.

Charcoal is produced by slow heating wood (carbonisation) in airtight ovens or retorts, in chambers with various gases, or in kilns supplied with limited and controlled amounts of air. The charcoal yield decreased gradually from 42.6 to 30.7% for the hazelnut shell and from 35.6 to 22.7% for the beech wood with an increase of temperature from 550 to 1,150 K while the charcoal yield from the lignin

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content decreases sharply from 42.5 to 21.7% until it was at 850 K during the carbonisation procedures (Sivkov, 1964). The charcoal yield decreases as the temperature increases, while the ignition temperature of charcoal increases as the carbonisation temperature increases. The charcoal briquettes that are sold on the commercial market are typically made from a binder and filler.

Improved Cook Stoves

Traditional wood stoves are commonly used in many rural areas. These can be classified into four types: three stone, metal cylindrical shaped, metal tripod and clay type. Indeed, improvements of traditional cookers and ovens to raise the efficiency of fuel saving can secure rural energy availability, where woody fuels have become scarce. However, planting fast growing trees to provide a constant fuel supply should also be considered. The rural development is essential and economically important since it will eventually lead to a better standard of living, people's settlement, and self-sufficiency.

Biogas Technology

Biogas technology cannot only provide fuel, but is also important for comprehensive utilisation of biomass forestry, animal husbandry, fishery, agricultural economy, protecting the environment, realising agricultural recycling as well as improving the sanitary conditions, in rural areas. However, the introduction of biogas technology on a wide scale has implications for macro planning such as the allocation of government investment and effects on the balance of payments. Hence, factors that determine the rate of acceptance of biogas plants, such as credit facilities and technical backup services, are likely to have to be planned as part of general macro-policy, as do the allocation of research and development funds (Barabaro, Coppolino, Leone, & Sinagra, 1978).

Improved Charcoal

Dry cell batteries are a practical but expensive form of mobile fuel that is used by rural people when moving around at night and for powering radios and other small appliances. The high cost of dry cell batteries is financially constraining for rural households, but their popularity gives a good indication of how valuable a versatile fuel like electricity is in rural areas (Table 6). However, dry cell batteries can constitute an environmental hazard unless they are recycled in a proper fashion. Tables 6 & 7 further show that direct burning of fuel-wood and crop residues constitute the main usage of biomass, as is the case with many developing countries. In fact, biomass resources play a significant role in energy supply in all developing countries. However, the direct burning of biomass in an inefficient manner causes economic loss and adversely affects human health. In order to address the problem of inefficiency, research centres around the world, e.g., Hall & Scrase (1998) have investigated the viability of converting the resource to a more useful form of improved charcoal, namely solid briquettes and fuel gas. Accordingly, biomass resources should be divided into residues or dedicated resources, the latter including firewood and charcoal can also be produced from forest residues (Table 7). Whichever form of biomass resource used, its sustainability would primarily depend on improved forest and tree management.

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Table 6. Energy carrier and energy services in rural areas

Energy Carrier	Energy End-Use
Fuel-wood	Cooking Water heating Building materials Animal fodder preparation
Kerosene	Lighting Ignition fires
Dry cell batteries	Lighting Small appliances
Animal power	Transport Land preparation for farming Food preparation (threshing)
Human power	Transport Land preparation for farming Food preparation (threshing)

Table 7. Biomass residues and current use

Type of Residue	Current Use
Wood industry waste	Residues available
Vegetable crop residues	Animal feed
Food processing residue	Energy needs
Sorghum, millet, and wheat residues	Fodder, and building materials
Groundnut shells	Fodder, brick making, and direct fining oil mills
Cotton stalks	Domestic fuel considerable amounts available for short period
Sugar, bagasse, and molasses	Fodder, energy need, and ethanol production (surplus available)
Manure	Fertiliser, brick making, and plastering

Gasification

Gasification is based on the formation of a fuel gas (mostly CO and H_2) by partially oxidising raw solid fuel at high temperatures in the presence of steam or air. The technology can use wood chips, groundnut shells, sugarcane bagasse, and other similar fuels to generate capacities from 3 kW to 100 kW. Many types of gasifier designs have been developed to make use of the diversity of fuel inputs and to meet the requirements of the product gas output (degree of cleanliness, composition, heating value, etc.) (Pernille, 2004).

Biomass and Sustainability

A sustainable energy system includes energy efficiency, energy reliability, energy flexibility, fuel poverty, and environmental impacts. A sustainable biofuel has two favourable properties, which are availability from renewable raw material, and its lower negative environmental impact than that of fossil fuels. Global warming, caused by CO_2 and other substances, has become an international concern

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in recent years. To protect forestry resources, which act as major absorbers of CO_2, by controlling the ever-increasing deforestation and the increase in the consumption of wood fuels, such as firewood and charcoal, is therefore an urgent issue. Given this, the development of a substitute fuel for charcoal is necessary. Briquette production technology, a type of clean coal technology, can help prevent flooding and serve as a global warming countermeasure by conserving forestry resources through the provision of a stable supply of briquettes as a substitute for charcoal and firewood.

There are many emerging biomass technologies with large and immediate potential applications, e.g., biomass gasifier/gas turbine (BGST) systems for power generation with pilot plants, improved techniques for biomass harvesting, transportation and storage. Gasification of crop residues such as rice husks, groundnut shells, etc., with plants already operating in China, India, and Thailand. Treatment of cellulosic materials by steam explosion which may be followed by biological or chemical hydrolysis to produce ethanol or other fuels, cogeneration technologies, hydrogen from biomass, striling energies capable of using biomass fuels efficiently, etc. Table 8 gives a view of the use of biomass and its projection worldwide.

However, a major gap with biomass energy is that research has usually been aimed at obtaining supply and consumption data, with insufficient attention and resources being allocated to basic research, to production, harvesting and conservation processes. Biomass has not been closely examined in terms of a substitute for fossil fuels compared to carbon sequestration and overall environmental benefits related to these different approaches. To achieve the full potential of biomass as a feedstock for energy, food, or any other use, requires the application of considerable scientific and technological inputs (D'Apote, 1998). However, the aim of any modern biomass energy systems must be:

1. To maximise yields with minimum inputs;
2. Utilise and select adequate plant materials and processes;
3. Optimise use of land, water, and fertiliser; and
4. Create an adequate infrastructure and strong research and development (R&D) base.

An afforestation programme appears an attractive option for any country to pursue in order to reduce the level of atmospheric carbon by enhancing carbon sequestration in the nation's forests, which would consequently mitigate climate change. However, it is acknowledged that certain barriers need to be overcome if the objectives are to be fully achieved. These include the followings.

- Low level of public awareness of the economic/environmental benefits of forestry.
- The generally low levels of individuals' income.
- Pressures from population growth.
- The land tenural system, which makes it difficult (if at all possible) for individuals to own or establish forest plantations.
- Poor pricing of forest products especially in the local market.
- Inadequate financial support on the part of governments.
- Weak institutional capabilities of the various Forestry Departments as regards technical manpower to effectively manage tree plantations.

However, social policy conditions are also critical. This is still very much lacking particularly under developing countries conditions. During the 1970s and 1980s different biomass energy technologies

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Table 8. Final energy projections including biomass (Mtoe)

Region	Biomass	Conventional Energy	Total	Share of Biomass (%)
1995				
Africa	205	136	341	60
China	206	649	855	24
East Asia	106	316	422	25
Latin America	73	342	416	18
South Asia	235	188	423	56
Total developing countries	825	1632	2456	34
Other non-OECD countries	24	1037	1061	1
Total non-OECD countries	849	2669	3518	24
OECD countries	81	3044	3125	3
World	930	5713	6643	14
2020				
Africa	371	266	631	59
China	224	1524	1748	13
East Asia	118	813	931	13
Latin America	81	706	787	10
South Asia	276	523	799	35
Total developing countries	1071	3825	4896	22
Other non-OECD countries	26	1669	1695	1
Total non-OECD countries	1097	5494	6591	17
OECD countries	96	3872	3968	2
World	1193	9365	10558	11

were perceived in sub-Saharan Africa as a panacea for solving acute problems. On the account of these expectations, a wide range of activities and projects were initiated. However, despite considerable financial and human efforts, most of these initiatives have unfortunately been a failure.

Therefore, future research efforts should concentrate on the following areas:

- Directed R and D in the most promising areas of biomass to increase energy supply and to improve the technological base.
- Formulate a policy framework to encourage entrepreneurial and integrated process.
- Pay more attention to sustainable production and use of biomass energy feedstocks, methodology of conservation and efficient energy flows.
- More research aimed at pollution abatement.
- Greater attentions to interrelated socio-economic aspects.
- Support R and D on energy efficiency in production and use.
- Improve energy management skills and take maximum advantage of existing local knowledge.
- Closely examine past successes and failures to assist policy makers with well-informed recommendations.

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Combined Heat and Power (CHP)

District Heating (DH), also known as community heating can be a key factor to achieve energy savings, reduce CO_2 emissions and at the same time provide consumers with a high quality heat supply at a competitive price. Generally, DH should only be considered for areas where the heat density is sufficiently high to make DH economical. In countries like Denmark for example, DH may today be economical even to new developments with lower density areas, due to the high level of taxation on oil and gas fuels combined with the efficient production of DH.

Most of the heat used for DH can be produced by large CHP plants (gas-fired combined cycle plants using natural gas, biomass, waste or biogas) as shown in Table 2. DH is energy efficient because of the way the heat is produced and the required temperature level is an important factor. Buildings can be heated to a temperature of 21°C and domestic hot water (DHW) can be supplied at a temperature of 55°C using energy sources other than DH that are most efficient when producing low temperature levels (<95°C) for the DH water (David, 2000). Most of these heat sources are CO_2 neutral or emit low levels. However, only a few of these sources are available to small individual systems at a reasonable cost, whereas DH schemes because of the plant's size and location can have access to most of the heat sources and at a low cost. Low temperature DH, with return temperatures of around 30-40°C can utilise the following heat sources:

- Efficient use of CHP by extracting heat at low calorific value (CV).
- Efficient use of biomass or gas boilers by condensing heat in economisers.
- Efficient utilisation of geothermal energy.
- Direct utilisation of excess low temperature heat from industrial processes.
- Efficient use of large-scale solar heating plants.

Heat tariffs may include a number of components such as a connection charge, a fixed charge and a variable energy charge. Also, consumers may be incentivised to lower the return temperature. Hence, it is difficult to generalise but the heat practice for any DH company, no matter what the ownership structure is, can be highlighted as follows:

- To develop and maintain a development plan for the connection of new consumers.
- To evaluate the options for least cost production of heat.
- To implement the most competitive solutions by signing agreements with other companies or by implementing own investment projects.
- To monitor all internal costs and with the help of benchmarking, improve the efficiency of the company.
- To maintain a good relationship with the consumer and deliver heat supply services at a sufficient quality.

Also, installing DH should be pursued to meet the objectives for improving the environment through the improvement of energy efficiency in the heating sector. At the same time DH can serve the consumer with a reasonable quality of heat at the lowest possible cost. The variety of possible solutions combined with the collaboration between individual companies, the district heating association, the suppliers and consultants can, as it has been in Denmark, be the way forward for developing DH in the United Kingdom.

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Fuel Cells

Platinum is a catalyst for fuel cells and hydrogen-fuelled cars presently use about two ounces of the metal. There is currently no practicable alternative. Reserves are in South Africa (70%), and Russia (22%). Although there are sufficient accessible reserves in South Africa to increase supply by up to 5% per year for the next 50 years, there are significant environmental impacts associated with its mining and refining, such as groundwater pollution and atmospheric emissions of sulphur dioxide ammonia, chlorine and hydrogen chloride. The carbon cost of platinum use equates to 360 kg for a current fuel cell car, or 36 kg for a future car, with the target platinum loading of 0.2 oz, which is negligible compared to the CO_2 currently emitted by vehicles (IHA, 2003). Furthermore, Platinum is almost completely recyclable. At current prices and loading, platinum would cost 3% of the total cost of a fuel cell engine. Also, the likely resource costs of hydrogen as a transport fuel are apparently cheapest if it is reformed from natural gas with pipeline distribution, with or without carbon sequestration. However, this is not as sustainable as using renewable energy sources. Substituting hydrogen for fossils fuels will have a positive environmental impact in reducing both photochemical smog and climate change. There could also be an adverse impact on the ozone layer but this is likely to be small, though potentially more significant if hydrogen was to be used as aviation fuel.

Hydrogen Production

Hydrogen is now beginning to be accepted as a useful form for storing energy for reuse on, or for export off, the grid. Clean electrical power harvested from wind and wave power projects can be used to produce hydrogen by electrolysis of water. Electrolysers split water molecules into its constituent parts: hydrogen and oxygen. These are collected as gases; hydrogen at the cathode and oxygen at the anode. The process is quite simple. Direct current is applied to the electrodes to initiate the electrolysis process. Production of hydrogen is an elegant environmental solution. Hydrogen is the most abundant element on the planet, it cannot be destroyed (unlike hydrocarbons) it simply changes state (water to hydrogen and back to water) during consumption. There is no CO or CO_2 generation in its production and consumption and, depending upon methods of consumption, even the production of oxides of nitrogen can be avoided too. However, the transition will be very messy, and will take many technological paths to convert fossil fuels and methanol to hydrogen, building hybrid engines and so on. Nevertheless, the future of hydrogen fuel cells is promising. Hydrogen can be used in internal combustion engines, fuel cells, turbines, cookers gas boilers, road-side emergency lighting, traffic lights or signalling where noise and pollution can be a considerable nuisance, but where traffic and pedestrian safety cannot be compromised.

Hydrogen is already produced in huge volumes and used in a variety of industries. Current worldwide production is around 500 billion Nm^3 per year (EWEA, 2003). Most of the hydrogen produced today is consumed on-site, such as at oil refineries, at a cost of around $0.70/kg and is not sold on the market (Steele, 1997). When hydrogen is sold on the market, the cost of liquefying the hydrogen and transporting it to the user adds considerably to the production cost. The energy required to produce hydrogen via electrolysis (assuming 1.23 V) is about 33 (kWh/kg). For 1 mole (2 g) of hydrogen the energy is about 0.066 (kWh/mole) (Sitarz, 1992). The achieved efficiencies are over 80% and on this basis electrolytic hydrogen can be regarded as a storable form of electricity. Hydrogen can be stored in a variety of forms:

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- Cryogenic; this has the highest gravimetric energy density.
- High-pressure cylinders; pressures of 10,000 psi are quite normal.
- Metal hydride absorbs hydrogen, providing a very low pressure and extremely safe mechanism, but is heavy and more expensive than cylinders, and
- Chemical carriers offer an alternative, with anhydrous ammonia offering similar gravimetric and volumetric energy densities to ethanol and methanol.

Hydropower

Hydropower has a valuable role as a clean and renewable source of energy in meeting a variety of vital human needs. Water is a basic requirement for survival: for drinking, for food, energy production and for good health. As water is a commodity, which is finite and cannot be created, and in view of the increasing requirements as the world population grows, there is no alternative but to store water for use when it is needed. However, the major challenges are to feed the increasing world population, to improve the standards of living in rural areas and to develop and manage land and water in a sustainable way. Hydropower plants are classified by their rated capacity into one of four regimes: micro (<50kW), mini (50-500 kW), small (500 kW-5 MW), and large (>5 MW) (Agnew & Duncan, 1989).

The total world installed hydro capacity today is around 1000 Giga Watts (GW) and a lot more are currently planned, principally in developing countries in Asia, Africa and South America as shown in Table 9, which is reproduced from (Okkan, 1993). However, the present production of hydroelectricity is only about 18 per cent of the technically feasible potential (and 32 per cent of the economically feasible potential); there is no doubt that a large amount of hydropower development lies ahead (Okkan, 1993).

Wind Energy

Water is the most natural commodity for the existence of life in the remote desert areas. However, as a condition for settling and growing, the supply of energy is the close second priority. The high cost and

Table 9. World hydro potential and development

Continent	Africa	Asia	Australia and Oceania	Europe	North and Central America	South America
Gross theoretical hydropower potential ($GWhy^{-1}$)	$4x10^6$	$19.4x10^6$	$59.4x10^6$	$3.2x10^6$	$6x10^6$	$6.2x10^6$
Technically feasible hydropower potential ($GWhy^{-1}$)	$1.75x10^6$	$6.8x10^6$	$2x10^6$	10^6	$1.66x10^6$	$2.7x10^6$
Economically feasible hydropower potential ($GWhy^{-1}$)	$1.1x10^5$	$3.6x10^6$	$90x10^4$	$79x10^4$	10^6	$1.6x10^6$
Installed hydro capacity (MW)	$21x10^3$	$24.5x10^4$	$13.3x10^4$	$17.7x10^4$	$15.8x10^4$	$11.4x10^4$
Production by hydro plants in 2002 or average ($GWhy^{-1}$)	$83.4x10^3$	$80x10^4$	$43x10^3$	$568x10^3$	$694x10^3$	$55x10^4$
Hydro capacity under construction (MW)	> 3024	$>72.7x10^3$	>177	$>23x10^2$	$58x10^2$	$>17x10^3$
Planned hydro capacity (MW)	$77.5x10^3$	$>17.5x10^4$	>647	$>10^3$	$>15x10^3$	$>59x10^3$

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the difficulties of mains power line extensions, especially to a low populated region can focus attention on the utilisation of different and more reliable and independent sources of energy like renewable wind energy. Accordingly, the utilisation of wind energy, as a form of energy, is becoming increasingly attractive and is being widely used for the substitution of oil-produced energy, and eventually to minimise atmospheric degradation, particularly in remote areas. Indeed, utilisation of renewables, such as wind energy, has gained considerable momentum since the oil crises of the 1970s. Wind energy, though site-dependent, is non-depleting, non-polluting, and a potential option of the alternative energy source. Wind power could supply 12% of global electricity demand by 2020, according to a report by the European Wind Energy Association and Greenpeace (Njeru, 2013).

Wind energy can and will constitute a significant energy resource when converted into a usable form. As Figure 1 illustrates, information sharing is a four-stage process and effective collaboration must also provide ways in which the other three stages of the 'renewable' cycle: gather, convert and utilise, can be integrated. Efficiency in the renewable energy sector translates into lower gathering, conversion and utilisation (electricity) costs. A great level of installed capacity has already been achieved. Figure 2 clearly shows that the offshore wind sector is developing fast, and this indicates that wind is becoming a major factor in electricity supply with a range of significant technical, commercial and financial hurdles to be overcome. The offshore wind industry has the potential for a very bright future and to emerge as a new industrial sector, as Figure 3 implies.

Figure 1. The renewable cycle

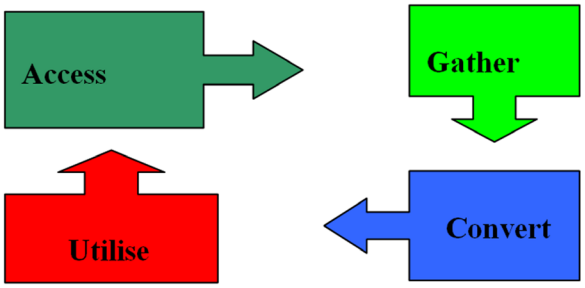
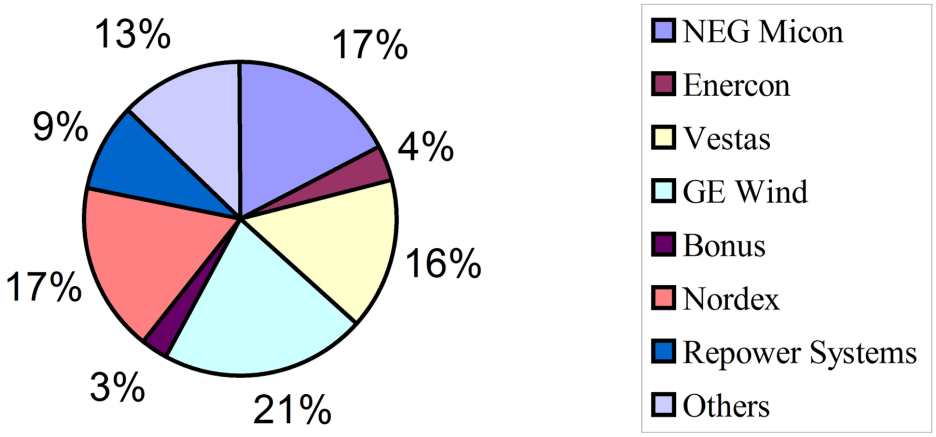
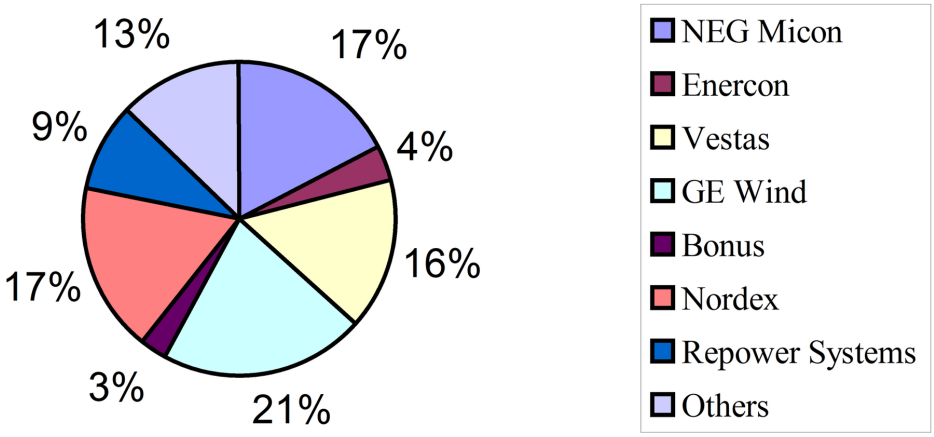


Figure 2. Global prospects of wind energy utilisation by 2003-2010



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Figure 3. Prospect turbines share for 2003-2010



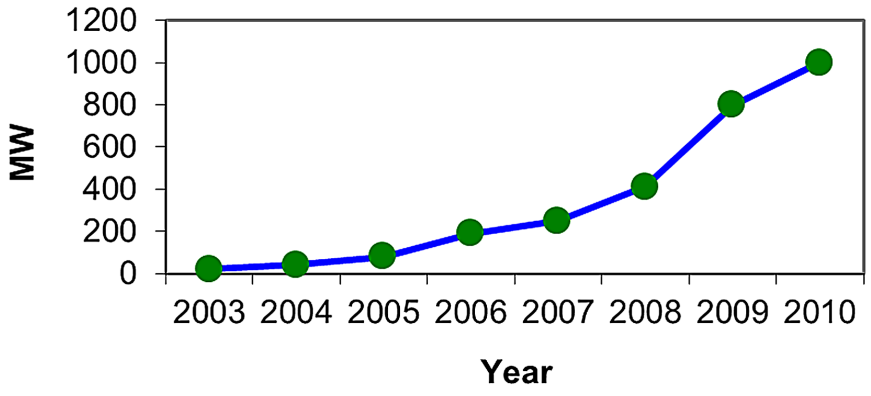
The speed of turbine development is such that more powerful models would supersede the original specification turbines in the time from concept to turbine order. Levels of activities are growing at a phenomenal rate (Figure 4), new prospects developing, new players entering, existing players growing in experience; technology evolving and, quite significantly, politics appear to support the sector.

ENERGY AND SUSTAINABLE DEVELOPMENT

Sustainability is defined as the extent to which progress and development should meet the need of the present without compromising the ability of the future generations to meet their own needs (Odeku, Maveneka, & Konanani, 2013). This encompasses a variety of levels and scales ranging from economic development and agriculture, to the management of human settlements and building practices. Tables 10, 11 & 12 indicate the relationship between energy conservation, sustainable development and environment.

The following issues were addressed during the Rio Earth Summit in 1992 (Abdeen, 2009):

Figure 4. Average windfarm capacity 2003-2010



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Table 10. Energy and sustainable environment

Technological Criteria	Energy and Environment Criteria	Social and Economic Criteria
Primary energy saving in regional scale	Sustainability according to greenhouse gas pollutant emissions	Labour impact
Technical maturity, and reliability	Sustainable according to other pollutant emissions	Market maturity
Consistence of installation and maintenance requirements with local technical known-how	Land requirement	Compatibility with political, legislative and administrative situation
Continuity and predictability of performance	Sustainability according to other environmental impacts	Cost of saved primary energy

Table 11. Classification of key variables defining facility sustainability

Criteria	Intra-System Impacts	Extra-System Impacts
Stakeholder satisfaction	• Standard expectations met • Relative importance of standard expectations	Covered by attending to extra-system resource base and ecosystem impacts
Resource base impacts	• Change in intra-system resource bases • Significance of change	• Resource flow into/out of facility system • Unit impact exerted by flow on source/sink system • Significance of unit impact
Ecosystem impacts	• Change in intra-system ecosystems • Significance of change	• Resource flows into/out of facility system • Unit impact exerted by how on source/sink system • Significance of unit impact

Table 12. Positive impact of durability, adaptability, and energy conservation on economic, social, and environment systems

Economic System	Social System	Environmental System
Durability	Preservation of cultural values	Preservation of resources
Meeting changing needs of economic development	Meeting changing needs of individuals and society	Reuse, recycling and preservation of resources
Energy conservation and saving	Savings directed to meet other social needs	Preservation of resources, reduction of pollution and global warming

- The use of local materials and indigenous building sources.
- Incentive to promote the continuation of traditional techniques, with regional resources and self-help strategies.
- Regulation of energy-efficient design principles.
- International information exchange on all aspects of construction related to the environment, among architects and contractors, particularly non-conventional resources.
- Exploration of methods to encourage and facilitate the recycling and reuse of building materials, especially those requiring intensive energy use during manufacturing, and the use of clean technologies.

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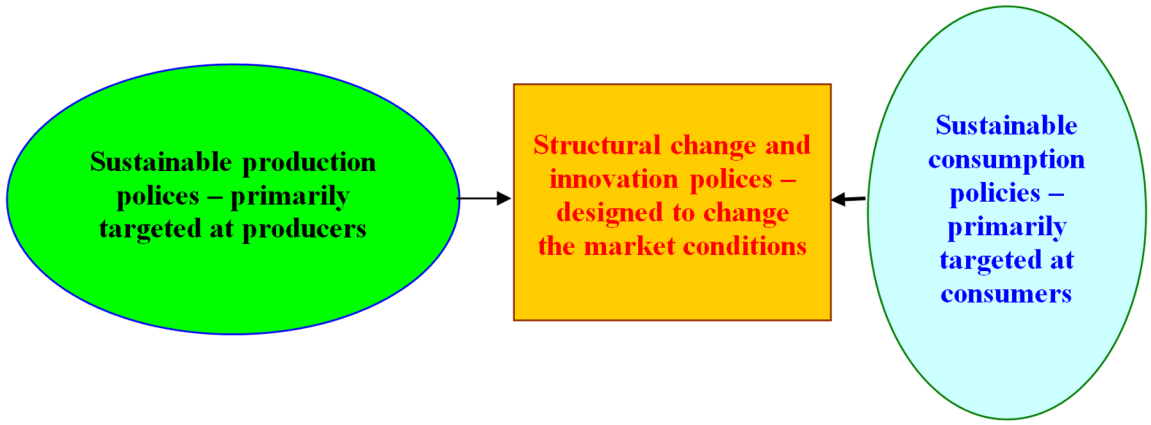
And, the following action areas for producers were recommended:

- **Management and Measurement Tools:** Adopting environmental management systems appropriate for the business.
- **Performance Assessment Tools:** Making use of benchmarking to identify scope for impact reduction and greater eco-efficiency in all aspects of the business.
- **Best Practice Tools:** Making use of free help and advice from government best practice programmes (energy efficiency, environmental technology, resource savings).
- **Innovation and Eco-Design:** Rethinking the delivery of 'value added' by the business, so that impact reduction and resource efficiency are firmly built in at the design stage.
- **Cleaner, Leaner Production Processes:** Pursuing improvements and savings in waste minimisation, energy and water consumption, transport and distribution, as well as reduced emissions.
- **Supply Chain Management:** Specifying more demanding standards of sustainability from 'upstream' suppliers, while supporting smaller firms to meet those higher standards.
- **Product Stewardship:** Taking the broadest view of 'producer responsibility' and working to reduce all the 'downstream' effects of products after they have been sold on to customers.
- **Openness and Transparency:** Publicly reporting on environmental performance against meaningful targets; actively using clear labels and declarations so that customers are fully informed; building stakeholder confidence by communicating sustainability aims to the workforce, the shareholders and the local community (Figure 5).

This is the step in a long journey to encourage progressive economy, which continues to provide people with high living standards, but, at the same time helps reduce pollution, waste mountains, other environmental degradation, and environmental rationale for future policy-making and intervention to improve market mechanisms. This vision will be accomplished by:

- 'Decoupling' economic growth and environmental degradation. The basket of indicators illustrated in Table 13 shows the progress being made. Decoupling air and water pollution from growth, making good headway with CO_2 emissions from energy, and transport. The environmental im-

Figure 5. Link between resources and productivity



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pact of our own individual behaviour is more closely linked to consumption expenditure than the economy as a whole.
- Focusing policy on the most important environmental impacts associated with the use of particular resources, rather than on the total level of all resource use.
- Increasing the productivity of material and energy use that are economically efficient by encouraging patterns of supply and demand, which are more efficient in the use of natural resources. The aim is to promote innovation and competitiveness. Investment in areas like energy efficiency, water efficiency and waste minimisation.
- Encouraging and enabling active and informed individual and corporate consumers.

Chemicals

Humans and wildlife are being contaminated by a host of commonly used chemicals in food packaging and furniture, according to the World Wildlife Federation (WWF) and European Union (Abdeen, 2008). Currently, the chemical industry has been under no obligation to make the information public. However, the new proposed rules would change this. Future dangers will only be averted if the effects of chemicals are exposed and then the dangerous ones are never used. Indeed, chemicals used for jacket waterproofing, food packaging and non-stick coatings have been found in dolphins, whales, cormorants, seals, sea eagles and polar bears from the Mediterranean to the Baltic. The European Commission has adopted an ambitious action plan to improve the development and wider use of environmental technologies such as recycling systems for wastewater in industrial processes, energy-saving car engines and soil remediation techniques, using hydrogen and fuel cells (Abdeen, 2012). The legislation, which has not been implemented in time, concerns the incineration of waste, air quality limit, values for benzene and carbon monoxide, national emission ceilings for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia and large combustion plants.

Wastes

Waste is defined as an unwanted material that is being discarded. Waste includes items being taken for further use, recycling or reclamation. Waste produced at household, commercial and industrial premises are control waste and come under the waste regulations. Waste Incineration Directive (WID) emissions limit values will favour efficient, inherently cleaner technologies that do not rely heavily on abatement. For existing plant, the requirements are likely to lead to improved control of:

- NO_x emissions, by the adoption of infurnace combustion control and abatement techniques.
- Acid gases, by the adoption of abatement techniques and optimisation of their control.
- Particulate control techniques, and their optimisation, e.g., of bag filters and electrostatic precipitators.

The waste and resources action programme has been working hard to reduce demand for virgin aggregates and market uptake of recycled and secondary alternatives. The programme targets are:

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Table 13. The basket of indicators for sustainable consumption and production

Economy-Wide Decoupling Indicators
1. Greenhouse gas emissions 2. Air pollution 3. Water pollution (river water quality) 4. Commercial and industrial waste arisings and household waste not cycled
Resource Use Indicators
5. Material use 6. Water abstraction 7. Homes built on land not previously developed, and number of households
Decoupling Indicators for Specific Sectors
8. Emissions from electricity generation 9. Motor vehicle kilometres and related emissions 10. Agricultural output, fertiliser use, methane emissions and farmland bird populations 11. Manufacturing output, energy consumption and related emissions 12. Household consumption, expenditure energy, water consumption and waste generated

- To deliver training and information on the role of recycling and secondary aggregates in sustainable construction for influences in the supply chain, and
- To develop a promotional programme to highlight the new information on websites.

Global Warming

This results in the following requirements:

- Relevant climate variables should be generated (solar radiation: global, diffuse, direct solar direction, temperature, humidity, wind speed and direction) according to the statistics of the real climate.
- The average behaviour should be in accordance with the real climate.
- Extremes should occur in the generated series in the way it will happen in a real warm period. This means that the generated series should be long enough to capture these extremes, and series based on average values from nearby stations.

On some climate change issues (such as global warming), there is no disagreement among the scientists. The greenhouse effect is unquestionably real; it is essential for life on earth. Water vapour is the most important GHG; followed by carbon dioxide (CO_2). Without a natural greenhouse effect, scientists estimate that the earth's average temperature would be –18°C instead of its present 14°C (Raphael, 2012). There is also no scientific debate over the fact that human activity has increased the concentration of the GHGs in the atmosphere (especially CO_2 from combustion of coal, oil and gas). The greenhouse effect is also being amplified by increased concentrations of other gases, such as methane, nitrous oxide, and CFCs as a result of human emissions. Most scientists predict that rising global temperatures will raise the sea level and increase the frequency of intense rain or snowstorms. Climate change scenarios sources of uncertainty and factors influencing the future climate are:

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- The future emission rates of the GHGs (Table 14).
- The effect of this increase in concentration on the energy balance of the atmosphere.
- The effect of these emissions on GHGs concentrations in the atmosphere, and
- The effect of this change in energy balance on global and regional climate.

It has been known for a long time that urban centres have mean temperatures higher than their less developed surroundings. The urban heat increases the average and peak air temperatures, which in turn affect the demand for heating and cooling. Higher temperatures can be beneficial in the heating season, lowering fuel use, but they exacerbate the energy demand for cooling in the summer times.

Neither heating nor cooling may dominate the fuel use in a building in temperate climates, and the balance of the effect of the heat is less. As the provision of cooling is expensive with higher environmental cost, ways of using innovative alternative systems, like the mop fan will be appreciated. The solar gains would affect energy consumption. Therefore, lower or higher percentages of glazing, or shading devices might affect the balance between annual heating and cooling loads. In addition to conditioning energy, the fan energy needed to provide mechanical ventilation can make a significant further contribution to energy demand. Much depends on the efficiency of design, both in relation to the performance of fans themselves and to the resistance to flow arising from the associated ductwork. Figure 6 illustrates the typical fan and thermal conditioning needs for a variety of ventilation rates and climate conditions.

Ground Source Heat Pumps

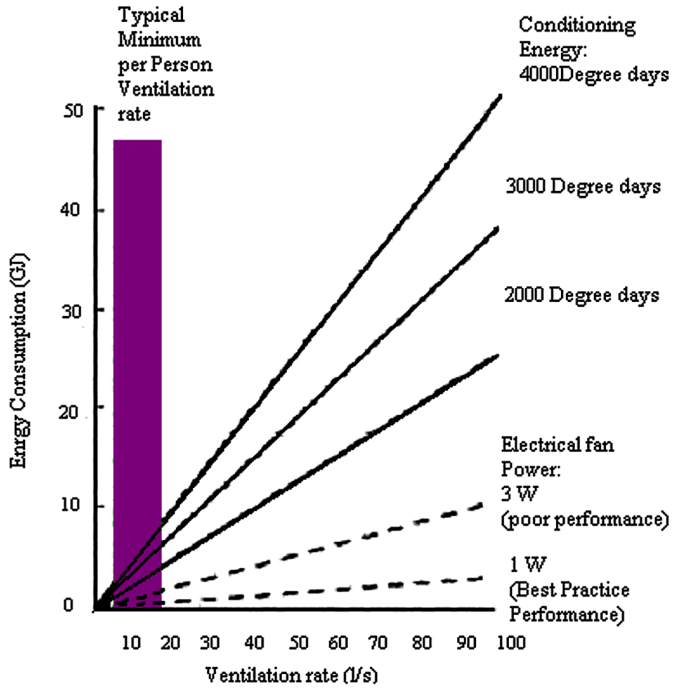
The term "ground source heat pump" has become an all-inclusive term to describe a heat pump system that uses the earth, ground water, or surface water as a heat source and/or sink. Some of the most common types of ground source ground-loop heat exchangers configurations are classified in Figure 7. The GSHP systems consist of three loops or cycles as shown. The first loop is on the load side and is either an air/water loop or a water/water loop, depending on the application. The second loop is the refrigerant loop inside a water source heat pump. Thermodynamically, there is no difference between the well-known vapour-compression refrigeration cycle and the heat pump cycle; both systems absorb heat

Table 14. West European states GHG emissions

Country	1990	1999	Change 1990-99	Reduction Target
Austria	76.9	79.2	2.6%	-13%
Belgium	136.7	140.4	2.8%	-7.5%
Denmark	70.0	73.0	4.0%	-21.0%
Finland	77.1	76.2	-1.1%	0.0%
France	545.7	544.5	-0.2%	0.0%
Germany	1206.5	982.4	-18.7%	-21.0%
Greece	105.3	123.2	16.9%	25.0%
Ireland	53.5	65.3	22.1%	13.0%
Italy	518.3	541.1	4.4%	-6.5%
Luxembourg	10.8	6.1	-43.3%	-28.0%
Netherlands	215.8	230.1	6.1%	-6.0%
Portugal	64.6	79.3	22.4%	27.0%
Spain	305.8	380.2	23.2%	15.0%
Sweden	69.5	70.7	1.5%	4.0%
United Kingdom	741.9	637.9	-14.4%	-12.5%
Total EU-15	4199	4030	-4.0%	-8.0%

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Figure 6. Energy impact of ventilation

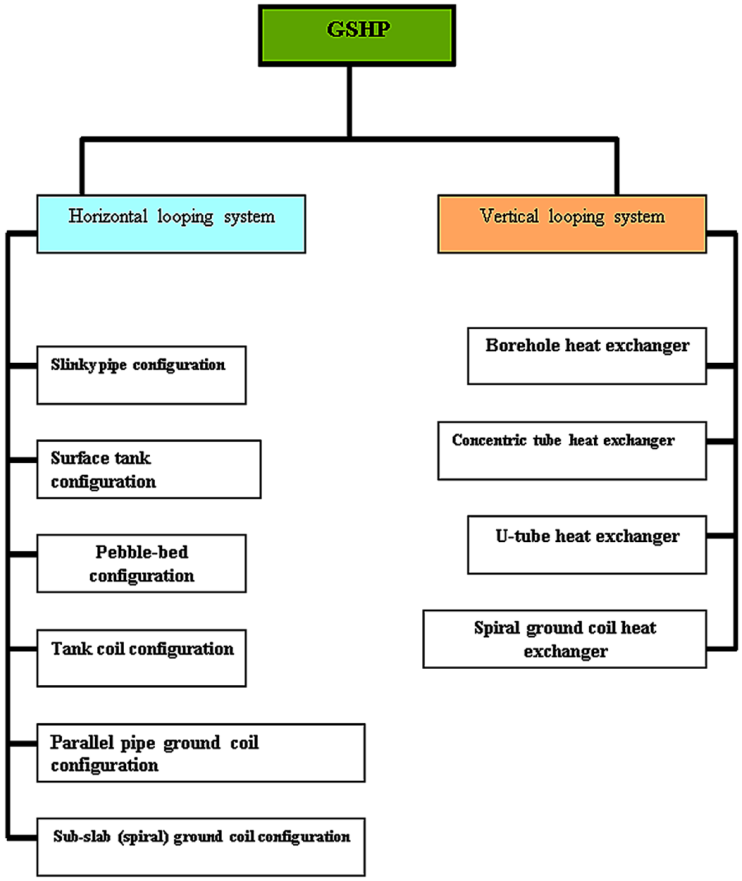


at a low temperature level and reject it to a higher temperature level. However, the difference between the two systems is that a refrigeration application is only concerned with the low temperature effect produced at the evaporator, while a heat pump may be concerned with both the cooling effect produced at the evaporator and the heating effect produced at the condenser. In these dual-mode GSHP systems, a reversing valve is used to switch between heating and cooling modes by reversing the refrigerant flow direction. The third loop in the system is the ground loop in which water or an antifreeze solution exchanges heat with the refrigerant and the earth.

The GSHPs utilise the thermal energy stored in the earth through either vertical or horizontal closed loop heat exchange systems buried in the ground. Many geological factors impact directly on site characterisation and subsequently the design and cost of the system. The solid geology of the United Kingdom varies significantly. Furthermore there is an extensive and variable rock head cover. The geological prognosis for a site and its anticipated rock properties influence the drilling methods and therefore system costs. Other factors important to system design include predicted subsurface temperatures and the thermal and hydrological properties of strata. The GSHP technology is well established in Sweden, Germany and North America, but has had minimal impact in the United Kingdom space heating and cooling market. Perceived barriers to uptake include geological uncertainty, concerns regarding performance and reliability, high capital costs and lack of infrastructure. System performance concerns relate mostly to uncertainty in design input parameters, especially the temperature and thermal properties of the source. These in turn can impact on the capital cost, much of which is associated with the installation of the external loop in horizontal trenches or vertical boreholes. The climate in the United Kingdom makes the potential for heating in winter and cooling in summer from a ground source less certain owing to the temperature ranges being narrower than those encountered in continental climates. This project will

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Figure 7. Common types of ground-loop heat exchangers



develop an impartial GSHP function on the site to make available information and data on site-specific temperatures and key geotechnical characteristics.

The GSHPs are receiving increasing interest because of their potential to reduce primary energy consumption and thus reduce emissions of greenhouse gases. The technology is well established in North Americas and parts of Europe, but is at the demonstration stage in the United Kingdom. The information will be delivered from digital geoscience's themes that have been developed from observed data held in corporate records. This data will be available to the GSHP installers and designers to assist the design process, therefore reducing uncertainties. The research will also be used to help inform the public as to the potential benefits of this technology.

The GSHPs play a key role in geothermal development in Central and Northern Europe. With borehole heat exchangers as heat source, they offer de-central geothermal heating with great flexibility to meet given demands at virtually any location. No space cooling is included in the vast majority of systems, leaving ground-source heat pumps with some economic constraints. Nevertheless, a promising market development first occurred in Switzerland and Sweden, and now also in Austria and Germany. Approximately 20 years of R and D focusing on borehole heat exchangers resulted in a well-established concept of sustainability for this technology, as well as in sound design and installation criteria. The market success brought Switzerland to the third rank worldwide in geothermal direct use. The future prospects

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are good, with an increasing range of applications including large systems with thermal energy storage for heating and cooling, ground-source heat pumps in densely populated development areas, borehole heat exchangers for cooling of telecommunication equipment, etc.

Loops can be installed in three ways: horizontally, vertically or in a pond or lake. The type chosen depends on the available land area, soil and rock type at the installation site. These factors help to determine the most economical choice for installation of the ground loop. The GSHP delivers 3-4 times as much energy as it consumes when heating, and cools and dehumidifies for a lower cost than conventional air conditioning. It can cut homes or business heating and cooling costs by 50% and provide hot water free or with substantial savings. The GSHPs can reduce the energy required for space heating, cooling and service water heating in commercial/institutional buildings by as much as 50%.

Efficiencies of the GSHP systems are much greater than conventional air-source heat pump systems. A higher COP (coefficient of performance) can be achieved by a GSHP because the source/sink earth temperature is relatively constant compared to air temperatures. Additionally, heat is absorbed and rejected through water, which is a more desirable heat transfer medium because of its relatively high heat capacity. The GSHP systems rely on the fact that, under normal geothermal gradients of about 0.5°F/100 ft (30°C/km), the earth temperature is roughly constant in a zone extending from about 20 ft (6.1 m) deep to about 150 ft (45.7 m) deep. This constant temperature interval within the earth is the result of a complex interaction of heat fluxes from above (the sun and the atmosphere) and from below (the earth interior). As a result, the temperature of this interval within the earth is approximately equal to the average annual air temperature (Roriz, 2001). Above this zone (less than about 20 feet (6.1 m) deep), the earth temperature is a damped version of the air temperature at the earth's surface. Below this zone (greater than about 150 ft (45.7 m) deep), the earth temperature begins to rise according to the natural geothermal gradient. The storage concept is based on a modular design that will facilitate active control and optimisation of thermal input/output, and it can be adapted for simultaneous heating and cooling often needed in large service and institutional buildings (Strauss, 2013). Loading of the core is done by diverting warm and cold air from the heat pump through the core during periods with excess capacity compared to the current need of the building (Tukahirwa, 2013; Valkila & Saari, 2012; Vargas-Parra, 2013). The cool section of the core can also be loaded directly with air during the night, especially in spring and fall when nights are cold and days may be warm.

DISCUSSION

Peoples rely upon oil for primary energy and this for a few more decades. Other conventional sources may be more enduring, but are not without serious disadvantages (Vargas-Parra, 2013). The renewable energy resources are particularly suited for the provision of rural power supplies and a major advantage is that equipment such as flat plate solar driers, wind machines, etc., can be constructed using local resources and without the advantage results from the feasibility of local maintenance and the general encouragement such local manufacture gives to the build up of small-scale rural based industry. This communication comprises a comprehensive review of energy sources, the environment and sustainable development. It includes the renewable energy technologies, energy efficiency systems, energy conservation scenarios, energy savings in greenhouses environment and other mitigation measures necessary to reduce climate change. This study gives some examples of small-scale energy converters, nevertheless it should be noted that small conventional, i.e., engines are currently the major source of power in rural

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areas and will continue to be so for a long time to come. There is a need for some further development to suit local conditions, to minimise spares holdings, to maximise interchangeability both of engine parts and of the engine application. Emphasis should be placed on full local manufacture. It is concluded that renewable environmentally friendly energy must be encouraged, promoted, implemented and demonstrated by full-scale plant (device) especially for use in remote rural areas.

The communication reviews various options of renewable energy sources that are possibly be applied to rural based energy needs which may wholly or partly replace the conventional sources of energy. Sustainable energy is a prerequisite for development. Energy-based living standards in developing countries, however, are clearly below standards in developed countries. Low levels of access to affordable and environmentally sound energy in both rural and urban low-income areas are therefore a predominant issue in developing countries. In recent years many programmes for development aid or technical assistance have been focusing on improving access to sustainable energy, many of them with impressive results. Apart from success stories, however, experience also shows that positive appraisals of many projects evaporate after completion and vanishing of the implementation expert team. Altogether, the diffusion of sustainable technologies such as energy efficiency and renewable energy for cooking, heating, lighting, electrical appliances and building insulation in developing countries has been slow. Energy efficiency and renewable energy programmes could be more sustainable and pilot studies more effective and pulse releasing if the entire policy and implementation process was considered and redesigned from the outset. New financing and implementation processes, which allow reallocating financial resources and thus enabling countries themselves to achieve a sustainable energy infrastructure, are also needed. The links between the energy policy framework, financing and implementation of renewable energy and energy efficiency projects have to be strengthened and as well as efforts made to increase people's knowledge through training. Different sources of energy, which can be used for different final uses. Those sources are wind power, solar energy, geothermal energy, the existing electricity production system and the conventional fuels with direct use (Figure 8). The main categories of final uses are: transportation, space heating, water heating and electricity for other uses.

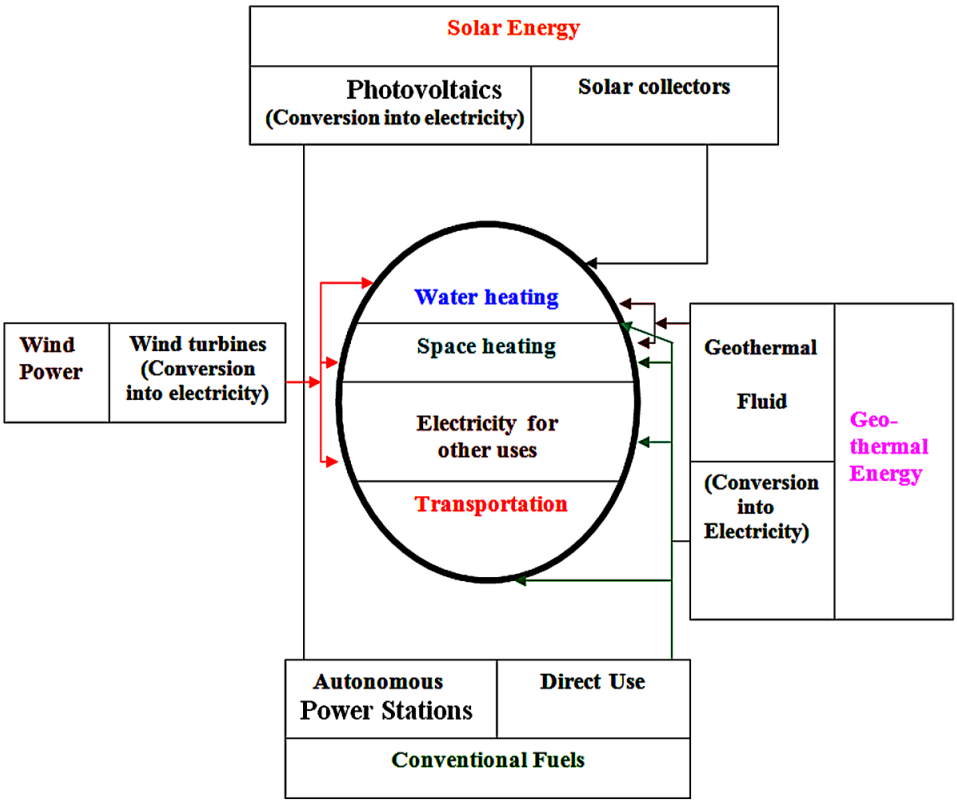
CONCLUSION

There is strong scientific evidence that the average temperature of the earth's surface is rising. This is a result of the increased concentration of carbon dioxide and other GHGs in the atmosphere as released by burning fossil fuels. This global warming will eventually lead to substantial changes in the world's climate, which will, in turn, have a major impact on human life and the built environment. Therefore, effort has to be made to reduce fossil energy use and to promote green energy, particularly in the building sector. Energy use reductions can be achieved by minimising the energy demand, rational energy use, recovering heat and the use of more green energy. This study was a step towards achieving this goal.

The adoption of green or sustainable approaches to the way in which society is run is seen as an important strategy in finding a solution to the energy problem. The key factors to reducing and controlling CO_2, which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These

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Figure 8. Energy sources their final uses



benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development.

However, by adopting coherent strategy for alternative clean sustainable energy sources, the world as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest – plantation cover, every nation's resource base would be greatly improved while the international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources.

The non-technical issues related to clean energy, which have recently gained attention, include:

1. Environmental and ecological factors, e.g., carbon sequestration, reforestation and revegetation;
2. Renewables as a CO_2 neutral replacement for fossil fuels;
3. Greater recognition of the importance of renewable energy, particularly modern biomass energy carriers, at the policy and planning levels;
4. Greater recognition of the difficulties of gathering good and reliable renewable energy data, and efforts to improve it; and
5. Studies on the detrimental health efforts of biomass energy particularly from traditional energy users.

The chapter is one effort in touching all these aspects.

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RECOMMENDATIONS

- Launching of public awareness campaigns among local investors particularly small-scale entrepreneurs and end users of the RET to highlight the importance and benefits of renewable, particularly solar, wind, and biomass energies.
- Amendment of the encouragement of investment act, to include furthers concessions, facilities, tax holidays, and preferential treatment to attract national and foreign capital investment.
- Allocation of a specific percentage of soft loans and grants obtained by governments to augment budgets of the (R&D) related to manufacturing and commercialisation of the RET.
- Governments should give incentives to encourage the household sector to use renewable energy instead of conventional energy. Execute joint investments between the private sector and the financing entities to disseminate the renewable information and literature with technical support from the research and development entities.
- Availing of training opportunities to personnel at different levels in donor countries and other developing countries to make use of their wide experience in application and commercialisation of the RET particularly renewable energy.
- The governments should play a leading role in adopting renewable energy devices in public institutions, e.g., schools, hospitals, government departments, police stations, etc., for lighting, water pumping, water heating, communication and refrigeration.
- Encouraging the private sector to assemble, install, repair and manufacture renewable energy devices via investment encouragement and more flexible licensing procedures.

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KEY TERMS AND DEFINITIONS

Biomass Energy: The energy embodied in organic matter ("biomass") that is released when chemical bonds are broken by microbial digestion, combustion, or decomposition. Biofuels are a wide range of fuels, which are in some way derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price spikes and the need for increased energy security.

Environment: The natural environment, commonly referred to simply as the environment, encompasses all living and non-living things occurring naturally on Earth or some region thereof. The biophysical environment is the symbiosis between the physical environment and the biological life forms within the environment, and includes all variables that comprise the Earth's biosphere.

Geothermal Energy: Geothermal power (from the Greek roots geo, meaning earth, and thermos, meaning heat) is power extracted from heat stored in the earth. This geothermal energy originates from the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. Heat transferred from the earth's molten core to under-ground deposits of dry steam (steam with no water droplets), wet steam (a mixture of steam and water droplets), hot water, or rocks lying fairly close to the earth's surface.

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Greenhouse Gases: Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. The main greenhouse gases in the Earth's atmosphere are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Changes in the concentration of certain greenhouse gases, due to human activity such as fossil fuel burning, increase the risk of global climate change.

Hydropower: Hydropower, hydraulic power or waterpower is power that is derived from the force or energy of moving water, which may be harnessed for useful purposes. Hydropower is using water to power machinery or make electricity. Water constantly moves through a vast global cycle, evaporating from lakes and oceans, forming clouds, precipitating as rain or snow, and then flowing back down to the ocean.

Renewable Energy: Renewable energy is energy generated from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Energy obtained from sources that are essentially inexhaustible (unlike, for example the fossil fuels, of which there is a finite supply). Energy sources that are, within a short time frame relative to the Earth's natural cycles, sustainable, and include non-carbon technologies such as solar energy, hydropower, and wind, as well as carbon-neutral technologies.

Resource Management: Efficient incident management requires a system for identifying available resources at all jurisdictional levels to enable timely and unimpeded access to resources needed to prepare for, respond to, or recover from an incident. Resource management is the efficient and effective deployment for an organisation's resources when they are needed. Such resources may include financial resources, inventory, human skills, production resources, or information technology (IT).

Solar Energy: Energy from the sun that is converted into thermal or electrical energy; "the amount of energy falling on the earth is given by the solar constant, but very little use has been made of solar energy". Energy derived ultimately from the sun. It can be divided into direct and indirect categories. Most energy sources on Earth are forms of indirect solar energy, although we usually do not think of them in that way. Solar energy uses semiconductor material to convert sunlight into electric currents. Although solar energy only provides 0.15% of the world's power and less than 1% of USA energy, experts believe that sunlight has the potential to supply 5,000 times, as much energy as the world currently consumes.

Sustainable Development: Development, which seeks to produce sustainable economic growth, while ensuring future generations' ability to do the same by not exceeding the regenerative capacity of the nature. In other words, it is trying to protect the environment. A process of change in which the resources consumed (both social and ecological) are not depleted to the extent that they cannot be replicated. Environmentally friendly forms of economic growth activities (agriculture, logging, manufacturing, etc.) that allow the continued production of a commodity without damage to the ecosystem (soil, water supplies, biodiversity or other surrounding resources).

Wind Energy: Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators. Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, wind mills for mechanical power, wind pumps for pumping water or drainage, or sails to propel ships.

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Chapter 45
Environmental Accounting for Industrial Growth and Sustainable Development in India:
An Overview and Theoretical Framework

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ABSTRACT

Environmental accounting is an important function that provides industry with a means to incorporate information with business decision making and business operations. This chapter evaluates the extent to which the process of environmental accounting can be applied as a solid foundation for industrial growth and sustainability. Having an environmental accounting system in place allows the industry to better manage environmental costs and to discover new opportunities to minimize environmental costs through environmental thinking to the industrial sector. Researchers have adopted systematic literature review as a methodology to generate strong knowledge base for the study. In this paper, the theoretical foundation of environmental accounting and reporting is discussed with reference to India. The insights gained will shed light on positive outcomes of adopting environmental accounting for sustainability and manufacturing management in the industrial sector of India.

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1. INTRODUCTION

There is a growing concern towards lack of adequate measures to ensure sustainability in our society. Environmental business management has focused its attention on how and why existing firms can become greener. The field of green management has begun to broaden its arena and recently there has been a growing recognition of the importance of several factors impacting green management such as linking sustainability and innovation, the role of small and medium enterprises in innovating products and processes keeping sustainability in mind. The importance of sustainability in strategic business development and green practices in industries is must. For an industry to have a positive environmental influence, real improvement can be created only if the production processes, products and services are environment friendly. Environment is the aggregation of the eco system of living organisms and the non living components like air, water, soil, etc. around us which together affects the livelihood of men and animals on earth. Natural Capital Accounting (NCA) is the measurement and valuation of natures benefits in terms of ecosystems, goods and services-like fresh water, flood control and forest products-to be incorporated into a general standard format consistent with conventional national accounts. (http://www.conservation.org/projects/pages/valuing-and Accounting-for-Natural-Capital)

Natural capital accounting (NCA) gives insights on how economic development depends on natural resources both for production as well as for absorption of effluents and pollution. This information will help policy makers while charting the development plan.

A native American proverb states that, "Only when the last tree is cut, only when the last river is polluted, only when the last fish is caught only then they will realize that we cannot eat money." In this background, it is not only imperative that we are aware of the importance of and need for sustainable development but it is also a requirement to bring on record and report to the stakeholders the extent of environment friendly measures or otherwise adopted and practiced by the organisation. Environmental accounting thus plays an important role in this regard and is now gaining importance in the reporting function of an organisation.

In the early 1970's, Norway's ministry of environment initiated the first natural resource accounting system which was later followed by other countries. In India environmental accounting is optional. Since the 1990's, Europe has been focusing on sustainable accounting indicating that the accounting profession has a significant role to play through environment sustainability reporting. Accounting for social economic and environmental aspects and reporting the same for decision making of internal and external stakeholders is facilitated through financial statements A customized format for identifying and recording environment related data can be created for disclosure. Business is an integral part of society and such disclosure shows the responsibility and commitment of the entities. Many researchers have discussed environmental accounting with reference to India and it is noted that awareness and adoption of environmental accounting is not a choice but a necessity. Since the new economic policy 1991 was implemented in India, the intensity of global competition has increased. Eco auditing is essentially related to Green accounting (Jasch, 2001). Green accounting is concerned with the appropriate analysis and reporting of environmental issues of an organization.

The present civilization is involved in various economic and non-economic activities which generates waste with potential constituents. Responsibility towards the environment is one of the crucial areas of social responsibility. Environmental pollution is a worldwide phenomenon and we must not forget that the earth's environment has been handed to us by the previous generations and nature. Wealth is enough to satisfy everyone's need but not their greed. Therefore environment protection is a critical issue in the

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present day context. The indiscriminate disposal of such wastes contributes towards the environmental pollution and hazards. At present, the magnitude of environmental pollution is increasing at a very alarming magnitude in different parts of the globe.

Environmental issues are currently receiving due attention from the public and private sector. It has become crucial especially for manufacturing industries, to carefully monitor the effects of their activities on the environment. There exists a correlation between manufacturing industries and cost and challenges these industries need to face in the process of implementing environmental management accounting. Some of the companies adopt internally developed environment policies but they also face challenges in defining, separating, identifying, classifying, measuring and controlling the environmental protection cost. Namakonzi & Inanga. (2014).

The importance of environmental accounting information for management supports the prevalence of decision making usefulness theory in the implementation of environmental management systems. Nowadays members of the society appreciates the ill effects of exploitation of the environmental resources and are therefore concerned about the same. Environmental awareness is the new value emerging in our society and the same values need to be incorporated in the industrial sector. Every organisation needs to articulate its environmental management policy through an information system that helps to analyze the interaction between firms and environment. Being a corporate citizen, an entity is evaluated by its financial as well as environmental performance. The Indian corporate sector needs to improve as far as environmental performance. Laws have been laid down and amended for them to fulfill corporate social responsibility for the economic development of the Indian Economy. In the global and Indian context, environmental responsibility is of vital importance and a very crucial area. India being a developing country whose focus is on growth and development must ascertain the benefits and costs of environmental damages and degradation. The gross domestic product is highly impacted due to the environmental cost. Accounting is a language of business and it is very important that through accounting, the government and entities should fulfill the responsibilities towards the environment by measuring and reporting the costs of used or misuse of natural resources. Thus the need of environmental accounting has emerged. At the global level, the environment movement has grown giving birth to the United Nations Environment Programme (UNEP). When environment issues became a worldwide problem in the 1980's the world commission on environment and development (WCED) known as Bruntland commission was established by the United Nations. It published a report on sustainability called "Our common future."

Green economy has become the language at the global level to develop the environment. There are different social dimensions of sustainability and many concerns in the emerging framework for sustainable development. It is very important for the industry to raise general questions about measuring sustainability and to focus on sustainable economic renewal. Davies & Mullin (2011).

1.1 Environment Accounting: A Conceptual Analysis

Industries utilize natural resources for their production process. Consequently, it leads to environment pollution and degradation. Environmental consciousness is increasing day by day at the global level. The role of sustainable development is major and central as an organizing principle in industry as human activity and its impact on environment has become more evident. The two major concerns emerging out of it is to address innovation in our mode of thinking and policy in practice settings to explore knowledge. One outcome is development of different disciplines progressing sustainable development like sustainability science. Bebbington & Larrinaga (2014).

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Corporate stakeholders need to pay attention on environmental accounting for reducing and avoiding costs and to improve the quality of the environment. Environmental accounting can be supported at the micro and macro level in relation to financial accounting, cost accounting and managerial accounting. Industrial, commercial and service industry at different levels must measure and evaluate the actual environmental impacts of various projects for development decisions which are economically and environmentally sound. Issuance of environmental regulations for new solutions needs to be updated for which accounting can play a vital role.

The consequences of environmental accounting are on the economic, social and legal status of a nation. Undoubtedly, the industry enjoys the competitive advantage by following proper environmental management. Government policies have not come out with great outcomes in this regard. It is very important for a developing nation like India to come up with incentives and rewards for quality environmental reporting. Stakeholders expect the business entities to meet environmental standards. Smith (2002) and companies need to provide environmental management system to support the same. Fortis (2002).Accountants that are responsible for the communication of business need to open their eyes to the impact of environmental issues on accounting, auditing and disclosure. Globally accountants are expected to be proactive and show their concern for the environment protection process. Liberalization and globalization has made environment accounting of vital importance today.

Environmental accounting is a growing field. Industries are taking serious attempts to identify the environment issues by the business houses. There is no single definition encompassing the scope of Environmental accounting. Data that have been included in the environmental accounts of different countries includes pollutant eminents in physical terms by economic sector, actual environmental protection expenditures by economic sector and hypothetical expenditures that would be required to further reduce pollution(sometimes called "maintenance cost"), by economic sector.

It assesses the costs and benefits to an enterprise due to environment preservation activities that are undertaken. Environmental accounting involves the identification, measurement and allocation of environmental costs, the integration of these costs into business, identifying environmental liabilities if any and finally communicating this information to the company's stakeholders.

The three main aspects of environmental accounting are—economic, social, and environment (Ball 2005; Milne 1996). Studies have been conducted for evaluating the financial and sustainable impact on financial management (Lamberton, 2005; Schaltegger & Wagner, 2006; Taplin, Bent & Aeron-Thomas, 2006). Gray (2006) was concerned that sustainability accounting must include revealing the right information to stakeholders for a sustainable organization. As a consequence, sustainability accounting needs to take care of environmental and social accounting issues. Environmental accounting and its disclosure is not mandatory. In the current era environmental problems are vital issues which makes environment accounting a strong branch of accounting. Legal authorities and standard setting bodies have made a conceptual framework of environmental accounting and its disclosures. Pramanik et al (2007).

Major functions of environmental accounting are to minimize the negative environmental effects of old accounting practices, to know environment related costs and to take active steps to set up initiatives in order to ameliorate the existing environmental effects of conventional accounting practices. Published sources of ACCA acknowledge full environmental costing to be adopted by business. Bebbington, Gray, Hibbit & Kirk (2001).

The forms of environmental accounting are environmental management accounting (EMA), environmental financial accounting (EFA) and environmental national accounting (ENA).EMA is an internal environmental accounting tool to support sustainable environmental management activities and environ-

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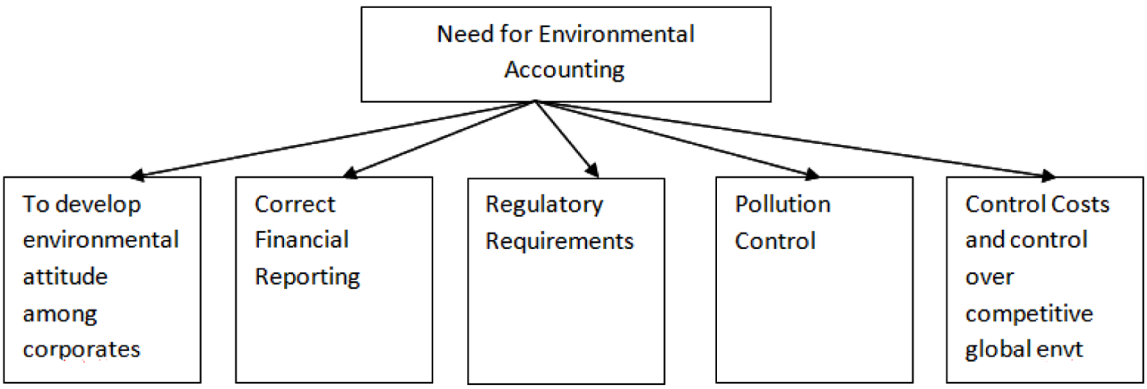
mental reporting. It includes segment environmental accounting, eco balance environmental accounting and corporate environmental accounting. EMA emphasis on energy and material flow information and environmental cost information. Economic performance is evaluated through environment management accounting theoretically, the concern remains rare. Christ & Burritt.(2013). It's an internal environmental accounting tool to select a project or investment activity. It consists of segment environmental accounting, eco balance environmental accounting and corporate environmental accounting. Segment environmental accounting includes environmental accounting tool to select an investment activity, eco balance environmental accounting talks about sustainable environmental management activities and corporate environmental accounting is concerned with informing proper financial reporting in accordance with environmental accounting. EFA focuses on environmental liability cost and other environmental costs. EFA is a method of reporting environmental liability cost and other significant environmental cost through financial accounting. ENA focuses on natural resources and environment cost at the national level. The specific focus of ENA is natural resources, stocks and flows, environmental cost and externality costs, etc.

The need for environmental accounting includes the factor show in Figure 1.

Environmental accounting is required to fulfill the responsibility of different stakeholders. The objectives include increasing environmental transparency, to determine positive relation between the company and society. The environmental accounting consumerism movement launched by the environmental lobby groups encourages the consumers to purchase environmental friendly products. Industries producing green products enjoy marketing advantage by doing so. Through this method of accounting, industries can show commitments by making environmental disclosures. Industries that are not focused on environment friendliness may use green accounting to overcome negative public opinions.

Due to environmental accounting, environmental awareness is enhanced and environmental commitment becomes a shared responsibility amongst the stakeholders. Environmental costs can be offset by generating higher revenues through sale of by-products or recycling. It helps in deciding cost of the product and helps in focusing perpetually on natural resource asset. Sustainability at the ecological level enhances national wealth and national economic accounts to find an economy's total wealth. It is important to know the physical flow accounts to determine the right policies by taking into consideration data on pollution and waste along with designing and evaluating environmental taxes. To asses economic progress there is a need to meet regulatory requirements of the industrial sector, to operate in an environmental friendly manner with an environmental attitude controlling operational efficiency and optimize cost and

Figure 1. Need for environmental accounting



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waste. The important aspects of environmental accounting involves both internal and external factors. Internally they are the business and the investment made by the industry for minimizing losses to environment. This includes environment saving equipment and measurement in monetary terms is possible. Externally it constitutes costs of de gradation and destruction of soil, coastal and marine pollution and exploitation of non renewable sources like minerals, gas etc along with deforestation and land use. This step of accounting is very challenging and complicated. It is difficult to measure the loss accurately.

2. ENVIRONMENTAL ACCOUNTING IN INDIA: AN OVERVIEW

The developing countries like India are currently facing the challenge of promoting economic development without causing any negligence to the environment. A tradeoff between environmental protection and development is a major concern today. The concern of environmental responsibility and the sustainable industrial development has given rise to a novel branch of accounting known as environmental accounting.

Accounting is defined by the AICPA as "The art of recording, classifying, and summarizing in a significant manner and in terms of money, transactions and events which are, in part at least, of financial character, and interpreting the results thereof."

Following the end of the British rule, India plunged into serious troubles of communal riots. Initially India did not pay much attention towards the environment. The five year plans were implemented with a view to the economic development of the country. The second five year plan focused on industrial development. But the plans remained unconcerned about protecting nature. The public awareness on environmental issues grew after the beginning of the seventies when a law for protection of environment was passed. As there was requirement of environment related information from business on a periodic basis, the ministry of environment and forests has proposed that every company shall in the report, in the report of its board of directors disclose briefly the measures taken towards the adoption of clean technologies for the prevention of pollution, waste minimization, waste recycling and utilization, pollution control measures, investment on environmental protection and its impact.

Countries like India have to focus on environmental problems as well as make sure that the pace of economic development is high. Therefore it is must to have a tradeoff between the two. Proper evaluation of cost and damages to the environment should be studied to know the impact of major problems in terms of monetary costs. Environmental accounting will work as a tool to enumerate economic efficiency and environmental efficiency as a whole. In India disclosures related to environment in the corporate annual reports both financial and non-financial is not an encouraging level. Neither company law nor the accounting standards issued by ICAI prescribes disclosing norms for environment related matter in the corporate financial statements. There is a lack of environment awareness, poor enforcement of the of the environment protection acts is also partly responsible for freeing the companies from disclosure of such information. In the absence of standardized environmental accounting practices and disclosure techniques at both national and global level along with legal enforcement to advocate environmental accounting practices from a global perspective.

In the past, issues related to the environment were ignored by, large companies and small medium enterprises to a great extent. However, due to increasing concerns and awareness environmental accounting is receiving increased attention in the recent times. Many companies now consider it important to be green and follow green practices, as many investors place a high value on environmental responsibility. Environmental costs can be significantly reduced and eliminated due to business decisions, ranging

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from operational to investment in greener process technology to redesign processes or products. Better natural resource and green accounts would provide valuable insights into the interaction between the environment and the economy. Industrialization is the main cause for environment degradation. Though it is vital for economic growth, but it drastically damages the environment. Optimum utilization of resources is the prime responsibility of every industry which has given birth to a new branch of accounting called environmental accounting. It is a must for organizations to implement the concept of sustainable development for balancing ecological activities and to measure the organization in an economic manner.

In the early 1990's Indian companies faced cut throat international competition wherein International firms disclosed non-financial information including environmental information to meet the expectation from Indian companies and to improvise their corporate image showing socially responsible behavior. Thus it was expected that Indian companies should report their environmental performance. But the disappointing part is that in the developing countries very little attention has been given to the state of environmental accounting. (Ahmed & Sulaiman, 2004; Thompson & Zakaria, 2004; Nafez & Kamal, 2000). Pahuja (2009) concluded that companies which have better environmental performance provide more environmental information in the annual reports as compared to poor performers. Her study also indicated the existence of statistically significant ''size'' and ''profitability'' effect. Hence, larger and more profitable companies disclose more information on environment as compared to smaller and less profitable companies. Environmental reporting by the public sector is higher than the private sector. Jaffar et al (2002) measured environmental performance on the basis of legal action taken on companies for noncompliance of environmental regulations by the department of environment. Companies having better environmental performance disclose more on the environment.

Rapid industrialization growth has great effect on the environment and is of major concern to the economy. The government has been supporting small enterprise sectors and they are tended to be the worst polluters. It is very important to pay attention to environmental issues as a part of their operations. Although existing environmental legislations serve some purpose of protecting the environment, the small scale and large enterprises have significant differences in the way they approach environmental issues (D'Souza & Peretiatko, 2002)

2.1 Environmental Accounting in Indian Industry: The Road Ahead

Eresi (1996) in his study disclosed that companies gave only positive information about the practices adopted by them in the context of environment conservation. Kumar (2002), examined the Indian Scenario and stated that accounting and reporting aspects of environmental protection is a must for policy statements in an annual report and emphasized that the environmental reporting in India was limited to little more than a sentence or two each in the annual report. Vasal (1998) administered a study on 144 companies found that the practice of preparing stand-alone environmental reports was yet to rake roots in India. Roy (2000) observed that companies giving environment disclosure in the public sector was more than in the private sector. Pradhan & Bal (2002) agreed that a company must reveal information environmental policy, environmental audit report, future targets. Shah analyzed 50 annual reports of large and medium sized companies and found that hardly any company report on failure regarding environmental protection or damage caused by the company to the environment and society. Environmental issues are of low priority for some companies who consider environmental protection as a trustee duty. Industries who consider environmental goals are supplementary to the business attempt to pilot and

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control environmental impacts in an efficient manner, industries located in the upper right hand treat environmental issues as central to their core business

Environmental accounting can be implemented by industries of large, medium and small scale sizes. Whether administered by a global corporation or a small business, elements need to be in place for success. The business entities management must support these practices. These leaders need to focus in setting a positive tone when communicating the benefits of environmental accounting practices to the employee population and implementing it. Consisting of employees across all business lines, including finance, sales, manufacturing and procurement, these teams ensure that all environmental accounting policies and procedures are communicated and followed. The green entrepreneurs activities have an overall positive impact on the natural environment and moves towards a more sustainable future. All their business is structured and operated in such a way that every component has a neutral or positive impact on the environment. Environmental and social entrepreneurs, or ecopreneurs, lead socially committed, break-through ventures that are driven by environmental, social and economic goals. There exists a strong link between youth entrepreneurialism and environmentalism. A model called as Green-Works business model has been developed for attaining sustainability of the environment and social objectives of the organization. Sarah E.A. Dixon et al. Entrepreneurship can be driven by moral attitudes. Anderson (1998).

It has become important to give ecopreneurship a serious consideration as we are rapidly losing our natural resources which are the true capital of any nation. Unlike past decades where economic gains were the only measure of a nation's progress, now a day's sustainability is given high importance. Joshi, TOI. Environmental awareness and reporting in India is a wide road ahead to understand the reasons for environmental disclosure by taking into consideration the global scenario. Due to the depletion rate there is a contradiction in the growth of renewable resources and growing demand. Industries need to realize and make a genuine attempt on the optimum use of resources and curtail environmental damage. Initially GNP was considered growing with the growth of industrialization and technological advancement, but in reality industrialization has resulted in heavily polluted environments having a negative impact on the quality of life. Therefore industries must realize the prime responsibility for clean technologies which would contribute to the nation in the long run. Cost volume profit (CVP) analysis, standard costing and variance analysis cannot be adequately used as a measure of control in the present manufacturing system. (Bromwich and Bhimani, 1994; Kaplan, 1983; Lucas, 1997). Production process and less labor usage consequently may lead to non-existence of above tools (Drury et al, 1993; Hilton, 2002).

Economic, social and ecological systems of environment integrate to sustainability. Thus companies need to acquire sustainable development. Dixon & Fallon (1989).A sustainability management accounting system (SMAS) refers to sustainability and management accounting concepts and practices that deal with environmental and social issues. Development areas are related to human, social, economic and environmental aspects. Goodland (2002).

Environmental accounting seeks to better measure sustainability by expanding gross measures of national welfare (product, investment, etc.) to include non-market values, in particular ones associated with environmental goods and services. In addition, it also seeks to incorporate costs and benefits of environmental protection and depletion of natural capital – two measurements not typically included in national accounting systems such as gross domestic product. While opinions vary on how to perform green accounting, the technique is used worldwide and is well-established in the US.

Indian industry needs to have accounting practices which are conservative and innovative. It is very important to develop future accountants who can measure environmental degradation in quantitative

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terms. It is a challenge and duty for India to understand the importance of the implementation of environmental accounting in the curriculum. Business should take care of social environmental liabilities.

Since 1991, the liberalization of the Indian economy has increased the pressure for international competition and changed the information needs of Indian companies. The future emphasis in India is on traditional practices and less on the new techniques, because higher benefits were derived from such techniques. Size (total assets) has an influential factor in the adoption of the newly developed practices. Most of the differences could be attributed to the differences in cultural values. Indian management generally avoids risk, is quite conservative, and less innovative in adopting new management accounting techniques. Since, Indians have a long history of their heritage; it takes them longer time to change their societal values and practices, which also seems true in the case of adopting new management accounting practices. Due to cost pressures, customer awareness, supply chain relations and activities of environmental campaigners encourage the companies to go for environmental initiatives Perry & Sheng(1999). Developed countries are highly concerned with the quality of their lives due to the arising alarm of pollution. The same concern is shared by developing countries hence; many laws pertaining to environmental protection are enacted. Industries need to integrate environmental issues into their strategic planning process. Banerjee (2001).

3. ENVIRONMENTAL ACCOUNTING: THE REGULATORY FRAMEWORK COST AND BENEFITS

Environmental accounting and reporting practices are in the evolution stage in India. Even though Indian industries comply with the rules and regulations with regard to environmental protection, till now no clear cut policies are formulated at the National, State or even at the industry level, for ensuring the level of compliance to environmental norms. Indian practice, voluntary environmental reporting with regard to the environmental parameters identified.

There has been an increased trend towards environment management and disclosure in annual reports, but meaningful disclosure has not been achieved in socially related company activities such as pollution control. So, reporting is yet to attain the desired shape in terms of both the quantity and the quality. This shortcoming may be because of the absence of any standard specifying the kind of information required to be disclosed, and the absence of any compulsion on the firms regarding such disclosures. Regular attempts have been made in this regard in the different countries to streamline the environmental reporting practices for industry. They are yet to come up with form of legislations; a comprehensive accounting standard. In India, a few such legislations require submission of different environment statements to be respective regulatory bodies. But nothing exists by now, which requires disclosure of environmental information through annual reports. In such situations it is quite encouraging to note that industries are voluntarily disclosing environmental (howsoever inadequate that may be) through their annual reports. Data on environmental accounting plays an important role to different users at different levels for different reasons. Now a days there is a huge demand on financial and economic data on environmental and natural resources for civilizing environmental performance and for the own self interest of the industry. Singh & Joshi. (2009).

Industry environment reporting is an important tool for developed countries driven by legal compliance. Green economic development aims at reducing environmental damage and government regulations along with voluntary self regulatory measures to curtail the impact on local environment is a must.

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Such environmental management practices should be synchronized in different sectors of the society to promote green economic development. Gibson &Collins.

In the constitution under the directive principle of state policy‟ it is expressly mentioned that it is the duty of the state to protect and improve the environment and to safeguard the forest and wildlife of the country.” It is the fundamental duty of every citizen of India to protect and improve the natural environment including forest, lakes, rivers and wildlife.‟ Government of India enacted numbers of laws which can directly and indirectly help the protection of environment and natural resources. In addition to that union ministry of environment and forest and corresponding state governments have made a provision for environmental clearance before any industrial unit actually set up. However, there is no any specific guideline regarding accounting and disclosure of environmental cost and liabilities except provisions of company about disclosure of conservation of energy, technology absorption in director's report under sec 217(1). Recently ministry of corporate affairs laid more emphasis on corporate social responsibility and accordingly issued national voluntary guidelines on social environmental and economic responsibility of the business in 2011. In such guidelines, it also mentions that business should provide goods and service that are safe and contribute to sustainability throughout their lifecycle. It is explicitly mentioned that business should respect, protect and make efforts to restore environment. In pursuance of that a business should report:

Percentage of materials used that are recycled input materials, total energy consumed by the business entity for its operations, statement on use of energy saving processes and the total energy saved due to use of such processes, use of renewable energy as percentage of total energy consumption, Total water consumed and the percentage of water that is recycled and reused, statement on quantum of emissions of greenhouse gases and efforts made to reduce the same, statement on discharge of water and effluents indicating the treatment done before discharge and the destination of disposal, details of efforts made for reconstruction of bio-diversity.

The disclosures of above mentioned information are voluntary and there are no specific guidelines on format of reporting. On the other hand accounting standard board and Ministry of Corporate Affairs is till silent on environmental accounting and disclosure issue in corporate accounting and reporting. Environmental conservation benefit is measured in physical units and is the benefit obtained from the prevention, reduction, and/or avoidance of environmental impact, removal of such impact, restoration following the occurrence of a disaster, and other activities. By assessing the economic value of environmental conservation benefits which are measured in physical units, results are described in monetary values by some cases. Currently, in the field of environmental economics, a number of valuation methods are being developed for the purpose of determining the environment's economic value.

At the global level, environmental protection concern has increased; countries like India also had to set up a union ministry of environment along with essential legislations for coordination among the states and various industries. Although licensing for industry is abolished in India but environmental clearance is of vital importance.

The various laws relevant to environmental protection are as under: (a) Directly related to environment protection: i. Water (Prevention and Control of Pollution) Act, 1974. ii Water (Prevention and Control of Pollution) Cess Act, 1977. iii. The Air (Prevention and Control of Pollution) Act, 1981. iv. The Forest (Conservation) Act, 1980. v. The Environment (Protection) Act, 1986. (b) Indirectly related to environment protection: vi. Constitutional provision (Article 51A). vii. The Factories Act, 1948. viii. Hazardous Waste (Management & Handling) Rules, 1989. ix. Public Liability Insurance Act, 1991. x. Motor Vehicle Act, 1991. xi. Indian Fisheries Act, 1987. xii. Merchant of shipping Act, 1958. xiii. Indian Port

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Act. xiv. Indian Penal Code. xv. The National Environment Tribunal Act, 1995. It is important to note that all new projects require environment clearance. This clearance concerns both the Union Ministry of Environment and Forests and the corresponding State Govt. department of environment. Guidelines have been issued and all such projects are expected to obtain environmental and antipollution clearance before they are actually set up. A Central Pollution Control Board (CPCB) has also been set up. Wherever cases of violating of standards of water or air pollution have been detected, show cause notices have been issued to industrial units and all such units are being kept under regular inspection. (A report on environmental accounting: a general overview and Indian perspective social statistics division central statistics office ministry of statistics & programme implementation New Delhi).

System of integrated environmental and economic accounting (SEEA) is concerned with integrating different methodologies into an organised framework. It comprises of pure physical data relating to flow of material and energy, it takes those elements that are relevant to good management of the environmental and has environment related transactions and accounts of environmental assets measured in physical and monetary terms. It emphasis on depletion, defensive expenditures relating to environmental degradation.(Green National Accounts in India A Framework A Report by an Expert Group Convened by the National Statistical Organization Ministry of Statistics and Programme Implementation Government of India March 2013). It is vital to implement environmental accounting system for accurate information on environmental analysis, Mein-chin (2002), as it will ensure environment friendly management decisions. The usage of environmental accounting has changed over the past 2 decades. Now it is an important source of information for a company's manager. Schaltegger et al (1996).International accounting standards address the general principles for the measurement and disclosure of environmental matters in the financial report. (IAS 37). Any industry failing to comply with legal compliance requirements concerning environmental matters may face fines and penalties. It is important that some entities must recognize environmental obligations as liabilities in the financial statement. For example: obligations related to solid waste. The industry in which the entity operates must focus on environmental issues and should have accounting treatment adopted for environmental cost and environmental restoration liabilities (Pinckard & Wendy, 2000).

Environmental accounting techniques and the incomplete efforts of accountants and their allies to overcome environmental issues makes it mandatory to explore cost–benefit analysis. The identification and allocation of environmental costs requires accounting and book keeping knowledge. There is no universally accepted definition of environmental cost. It depends on the industry and its entity how the information will be used. Bouma (1998). According to the United Nations division for sustainable development, "the main problem of environmental management accounting is that we lack a standard definition of environmental costs". Environment cost that has been incurred by an entity with no return or benefit like damages done which cannot be recovered is environmental loss. The Canadian Institute of Chartered Accountants (CICA) (1993)Environmental cost can be listed as atmospheric emissions waste, energy consumption, material usage, oil & gas consumption, packaging, transportation costs, waste and waste resource use. By integrating social and ecological costs and benefits resulting from the natural environment into traditional economic accounting systems, green accounting aims to capture the interdependency and dynamic interactions between the three pillars of sustainability (economy, society, and environment). More accurately valuing natural resources costs and benefits may contribute to the development of more appropriate and sustainable economic, trade, and development policies.

Product related cost and research and development expenditure incurred can be categorized as capital investment, operating costs, research and development cost, environment administration and planning,

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expenditures for remedial measures and recovery measures (Pramanik, 2002). From the time of acquisition to the cost incurred for capitalization of environment expenditure needs to be justifiable to mitigate environmental contamination. Contingent environment liability may or may not occur but to compensate a third party suffered is an obligation to pay future expenditure for environmental damage. Quantifiable environmental liabilities are shown with the accurate balance in the balance sheet and unquantifiable one are shown as foot notes explaining the nature. All natural assets are environmental assets but not vice versa (Mohamed, 2003).

4. HOW CAN ENVIRONMENTAL ACCOUNTING CONTRIBUTE TO THE SUSTAINABLE INDUSTRY GROWTH?

Sustainability is recognised the world over as the litmus test for any new project to be launched. The process of sustainability is uninterrupted and has forms diversity Rizkallah & Bone (1998). Mebratu (1998).The World Commission on Environment and Development was asked to formulate a global agenda for change. The General Assembly of the United Nations was called upon to propose long-term environmental strategies in order to achieve sustainable development. The term sustainable development was discussed by the World commission on environment and development in 1987 in their report which was titled as "Our Common Future". Sustainable development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development (1987). Our Common Future. Oxford: Oxford University Press, p.43.) is supposed to be the global mission, necessity and hopefully, reality. Awareness of this problem1 leads to the fact that "all the world is in the same boat", that everyone should somehow contribute to the sustainable development and to communicate about problems, activities and accomplishments in this threatening area. Sustainability needs to pay attention to the poor of the present and future generation as they are the wealth of the nation. Sen (2013). Kordestani et al. (2015) have summarized the area of research towards developing sustainability. Manners in 2014 proposed sustainability economics as subservient to society. The concept of sustainability is important for all stakeholders, who take and implement the concept of sustainability in different stakes. Felix et al (2015). HR policies and interventions are pivotal to the success of sustainability (Dubey & Gunasekaran, 2015).

The heart of sustainable development is accountability of socio-economic policies for their environmental impacts. Development analysis comprises of non-economic objectives that do not lend themselves to monetary valuation. Integrating environmental concerns into economic policies is accounting for economic performance. Social evaluation of these objectives by means of norms, standards, and targets is required for integrated development.

Long term sustainability can be achieved through environmental instruments to decrease environmental footprint and for the betterment of relationship with the stakeholders. It is very important for an industry to comply all their operations with the principles of sustainable development as far as environmental responsibilities are concerned. They must inculcate more and greener environment practices in their business strategies for which developing and implementing environmentally sustainable practices and assessment of the same through environmental accounting and reporting need to be emphasized. Sandra & Dubravka (2014).Environment problem impacts every area globally and it is very important to study and explore the roots of environmental accounting (Moorthy, Yacob) 'Green procurement' practices and conceptualizes a strategic framework is required to further strengthen the linkage between the business

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entity and industry. Dubey, Bag, Ali & Venkatesh (2013). The need for consistent, decisive environmental accounting principles is pervasive. A loss of nature's carrying capacity entails damage from an accounting perspective. Generally accepted accounting principles illustrate the need for environmental accounting. Environmental accounting entails a subset of GAAP and gives a holistic picture of both financial activity and associated risks. It would require additional disclosure to cover environmental contingencies; thus creating better awareness of a firm's overall financial position, and better educating management.

Accounting is a product of environment and it is shaped by the environment. (Choi & Mueller, 1992; Perera, 1989; Radebaugh & Gray, 1993). Core sectoral company's disclosure covering informational needs of stakeholders supports suitable framework for environmental disclosure. Environmental accounting is an emerging issue required to support the Indian industry. Incorporating environmental accounting into national economic accounts could provide a measure of sustainability; however, considerable advances in methods of measurement and valuation are needed. From a purely accounting perspective, particular forms of capital could be diminished or, in an extreme case, wholly eliminated without decreasing overall welfare if other forms can be substituted for it. There are, of course, no substitutes for the life-sustaining services of nature and the question of when and how to account for this fact is the source of many ongoing debates in green accounting.

To progress from an economic and social angle without endangering the natural equilibrium of the planet is a primary condition for sustainable development. Citizens as well as industries as their true stake of the future must avoid environment degradation. Environmental accounting is the expression of a new ethics that answers to the human worries for planetary development and progress. Letiţia & Dănuleţiu (2010).The progress and welfare of an economy is measured by the per capita income. Per capita income is calculated by dividing population with the national income. National income accounting is a tool for economic analysis reflecting changes in investment, savings, structure of industry, etc. Environmental degradation and scarcity of natural resources has a negative impact on development. Deterioration of environment and scarce natural resources add to the cost of development. Increase in the cost can hamper the future development of an economy. Some of the overarching methods currently in use for green accounting include natural resource accounts; emissions accounting; disaggregation of conventional national accounts; value of non-marketed environmental goods and services; and, green gross domestic product.

Identifying such costs promotes better decision making and better utilization of resources. In addition, it gives an incentive to management to save on environmental protection costs such as pollution reduction, fines, waste management, legal fees, monitoring, insurance, and regulatory reporting and consequently improve the environment. This calls for accountants to adopt and understand better environment management and accounting systems that can aid in identification, classification, allocation and control of environmental costs for better decision making and better environmental management among other benefits. Roger Adams, (2002) affirms that much of the interest surrounding environmental issues has been directed at external reporting and financial accounting and less in EMA which is intended for internal decision making. Environment accounting might also avoid huge, but predictable swings in revenue and expenses. Environmental economists are, in fact, already attempting to place a value on nature's services, something that a generation or two ago might have been considered unquantifiable, or worse, limitless. Many critical environmental valuations and estimates, accountants are the natural leaders for a team of professionals necessary to incorporate all of this valuable environmental data into a financial reporting package.

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Industrial sustainability is a great challenge and accounting as a source of information can meet the criteria of sustainability. The 'going concern' principle outlines the accounting point of view of sustainability. Pollution control, equitable distribution of wealth poses challenges to industry. Sustainability is a concept understood at the global level and applied at the organizational level (Gray & Milne, 2002). Industrial sustainability is a situation of achieving economic, social and environmental performance.

Raising awareness of environmental issues and developing guidelines to assist identification of environmental issues and evaluation and reporting is required to provide education programs across disciplines focused on environmental issues and their accounting treatment. Indian civilization has a long tradition of taking care of the environment.

It includes Environmental conservation benefit associated with the inputs of resources into business operations, Environmental conservation benefit associated with environmental impact and waste emissions from business operations,

Environmental conservation benefit associated with the goods and services produced by business operations and Environmental conservation benefit associated with transports and other operations.

New methodologies and concepts for the successful implementation of environmentally sound and sustainable socio-economic development has increased its attention globally and has been emphasized in the report of world commission on environment and development.

5. LIMITATIONS OF ENVIRONMENT ACCOUNTING

Environmental accounting has various limitations which include difficulty in measuring cost and also measuring the benefits of environmental accounting. It is very critical to evaluate the right environmental cost and benefits in a systematic quantitative manner. Another paradox is consideration of internal cost and exclusion of cost to society. As of now, there are no standard accounting methods for environmental accounting. It is very difficult to do an intra firm comparison analysis between two firms and two countries. It is almost impossible to track the use of energy and material.

The limits of the accounting regulations to distinguish the environmental cost are an obstacle to the internalization of environmental externalities and do not support the main issue of a proactive environmental system. Bracci & Maran.(2013)

Valuation techniques for environmental goods and services are imperfect and shadow prices depict only partial valuations. The change in values for environmental goods and services are uncertain. Economic values are marginal and incremental, not absolute and total reliable industry data are not readily available. Environmental accounting is an ongoing and a long process, it needs to be integrated with financial accounting which in turn makes it complicated. Environmental accounting is a longitudinal process. Therefore, to draw a conclusion with help of it is not easy. Integration of environmental accounting with financial accounting, cost accounting and management accounting is a difficult task. User of environmental accounting needs to have adequate knowledge about rules and regulations and environmental aspects. In India, environmental accounting is still in the developing phase. It is a must for the corporate to formulate firm environmental policies for sustainable development.

Costs and benefits relevant to the environment are not easily available and measurable. Proper tracking of the use of energy and material or the cost of inefficient materials use, waste management and related issue is not done by many business and the Government organizations and they underestimate the environmental cost. It mainly considers the cost internal to the company and excludes cost to society.

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The user of information contained in the environmental accounting needs adequate knowledge of the process of environmental accounting as well as rules and regulations prevailing in that country either directly or indirectly related to environmental aspects.

6. CONCLUSION

The primary challenge of environmental accounting is the absence of standards in identifying all that needs to be measured and deciding how it is to be measured. A number of initiatives have been undertaken to address the issues including the one undertaken by the United Nations. Experimental ecosystems accounting (EEA). An accounting framework for ecosystem is attempted to be developed by using a consistent set of principles to document information on ecosystem benefits as well changes to ecosystems over time. Wealth Accounting and Valuation of Ecosystems Services(WAVES), a World Bank let global partnership is also working in this area to promote sustainable development through implementation of NCA in several countries. However, the sheer intangibility of many of the resources does not lend itself for quantification and it is here that the concept of environmental accounting as a whole has not received the seriousness and commitment that it deserves.

One of the challenges of the reporting community at large in India is to improve comparability among environmental reports. Reviewed reports currently do not address issues on environmental reporting. It can be interpreted in any manner. Environmental accounting is a must for understanding the role played by natural environment in the development of an economy. It consists of data that contains the contribution of natural resources to the economic well-being and emphasizes on the costs imposed by environmental pollution and resource degradation. Reporters must give careful consideration to, how they identify issues for reporting. Even if researchers have propounded theories of environmental accounting, there is a need to investigate the feasibility and dependability of such studies by studying the longitudinal data. Involvement and commitment of corporate accountants in environmental management appears to be limited due to lack of regional reporting guidelines. Inviting inputs from stakeholders, while formulating guidelines, will be a valuable means of engaging stakeholders and enhancing mutual interests and priorities (Sustainability Ltd and UNEP, 1999). Such a bold and participative approach would ensure benefits of enduring value both to the industry and its stakeholders. Environmental awareness provides a transparent and dynamic way of reporting environmental performance for the business. It provides the internal and external users with reports which helps in capital decisions and pricing decisions. Environmental management accounting is more for the internal use of the business. Bartolomeo et al (2000).

Efficiency of the Indian economy is dependent to a great extent on business environmental efficiency. Environmental accounting reporting is concerned with cost and benefits arising due to the process and product of firms which also have environmental impact. It is very difficult to state whether corporate enterprises are environmentally sustainable ones. It is a must for the corporate enterprise to consider the impact on environment and then determine their profit level to assure that they leave the planet same at the start and end of the accounting period. Environmental accounting is vital and mandatory for a green economy. Developing countries like India may have to choose various possible approaches as per their needs, level of development and environmental management problems. Hence, a country wise analysis should be done based on a simple accounting framework with practical recommendations to comprehensively cover the needs of an economy for a successful planning process.

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Moreover, the relationship between the business entity and the environment is receiving high attention. Environmental reporting is yet to find a permanent position in the financial sections of the annual report. Positive relationship exists between the profitability, size of the company. It indicates that the companies in India are becoming more enlightened as to the corporate environmental disclosures and social responsibility in this regard. At present, a debate on global climatic change and biodiversity is becoming more commonplace in corporate world, together with concern over water, air and soil pollution. Although the sustainability of economic development is a shared responsibility of organization and stakeholders, but business entities can play a vital role in slowing down the environmental degradation. A business entity has all the resources, technological knowledge, institutional capability and long-term vision to find out various environmental solutions. Effectiveness, efficiency and innovation can improve and streamline the manufacturing process, products with optimum use of raw materials along with decrease in the waste generated from production. Waste disposal methods and activities to keep pollution under control should be designed for quality environment management. Consequently environmental performance, customers' satisfaction and company performance will improve.

Environmental disclosure practices by Indian companies are of casual nature quantitative information and proper accounting pronouncements from regulatory authorities needs to be mentioned in the annual reports. The annual reports must disclose all information related to the environment. The lack of awareness and commitment on the part of company management about the social responsibility of the firm also keeps the firm away from reporting environmental costs and benefits. Thus, it can be concluded that the absence of a standardized environmental accounting practice and disclosure norms at national as well as international levels spur the corporate to be away from the environmental accounting practices and to shut their eyes towards the deterioration in the environment. In India, currently environmental accounting and reporting is at a preliminary stage and limited to demonstrating compliance to regulations and rules in the act to some extent.

Environment related disclosures in the corporate annual reports require due consideration. There are no latest company law and accounting standards; even ICAI does not prescribe the disclosure norms for environmental related aspects in the corporate financial reports. For few industries environmental accounting is mandatory such as oil and petroleum, natural gas, cement, steel, etc. For the rest environmental disclosures are voluntary in nature. The poor environmental performance of the company may also bind them to no-disclosure.

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Chapter 46
Development of the Green Economy in Romania:
Dimensions, Strengths and Weaknesses

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ABSTRACT

The socio-economic context and globally discouraging trends observed in recent years regarding resource conservation and regeneration, control of climate change, technical, technological and informational inequality, progress gaps among nations and locally among citizens of the same country, have led to the need for developing policies, reforms and programs to support sustainable development. In this chapter the authors analyze some important issues regarding the Romanian experience in developing the green economy. They start with the background analysis of the concept, emphasizing several European Union documents regarding green economy and sustainable development. Then, the authors analyze the social and economic profile of Romania, in relation with some suggestive indicators of welfare, sustainability, equity and economic opportunities etc. Special attention is given to the environmental Performance Index (EPI) and Human Development Index (HDI). In the last part of the research, the authors present a short SWOT analysis for the green economy in Romania and several future research directions.

INTRODUCTION

In response to the environmental impact of current economic development, a new type of economy is promoted by the world countries, especially the developed ones. Although the concepts of "green products", "green investment" and "green energy" have been used in recent decades, the concept of green economy has been placed on the international agenda due to financial and economic crisis triggered in 2008. Green economy is seen as a framework for restoring economic growth, while addressing climate change and other issues of environmental sustainability and economic development.

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It is obvious that there are many perspectives from which the concept of "green economy" can be analyzed. There are many economic schools with common ideas, but there are also schools with divergent views. Many of these ideas have been weak in showing that it can lead to a living standard at least equivalent to the current one. Often economic and social benefits of "green economy" were either poorly treated or incorrectly communicated.

Romania is among the countries that have rapidly adopted the concept of green economy; it has natural resources for its development, but has not yet recorded notable performances compared to other European countries.

The aim of this study is to provide an exploratory review of the extent to which the natural, social and economic profile of Romania is suitable for development of a green economy.

The first part presents some theories and practical issues related to the concept, and the last part discusses the threats and opportunities that arise through the development of green economy in Romania.

In this research we used a secondary data analysis conducted with national and European statistical data to highlight trends of indicators characterizing the natural, social and economic profile for Romania during 2004-2012 (www.insse.ro, eurostat.eu). Was also used the SWOT analysis to obtain a qualitative diagnosis of green economy stage of development. This study was conducted using various sources of information, such as national strategies, European and world reports of the various competent authorities in the field.

BACKGROUND

Simply said, the concept of "green economy" can be considered a synonym of the term "sustainable economy". However, the concept of "green economy" is often understood in a more distinctive sense that specifically focuses on the fundamental changes necessary to ensure sustainability of economic systems.

Ecological, industrial and environmental economic sciences are the three disciplines closely related to the "green economy" term (Huberman, 2010).

The term "green economy" was first introduced in a report to the Government of the United Kingdom in 1989 by Pearce, Markandya and Barbier, a group of environmental economists, in their work "Blueprint for a green economy". They aimed to advise the government on the existence of a single definition for "sustainable development" and on its implications for measuring economic progress and evaluating policies and projects. The term was not, however, defined; it was only mentioned in the title. Afterwards it followed another series of papers on the same subject: *Blueprint 2: Greening the world economy*, *Blueprint 6: For a sustainable economy*, and among the most recent: *New Blueprint for a green economy*, in 2012.

Measures to adopt green economy policies were initially discussed in international negotiations in 1992 at UNCED in Rio. The Rio Declaration included principles that promote eliminating unsustainable consumption and production (Principle 8), internalization of environmental costs and the use of economic instruments (Principle 16). 21 Agenda further elaborated these principles, integrating national expansion strategies, legal framework and regulations, as well as systems for integrated environmental and economic accounting. It was then when the United Nations Framework Convention on Climate Change (UNFCCC) was developed; it aimed economic, regulatory and market measures to control climate change by reducing carbon emissions.

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In 2002, through Johannesburg Implementation Plan (JPol) the need to change production and consumption has been identified; a 10-year framework for sustainable consumption and production programs was designed. In 2003 and 2005 the International Meetings of Experts marked the need to promote social and economic expansion within the environmental capacity limits.

With the new context of 2007-2008, there have been attempts to simultaneously face economic crisis and to build a new system for attempting a transition to protect the environment and resources. So they developed "green incentive packages" and focused on specific areas where large-scale public investment could start a "green economy" (Atkisson, 2012).

Goals that characterize the "green economy" are the welfare of mankind and reduction of long term environmental risks. Many national economic stimulus plans were proposed or adopted in late 2008 and early 2009 and had a "green" part, such as in the U.S., Japan and South Korea, New Zealand and Australia.

The aspiration to sustainable economy is supported by the European Union's 2020 strategy (European Commission, 2010) which aims to develop: a smart growth (which involves education, knowledge and innovation); sustainable growth (promoting a more efficient economy in terms of resource use, greener and more competitive); inclusive growth (employment at the highest level, economic, social and territorial cohesion).

European Commission (2011) considers the green economy as one that "generates growth, creates jobs and eliminates poverty by investing in and preserving the natural capital on which depends long-term survival of our planet."

In 2008, the United Nations Environment Programme (UNEP) has launched an initiative called Green Economy, which culminated in 2010, with the publication of a report on the Green Economy. In this report, United Nations Environment Programme (2010) defines a green economy as the process of reconfiguring businesses and infrastructure to get a better return on natural capital investments, human and economic investments, while reducing emissions of greenhouse gas emissions, extracting and use of fewer natural resources, creating less waste and reducing social disparities.

The green economy has rapidly evolved from the theoretical and global side to the national and practical level. According to Barbier (2009) global recession requires a global initiative and vision. He believes that Global Green New Deal is the necessary response to these challenges.

Also in 2008, the Organisation for Economic Co-Operation and Development began working on an ambitious green growth strategy, defined as a way to continue economic growth and development, while preventing environmental degradation, biodiversity loss and unsustainable use of natural resources (Organisation for Economic Co-Operation and Development, 2011, p 9).

The world is in transition to a "green economy". It is understood that this is a long-term change, since today till in 2050, that will have different levels of intensity for different countries according to their motivation to develop in general and specifically at a social level and according to trade revitalization plans and poverty solving (DeLacy & Lipman, 2010).

Green economy aims investment in natural capital, economy decarbonisation and creating green jobs. According to United Nations Environment Programme (2010), this concept can be applied in various sectors such as agriculture, tourism, forestry, fisheries, industry, construction, transport, urban planning, renewable energy, water and waste management. The UNEP (2011) demonstrates that the transition to a green economy is possible by investing 2% of GDP (1.3 trillion $) per year from now until 2050 to greening sectors mentioned above; these investments must be supported by national and global policy reforms (Schmalensee, 2012).

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From this perspective, there are various ways in which green economy can favor both developed countries and developing ones. This type of economy should maintain, and also intensify the value derived from agriculture, fisheries and forestry, and all activities that depend on a protected environment, for underdeveloped countries. In the same time it should also reduce limits on energy quantities by providing renewable energy distribution systems at low cost; it should minimize their vulnerability to the impact of climate change, desertification, water degradation and biodiversity loss before as well as local impact of water, air and soil pollution. Green economy should generate both in the developed and developing countries, new innovative activities, and activities that create more jobs than traditional sectors, and increase industrial efficiency and energy security (Cosbey, 2011).

Although this concept is defined globally, it has a specific application: priorities and actions taken to facilitate the transition to a green economy can vary from sector to sector, from a value chain to another and according to individual national conditions (International Chamber of Commerce, 2011).

The transition to a green economy will considerably vary from one nation to another, as it depends on the specific of natural and human capital of each country and on its relative level of expansion. To achieve this goal a number of applicable conditions will be needed; these will consist of national legislation, policies, subsidies and incentives, international protocols for trade and assistance, market and legal infrastructure. Currently these conditions are oriented towards and encourage "brown economy" or "black economy" (United Nations Environment Programme, 2011). This black type of economy means that economic growth depends on petrochemicals such as coal, oil and gas and that production is realized with large amounts of carbon dioxide that are released into the atmosphere, resulting in air pollution and depletion of natural resources.

In the United Nations Environment Programme (2011) report *Towards a Green Economy. Pathways to Sustainable Development and Poverty Eradication*, is stated that a green economy grows faster than a brown economy, maintaining and restoring natural capital. Now, we live in a world where the pursuit of economic growth - defined as the real rate of gross domestic product growth - is one of the priorities of governments, private sector and even some segments of civil society, many of them dependent on the increase for financial support and overall stability. Therefore, the transition to a green economy without undermining economic growth would be a positive thing.

The green economy aims both the public and private sector. The difficulties that communities from developing countries are facing, as a result of climate change, raise problems for the business sector. Communities' risks are also business' risks. Local and global companies depend on community members as suppliers, customers, labor and resources, services and local infrastructure in order to operate. Companies that connect the community's welfare and their viability and that adapt to climate change having customers as a main concern, can gain competitive advantage, or the opposite may lose their reputation. To make the transition to green practices, companies must connect climate adaptation and resistance to organizational culture, to start from existing initiatives, to integrate climate adaptation to central processes of strategic business planning, to align goals with the priorities of adjustment, to build a portfolio of climate-specific goods and services, to build mutually beneficial relationships with stakeholders, to have partnerships with internal and external decision makers (World Resources Institute, 2011). So far, companies have been the ones that have achieved significant results in the fight against pollution, extraction and resource depletion (Kohr, 2011).

Green entrepreneurship is seen as the engine for the establishment of an economic - social - environmental holistic and sustainable system (Gibbs & O'Neill, 2012). For this it is necessary to establish a link among education, training, employment and environmental policies. Availability of skills for green

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jobs has a crucial role in triggering change and facilitating a smooth and timely transition. Green sectors will require new types of jobs, while re-qualifying the existing ones. A well trained human resource and environmental conscious will also be more innovative in resource efficiency. Green technologies offer the possibility of new jobs for those who will quickly respond to the new paradigm (Pop, Dina & Martin, 2011).

Many of the costs required to start business in the green economy are high, especially those that are related to energy production. Research, development and investment in green energy are very expensive and still in an early stage. This aspect is not perceived as entirely economically viable for public.

Although green economy opportunities have been extensively discussed, the threats arising from the transition to a green economy have been treated within the holistic framework provided by UNCED, Rio Principles and Agenda 21, as shown in a few major works, among which: „Report by Panel of Experts on The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective" (UN-DESA, UNEP &UNCTAD), „A Brief for Policymakers on the Green Economy and Millennium Development Goals" (United Nations Environment Programme, 2010).

The main risks that can be generated by switching to green economy are: its application in an unidimensional form, the "single size" approach, the adoption of protectionist trade policies, handling grants and financial aids, deepening social tensions, increase of population migration, the introduction of overly rigid standards for products marketed by developing countries, and others.

Moreover, countries of the world develop national policies and strategies to ensure the development of green economy and mitigation of risks arising from.

Although aspects of sustainable development in Romania are treated in numerous papers and from different perspectives, the same cannot be said about the green economy issue. Romania's situation regarding the dimension of green economy is briefly presented, among other countries, in some global and regional studies drawn up by international organizations.

A recent study by Deichmann and Fan (2013) includes Romania (among other countries) as a case study to analyze the economic benefits of implementing green economy. This report shows that rapid progress in energy efficiency, a shift to cleaner energy systems and a better management of green natural resources will bring benefits in climate action in Romania.

The employment dimension of green economy is treated extensively in the reports of project *New skills for green jobs: the case for a more gender inclusive labour market?* (2012), co-funded by the European Commission, DG Employment, Social Affairs and Inclusion in the framework of the PROGRESS programme. According to the final report (2012) in Romania there is a wider policy concern with building the capacity of the education and training system in order to develop occupational standards for green jobs.

The main national document that includes items related to policies and strategies to develop the green economy is the *National Sustainable Development Strategy Romania 2013-2020-2030* realized by the Government of Romania and United Nations Development Program (2008).

GREEN ECONOMY DEVELOPMENT POTENTIAL IN ROMANIA

The Romanian economy has been marked over the years by many transformations, mainly generated by the political regime and the vision regarding economic and financial resources' destination. Lack of stability at micro and macro-economic level and the consistency in the application of clear stratagems

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of economy expansion led to a delay in our country development, despite the potential of natural capital and favorable geographical position at the crossroads of many trade exchange centers.

Despite the progress made in recent years is a fact that Romania still has an economy based on intensive use of resources, a society and a government still in search of a single vision and a natural capital affected by the risk of damages that may become irreversible.

In the second decade of XXI century after a difficult transition to a market economy, Romania has recovered significant differences compared to the other Member States of European Union, together with learning and putting into practice the principles and practices of sustainable development in the context of globalization.

Economic and financial crisis that covered the globe after 2008 emphasized the confusion state of the economy and halted for the moment the favorable situation that characterized our country once with the influx of investors who were operating in various areas of Romania.

Camasoiu, Caragea and Cristea (2013) present the importance of the green economy for Romania in the context of sustainable development and conclude that the sectors as agriculture, forestry, fisheries, food, as well as parts of chemical, biotechnological and energy industries have a large innovation potential based on sciences (life sciences, agronomy, food science, social sciences) enabling and industrial technologies (biotechnology, information and communication technologies) and local knowledge.

According Costache (2012), bio-agriculture, renewable energies, research and development, waste management are the sectors with the main potential for green growth and green jobs. Between obstacles facing green growth the author includes: lack of financial resources and funding, insufficient human resources at the institutional level responsible for formulating and implementing policies, lack of specialised staff, and a lack of implementation of strategies.

Natural Profile of Romania: Indicators of Natural Capital and Environmental Efficiency

The natural capital as well as the extent to which a country effectively uses it and protects its environmental assets is one of the green economy's dimensions that should be considered in the analysis.

Romania, a medium-sized country in the European Union, presents a variety of natural resources and geo-climatic conditions extremely important. These include: 94 habitats (out of 198 in Europe), 13 national parks, 14 natural parks, more than 20 billion tonnes of untapped mineral resources (nonferrous minerals, iron, salt, etc.), 150 types of forest ecosystems, 227 types of forests, 3,480 rivers, 246 alpine lakes, 105 species of mammals, 216 species of fish, 3,630 species of plants, etc. (NIS, 2011).

As shown in Table 1, water resources had a fluctuating trend, the total area covered by forests remained relatively constant between 6,233 to 6,354 thousands ha. The harvested wood slightly increased, while net annual wood growth parameters remained around the same value.

Similar to the EU-27, In Romania there is a general downward trend in emissions of greenhouse gases (including CO_2) a trend that should be encouraged in accordance with the objectives set in the National Strategy for Sustainable Development; it foresees for a reduction of greenhouse gas emission with 20% by 2020. The largest amount of emission is found in the energy sector, followed by industry and agriculture, 16776 tons, representing a situation valid for most of European countries. According to Eurostat, Romania has a low level of acidifying substances emissions (SO_2, NO_x şi NH3) and consistently decreasing; it also has the lowest amount of nitrogen fertilizer in Europe, less than 30 kg per hectare (Table 2).

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Table 1. Natural capital of Romania

N.C. Indicators	2004	2005	2006	2007	2008	2009	2010	2011	EU-27 (2011)
Water resources (mil. m^3)	39,950	63,760	55,950	37,805	39,406	34,480	61,878	30,678	247,000
-captured water	5,850	5,301	5,330	6,884	7,220	6,876	6,219	6,592	-
-freshwater (%)	14.64	8.31	9.53	18.21	18.32	19.94	10.05	21.49	10.9
Release of organic matter as oxygen in rivers (tons / day)	392	178	268	332	311	323	278	267	-
Harvested wood mass (1000 m^3)	17,082	15,671	15,684	17,238	16,705	16,520	16,992	18,705	531,636
Net annual wood growth (1000 m^3)	-	-	-	-	19,013	19,677	19,545	-	426,752
Forest - forestry fund (thousand ha)	-	6,233	6,272	6,314	6,309	6,334	6,354	-	157,193

Source: National Institute of Statistics (2011), National Institute of Statistics (2013), Eurostat.

Table 2. Natural profile

Indicators	2005	2006	2007	2008	2009	2010	2011
Total emissions of greenhouse gas emissions (thousand tons)	113,521.44	118,038.25	117,506.44	116,165.41	92,055.61	90,808.74	98,054.21
Energy dependence (%)	28.6	31.3	30.3	27.4	18.3	21.2	23
The CO_2 intensity of energy consumption (tones/thousands lei)	788.69	764.10	699.92	649.34	595.43	577.91	619.13 (semi-final dates)
SO_2 emissions (kilotons)	642.5	697.4	577.2	566.2	459.8	371.9	-
NH_3 emissions (kilotons)	198.5	196.7	203.4	187.2	187.4	161.3	-
Domestic material consumption / capita (tons/capita)	15.49	16.70	19.90	25.62	20.15	-	-
Domestic material consumption (1000 tons):	334,986.316	360,480.190	428,602.292	550,978.132	432,585.117	334,986.316	360,480.190
-fuels	56,548.606	61,152.771	63,239.312	61127.796	53,916.144	56,548.606	61,152.771
-minerals	211,939.204	235,946.895	314,970.038	426,462.083	320,414.283	211,939.204	235,946.895
-biomass	66,404.430	63,292.697	49,901.365	62,603.975	57,503.549	66,404.430	63,292.697
-waste and other	94.077	87.827	491.577	784.278	751.142	94.077	87.827
Collected waste / capita (kg/capita)	303	293	287	305	291	248	239
Municipal waste recycling rate (%)	2.22	0.65	1.06	1.10	2	6	7

Source: National Institute of Statistics (2013), Eurostat.

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NIS data on total and per capita domestic material consumption, exhibit a yearly increase of this indicator, the most significant increase occurring in minerals consumption and for waste level. The upward trend is interrupted in 2009 due to the financial crisis effects. Also for this chapter, Romania has a relatively low level of collected waste per capita and an extremely small recycling rate, but with real growth tendencies.

These indicators show the potential of Romanian natural capital which supports the development of green economy relying on reducing greenhouse gases emissions and acidifying substances, as well as on natural resources that are superior to many other European countries.

Social Profile of Romania: Indicators of Welfare, Sustainability, Equity, and Sustainable Transportation

The United Nations Conference on Sustainable Development (or Rio +20) held in 2012 in Rio de Janeiro had the theme "Green Economy for Sustainable Development and Poverty Eradication". By explicitly linking the green economy with sustainable development objectives and poverty eradication, the Rio +20 process emphasized the importance of the social dimension of development.

A series of indicators of welfare, sustainability, equity and sustainable transport reflects the social dimension of the green economy in Romania.

It can be observed that the percentage of population connected to wastewater treatment plants increased from year to year, while the number of people aimed by those benefits evolved from 6,068,655 persons in 2006 to 6,582,104 in 2010; between 2009 and 2010, an increase of 345,579 persons was registered. An increase was experienced in the period under review for life expectancy at birth from 71.01 years to 73.43 years in 2010; in the gender wage gap level, from a share of 6.5% in 2006 to 11.6% in 2010; in green areas, from 20,098 ha in 2005 to 22,005 ha in 2010; in energy consumption for road transport, from 3,847 toe in 2003 to 4,734 toe in 2011; in air transport from 119 toe to 227 toe in 2011 (Table 3).

Energy consumption in both rail and waterway transport fluctuated in recent years due to fluctuations in the economy's evolution.

A slight increase was perceived in public expenditure on education as percentage of GDP, from 3.6% to 4.3% by 2011, but insufficient for current needs of the Romanian society.

Economic Profile of Romania: Indicators Regarding Response Policies and Economic Opportunities

A series of economic data such as investments for environment protection, expenditure on research and development (R & D) and renewable energy production, allow the characterization of a country economic potential to develop green economy.

Measures taken by national and local authorities in Romania to manage environment problems include investments oriented towards preventing and fighting pollution, natural resources protection and biodiversity conservation and other fields.

The largest investments for environment, in 2010, headed to first category reaching a total value of 3,598,479 lei; the highest percentage was recorded for fighting pollution in production and supply of electricity and for water supply and sanitation (Table 4).

According to the latest National Institute of Statistics data, the total expenditure for R&D in 2010 were 2,045,132 lei (as we can see in the Table 5), of which the largest share of the fields included in the

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Table 3. Social profile

Indicators	2005	2006	2007	2008	2009	2010	2011
Population connected to wastewater treatment plants	5,991,041	6,068,655	6,130,399	6,215,164	6,236,525	6,582,104	8,568,774
Life expectancy at birth (years)	71.76	72.22	72.61	73.03	73.33	73.43	71.76
Gender wage gap (%)	-	6.5	10.8	7.3	7.3	11.6	12.1
Public expenditure on education (% GDP)	3,6	4,3	4,3	4,4	4,24	3.53	3.07
Educational system leaving rate (%)	19.6	17.9	17.3	15.9	16.6	18.4	17.5
Employment growth (%)	-1.5	0.7	0.4	0	-2	-0.3	-0.8
Green space (ha)	20,098	20,269	20,724	21,124	21,232	22,005	-
Energy Consumption by Mode of Transportation (1000 Toe)							
Railway transport	209	151	274	249	204	221	286
Road transportation	3,839	3,933	4,055	4,646	4,869	4,531	4,734
Waterway	51	43	100	147	51	61	52
Air transport	121	160	233	275	238	277	227

Source: National Institute of Statistics (2013), Eurostat: http://appsso.eurostat.ec.europa.eu/.

Table 4. Environmental investment (2010)

Investment Categories	Total (Thousands lei)
Preventing and fighting pollution	3,598,479
Natural resources protection and biodiversity conservation	52,913
Other fields	1,102,201

Activity Sectors	Preventing and Fighting Pollution on Environmental Fields (Thousands lei)				Natural Resources Protection and Biodiversity Conservation (Thousands lei)	Other Fields (Thousands lei)
	Water	Air	Waste	Soil and Groundwater		
Forestry	-	-	-	3,023	8,566	673
Extractive industry	63,988	49,952	42,842	74,014	8,984	40,731
Processing industry	73,804	131,837	185,745	22,146	9,691	73,531
Production and supply of electricity, heat, gas, steam and air conditioning	10,426	596,324	199,147	118,190	1,452	39,018
Construction	1,791	4,176	2,513	678	220	1,525
Transportation	13,756	22,703	92	33,869	8	8,056
Water supply and sanitation	556,184	35,008	13,389	6,981	61	1,368
Collection, treatment and disposal of waste; recycling	1,841	1,356	381,591	1,036	-	2,186
Decontamination activities and services	4,696	-	1,004	43,187	-	-
Wholesale trade of waste and scrap	63	38	19,907	5	-	4

Source: National Institute of Statistics (2011), 2011 Yearbook: Geography, Meteorology and Environment.

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green economy was held by agriculture, with 170,729 lei, a relatively low value for the ordinary needs of a European country; ranked last is education, where there were spent 40,568 lei (National Institute of Statistics, 2011).

As it can be seen in Table 6 - Environmental taxes, Romania has a low level for revenues from environmental taxes share in the GDP, reaching a peak of 3.9% in 1999 and a minimum in 2008 of only 1.8% (EU average is 2.6% in 2010). From the total revenues from environmental taxes obtained by our country, the most significant share is held by taxes imposed in the energy field, fluctuating between 1.4 and 2.1% in recent years. Transportation tax imposed by local authorities had an upward trend, rising from 0.07% in 2001 to 0.36% in 2008, and later on descending. In the opposite direction, the share of taxes on pollution in GDP has decreased considerably from year to year, currently having an insignificant level. According to a study undertaken by the Center for Sustainable Policies Ecopolis (2011), our country recorded one of the lowest revenues from environmental taxes as a percentage of GDP; this translates into a total national inefficiency in terms of energy, low taxes and minimum excise adopted for electricity and fuels having negative effects on environment protection and on the effort to reduce the human intervention on it.

Table 5. R&D expenditure (2010)

Fields	Public Funds	Other National Funds	External Funds	Total (Thousands lei)
Earth exploration and exploitation	8,122	5,101	1,533	14,756
Environment	60,485	35,293	12,648	108,426
Health	46,421	70,547	8,402	125,370
Agriculture	96,810	55,069	18,850	170,729
Education	10,175	11,131	19,262	40,568
Total R&D	2,045,132			

Source: National Institute of Statistics (2011), 2011 Yearbook: Science, technology and innovation.

Table 6. Revenue from environmental taxes

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RO(%)	3	3.9	3.5	2.4	2.1	2.4	2.4	2	1.9	2.1	1.8	1.9	2.1
Mil. €	-	-	-	1,068	1,041	1,243	1,448	1,604	1,900	2,565	2,487	2,215	2,503
Categories													
Energy (%)	-	-	-	2	1.8	2	2.1	1.8	1.7	1.7	1.4	1.6	1.8
Mil. €	-	-	-	872	844	1,058	1,312	1,465	1,665	2,110	1,969	1,905	2,235
Transport (%)	-	-	-	0.07	0.07	0.07	0.06	0.06	0.15	0.35	0.36	0.26	0.21
Mil. €	-	-	-	32.3	34.5	32.5	38.8	49.6	143	432	504	302	252
Pollution (%)	-	-	-	0.36	0.34	0.28	0.16	0.11	0.09	0.02	0.01	0.01	0.01
Mil. €	-	-	-	164	163	149	96	90	92	22	14	8	16

Source: Eurostat, appsso.eurostat.ec.europa.eu.

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The green certificates market registered considerable growth in Romania. A green certificate is a document confirming the 1MWh use of electricity from renewable sources, specifically non-fossil, such as solar, wind, geothermal, aerothermal, hydrothermal, hydropower, biomass, waste fermentation gas and sludge (from wastewater treatment plants) fermentation gas and biogas. According OPCOM (Romanian gas and electricity market operator), the national body responsible for supervising and trading green certificates in Romania, those are subject to a national mechanism which promotes the production of electricity from renewable sources by a quota system imposed by the acquisition of such certificates. Their value represents a supplement for producers received for "greening" the delivered energy; the price is set on the centralized market of green certificates (PCCV). Data in Table 7 shows that both the number and value of transactions with green certificates have increased considerably over the years, starting from 7841 certificates traded at a price of 155 RON / certificate to 410,628 certificates sold at a price of 241 RON / certificate.

Green energy has a critical potential for the economic development of our country. Currently, the Romanian electricity market has producers from all sectors of renewable energy, some achieving remarkable results. In Table 8 one can observe the fluctuating evolution of RES share in total electricity produced, the values being still high.

According to the study by Ernst & Young (November 2012), Romania is the main actor of Eastern Europe in the renewable energy chapter. In their ranking, our country ranks 13 in the index for all forms of renewable energy, ahead of countries like Poland, South Korea, Spain, etc.; it also ranks 10th for wind energy and 24th for solar energy, from 40 analyzed countries. The favorable situation of Romania is mainly due to substantial investments in RES-E programs (especially wind energy) from recent years. Solar energy is still underdeveloped, but announces a capacity for future growth due to improving the legal framework of authorization.

Romania has a great and diversified potential for renewable energy, estimated at 1.2 TW for solar energy, 23 TW for wind energy, 36 TW for hydropower (NIS, 2013).

Environmental Performance Index (EPI) and Human Development Index (HDI)

In addition to data characterizing natural, social and economic profile of a country there are a number of indicators that complete the performance analysis on sustainable development and green economy.

Table 7. Evolution of green certificates in Romania

Transactions	2006	2007	2008	2009	2010	2011
Number	7,841	37,703	95,593	141,607	248,694	410,628
Value (euro)	269,143.82	1,293,939.97	3,355,240.88	6,825,921.12	13,029,068.18	22,761,359.77

Source: OPCOM (2012).

Table 8. Share of RES-E in total electricity

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
RO (%)	28.6	29.9	23.9	29.8	34.5	30.2	26.8	26.8	27.6	34.3	27.1

Source: National Institute of Statistics (2013).

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Among these, Environmental Performance Index (EPI) by Yale University designed and Human Development Index (HDI) calculated by the United Nations Development Programme (UNDP); they are relevant as they measure how countries act to protect human health from the damage caused by environment and how they act to ensure ecosystems' protection, increase life expectancy, literacy, education and standard of living.

Environmental Performance Index (EPI) for 2012 compares and ranks 132 countries (30 in Europe, including Romania, 24 from America, 21 from sub-Saharan Africa, 18 in the Middle East and North Africa, 18 in Eastern Europe and Central Asia, 21 in the Asia Pacific region) worldwide, according to 22 indicators grouped into ten categories: environmental impact on diseases, the impact of water on health, the air pollution effects on health, air pollution effects on ecosystems, water resource effects on ecosystem, biodiversity and habitat, forestry, fisheries, agriculture and climate change.

These categories, and implicitly the indicators, track progress and performance of each country based on two objectives: environmental health and ecosystem vitality. For each indicator there is a target, which helps to achieve the final score along with weights and scores associated to each.

This index also outlines trends in the environmental performance of each country in the last decade, and the authorities' commitment for the future.

Romania ranks 88 of 132 countries in the EPI ranking, with an overall score of 48.3 (see Table 9), a similar performance to that of other countries, such as Ukraine, Cuba, Mexico, Azerbaijan and the Dominican Republic. Regarding the two major objectives of EPI, environmental status and ecosystem vitality, our country has achieved a score of 60.7, respectively 43, ranking 78 and 84.

Our country has achieved a high score of 51.6 for agriculture (through subsidies and regulation of pesticides), a score of 93.2 for forests (loss, covered areas and regeneration) and a score of 77.5 for diseases caused by the environment. Favorable positions are occupied by Romania in the categories: fisheries - rank 14, forests - rank 32, illnesses caused by environment - rank 55, and agriculture - rank 66.

In terms of trend analysis, our country occupies a very good position, 3rd, after Latvia and Azerbaijan, showing improvements for agricultural subsidies, fisheries and climate change. As a trend, Romania has a performance level similar to France, Belgium, Italy, Albania and Great Britain.

Switzerland, leader of Environmental Performance Index in 2012, achieved an overall score of EPI of 76.7, with 28.3 points more compared to our country, similar to France, Great Britain, Lithuania, Germany and Latvia. For the first objective of the EPI, the environmental status, Switzerland has gained 93.2 points, with 32.5 points more than Romania. In this category, Switzerland excels in air effects on health, which aims to minimize the use of solid fuels with serious repercussions on human health, for which it has a maximum number of points. 100 points are recorded also for water effects on health, and public access to sanitation.

Regarding ecosystem vitality, Switzerland is ranked first with a score of 69.6, with 26.6 points more than Romania. In this section, Switzerland stands out at biodiversity and habitat, with 98.1 points, at air effects on the ecosystem with 72.6 points, compared to only 21.4 points for our country, and at water resources with 50.8 points compared to only 25.7 points for Romania. Instead, our country succeeds in obtaining better results as regards forests and agriculture, where Switzerland is ranked 109. In trend level, Switzerland is ranked 89 with a score of only 2.4 for EPI trend, similar to countries like Japan, Venezuela, Togo, Canada and Colombia.

Bulgaria holds 53 the position of 132 countries with a score of 56.3 points, with 8 points more than Romania. For the two objectives, Bulgaria has achieved a better score of 92.2 than our country in the environmental status, but less than Romania (rank 43) in the ecosystem vitality level of 40.9 points.

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Bulgaria's performance is similar to Cyprus, Israel, Malta, Greece and Canada. This country has a better score than Romania in agriculture, 60.1 compared to 51.6, in biodiversity and habitat, fisheries and forests, in the latter being a leader. Bulgaria performs bad in air effects on the ecosystem, climate change and water resources; at trend level it occupies the 16th position.

Human Development Index (HDI), is globally applied at the level of 187 countries by the United Nations Development Programme to measure social development based on combining several relevant indicators, life expectancy at birth, educational stock (average number of years spent in an education institution and schooling expected value) and gross national product per capita; they are grouped into three dimensions: health, education and living standards. HDI requires a minimum and a maximum for each dimension (frame) and measures the performance of each country in relation to them by providing values between 0 and 1.

In this ranking, Romania ranks 56, with an HDI of 0.786 (as we can see in Table 10), above the regional average value of 0.771, an increase of 11 percent over 1990. According to this indicator, Switzerland ranks ninth with a score of 0.913, and Bulgaria is situated after our country, 57th with a close value for HDI of 0.782. In terms of health index, Romania allocates a percentage of 4.4% of GDP for public health, less by 2.4% compared with Switzerland and with 0.7% more than Bulgaria. Life expectancy in our country has grown in recent years from 69.6 to 74.2 years, an average quite low compared

Table 9. Environmental Performance Index (2012)

Category (2012)	Romania				Switzerland				Bulgaria			
	Performance		Trend		Performance		Trend		Performance		Trend	
	Score	Rank	Scor	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
EPI	48.3	88	16.9	3	76.7	1	2.4	89	56.3	53	11.2	16
Environmental status	60.7	78	17.5	35	93.2	29	4.8	109	92.2	31	16.7	38
Air effects (health)	60.6	81	12.8	26	100	1	0	73	100	1	0	73
Diseases due to environment	77.5	57	28.5	29	86.4	39	9.5	95	84.3	42	33.4	19
Water effects (health)	27	102	0	84	100	1	0	84	100	1	0	84
Ecosystem vitality	43	84	16.5	4	69.6	1	0.5	49	40.9	91	6.7	22
Agriculture	51.6	66	49.9	1	33.4	109	3.6	53	60.1	50	-22.9	124
Air (ecosystem effects)	21.4	108	11.6	59	72.6	2	0.6	101	0	130	0	104
Biodiversity and habitat	45.3	89	32	9	98.1	10	5.4	49	57.2	75	41.7	4
Climate change	41.8	72	23	20	58.2	44	10.9	40	29.6	98	4.2	65
Fisheries	39.7	14	25	3	-	-	-	-	48	7	28.9	1
Forests	93.2	32	-3.4	32	78.5	73	-10.8	73	100	1	0	1
Water resources	25.7	79	-37.1	79	50.8	17	-24.6	17	14.9	99	-42.6	99

Source: Yale Center for Environmental Law & Policy (2012).

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Table 10. Human Development Index (2012)

Category	Romania	Switzerland	Bulgaria
HDI	0.786	0.913	0.782
HDI rank	56	9	57
Health - index	0.855	0.985	0.845
Health public expenditure (% of GDP)	4.4	6.8	3.7
Life expectancy at birth (years)	74.2	82.5	73.6
Education - index	0.821	0.873	0.810
Average years of schooling (years)	10.4	11.0	10.6
Inequality-adjusted HDI value	0.687	0.849	0.704
Losses caused by income inequality (%)	22.2	14.3	15.4
Poverty - index	-	-	-
Population living with less than 1.25$ / day (%)	0.4	-	0.05
Gender inequality - index	0.327	0.057	0.219
Participation in the labor market	0.749	0.808	0.806
Innovation and Technology	-	-	-
Fixed and mobile subscribers per 100 people	135.9	177.7	164.9
Income - index	0.694	0.886	0.700
GDP per capita ($)	10905	37979	11799

Source: United Nations Development Programme (2013).

to Switzerland which has seen an increase from 75.7 to 82.5 years. In the education index, Romania has an average of 10.4 years of schooling, close to the values of the other two countries. In the other aspects, the (income) inequality index, poverty, gender inequality, innovation and technological development, our country has unfavorable values. GDP per capita shows that Romania is behind both countries with which the comparison is made.

THREATS AND OPPORTUNITIES REGARDING GREEN ECONOMY DEVELOPMENT IN ROMANIA

Based on the above presented elements, strengths and weaknesses, threats and opportunities of the green economy development in Romania were identified and presented in the Table 11.

FUTURE RESEARCH DIRECTIONS

Given the importance of the topic and its novelty, green economy development in Romania will remain on the agenda of various national and international institutions and many authors.

The main directions of future research include, but are not limited to, the following:

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Table 11. Strengths and weaknesses, threats and opportunities of the green economy development in Romania

Strengths	• The increase in the renewable energy resources use for electricity and heat production by improving the green certificate market; promoting mechanisms to support renewable energy resources usage in energy production. • Solving energy-intensive buildings problem, which account for 40% of carbon dioxide emissions through energy auditors certification activities, a program for thermal rehabilitation of buildings, development of a calculation methodology, interest subsidy on loans requested by buildings owners. • Well-trained human resources for various fields applicable to the introduction and development of green economy. • IT and technological potential for developing green technologies. • Annual investments in R&D activities in areas related to green economy. • increasing the number of green certificates sold in recent years to entrepreneurs. • Low level of acidifying substances in our country (SO_2, NO_x and NH_3) and the lowest amount of nitrogen fertilizers in Europe, less than 30 kg per hectare. • Downward trend in greenhouse gases emissions. • Increasing tendency for using waste to produce electricity. • Significant natural capital of our country. • Increases in the number of people connected to wastewater treatment plants, in the life expectancy, in green areas and in public spending on education as a share of GDP. • Agriculture potential of "greening", by reusing traditional methods of growing plants and by applying for grants.
Weaknesses	• Lack of a vision and a clear strategy on adopting measures for the introduction of green economy in all economic and social sectors. • Confusion among citizens regarding the existence and application of a unitary national policy for regulating green economy (national sustainable development strategies, government spending directed towards green sector, taxes on pollution, limiting carbon emissions, waste management policies). • Lack of publicity for this phenomenon. • Perceived impact of chemicals on health. • Urban problems (pollution, noise, traffic, etc.). • Uncertainty regarding policies for currently granting green certificates. • Small level of investment for natural resources protection and biodiversity conservation in recent years. • A low level of revenues from environmental taxes, below the European average.
Opportunities	• Measures to improve the environment in rural areas and biodiversity through sustainable management of agricultural lands, investments financed by the National Rural Development Programme. The environmental investments contribute to creating new jobs specific to green economy; we mention services in the environmental field, including development and maintenance of the necessary infrastructure (for instance: waste management, pollution control, maintenance of protected areas, the production of energy from renewable resources, prevention of natural risks, even activities from outside the environmental sector such as protecting natural heritage) offers an important prerequisite. • Continuous expansion of wind energy sector by developing new wind parks. • Solar energy market development through foreign investment (for instance Lukoil). • The entry on the "low-carbon" product market (solar panels, green materials, green supplies, etc.). • Improving transport efficiency through the introduction of alternative fuels. • Restructuring all interest systems (education, health, tourism, agriculture, forestry, etc.) and the achievement of necessary performance for our country's progress. • Promoting eco-tourism. • Reducing dependence on fossil fuels. • Creating new jobs through related areas that include green economy. • Innovation by creating sustainable products. • Increase economic competitiveness by raising the efficiency of resources use in production. • Accessing new markets for organic products, and increase of exports. • Designing a new sustainable development strategy that focuses on actions and not on objectives.
Threats	• Negative perceptions of citizens on issues that will affect community in the next five years: the need for economic development, creating jobs, clean water, waste management. • Reducing subsidies to photovoltaic energy sector and therefore stopping the advance in this area. • Lack of cooperation from authorities and citizens. • Demographic decline. • Lack of unity in development strategies. • High costs for green investments. • Extending economic and financial crisis. • Reluctance of consumers to change their consumption habits. • High prices associated with green products.

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1. Study on the competitiveness of the Romanian eco-industry, especially of small and innovative companies acting in the field of renewable energy, waste recycling, environmental auditing and consultancy.
2. Study of the synergy between digital economy and green economy in Romania and the place of innovation. Innovation in the green economy is in the form of a mix of green innovation, industries, and regions. It is important to realize the potential of ICT-based innovations for a greener economy.
3. The barriers and opportunities for green investment in Romania. Beyond the known infrastructure investment barriers and constraints, the challenge will be to identify the premises for green investment in Romania and what actions are needed to effectively increase green investment. In the same context must be examined the gap between business-as-usual investment levels and the amounts needed to address climate change and other environmental challenges.

CONCLUSION

Changes in investment patterns, technology, production and consumption associated with sustainability, often referred to as green economy are central in international circles. Economic and social development, in terms of sustainability, represented in recent years a major goal of many countries in Europe and beyond. To achieve this goal, the forms of government in different countries have developed national strategies, including both country-specific policies and general methods recommended to be worldwide adopted by specialized institutions, under Agenda 21 and the Rio Declaration.

There are many different assessments of the opportunities, costs and benefits of the transition to green economy for different social groups, countries and regions and also divergent views on the various approaches to achieving social, environmental and economic goals, inherent in the concept of sustainable development.

Romania, in the National Strategy for Sustainable Development 2013-2020-2030 Horizons, developed by the Ministry of Environment and Sustainable Development, analyzes the challenges in its attempt to make the transition to a green economy in relation to the objectives imposed at European level, and considers the following:

- **Climate Change and Clean Energy:** Romania's strategy aims at an optimal level of energy in the short, medium and long term and the prerequisites establishment for achieving energy security, the fulfillment of obligations to reduce emissions of greenhouse gases by 8%, and ensuring the energy system functioning and the development of measures to manage climate change.
    - **Actions:** Continuing the process of 35% energetic rehabilitation of residential and commercial buildings, connecting new electricity generation units, two new reactors and increasing awareness of the importance of climate change effects.
- **Sustainable Transport:** Continuous change of transport infrastructure, reducing the amount of used resources and the achievement of sustainability parameters as required by EU average level, by providing financial and technical conditions for infrastructure modernization projects, ensuring funds and completion of projects from the Operational Programme 2007-2013, extending the traffic management system.
- **Sustainable Production and Consumption:** The control of sustainable resource consumption by adopting a model of sustainable consumption and production to increase sustainable performance;

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decoupling economic advance from environmental degradation by changing the ratio between resource consumption and added value creation;
    - **Actions:** Analysis of products impact on environment throughout their life cycle; supporting R&D activities; promoting digital technologies; reducing specific consumption of materials, etc.
- **Natural Resources Management and Conservation:** Reducing the current gap on environmental infrastructure compared to other EU member states;
- **Public Health:** Improving the structure of health system the quality of medical act and patient care through national programs implementation.

The transition to a green economy is a complex process, which raises difficulties for both developed and developing countries. To simplify the adoption of this phenomenon is important to design a national strategy based on the specific characteristics of Romania, on natural capital, human resources and the actual technological potential.

Through this study we aimed to identify threats and opportunities for the introduction of the green economy in Romania. As it can be seen from the analysis, there are currently a number of significant threats that can pose obstacles to the introduction of green economy, such as halting the advance in solar energy by reducing subsidies, lack of clear implementation tactics, the prices associated with green products, current crisis, etc.; there is also a number of opportunities, such as continuous expansion of wind energy sector and the favorable position of Romania among countries with claims in this area, entering the low carbon products market, etc.

The conclusion of this research is that Romania's transition to a green economy and its subsequent expansion will be a difficult process, given that our country is still in a poor stage of development in all sectors of interest, which require a complete restructuring as a preparation for full implementation of this concept; however, there is natural potential for its development.

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KEY TERMS AND DEFINITIONS

Energy Efficiency: A very broad term that refers to the many ways in which we can achieve the same benefit (light, heat, motion, etc.) using less energy. The field covers efficient cars, light bulbs, improved industry practices, better insulation of houses and a range of other technologies. Because saving energy means saving money, energy efficiency is very profitable.

Environmental Investment: Investment for researching, proposing and implementing solutions to climate change which seeks to consider both financial return and social good.

Green Certificate: A document confirming the 1MWh use of electricity from renewable sources, specifically non-fossil such as solar, wind, geothermal, aerothermal, hydrothermal, hydropower, biomass, waste fermentation gas and sludge (from wastewater treatment plants) fermentation gas and biogas.

Green Energy: Also referred as clean energy or renewable energy. Energy from sources that either regenerates itself in a short time or are practically inexhaustible sources (solar energy, the wind, flowing water, biological processes, geothermal heat).

Natural Capital: Capital stock derived from natural resources such as biodiversity, ecosystems and the services they provide. Natural capital of a geographical or political-administrative area consists of ecological systems that function in natural or semi-natural regime and anthropological systems resulting from transformation and simplification of the above category.

Sustainable Consumption: The consumption which is looking at how the goods and services improve quality of life by keeping the energy, material and pollution intensity of all consumption functions within the carrying capacities of natural ecosystems.

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Sustainable Production: The production of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of pollutants and waste over the life cycle, so as not to jeopardize the needs of future generations. The sustainable production is focusing on improving environmental performance in key economic sectors, such as industry, agriculture, energy, tourism and transport.

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Chapter 47
Exploring Landscapes in Regional Convergence:
Environment and Sustainable Development in South Asia

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ABSTRACT

The South Asian region is a key economic zone, as seen from the global perspective. In the past two decades, it has witnessed a healthy growth in GDP terms. Globalization has propelled the countries in the region towards regional cooperation as a means to address common growth concerns. Along with geo-political compulsions that have fostered this convergence, we find that there are also socio-cultural and historical factors present that could serve as binding stones. However environment and climate change pose a huge challenge to the economic integration and growth in this region. While a number of institutional and policy regional cooperative measures have been put in place, there are certain bottlenecks in the region, which are again a product of its history, that need to be addressed. We feel that reassessment of national interests and priorities through strong political will are essential to mitigate these bottlenecks to realize the true potential of convergence in this region.

This is not just a technical issue. Everybody's actions are motivated by their inner life, their moral, spiritual and ethical values. Global agreements will be effective when they are rooted in the individual commitment of people, which arises from their own inner life. -Maurice Strong, Chair, Rio Earth Summit, 1992

INTRODUCTION

Sustainable development has emerged as a core theme of government policies, international cooperation, aid agency norms and civil society concern. Developing countries of the world have increasingly attuned their policies striving to balance developmental programs with conservation of natural resources that

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sustain large rural populations depending on agriculture, forestry and related vocations. South Asian countries in particular have unique circumstances influencing their programs in this regard. The Himalayas, from where the major rivers of the region originate, straddle across five of the region's countries viz., Afghanistan, Bhutan, India, Nepal and Pakistan. Barring Sri Lanka, all the countries share waters of these rivers and exploit the ecological resources that the Himalayas and river systems offer. The seas surrounding the region are a major source of livelihood and the forests in the region are home to nearly a fourth of the region's population. The statistics published by the Asian Development Bank (ADB) indicate that the region has about 23% of the world's population and 15% of the world's arable land, but receives less than 1% of global foreign investment and tourism revenues, only 2% of global GDP, and 1.2% of world trade. Furthermore, South Asia is still home to about 410 million of the 720 million poor living in the Asia-Pacific region despite the rapid economic growth in India and, to a lesser extent, other countries. Of the 1.4 billion people in South Asia, 42% or 488 million live on less than a dollar a day (World Bank, 2008). In addition, key indicators suggest that social development still remains relatively low when compared to other Asian regions (ADB, 2006). Occupying about 5 per cent of the world's land mass, its population is expected to rise to about 25 per cent of world's population by 2025. Three-quarters of South Asia's population lives in rural areas. UNEP concludes that South Asia is very vulnerable to climate change. Impacts of climate change have been observed in the form of glacier retreat in the Himalayan region, where the approximately 15,000 glaciers will likely shrink from the present total area of 500,000 km^2 to 100,000 km^2 by 2035. These glaciers form a unique reservoir, which support perennial rivers such as the Indus, Ganges and Brahmaputra, which, in turn, are the lifeline of millions of people in South Asian countries (Bangladesh, Bhutan, India, Nepal, and Pakistan). This will exacerbate the challenges of poverty reduction and improving access to safe drinking waters, two of the Millennium Development Goals (UNEP, 2009). The region is considered to be the least economically developed as a geographical sub-region and their biggest as yet challenge seems to emanate from environment. Bindu Lohani (2014), ADB Vice-President for Knowledge Management and Sustainable Development says, "South Asia's economy is under serious threat and the lives and livelihoods of millions of South Asians inhabiting the region's many mountains, deltas, and atolls are on a knife edge. Countries must respond individually and collectively to cope with rising sea levels, disrupted water, food, and energy supply and increased disease".

While it is so, the region suffers from overt to subtle political imbalances that prevent convergence of energies towards addressing the issue of sustainable development. External conflicts and internal security challenges, partly from inherited colonial legacies and partly from perceived assertion for regional supremacy, have ridden the region through the past seven decades. These have created stalemates in regional dialogues towards convergence. It is evident that these obstacles can only be surmounted through constructive political will which is prepared to set aside narrowly defined 'national interests' for achieving common regional good. While the question of settling boundaries and defining maritime limits may take prolonged timeline, the issue of convergence on environmental challenges merits immediate attention as it has the potential to add to economic growth agenda and directly contribute to improving the livelihoods of millions in the region. Their economic stability, in turn, may perceivably contribute to mitigating the security challenges in the region leading to a more viable environment for resolving other major issues. The hypothesis therefore is that the environmental challenge to the economic prosperity of South Asia enjoins an urgent note to the indispensability of regional cooperation.

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This proposition arises not out of the niceties, if it may be politely said, of the global trend towards regionalism as a political tool for negotiating the delicacies of international politics. It arises out of the geological fact that the Himalayas, Bay of Bengal and Arabian Sea determine how the climatic conditions in the region will prevail and that what affects these features, like global warming for example, will affect the delicate balance between nature and livelihood of nearly a fifth of humanity.

OBJECTIVE

A large number studies have been undertaken by aid agencies such as the World Bank (WB), ADB and academics on environment, poverty alleviation and sustainable development. While a review of such works may be of interest to the reader, since this chapter attempts to evolve a perspective of the factors that mutate into the causes of environmental issues in South Asia in general and, India in particular, a conscious omission is made on this account. Also, the chapter explores environment and sustainability paradigm not just as a livelihood issue. It rather attempts to see whether the commonality of challenges on these fronts can form a platform for dialogue among South Asian countries and whether it can aid as a foreign policy tool strengthening regional convergence. Such an exploration is uncommon in the studies concerning sustainable development, foreign policy or regional cooperation and is also unique since the studies on environment and sustainable development generally tend to limit themselves to scientific aspect of environmental degradation or the econometrics of environmental impact and studies on foreign policy or regional cooperation tend to focus on geopolitical issues. The attempt to evolve a perspective of sustainability initiatives as a foreign policy option therefore, it is felt, may provoke thought process that may contribute to strengthening regional convergence from the environmental dimension.

METHODOLOGY AND OUTLINE

Keeping these perspectives in mind, this chapter, in seven parts, explores the landscape of regional cooperation through the prism of environmental economics in South Asia. Part I examines socio-cultural factors, colonial economics, global and regional geopolitical factors. The historical perspective is essential since the policies and practices which emerged out of these factors in the region have largely remained in place and continue to influence the institutions that are concerned with management of natural resources like forestry for example. Part II considers environmental economics vis-à-vis livelihood by looking at forestry, land use and rural-urban migration prompted by environmental issues. Part III considers certain case studies to assess how grassroots environmental sustainability practices and initiatives impact rural livelihoods. The purpose is to consider whether there is a case for regional cooperation for obtaining larger good. Part IV outlines how donor agencies have come to view development assistance in the context of sustainability. Part V explores existing policies and institutional measures in regional cooperation. It infers the emergence of conscious policy outlook on development through sustainable practices as essential in the context of South Asia and that sustainable management of natural resources necessitates cooperation due to peculiar geographical factors in the region. Part VI looks at civil society activism that has emerged as an influential factor in defining institutional programs and practices for

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sustainable development as civil society activism plays an important role in shaping the contours of cooperation. Part VII attempts to evaluate regional convergence underlining the need for deliberate steps towards cooperation and de-bureaucratization of endeavors for larger public good. In conclusion, the study draws upon the example of European Union (EU)to suggest setting aside of politically weighted resistance to strengthen regional cooperation initiatives in order to meaningfully share environmental resources, thereby promoting sustainable livelihood in the region.

PART I: THELANDSCAPE OF CONVERGENCE

Socio-Cultural Factors

Geopolitical birth of South Asia as a regional cluster of nations can be dated to the late 1940s, except Afghanistan, Bangladesh and Nepal. Afghanistan and Nepal had existed as independent nations for centuries before and had umbilical relations with the rest of the subcontinent through the history and culture of their people. Nepal is intrinsically connected to the Hindu culture since for millennia Hindus of the subcontinent have considered the pilgrimage to Mansarovar and Mt Kailash through Nepal as one their holiest undertakings. The Pashupathinath temple at Kathmandu is considered as one of the holiest Shiv temples in the region, believed to have been constructed around 400 AD. The sub-continental appeal of the temple can be judged by the fact that Namboothiri Brahman priest from Kerala (at the southern tip of India) have been priests in the temple for over 350 years (Parameshwaranand, 2004; Shrestha & Singh, 1972). Afghanistan, on the other hand, is the land from which Babur the founder of the Mughal Empire in India hailed from. Through the course of Mughal rule of three centuries and subsequently through the follies of East India Company's adventures for installing puppet regimes in Kabul by undertaking three colossal Afghan Wars, in the late 19th century, the societies of both the regions remained entwined (Dalrymple, 2012). British colonial obsession with 'the Great Game', a term popularized by Rudyard Kipling's 1901 novel *Kim*, of Russian sphere of influence over Central Asia continues to influence the policies of western powers concerning Afghanistan (Bilgrami, 1972; Warikoo, 1989; Allworth, 1994). Afghanistan remains one of the central reasons for the rivalry between India and Pakistan for dominant status in South Asia (Warikoo, 2002; Cooley, 2012).

Bhutan on the central Himalayas had preserved its sovereignty and its historical relations with people of the subcontinent are not exactly dated. However, in AD 747, in the form of Padmasambhava, Buddhism arrived in Bhutan from India ((Bandopadhyay, 2009). Throughout the Mughal, Colonial and early independent period of India, Bhutan maintained cordial relations with the governments of the day. Sri Lanka, the largest island in the region, has had very deep cultural and historical relations with the subcontinent. To give an example, there are 16 sites related to the great epic Ramayana located in Sri Lanka. Kandy and Kadirgamam in Sri Lanka are home to important Hindu temples dedicated to Kartikey, the mythological son of Lord Shiv of the Hindu trinity. Buddhism was brought to Sri Lanka by Sanghamitra and Mahindra, both children of the great Mauryan emperor Ashoka, from India. Ashoka also presented the tooth of Buddha which is a national relic of Sri Lanka kept at Sri Dalada Maligawa, Kandy. The Tamils of northern Sri Lanka have familial connections in Tamil Nadu, India. Issues affecting the Lankan Tamils are at the forefront of Tamil Nadu politics and greatly influence coalition partnerships in New Delhi (de Silva, 1981; Perera, 1988).

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Maldives came into being in 1965, transiting to independence from Britain. Historically, it had enjoyed trade relations with the subcontinent and African-Arab merchants for over two thousand years. India is a critical partner in development of Maldives. In 1988, India helped preserve peace from a coup attempt by militant groups by deploying 1600 Indian troops. Since then, Maldives has transformed into a stable democracy, though essentially remaining Islamic. From environmental perspective, Maldives is the most critically affected country in the world due to global warming. More than 80 percent of the nation's islands are just about a meter high above the ocean and increasing salinity is threatening livelihoods and occupations (GCCA-EC, 2009).

Bangladesh is the youngest nation in the region, becoming independent from Pakistan in 1971. The partition of Bengal during colonial rule in the subcontinent was ominous. Notwithstanding the separate nationality and predominant Islamic outlook, people of Bangladesh have the same cultural, linguistic and historical antecedents as the Bengali population in India. As the lower riparian, Bangladesh receives the waters of two of India's major river systems – the Ganges and the Brahmaputra. Sharing of these waters remains at the heart of Indo-Bangladesh relations.

The brief socio-cultural history presented above, forged by a variety of factors and actors, and is evidence of mutual influence and cooperation that has existed in the region for millennia. The strength of the socio-cultural bond predating present political boundaries augurs well with political cooperation necessitated by the process of globalization.

Colonial Economic Undertakings

In the political sense, the bulk of the subcontinent was unified by the Mughals and their administration developed a unique blend of local kingdoms superimposed by a central regal authority. The decentralized administrative structure left large areas of the region autonomous enough to deal with local resources as per priorities of local populations. Urbanization that began with the arrival of the British was conspicuously absent during the Mughal period. British Rule per se commenced when the Crown took over the rule of the subcontinent after the 'Sepoy Mutiny of 1857'. In the succeeding nine decades, Britain embarked upon the most successful commercial exploitation in history of its 'jewel in the crown'[1]. Four factors during the British Rule came to affect the environment and ecology of the subcontinent, though their impact on environmental economics of the region remains yet to be understood in its entirety. These are: the introduction of German forestry in the garb of scientific forestry, the making of the Indian Railways, the economic-ecological demand on the subcontinent for WW I & II by the Empire and the successive droughts that plagued the region between 1860 and 1900. Brief appreciation of these factors is essential to appreciate how environment is intricately and delicately linked to the economic lives of people in the subcontinent and therefore must remain at the heart of regional cooperation.

German Forestry and British India

Political consolidation of the subcontinent by the British in India was completed after the Sepoy Mutiny of 1857. Stung by their setbacks in quelling rebellion in their Bengal Army, British went about consolidating their rule with vehement fervor primarily for economic reasons. A tip-of-the-iceberg example is the report of the House of Commons Commission that examined the affairs of the East India Company (House of Commons Report, 1832). The report observed:

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The following statement for the year 1828-29 will show the proportion in which the revenue is derived from different sources….Land Revenue £ 12895366[2]*…Opium trade £ 1930891…making a total £ 22691721.*

The report in page viii, noted with satisfaction that the Revenues from India have progressively increased from £ 16764700 in the three year term ending 1814 to £ 22987472 in the three year term ending 1828-29. The figures are annual averages, making a staggering 37.12 percentile growth. The phase of consolidation also witnessed a huge demand for forest produce, particularly timber for ship building and military use(Bowen, Lincoln, & Rigby, 2002). Since the loss of America, Britain was under pressure to find alternate sources of supply in the subcontinent since 'the forests that used to supply Bombay and Calcutta docks have fallen off from extreme exhaustion' (Gov of UK, 1832). India offered in the British calculation unlimited supply, though later it was explicitly accepted that such exploitation would force the natives to turn their attention to other natural resources for sustenance(House of Commons Minutes, 1832).

The 'extreme exhaustion' that was noticed in the forests of western India turned the British attention to the Himalayas. Guha (2010) studying the steady intrusion of state into the forests observes that their attention that was limited to Saal forests in the foothills between 1815 to 1850, culminated in the declaration of all forests as state property under the Act of 1878. By 1911, their economic interest resulted in the carving of extensive areas out of 'District Protected Forests' into protected forests where the state had the exclusive prerogative for commercial exploitation. In 1874, in an address to the Royal Scottish Arboricultural Society, Hugh Cleghorn (1875), the Inspector General of Forests in India, told his audience that "the government in India began to be seriously embarrassed by the scarcity of timber; its attention was directed to the management of the indigenous forests". Timber resources in India were declining rapidly under the pressures of the high timber demand in the British Empire, local use and above all the rapid expansion of colonial agriculture and the associated loss of forestry cover in India during the first half of the 19th century (Stebbing, 1922). At the heart of the transition from need-based requisition to large scale commercial exploitation of forests was one man named Dietrich Brandis and his implacable faith in German Forestry. Dietrich Brandis introduced scientific forestry in British India 1n 1856 and served as the first Inspector General of Forests. The history of German forestry and its influence on the management of natural resources, particularly forests, must be recognized as holding sway over the forest policies of the sub-continental nations even today (Saldanha, 1996).

Railways in the Subcontinent

The subject of railways and its impact on ecology and environment has received considerable academic attention. While the saga of railways is intrinsic to the consolidation of the Empire in the subcontinent, its introduction and expansion were primarily prompted by two factors. In 1839, the textile mills of Manchester ran into severe crisis due to the failure of cotton crop in America. India offered exceptional alternate source for cotton but the logistics in transporting cotton to the ports of Bombay, Madras and Calcutta were astronomical. This commercial compulsion was at the heart of introduction of railways in India in 1854. The Mutiny of 1857 with the attendant need to transport troops gave the project further fillip.

An important watershed in the environmental economic history of the subcontinent was the construction of a railway network after 1850. The network of tracks increased from only 32 kilometers in 1853 to over 51,650 kilometers in 1910. The construction of the railways required an enormous amount of timber because to build two kilometers of track almost 900 sleepers were needed. Indian trees, particu-

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lar sal (*Shorearobusta*), deodar cedar (*Cedrusdeodara*), and teak (*Tectonagrandis*) were much used as sleepers, because of their strength and perceived resistance against rotting. Already severely depleted by the clearance of forests for commercial purposes earlier in the century, India experienced a resource crunch, and the authorities realized that the intensive extraction of timber could not be sustained indefinitely. In order to secure a continuous flow of timber the forests had to be brought under control using a management regime that would protect the forests and perpetuate the production of timber (Guha, 1983; Poffenberger, McGean, &Khare, 1996; Buckles, 1999; Oosthoek, 2001).

The Draughts and Floods

The United Nations Environment Program (UNEP, 2009) made a summative finding on the draughts and floods in the subcontinent in the following words:"during the period between 1871 and 2000 there were 22 drought years and 19 flood years. There had been three cases of prolonged drought conditions in 1904-05, 1965-66 and 1985-87, which caused great anguish. Similarly, there had been two cases of prolonged flood conditions in 1892-94 and 1916-17. Studies indicate a clear relationship between the occurrence of droughts and floods in South Asia with El Niño (La Niña) events in the East Pacific Ocean. It has been observed that, during the period 1856-1997, there were 30 El Niño years in which the average monsoon rainfall over India was seven per cent below normal; and in 10 of these 30 cases, drought conditions prevailed over India. During the same period there were 16 La Niña years, nine of which featured flood conditions over India, particularly in 1878 and 1983. However, it appears from some of the recent studies that this relationship has been weakening in recent years, possibly due to global warming". It is imperative to note that the cause of draughts and floods are more important than the aftereffects including relief and rehabilitation. The ecological degradation that occurred due to unrestricted exploitation of natural resources had a huge contribution in the causation of these natural disasters.

The Two World Wars

It would perhaps appear as a gross injustice to the men who divined Allied victories in both the great wars to say that their victory would not have been possible but for the resources of British India. In all fairness, it must be acknowledged that the natural resources of the subcontinent played a huge role in Allied victory owing to the following:

- With the outbreak of the First World War the work of the forest department began to suffer for two reasons. Firstly, the young officers of the forest department were called to serve the Army and secondly, the department had to deal with the enormous demands for timber and other forest produce from the Army. The conditions of war also warranted the increased supply of timber for military, railways and other government departments. During the First World War, much of the forests were destroyed for fuel and timber (Janaki, 1990, p. 24).
- In 1935, Burma was separated from India and with it went the huge tracts of as yet unexploited forests in Burma. The undivided sub-continental India till then had 24% of forest cover. With the separation of Burma, the total forest cover in India (including present day Pakistan, Bangladesh regions) came to 11%(Karve, 1961, p. 123)
- A greater testimony to the level of deforestation in India is hardly needed. Then the Second World Warcame. The Minister for Railways while presenting the Railway Budget in 1948 observed that

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over 400 miles of railway tracks were uprooted lock, stock and barrel for the war efforts elsewhere in the world[3]. Carriages and sleepers and other infrastructure of the railways were extensively used by the Allied Forces in Africa and West Asia. He expressed his confidence that these would be built back for domestic needs of the country in the following years. The needs of the department of Defense for timber and forest products were larger than that of Railways with over 2.3 million Indians serving in the Allied Armies. Coal being prime commodity, wood was used extensively from Indian forests for railways and the Army throughout the war. The quantities of wood cut down for these requirements were colossal – for instance, over a million tons from the forests of United Provinces alone. The crushing demands of war often led to measures which worked against the basic principles of conservation and sustained yield. The war produced severe pressures on India's productivity and weakened the basis of forest based industries. It reduced the potentialities of production of timbers for various national requirements (Trivedi, 2011).

Global and Regional Geopolitical Factors

The nations of South Asia took their respective paths towards nation building after their independence. Each nation attempted to forge its own plans and methods to address issues of development. After experiencing sluggish growth in the initial three decades after independence, they attempted to align their economies in tune with the global trends in the late 1980's. However, their enthusiasm to adapt to the market economy of the west collectively created a dichotomous situation. Ahmad, Kelegama and Ghani (2010) observe that, "there are two faces of South Asia. The first South Asia is dynamic, growing rapidly, highly urbanized, and is benefiting from global integration. The second South Asia is largely agricultural, land-locked, exhibits high poverty, suffers from many conflicts, and is lagging. The divergence between the two faces of South Asia is on the rise. Many policy and institutional constraints contribute to this dichotomy. One important constraint is regional conflict that has made South Asia one of the least integrated regions of the world".

The geopolitical compulsions of the Cold war period resulted in alliances such as NATO, the Warsaw Pact, SEATO and CENTO. These emerged essentially as political alliances based on ideologies. However, the combined effect of the disintegration of USSR and globalization driven by market economy in the 1990's levied certain compulsions on nations to look for regional arrangements for mutual economic development. Regional groupings such as EU that emerged initially as political alliances based on common interest slowly transformed into economic alliances. Regionalism as a means to achieving common goals gained credence after the 1980's. The vibrancy seen in forging such alliances can be estimated by the fact that there are over 126 Regional Trading Alliances (RTAs) in the world of 198 nations. Apparently, the eagerness to find common grounds with neighbors and allies is driven both by geopolitics and market economics. The presence of highly industrialized countries on the one hand and the comparatively newly established countries with limited economic might on the other; the differences in ideologies and level of democracy; ability to build credible institutions to translate objectives of cooperation into development and challenges to internal stability in a vast number of countries pose serious challenges to successful regional cooperation. Hettne and Solderbaum (2006) observe that the new regionalism is characterized by its multidimensionality and complexity. It involves a rich variety of state and non-state actors, which often come together in informal networks and multi-actor coalitions operating at different levels of the world system. The feasibility to share technology, facilitate trade and therefore attain wider distribution of wealth between the alliance partners became a motivator for other

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regions of the world such as South Asia and Central Asia, etc. to develop regional mechanisms such as ASEAN, SAARC, BIMSTEC, SCO, and CAREC. While the progressively enlightened leadership in the Third World realizes the potential of such alliances to address common challenges like poverty, they are also plagued by notions of 'national interest' that undermine cooperation on multi-sectoral platforms, particularly related to environment.

Having been born in the throes and aftermath of the Great Wars and influenced by the Cold War that prevailed till late 1980's, South Asian cooperation, when it emerged in the form of SAARC, understandably riveted its emphasis on peace building. The SAARC Charter of 1985[4] declares:

Desirous of promoting peace, stability, amity and progress in the region through strict adherence to the principles of the UNITED NATIONS CHARTER and NON-ALIGNMENT, particularly respect for the principles of sovereign equality, territorial integrity, national independence, non-use of force and non-interference in the internal affairs of other States and peaceful settlement of all disputes. (Emphasis added)

There are strong arguments in favor of regional cooperation in South Asia. In an increasingly interdependent world, countries of the Third World are at particular disadvantage. Unlike the developed West, across Asia (with the exception of China), Asia-Pacific and Africa native economies are at best developing and are inadequate to generate knowledge, skilled man power and technology to facilitate social development. This handicap compels countries to seek global and regional alliances to fill the gaps in their capacity deficits. Neoliberalism or economic development that has come to be seen as the key to social development is being evaluated through the narrow prism of trade liberalization and opening of economy. However, liberalization alone is not a necessary condition for countries to turn to 'regional integration arrangements' (RIA). The pressures of globalization are compelling countries towards greater economic efficiency, larger markets, acute competition, access (and the need for) superior technology and greater opportunities for investment through RIAs. In addition, there is also a desire to extend assistance to neighboring countries for mutual benefit and to prevent the spillover of unrest or large scale economic migration. These compulsions, along with the near catastrophic East Asian crisis of 1997 contributed to the formation of BIMSTEC. To its credit, the founding philosophy of BIMSTEC focused towards two highly promising aspects of cooperation and expansion: one, it focused on those sectors of the economy and cooperation that were generally outside SAARC purview and secondly, it presented an opportunity to connect South and Southeast Asia by partnering with Thailand. Thus, BIMSTEC essentially was born due to policy induced changes warranted by perceived economic gains suited to all member countries. It is also noteworthy that the BIMSTEC Charter (the First Summit Declaration) (BIMSTEC, 1997) is focused on economic cooperation and development:

- Convinced that regional and sub-regional economic cooperation such as ours contribute to efforts towards global free and fair trade being pursued under the multilateral trading regime;
- Affirming that the above realities provide a firm foundation on which to build our partnership and overall cooperation;
- Resolving to foster a sense of community that will lead to the economic and social development of the entire region;

The initial areas identified by BIMSTEC for cooperation through 'lead' country initiatives were: trade and investment (Bangladesh), technology (Sri Lanka), transport and communications (India),

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energy (Myanmar), tourism (India), and fisheries (Thailand). Implementation of a free trade agreement (FTA) for trade in goods by July 2006 and another FTA accord for services and investment by July 2007 were two of its most significant goalposts. Even though the formation of SAARC and BIMSTEC issued forth a promise for greater cooperation in the region, the challenges in front are equally compelling. Bhaskar (2006) made an important observation: "A comparison with established regional blocs reveals the daunting challenge BIMSTEC faces. In 2004, exports among the Association of Southeast Asian Nations (ASEAN) countries were at the level of USD 123.7 billion. As pioneers of regional economic cooperation, the countries that make up the European Economic Community (EEC) traded extensively among themselves, even in the absence of a preferential trading arrangement. Before any liberalization, intra-EEC imports made up 25 per cent of total imports. Current intra-BIMSTEC trade, for its part, stands at just 4 percent of total trade". In contrast Nag and De (2007) state that "In case of EU, there has been harmony among France Germany, Italy and UK who played a major role in institutions building highlighting the loss of national sovereignty to be accompanied by strong compensation mechanism including provision of public goods from integration".

While economics became an important incentive for cooperation, it is necessary to examine the extent to which environmental economics is important to the collective prosperity of South Asia. We undertook this examination from two perspectives: the contribution of agriculture, forestry and fishery to the gross national income in the region and the impact of environmental economics on livelihoods using case studies from academia.

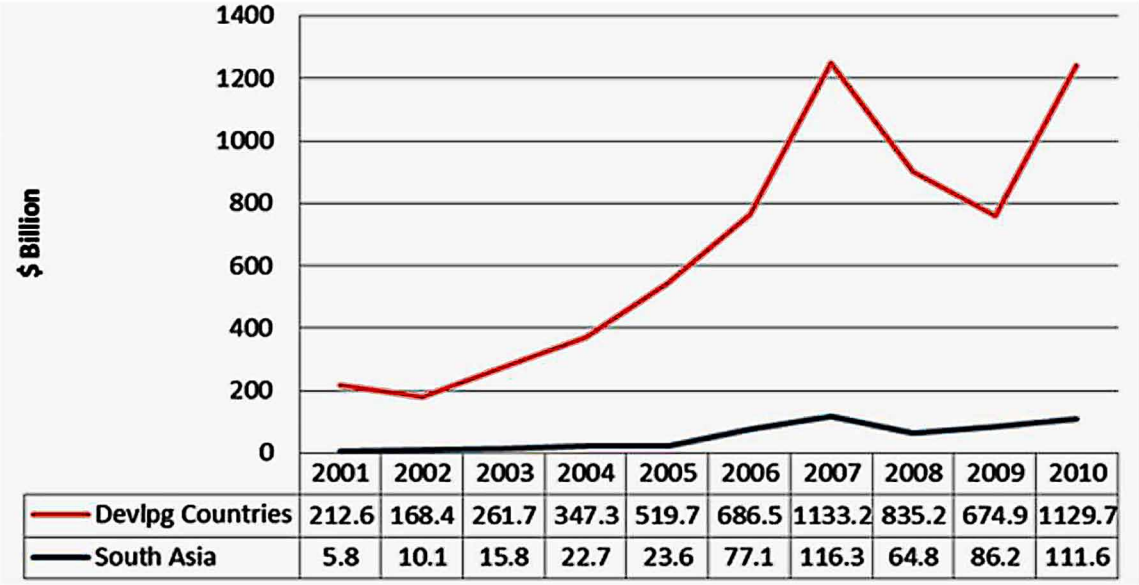
PART II: SOUTH ASIA ENVIRONMENTAL ECONOMICS: A BACKGROUNDER

The South Asian region is a key economic zone, as seen from the global perspective. It assumes prime importance due to two fundamental reasons. Firstly, its huge population makes it a lucrative market for all kinds of products and the fact that this region is growing fast, adds weightage to this prospect. Secondly, the countries of this region, with the exception of Maldives and possibly Sri Lanka, are all major debtor countries and unable to break free from the 'low-level equilibrium trap' - created by low rates of capital formation, that compounds the need to secure resources from other sources, to build up a capital base. Following the East Asian meltdown, there has been a diversion of global funds towards this region (Figure 1- Net Capital Flows to South Asia 2001-2010) and therefore, this is a very crucial stage for the region, as a whole. As the global economy tends to become smaller, international trade assumes far greater importance. Today, the world market is much more complex and developing countries are increasingly being marginalized by larger economic blocs such as the European Union. Political leaders have understood the need for co-operation at the regional level to ensure better terms of trade in the global marketplace. All of the above means that the region for its survival has to perform at higher qualitative levels and yet manage to produce the quantities that would be able to feed its rapidly growing population.

Over the last few years, South Asia has been one of the fastest growing regions in the world. Between 2000 and 2008, the region registered an annual GDP growth rate of 6.6 per cent, which was higher than the average annual growth rate of Southeast Asia (4.8 per cent) but slightly below East Asia's (the fastest growing region) 7.4 per cent. In 2010, GDP growth in South Asia slowed down to 5.5 per cent per annum, still higher than Southeast Asia's 3.8 per cent but falling behind East Asia's 6.7 per cent. Although such a high average GDP growth rate of South Asia was dominated by India, other South Asian countries also experienced relatively higher GDP growth, exceeding 5.0 per cent between 2002 and 2007, except for

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Figure 1. Net capital inflows developing countries 2001-2010
Source: By Author, based on data from World Bank Global Development Finance 2012



Nepal: and the Maldives in 2005 (Table 1- Growth Rate of GDP 2001-2010). The lower growth rates of Nepal were due to the civil conflict and in the case of Maldives was caused by the heavy damage from tsunami in 2005. South Asia's robust economic performance, supported by sustained growth in industry and service sectors, is expected to continue in 2006, with an average growth rate at 6.6 per cent. This projected GDP growth rate is higher than Southeast Asia's projected 5.4 per cent and comparable with East Asia's 6.9 per cent (ADB, 2005, 2005; NEC, 2008; World Bank, 2006).

The data above brings out two important factors: First, South Asian growth is competitive and even with all the challenges in cooperation; the region displays positive potential as compared to Southeast Asia or East Asia (minus China). Second, Indian economy is critical to collective growth and therefore lends a stronger case for intra-regional cooperation.

While the prospects for higher growth through regional cooperation are evident, how do environmental factors contribute to economy in the region? Are protection, conservation and sharing of environmental resources a necessary condition for sustainable development? In order to appreciate the relation between

Table 1. Growth rate of GDP South Asia 2000-2010

	2000-2008	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
South Asia	6.6	3.8	4.6	4.5	7.8	7.4	8	8.5	8.3	6.5	4.7	5.5
South Asia (excluding India)	5.3	3.3	3.4	5.8	6.7	5.7	5.5	6.2	6.8	4.8	2.3	3.4
India	7.2	4	5.2	3.8	8.4	8.3	9.3	9.7	9.1	7.3	5.9	6.5

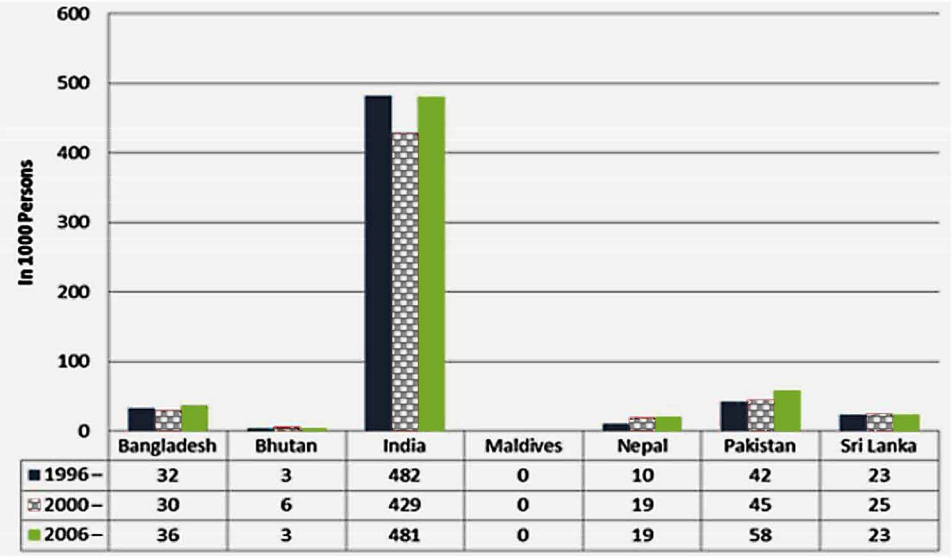
Source: Based on data collected from Table A3: Developing Economies – rates of Growth of Real GDP 2000-2010, World Economic Situation and Prospects 2010, Statistical Annexes, p 147

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growth and environment in South Asian context, we compared the employment potential of forestry and the contribution of forest revenues to the GDP in South Asia as a test case. The data in comparative charts are appended as Figure 2, 3 and 4 respectively. The statistical information was collected from FAO and UN databanks accessible publicly on the internet.

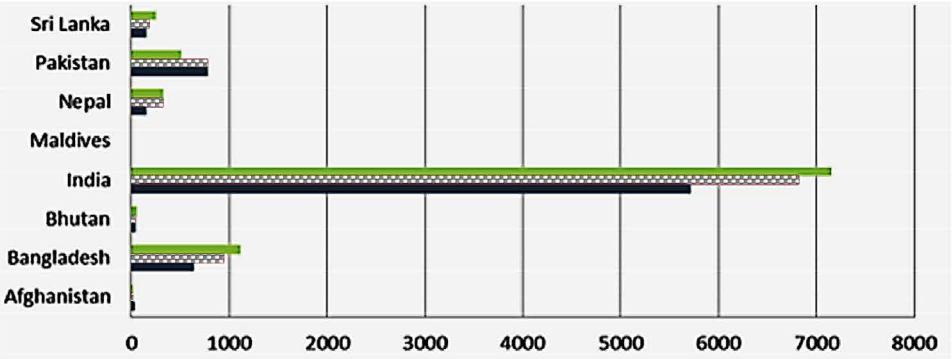
The data shows that the combined employment potential of forest sector has registered an increase from 592000 to 620000persons (4.73 percent) in the ten years taken. It also shows that the cumulative

Figure 2. Employment I forestry sector
Source: Author, based on ADB and World Bank data sources



	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
1996 –	32	3	482	0	10	42	23
2000 –	30	6	429	0	19	45	25
2006 –	36	3	481	0	19	58	23

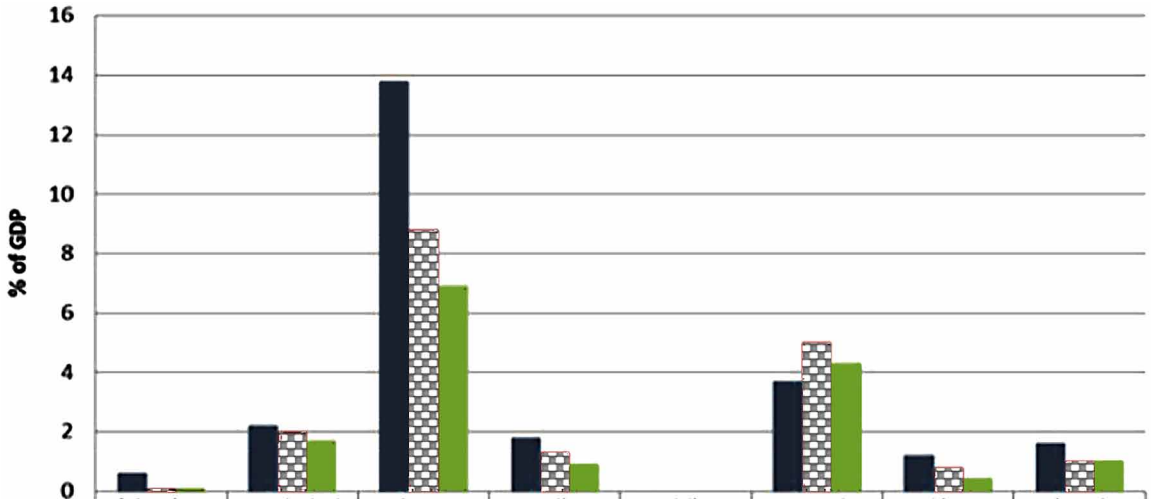
Figure 3. Contribution to National Income
Source: Author, based on ADB and World Bank data sources



	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
2006	5	1,118	61	7,151	0	330	510	247
2000	3	945	50	6,824	0	331	782	188
1996	38	645	48	5,716	0	150	781	157

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Figure 4. Forest revenue as percent of GDP
Source: Author, based on ADB and World Bank data sources



	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
1996	0.6	2.2	13.8	1.8	0	3.7	1.2	1.6
2000	0.1	2	8.8	1.3	0	5	0.8	1
2006	0.1	1.7	6.9	0.9	0	4.3	0.4	1

contribution to national incomes has increased from 7535 to 9422in US$ million (25.04 percent). If we take a combined regional GDP average, it is seen that revenue from forests contributes over 2% to GDP. In the case of countries like Bhutan and Nepal, it is in excess of 6.9 and 4 percent respectively. This data supports the premise that in the case of South Asia, a strong mechanism for cooperation on environment and forests will accrue employment and income generation and contribute substantially to the GDP growth rates.

When seen from the perspective that agriculture and related activities, a source of sustenance for over 60 percent of the population, depend on environmental and ecological factors and contribute to over 20 percent of GDP, the argument for regional cooperation appears to get fortified. Accordingly, we examined the land use practices and found that the region has four major farming systems on which nearly 87 percent of the population depends for their livelihoods directly or directly.

LAND USE PRACTICES

The number of people in South Asia is increasing at a rate of about 1.8 per cent per year and this increases the demand on food production to meet their requirements, without importing. However, a comparative increase in the amount of agricultural land is not seen and there is a slight decrease in some parts of South Asia. Around 60 per cent of the South Asian labor force is still involved in agriculture, while in Nepal more than 90 per cent of the populations are involved in this sector and 37 per cent of the Sri Lankan population is dependent on agriculture. The sector contributes to about 25 per cent of the GDP in the region. Between 1960 and 2000, the share of agriculture in national GDPs, in the region, has

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decreased by 20 per cent, and yet the population dependent on agriculture has remained the same. This has led to unemployment, underemployment and migration to urban areas. The region's agriculture is characterized by small landholdings in the alluvial lowlands, where too many people depend on too little land and production is largely for subsistence. The high rates of tenancy and lack of new technologies compound the problem. Rice is the staple food crop and is usually grown under wet conditions. The four most important agricultural systems used in the region are below (Table 2 Major Farming Systems in South Asia).

Ecological degradation and its effect on the river systems that are important to agriculture in the region need no substantiation. Table 2 demonstrates that 33 percent of the land under irrigation is directly depends on rivers and the 29 percent rainfed will get affected by environmental factors that will affect the monsoon pattern in the region.

RURAL VERSUS URBAN MIGRATION DUE TO ENVIRONMENT

The rural-urban migration induced by land use practices which are in turn affected by a combination of environmental factors and agro-economic policies are also important to understand the impact of environmental economics on sustainable development.

Within Asia and the Pacific, the Pacific sub-region is the most urbanized, with 71% of the population living in cities and towns. Micronesia (Federated States of), Papua New Guinea, Samoa, Solomon Islands, and Tonga are exceptions, each having less than 25% of their population living in urban areas. In contrast, *South and South-West Asia is the least urbanized with only 33% of the population living in urban areas.* Exceptions in this sub-region are Islamic Republic of Iran and Turkey, where approximately 70% of the population lives in urban areas. (Emphasis added)

Post 1990, however, South and South-West Asia have witnessed the fastest urban population growth rate of all the Asian and Pacific sub-regions at an average of 2.4% per year during 2005-2010. The South-East Asia urban population growth was somewhat slower at 2.2% per year, followed by East and North-East Asia at 2.0% and the Pacific at 1.8%. In North and Central Asia the urban population growth rate has hovered close to zero over the last two decades (0.3% for 2005-2010). The rural population of the world has grown slowly since 1950 and is expected to reach its peak in a few years. The global rural population is now close to 3.4 billion and is expected to decline to 3.2 billion by 2050 (Figure 5:

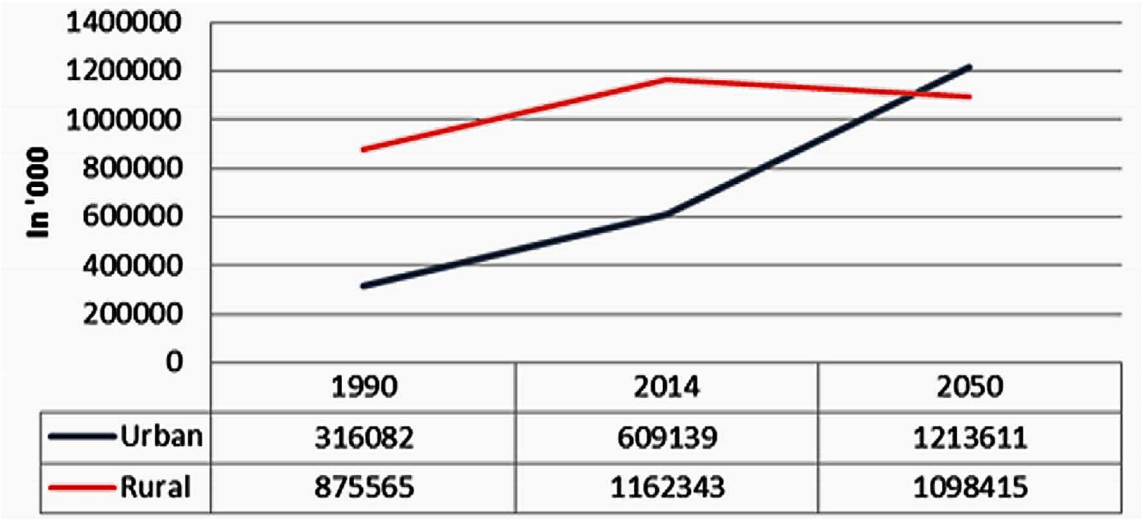
Table 2. Major Farming Systems in South Asia

Farming Systems	Land area (% of the Region)	Agricultural Population (% of the Region)	Principal Livelihoods
Rice	7	17	Wetland rice (both seasons), vegetables, legumes, off-farm activities
Rice-wheat	19	33	Integrated rice, wheat, vegetables, livestock including dairy, off-farm activities
Highland Mixed	12	7	Cereals, livestock, horticulture, seasonal migration
Rainfed Mixed	29	30	Cereals, legumes, fodder crops, livestock, off farming activities

Source: Based on FAO; World Bank 2001 Sources

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Figure 5. Urban rural population, Asia-Pacific sub-regions, 1990 and 2010
Source: Author, Based on data obtained from United Nations World Urbanization Prospects 2014



Urban Rural Population, Asia Pacific Sub-regions 1990-2050). Africa and Asia are home to nearly 90 per cent of the world's rural population. India has the largest rural population (857 million), followed by China (635 million) (UN, 2014). The table (Table 3: Rural Population in South Asia 1990-2050) below illustrates possible decline in rural population across the most populous countries in South Asia (population in '000).

Rural-Urban migration has been traditionally apportioned to individual characteristics based on age, sex or education that may or may not predispose them to migrate (Sjaastad, 1962). However, this view underwent a gradual change from individual decision to household decision in which the household decides whether a member migrates away for economic reasons or the entire household migrates with him (Mincer, 1978; Haug, 2008; Bodvarsson & Van der Berg, 2013). Migration theory has also recognized that the community or context of the household also plays a role. It also recognizes that the local community-contextual factors may themselves be seen as affected by higher level provincial and

Table 3. Rural population in South Asia 1990 – 2050

Country	1990	2014	2050
Afghanistan	9583	23059	30909
Bangladesh	86111	105386	89504
Bhutan	448	475	441
India	646911	857198	805652
Maldives	160	195	189
Nepal	16508	22991	23501
Pakistan	77124	114221	115335
Srilanka	14108	17517	16644

Source: Based on data obtained from United Nations World Urbanization Prospects 2014

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national policies and the latter by international factors (Woods, 1982; Bilsborrow, 2002). According to Todaro and Smith (2009) about two thirds of the poor in rural areas get by and sustain their lives with subsistence farming either as small farmers or working on land owned by other people. The other third are engaged in small scale activities. Poverty profiles for developing countries characterize the poor as being agricultural households with little arable land. In an agricultural based economy, where poor residents lack access to resources and there is a high level of inequality and an inequitable distribution of assets, non-farm labor becomes an important source of income for the poor. Environmental economists have come to recognize that environmental factors have considerable implications for rural-urban migration. As Bilsborrow (2002) observes:

This… migration also has significant environmental implications when directed predominantly to marginal, fragile areas that have often been made accessible recently through extensions of road networks. Through clearing of forests or other vegetation to establish croplands or pasture, the extensification process may: (a) damage watersheds; (b) reduce water retention and replenishment of underground aquifers; (c) increase surface runoff, flooding, soil erosion, and siltation of dams downstream; and (d) decrease soil fertility. While appropriate policies can control or moderate many of these consequences, most developing countries do not have the necessary resources and technology to implement such policies.

The effects of the environment on migration have received less attention than those of migrants on the environment; but these effects are now also attracting research interest (Reuveny, 2007). Today, interest in environmentally induced migration has focused on the issues of: (a) "environmental refugees"(international migrants compelled by environmental conditions to seek temporary asylum in another, usually neighboring, country); (b) "displaced persons" (people forced to migrate within their country by environmental disasters or civil strife); and (c) other persons who migrate from rural areas within their own country at least partly for reasons of environmental deterioration. The latter, not referred to as environmental refugees except in the sensationalistic literature, account for the largest number but have received little attention, both because the international funding community has generally neglected internal migration in low-income countries and because the issue does not usually involve persons in desperate need of assistance (Bilsborrow, 2002).

Considering the size of the population in South Asia that is dependent on environmental factors for supporting their sustenance, degradation of environment portends serious consequences. Though research interests in developing countries have not yet come to grapple with environmental factors as a moot point of sustainable livelihoods in a substantial manner, following case studies demonstrate that such a trend is evolving and environmental conservation will remain at the heart of environmental economics in the region.

PART III: CASE STUDIES ON ENVIRONMENT AND LIVELIHOODS

In the previous segments, we examined the indispensability of environmental economics to South Asian collective progress. Economists have traditionally felt that the externalities (such as products of nature) did not affect economics since in the first place the products of nature were taken for granted and, secondly, they were not available in the market with a price tag on them. As Panayotou (1997) observed,

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"the prevailing configuration of markets and policies leaves many resources outside the domain of markets, unowned, unpriced and unaccounted for. More often than not, it subsidizes their excessive use and destruction, despite their growing scarcity and rising social cost. The result is an incentive structure that induces people to maximize their profits not by being efficient and innovative but by appropriating other people's resources and shifting their own costs onto others". The 1972 Stockholm Summit made the first attempt to forge world opinion on preservation and the interrelations between man and nature. The Rio 1992 Earth Summit can truly be said to be the commencement of serious research into the dimensions of environmental economics, particularly the emergence of the concept called sustainable development. Even at that time, Maurice Strong, Chair of the 1992 Earth Summit prophesized, "The battle for sustainable development will be won or lost in Asia." He was not being dramatic. Asia is home to 4.4 billion of 7.2 billion humans on earth. Without relying on any statistics, we can imagine the need for resources to house, feed and clothe this population. A step further, it would also help to remember that two thirds of Asians depend on agriculture and forestry for sustenance and sustainable livelihood for them cannot be realized without sustaining the resources of nature. In order to explore the relevance of this approach, we examined a cross section of published case studies from across Asia and elsewhere. It was also felt that such an exploration would validate our belief that sustainable development is possible only on a strong foundation of environmental protection/conservation. The hypothesis was to see whether South Asian cooperation must stand on the stilt of environment owing to its relevance on sustainable livelihood or are we merely exploring environmental concerns to satisfy our urge to sound appropriate in the international forum.

Chittagong Hill Tracts, Bangladesh

Kar and Jacobson (2012) found that households in the Chittagong Hill Tracts, Bangladesh, use different types of NTFP[5]s for subsistence and cash income, suggesting that some NTFPs are more market oriented while others are more important for subsistence. The Chittagong Hill Tracts are a heavily degraded area, with informants saying that forest resources have declined by about 50% from levels about ten years ago; however, the region still provides the largest forest-based contribution of any region to Bangladesh's economy. The majority of NTFP use is subsistence based, with about 65% of collected NTFP-related household income being used for subsistence, while approximately one-third of surveyed households also sold NTFPs for cash income. The three most important NTFPs for cash income were bamboo, wild vegetables, and broom grass followed by sun grass, bamboo shoots, medicinal plants and menda.

Sinharaja World Heritage Site, Sri Lanka

Senaratne, Abeygunawardena and Jayatilake (2003) illustrate how the relative importance of NTFPs for household subsistence and cash income has changed over time among households living adjacent to the Sinharaja World Heritage site in Sri Lanka. Overall, 82 NTFP species help to meet household nutrition requirements, generally as side dishes or snacks rather than as a staple food (except for yams). However, it was found that the new concepts in forest management have adversely impacted the contribution of NTFPs to household subsistence and cash income. Senaratne, Abeygunawardena and Jayatilake (2003) listed two reasons for the same: First, forest management restricted villagers' access to forest resources. With timber extraction, hunting wild animals, shifting cultivation, and gem mining prohibited, some of

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the more lucrative NTFPs, such as wild game, are no longer an option for households. Second, changing socio-economic factors, such as decreased shifting cultivation and the growing importance of tea industry in Sri Lanka, have reduced household incomes. As a consequence, households now depend on this income to purchase foods and medicine rather than collecting them from the forests.

Pwo Karen Villages, Western Thailand

In Southeast Asia, research found that NTFPs make an important contribution to the livelihood of the households who gather and consume them. In particular, the consumption of NTFPs allows gatherers to live with lower amounts of cash than if they had to buy in the market what they can obtain from the forest for free. Understanding the economic value of non-marketed NTFPs helps determine the true income of the gatherers, and the amount of extra cash that they would need if they could no longer gather NTFPs. It also helps ascertain the true value of the standing forest, leading to more rational decisions about its alternative uses. Yet, the NTFPs that are not marketed are often ignored when estimates are made of the economic importance of NTFPs to rural populations. Data from one month of fieldwork in two Pwo Karen villages in ThungYaiNaresuan Wildlife Sanctuary in western Thailand concludes that wild food plants remain a preferred alternative to commercial food crops because gathering wild food plants is a much more efficient use of time than engaging in the market economy in order to purchase commercial food crops (Delang, 2006). The forest remains important for fuel wood, with 75% of households reporting gathering fuel wood from the forest and 49% of total fuel wood coming from the forest. Similarly, dependence on the forest for construction materials remains high, with 90% of households extracting construction materials for poles, pillars, and other purposes. They point out that these materials are durable and do not require regular collection, which means that the utilization of these forest resources conflicts less with tea cultivation because of the relatively lower time input compared with collecting NTFPs for food or medicine that is more time intensive(Agarwal, et al., 2012).

Kendrapada, Orissa, India

David Clover (2010) cites a case from the work of an Indian researcher. In October 1999, the state of Orissa in India was battered by a super cyclone that killed almost 10,000 people and caused a massive loss of livestock and property. Controversy ensued over whether the impact of the cyclone had been made worse by years of destruction of mangrove forests in the area. Many argued that a healthy barrier of mangroves might have buffered the effects of the storm and minimized the damages it caused. Saudamini Das, a researcher from SANDEE, assessed the factors that affected the impact of the storm. She found that mangroves do provide important storm protection to people, livestock, and buildings. Her study also found that, had the mangrove forests been intact, more than 90% of the deaths due to the 1999 cyclone would have been avoided (See Table 4: Effect of Mangroves on Mortality during 1999 cyclone in Kendrapada, India).

To put an economic value on the protective role that mangroves play, Das looked at the mitigating effects of standing mangroves in the area, at government compensation payments, and auto-compensated losses. She calculated that a hectare of mangrove forest land stopped damage worth $43,000 in the district during the super cyclone.[4] Of course, such severe storms do not occur every year. But even allowing for

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Table 4. The effect of Mangroves on mortality during 1999 cyclone in Kendrapada, India

Number of deaths caused by 1999 cyclone	392
With no mangroves: predicted mortality	603
With mangroves at 1950 level: predicted mortality	31

Source: Das, 2007

the fact that mangroves have no storm protection value during non-storm years, Das found a long-term protection value of about $8,700. At the time, a hectare of cleared land was fetching $5,000. Thus, Das showed that leaving mangroves as storm buffers generates more value to society than clearing them for development. It is not surprising that Das's work attracted widespread interest. A workshop convened in Orissa to discuss her research drew 175 officials, parliamentarians, media representatives, and NGOs. Her study was distributed by the Food and Agriculture Organization at a meeting about Cyclone Nargis, which struck Myanmar in 2008, and has been used in many other deliberations on coastal conservation issues.

The Forests in Chamoli, Uttarakhand

Guha (2010) finds that in Tribal India even today (the Tribal population constitutes over 8.6 percent of the country's population), "it is striking to see how in many of the myths and legends the deep sense of identity with the forest is emphasized" (p. 33). In such forest areas not only did the forests have a tremendous influence in molding religious and spiritual life, the inhabitants also exhibited a deep love of vegetation, often acting 'entirely from a sense of responsibility towards future generations' by planning species whose span of maturity exceeded a human lifetime. Guha's work on the link between people, nature and history of state control over the forests of Uttarakhand state in India retains monumental influence in discussions on sustainable livelihoods across the world. Guha's compelling evidence highlights the lesson that the world has gradually come to accept as important - native knowledge balances nature and livelihoods better that scientific knowledge imported from entirely different contexts. The case of German forestry in Colonial India is a telling example. This finding is also amply supported by a number of works related to Traditional Ecological Knowledge, (TEK) including but not limited to, as cited in Inglis (1993): Studies in the transmission of Traditional Ecological Knowledge (Ruddle & Chesterfield 1977); community-based Traditional Ecological Knowledge research approaches (Johnson, 1992); application of Traditional Ecological Knowledge to development (Brokensha, Warren & Werner, 1980) and to resource management (Klee 1980); detailed biological/ecological evaluation of fisheries Traditional Ecological Knowledge systems in Oceania (Johannes 1981); traditional conservation (Moruata, Pernetta & Heaney, 1982; McNeely & Pitt 1985); traditional coastal resource management systems (Lasserre & Ruddle 1983); Traditional Ecological Knowledge of northern ecosystems (Freeman & Carbyn 1988), dry land ecosystems (Niamir, 1990) and tropical forest ecosystems (Posey & Balee 1989); environmental philosophy and indigenous knowledge (Knutdson & Suzuki 1992); volumes of selected topics (Johannes 1989) and studies of traditional marine resource management systems in Asia and the Pacific (Ruddle & Johannes 1989).

Jodha (1986) while investigating the relationship between the rural poor and common property resources found that a large part of the consumption of the rural poor came from environmental resources. Their dependence on these resources for livelihood generation was unambiguously underlined in these

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studies. Such a premise dispels the myth maintained implicitly in policy circles that the rural poor contribute to environmental degradation by over-extraction. Jodha offers a number of explanations for the apparent contradiction:

- The poor have a high rate of discount for the future due to low levels of income.
- Population pressure constitutes the major reason for degradation of natural resources.
- A large part of the degradation of the environment is the consequence of the failure of the market and the state to provide appropriate modes of management of natural resources.

Amazon Forests, Brazil

A poorly designed land ownership policy, combined with a macroeconomic problem, were driving people's behavior in ways that were rational from the individuals' point of view but harmful to the environment and wasteful of society's resources. When environmental economists showed that these failures of economic policy were a major cause of rainforest destruction, many of the subsidies and incentives for land clearing were removed (Binswanger 1991). Even macroeconomic policies that, at first glance, have little relationship to the environment can have powerful environmental effects, as the Brazil example shows(Clover, 2010).

The above cases have two major implications, as per Clover (2010): First, environmental degradation has a massive impact on people, making environmental protection vital. Second, rural people need to be involved in the environmental management of the land they use and live on. This means that good environmental policy must take into account not only the well-being of the poor, but also their participation[6].

The critical understanding of the links between economic activity, livelihood generation and incentives for and against conservation centered management of natural resources comes from inter-disciplinary studies of scholars like Wade (1987), Chopra, Kadekodi and Murty (1990), Ostram(1990), and Bardhan (1993) with their groundings in economics, anthropology and sociology. A substantial number of these studies in South Asia aimed at exploring the relationship between poverty and environmental degradation. While poverty and over population were postulated as the largest polluters, the studies found that the poor had more close livelihood and consumption linkages with environmental resources. A natural question that arises, therefore, is: Could these links be expropriated positively to yield sustainable patterns of development?

The above case studies make it concrete that the biggest challenge facing South Asia – eradication of poverty – is not possible unless environmentally sustainable development in consultation with local populations is adopted by governments.

PART IV: DONOR PERSPECTIVE ON ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Development as well as environmental projects is capital intensive. Cash strapped developing nations rely on donor agencies like World Bank (WB) and Asian Development Bank (ADB) to bridge the gap between their development objectives and national capacities. With the global awareness on climate change and its impact on poverty alleviation, hunger and disease, these donor agencies have also devel-

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oped mechanisms that squarely attempt to raise funds as well as support developing nations in tackling these issues. World Bank (2013) for example states:

Climate change affects all of us. But it is expected to hit developing countries the hardest. Its potential effects on temperatures, precipitation patterns, sea levels, and frequency of weather-related disasters pose risks for agriculture, food, and water supplies. At stake are recent gains in the fight against poverty, hunger and disease, and the lives and livelihoods of people in developing countries. Tackling this immense challenge must involve both mitigation—to avoid the unmanageable—and adaptation—to manage the unavoidable—all while maintaining a focus on its social dimensions. Addressing climate change requires unprecedented global cooperation across borders. The World Bank Group is helping support developing countries and contributing to a global solution, while tailoring our approach to the differing needs of developing country partners. We are strengthening and building climate change partnerships with our member governments and a wide array of organizations.

ADB that works closely with South Asian governments has a clear appraisal of environment in the economic development of South Asia. Ahmad and Suphachalasai (2014) in their study for ADB "synthesizes the results of country and sector studies on the economic costs and benefits of unilateral and regional actions on climate change in ADB's six South Asia developing members, namely Bangladesh, Bhutan, India, the Maldives, Nepal, and Sri Lanka. The study takes into account the different scenarios and impacts projected across vulnerable sectors and estimates the total economic loss throughout the 21st century and amount of funding required for adaptation measures to avert such potential losses. It is envisioned to strengthen decision-making capacities and improve understanding of the economics of climate change for the countries in South Asia". The criticality attached to environment for the collective growth of South Asia is evident when we examine their report that states:

According to the report's findings the total climate change cost in South Asia will increase over time and will be prohibitively high in the long term. Without global deviation from a fossil-fuel-intensive path, South Asia could lose an equivalent 1.8% of its annual gross domestic product (GDP) by 2050, which will progressively increase to 8.8% by 2100. The model suggests that the Maldives will be hardest hit in GDP loss, while Bangladesh, Bhutan, India, Nepal, and Sri Lanka are projected to face 2.0%, 1.4%, 1.8%, 2.2%, and 1.2%, respectively, loss of annual GDP by 2050.

However, should the global community take actions along the Copenhagen–Cancun agreements to keep the global mean temperature rise below or within 2 degrees Centigrade, the region would only lose an average of 1.3% of GDP by 2050 and roughly 2.5% by 2100. Impacts on vulnerable sectors include:

Agriculture

Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation pattern (timing and amount) increase the likelihood of short-run crop failures and long-run production declines, posing a serious threat to food security. Although there will be gain in some crops in some regions, the overall impacts of climate change on agriculture are expected to be negative and need to be much better understood.

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Energy

A rise in average warming will increase energy requirements for space cooling (but reduce energy needed for warming), while increasing energy demand for irrigation. On the supply side, there is a direct influence on hydropower and thermal power generation through availability of water and the temperature of cooling water, respectively. Increases in intensity and frequency of extreme events like storms and sea level rise may cause more electrical system failures. Forest and other ecosystems Climate change will affect forest carbon pools in some countries of the region.

Health

The modeling results suggest that the mortality rate for the region caused by dengue, malaria, and diarrhea would increase over time as a consequence of climate change. Morbidity and deaths from such diseases could increase in the future under all scenarios.

Water

Although the monsoon-dominated annual precipitation cycle is expected to remain unchanged over South Asia, future decades are predicted to have drier and warmer winter months with reduced snow cover, while the summer/monsoon months are predicted to become wetter and warmer. The seasonal pattern of flows over the year could become more erratic, as rainfall is immediately converted to runoff instead of being stored as ice.

Adaptation Options, Policies and Strategies

The region's adaptation response need not be confined to symptomatic treatment of threats to traditional patterns of economic activity. More efficient regional economic diversification can create entirely new patterns and supporting infrastructure to take their place. In other words, policy makers need to take early action to adapt to climate risks, and this action needs to be informed by rigorous and timely evidence.

The South Asia developing member countries have by now developed their adaptation strategy. In some countries, such as India, state and sub national action plans have also been developed, allowing for integrating climate change adaption options in local project and facilities development. Building resilience to the impacts of climate change requires identifying the risks and vulnerabilities of sector and area development projects and programs, followed by developing the options for adaptation and mitigation measures that are socially, environmentally, and economically sound.

PART V: INSTITUTIONAL AND POLICY MEASURES IN COOPERATION

Globally viewing environment and cooperation on climate related issues as essential for economic progress has gained considerable momentum since the 1960s. Earlier, the word environment itself was usually associated with domestic or work environment and did not translate to the ecological and climatic context in which it is used today (Dauvergne, 2009). Environmental and ecological inputs into

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production were assumed to be free of cost as well as inexhaustible. In the process they tended to be omitted in any explorations of economic theories. As Pigou (1932) and others observed, "Traditional microeconomics treats environmental effects as externalities of production or consumption" (Ayres & Kneese, 1969; de Bryun, 2000; Hussen, 2013). The transition of 'environment' by the 1980's from being mere 'externalities' to being the inherent modulator was persuasive. We may note with some satisfaction that South Asian Region did not lag behind the emerging universal consensus on the inseparability of environment to economics and sustainable development. The awakening in South Asia was propelled by the following factors:

- The compelling political reason to find solution to the biggest challenge they face – poverty and the realization that poverty alleviation across the region has its roots in common cultural practices and traditional economic interactions.
- Emerging global activism in the wake of Stockholm 1972 and the run up to Rio 1992.
- Huge civil society activation in response to the development agenda of regional governments. For example, protests against Tehri Dam, Narmada river projects, agitations in Bangladesh against Farakka and Teesta projects, Indian objections to Chinese plans over hydroelectric projects across Brahmaputra in Tibet and the issue of Indus water sharing between India and Pakistan.
- Globalization and regional integration mechanisms in other parts of the world that are being tempered by donor insistence on sustainable growth agenda.

Recognizing that countries in the sub-region also need to pursue measures that reduce production and trading costs through sharing of basic resources, the South Asia Cooperative Environment Programme (SACEP) was established in 1982. The SAARC committee on environment was set up in 1992. In 1997, SAARC environment ministers agreed to an Environment Action Plan and a common SAARC position on climate change. In the Islamabad Declaration of January 2004, the Heads of State agreed to "undertake and reinforce regional cooperation for the conservation of water resources and environment, pollution prevention, control of, as well as preparedness to deal with natural calamities". They also expressed strong support for the "early and effective implementation of the SAARC Environment Action Plan and the preparation of a SAARC state of environment report, as well as the commissioning of the work on drafting a Regional Environment Treaty. The SAARC Environment Ministers meeting in Dhaka in July 2008 adopted the Dhaka declaration on Climate Change and an action plan on Climate Change.

Meetings of the SAARC Environment Ministers

The meetings of the SAARC Environment Ministers and the Technical Committee on Environment and Forestry provide key mechanisms to guide and facilitate the agenda of cooperation. Since 1992, SAARC Environment Ministers have met nine times. In addition, a Special Session of the Environment Ministers in the aftermath of the Indian Ocean Tsunami was held in Malé in July 2005. Regional Centers have also been established and constitute an important framework of SAARC Institutions to address diverse aspects of environment, climate change and natural disasters. These measures include:

1. SAARC Coastal Zone Management Center (SCZMC) -Established in 2004 to promote cooperation in planning, management and sustainable development of coastal zones, including research, training and awareness

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2. SAARC Forestry Center (SFC) - Established in 2007 for the protection, conservation and prudent use of forest resources by adopting sustainable forest management practices through research, education and coordination among Member States
3. SAARC Disaster Management Centre (SDMC) - Established in October 2006 to provide policy advice and facilitate capacity building including strategic learning, research, training, system development, expertise promotion and exchange of information for effective disaster risk reduction and management – the mandate of the Centre was expanded to include the development of a Natural Disaster Rapid Response Mechanism (Fifteenth SAARC Summit, Colombo, 2-3 August 2008)
4. SAARC Meteorological Research Centre in 1995 to carry out research on weather prediction and better understanding of monsoon.

Important Initiatives/Milestones

The Third SAARC Summit (Kathmandu, 2-4 November 1987) commissioned a Regional Study on the "Consequences of Natural Disasters and the Protection and Preservation of the Environment". The Study was completed in 1991.The Fourth SAARC Summit (Islamabad, 29-31 December 1988) directed that a joint study on the "Greenhouse Effect and its Impact on the Region" be undertaken. This study was initiated to provide a basis for an action plan for meaningful cooperation among Member States. The study was completed in 1992. The above two studies provided a comprehensive assessment of the state of the environment in the Member States of SAARC. The milestones of SAARC on the issue of Environment may be listed as below:

- SAARC Environment Action Plan (1997)
- Disaster Management in South Asia: A Comprehensive Regional Framework for Action 2006-2015
- Dhaka Declaration and SAARC Action Plan on Climate Change (2008)
- Delhi Statement on Cooperation in Environment (2009)
- Thimphu Statement on Climate Change (2010)
- SAARC Convention on Cooperation on Environment (2010)
- SAARC Agreement on Rapid Response to Natural Disasters (2011)

A Technical Committee on Environment was established in 1992 to monitor the progress made in the implementation of the abovementioned regional studies. The mandate of the committee has since been expanded to include meteorology and forestry. I additionally coordinates and monitors the progress of 1992 SAARC Environment Action Plan and 2008 SAARC Action Plan on Climate Change.

COLLABORATION WITH INTER-GOVERNMENTAL ORGANIZATIONS

SAARC also collaborates with many regional and international organizations on environmental issues. The initiatives include a Memorandum of Understanding (MOU) with the South Asia Cooperative Environment Programme (SACEP) in July 2004; United Nations Environment Programme (UNEP) in June 2007; the United Nations International Strategy on Disaster Reduction (UNISDR) in September 2008 and Asia Disaster Preparedness Centre (ADPC). SAARC avails technical and financial support in implementing regional programs through these MoU. SAARC is also an accredited Observer of the

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United Nations Framework Convention on Climate Change (UNFCCC) since COP 16 (Cancun, Mexico, 29 November-10 December 2010) and has presented common SAARC positions on climate change.

Donor Initiatives

Individually and through collaborative network, SAARC nations avail donor assistance for ecologically important projects. Agencies like ADB that extend financial assistance to South Asian governments have evolved and/or supported development of legal and institutional frameworks in these countries concerning environment. Few prominent examples of ADB support for various law-related environmental programs in South Asian region are (Davis, 2014):

- In Pakistan, ADB supported the Supreme Court in establishing green benches, extending assistance to institutionalize environmental law training in judicial academies, and strengthening environmental adjudication.
- In Bhutan, ADB has commenced initial work to support the creation of a Bench Book comprising all environmental policies, laws, regulations, and case law. This will be an invaluable resource for the judiciary in adjudicating environmental disputes.
- At the same time, ADB, together with other development partners, convened the Colloquium on Biodiversity in Hyderabad, India. The Colloquium was a first opportunity for judges to work with a multi-lateral environmental agreement, aiming to emphasize the importance of law and law enforcement, particularly in relation to crimes of illegal logging trade and destruction of habitat and biodiversity in both land and oceans.

Country Specific Initiatives

A number of scholars believe that as contrasted to the western parts of the world, in South Asia there exists a dilemma between how the world perceives environment on the macro level (as a developmental issue) and how people perceive environment (as a livelihood issue) at the micro level. The situation in the countries of South Asia appears then to be characterized best by a dilemma. The macro picture relegates resource and environment linked issues to the background, often to be brought into the forefront only at the behest of international agencies or in the course of political negotiations centered on the management of the global commons such as the climate change and WTO negotiations. At the local levels, natural resources constitute a significant issue, both from the consumption and livelihood viewpoints and the emergence of non-governmental organizations has drawn the attention of civil society to it (Jodha, 1986; Chopra, Kadekodi, & Murty, 1990; Dasgupta, 2010). This dilemma rises largely due to the realization in government level that two thirds of the population of these countries depends on the earth and its resources for their sustenance. Apart from economic considerations, the awareness of the link between man, environment and religious-cultural orientation of the societies have resulted in governments undertaking certain initiatives that promote man-nature harmony. Some of the examples that could be gainfully looked into are as below:

- **Bhutan:** The government of Bhutan has evolved a strict conservation policy that places greater emphasis on maintaining at least 60 percent of land area as closed forests in order to maintain climatic equilibrium and prevent soil erosion. In South Asia, Bhutan has the largest forest cover

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at 72.5 percent out of which 39.5 percent are closed. This policy orientation is rooted as much in economic and livelihood dependence on forests as much as it is rooted in Buddhist theological belief. In fact, as UNEP observes, Bhutan has even evolved its own standards in lieu of GDP called Gross National Happiness (GNH). *GNH,* as UNEP (2009) rightly observes is "the unique development philosophy adopted by Bhutan, is an attempt to define quality of life in more holistic and psychological terms than the conventional Gross National Product. The four pillars of GNH are the promotion of equitable and sustainable socio-economic development, preservation and promotion of cultural values, conservation of the natural environment, and establishment of good governance".

- **Maldives:** Maldives is the most threatened nation in the world due to global warming. *The National Environment Action Plan of the Maldives* outlines actions, policies and measures to protect and conserve the fragile biological diversity, particularly the marine ecosystem through integrated sustainable reef resources management since the entire population and economy of the country depend on local as well as global environmental factors.
- **India:** India has developed a National Policy and a Macro-level Action Strategy on Biodiversity, aimed at providing the framework for preparing detailed action programs at the macro level for conservation and sustainable use of the biological diversity that exists in the country.
- **Sri Lanka:** The *Biodiversity Conservation Action Plan (BCAP)* of Sri Lanka forms a broad framework for biodiversity conservation at the national level. It was prepared through wide stakeholder participation by the government and NGOs. A biodiversity secretariat has been set up by the Ministry of Environment and Natural Resources for implementation of BCAP. Its initiatives include development of measures for valuation of biodiversity, conservation of medicinal plants, establishment of a legal task force to identify gaps and recommendations in national legislation. Similarly, "WanaSenasuna" forest hermitage programme is another initiative by government of Sri Lanka to involve the Buddhist clergy and devotees for protecting the forests with cultural values. It integrates religious and cultural aspects into forest conservation to enhance to protection afforded to these areas.

PART VI: CIVIL SOCIETY ACTIVISM

People remain the reason why governments must exist. South Asia people, as has been amply pointed out above, have had close cultural and religious relationship with nature. The elements and resources of nature have not merely been deified by them; they have also taken upon themselves to usurp legal tools to safeguard their essential connection with nature and to preserve the resources of their environment. India, occupying more than 70 percent of South Asia and home to nearly 80 percent of its population takes the lead in environmental activism that has set standards for the region. We look briefly at civil society activism in India that has a huge influence on regional perspective on environmental cooperation.

The Constitution of India under part III guarantees fundamental rights which are essential for the development of every individual and to which a person is inherently entitled by virtue of being human alone. Right to environment is also a right without which development of individual and realization of his or her full potential shall not be possible. Articles 14, 19 and 21 of this part have been effectively usurped by the Judiciary as well as activists:

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- **Right to Life and Right to Environment:** According to Article 21 of the constitution, "no person shall be deprived of his life or personal liberty except according to procedure established by law". Article 21 has received liberal interpretation from time to time after the decision of the Supreme Court in Menaka Gandhi vs. Union of India[7]. Article 21 guarantees fundamental right to life. Right to environment, free of danger of disease and infection is inherent in it. Right to healthy environment is important attribute of right to live with human dignity. The right to live in a healthy environment as part of Article 21 of the Constitution was first recognized in the case of Rural Litigation and Entitlement Kendra vs. State[8] (Popularly known as Dehradun Quarrying Case). It is the first case of this kind in India, involving issues relating to environment and ecological balance in which Supreme Court directed to stop the excavation (illegal mining) under the Environment (Protection) Act, 1986. In M.C. Mehta vs. Union of India[9], the Supreme Court treated the right to live in environment free of pollution as a part of fundamental right to life under Article 21 of the Constitution.
- **Noise Pollution:** The constitution of India under Article 19 (1) (a) read with Article 21 of the constitution guarantees right to decent environment and right to live peacefully. In PA Jacob vs. The Superintendent of Police Kottayam[10], the Kerala High Court held that freedom of speech under article 19 (1)(a) does not include freedom to use loud speakers or sound amplifiers. Thus, noise pollution caused by the loud speakers can be controlled under article 19 (1) (a) of the constitution.
- **Profession and Health hazards:** Article 19 (1) (g) of the Indian constitution confers fundamental right on every citizen to practice any profession or to carry on any occupation, trade or business. This is subject to reasonable restrictions. A citizen cannot carry on business activity, if it is a health hazard to the society or general public. Thus safeguards for environment protection are inherent in this. The Supreme Court, while deciding the matter relating to carrying on trade of liquor in Cooverjee B. Bharucha vs. Excise commissioner, Ajmer[11] observed that, if there is clash between environmental protection and right to freedom of trade and occupation, the courts have to balance environmental interests with the fundamental rights to carry on any occupations.
- **Public Interest Litigation:** Interpretation of the Supreme Court under Article 32 and 226 of the constitution of India favoring litigation by unconnected persons on matters of public interest resulted in a wave of environmental litigation. The leading environmental cases decided by the Supreme Court include case of closure of limestone quarries in the Dehradun region[12] (Dehradun Quarrying case,), the installation of safeguard at a chlorine plant in Delhi[13] (M.C. Mehta V. Union of India,) etc. In Vellore Citizens Welfare Forum vs. Union of India[14], the Court observed that "the Precautionary Principle" and "the Polluter Pays Principle" as an essential feature of "Sustainable Development."
- **Local Government and Environment:** At local and village level also, after the 73rd Amendment, Panchayat (Local Governance body at village level in India) have been empowered under the constitution to take measures such as soil conservation, water management, forestry and protection of the environment and promotion of ecological aspect. While this devolution is a matter of precedence in developing countries, whether Panchayati Raj Institutions have been able to achieve these objectives is outside the purview of this chapter.

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PART VII: EVALUATING CONVERGENCE

Globalization as an inevitable process has huge impact on South Asian convergence. Historically the countries in the region came into being through political divisions during and in the aftermath of British colonial rule. The region continues to be dominated by the uneasy relationship between the two largest nations viz India and Pakistan. The course and quality of convergence of South Asian endeavors as a regional group as well as an economic entity will be defined by the quality of relations that these two countries will enjoy. Elsewhere in the world also, the course of the past two decades, as Pirages (2011) states "have been punctuated by increasing numbers of terrorist attacks, state failures, deadly epidemics, rapidly fluctuating world energy and food prices, a global economic meltdown, and intense storms and flooding that are very likely early effects of global warming. These and similar events have given impetus to the development of an alternative paradigm in international relations theory" focused on the intricate relations between man, his environment and sustainable development. This paradigm is not merely exploring the latent dimensions of economic theory that have grown out of the classical wealth generation oriented approach of the previous centuries; it explores an important link between development and human security or in the words of Pirages, 'ecological paradigm'. "An assumption inherent in this ecological or nontraditional paradigm is that significant threats to societies are just as likely to come from changes in human relationships with nature as they are from well-armed troops crossing borders" (Pirages, 2011).

South Asia like some other regions of the world remains a potentially violent region. Given its lengthy historical legacy of military and ethnic conflict, it is not surprising that security across South Asia is still narrowly defined in realist terms like absence of conflict. According to Geoffrey Dabelko and David Dabelko (1995), "at its most fundamental level, the term security has meant the effort to protect a population and territory against organized force while advancing state interests through competitive behavior." Given the effort that has been associated with this historical quest for wealth and power, limiting security concerns to mostly military matters is understandable, if not completely logical. Defense budgets, for the most part, are still used to purchase tanks and planes and not to fight infectious disease or stem global warming. But while troops massed on borders raise fears of impending destruction and death in some parts of the world, in other parts concerns over various kinds of environmental threats have been growing (Barnett, 2001; Kahl, 2006). Additionally, in an era of deepening globalization, infectious diseases can now cross borders more easily and are increasingly being recognized as very serious security threats.

In beginning of the chapter, we noted how regional cooperation that evolved from the political necessity for peace and stability slowly evolved into economic cooperation for sustainable growth. We also noted that through BIMSTEC, South Asia has extended its reach to integrate its economic progress with that of Southeast Asia. The traditional historical and cultural factors that have bound the societies of South Asia (as outlined earlier) provide the fundamentals for peace and stability that are important for regional integration to succeed in its objective. It is also important to recognize that ecological and environmental resources of the region are implicitly interdependent. For example, the Himalayas that are home to all the rivers that water the region are spread across five of the regions eight countries. Any action by an individual country that would adversely affect the ecology of Himalayas or the course of the flow of its rivers will adversely affect all the five in the long run. The sharing of the waters of Indus and Ganges are already at the heart of differences between India, Pakistan and Bangladesh.

Environmental economics of South Asia highlights an important factor that is unique to this region. The environmental resources of the region directly support the livelihoods of at least two thirds of

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its population. This one single factor is the most powerful argument in favor of regional convergence for sustainable development. Further through our discussion, we found that the forest resource alone contributes to more than one percent of the region's GDP and direct employment to over half a million people. The case studies indicate that the livelihoods and sustainable incomes of vast majority of non-agricultural rural households and indigenous forest dependent populations are intricately enmeshed with natural resources.

Except India which has registered vibrant growth and in the process built substantial foreign exchange reserves to counter-balance international debt, other countries depend on donor agencies for financial assistance to promote good governance and economic development. The evaluation by the donor agencies of the importance of environmental protection for sustainable development in these countries lends a strong argument towards the necessity for enhanced regional convergence on the subject.

Environment and sustainable development are not slogans in international parleys. These are the names for livelihood sources that directly support millions of people. Thus people become the most important stake holders in every initiative that is needed for sustaining livelihoods through rational use of environmental resources. In most cases, as seen in the case studies, the governments need to carry this lesson in their political-bureaucratic endeavors for evolving development projects in the course of their quest for modernization and liberalization of economy. The ordinary and the poor understand the value of protecting their environments much more than corporations and governments do. The highly active civil society Public Interest Litigations in the region are a testimony to this factor.

CONCLUSION

A coming together of different disciplines in an analysis of the nature of economic changes has resulted in a consensus, as Hueting and Reijnders (1998) say, that "life support systems of the earth cannot be replaced completely by technology" and that "uncompensated anthropogenic environmental risk to future generations is unacceptable". The above statement stands vindicated in a world where technological progress has been found insufficient to eradicate poverty and widening income gaps even in highly industrialized countries. Having adapted their economies to the compulsions of globalization, countries in South Asia at times have exhibited their preference to economic growth over sustainable environment. In the enthusiasm for higher GDP growth, environmental concern does appear misplaced. As Chopra (2000) observes, "the call for conservation seems somewhat misplaced. However, if one moves into the broader social and cultural context which prevails in most of South Asia, it is interesting to observe that an understanding of the human interaction with nature has always been built into it. This social and cultural backdrop has made it easier for micro-level initiatives in natural resource management to emerge in these societies". These social and cultural backdrops are what we believe the building stones for meaningful regional cooperation for sustainable development.

The mechanism for regional convergence in the form of SAARC, BIMSTEC, their extended agreements and agencies are already in place. The importance of convergence on environmental issues as the basis for economic development and sustainable livelihoods has also been registered on their agenda. However, the regional convergence in South Asia suffers from the legacies of partition of the subcontinent and the mistrust that has pervaded the relationships between its largest neighbors in past five decades. The deficit of trust that regional convergence suffers from is the lynch pin to collective progress.

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Sobhan (2011) finds the challenge (of convergence) for poverty alleviation that is critical to South Asian growth is compounded by three important factors:

- In South Asia, food costs constitute the average household's largest expenditure. If food prices continue to rise without a matching increase in incomes of people at the bottom of the economic ladder, it is estimated that approximately 100 million people could be pushed back into poverty.
- Over the past 25 years, natural disasters and environmental degradation have killed nearly half a million people in South Asia and inflicted colossal damages estimated at $59 billion.
- The lack of long-term energy planning by South Asian countries has caused human suffering and significantly hindered the entire region's economic growth prospects.

All the three factors outlined above are compelling enough on the region's countries to recalibrate their concept of national security, national interest and sovereignty. The progress of SAARC in the three decades and BIMSTEC in nearly two decades has important lessons in cooperation and eventual integration for South Asian countries. The arenas for cooperation and the possible gains have been explored by governments, experts, academia and donor agencies like World Bank and ADB. Countries like Japan have evinced keen interest in partnering with such initiatives for obvious economic and geopolitical gains. Compelled by globalization and market forces, individually the members of SAARC and BIMSTEC have initiated first generation policy reforms. However the next generation of reforms is besotted with challenges like the high cost of doing business, weak institutions, weak knowledge economy, high levels of corruption and poor infrastructure. Ahmad observes that South Asia also needs to expand its knowledge economy to raise the productivity of investment. These second-generation policy reforms have started; continued strong implementation will support the sustainability of growth (Ahmad & Ghani, 2007). In the same breath, Ahmad et al, also observe that regional cooperation can be an effective tool in addressing energy shortage, ensuring that no region/country is left behind, landlocked regions/countries have full access to markets, and *peace and stability are promoted*. There is a need for greater people-to-people contact through improved connectivity, phasing out of visa restrictions, and liberalizing the restrictions on the trade of services (for example, tourism, education, and health) where the risk of trade diversion is low. These initiatives would help increase investment and growth by reducing the infrastructure constraint and by lowering transaction costs. *Better regional cooperation and integration can also increase welfare by improving the regional political environment, thereby reducing conflicts* and associated social and economic costs (Ahmad & Ghani, 2007). (Emphasis added)

The most eloquent pointer for regionalism or 'constructive bilateralism' leading to political stability and economic progress is the EU. European history is a product of the continuous conflict between France and Germany. As the most prominent powers of the continent with differing philosophies, they had fought a number of wars, WWI and II inclusive. However, these two countries came together to address their differences in the most constructive manner throughthe Schuman Declaration of 1950 (EU, 1950) which states the following:

Europe will not be made all at once, or according to a single plan. It will be built through concrete achievements which first create a de facto solidarity. The coming together of the nations of Europe requires the elimination of the age-old opposition of France and Germany. Any action taken must in the first place concern these two countries.

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With this aim in view, the French Government proposes that action be taken immediately on one limited but decisive point.

It proposes that Franco-German production of coal and steel as a whole be placed under a common High Authority, within the framework of an organization open to the participation of the other countries of Europe. The pooling of coal and steel production should immediately provide for the setting up of common foundations for economic development as a first step in the federation of Europe, and will change the destinies of those regions which have long been devoted to the manufacture of munitions of war, of which they have been the most constant victims.

The solidarity in production thus established will make it plain that any war between France and Germany becomes not merely unthinkable, but materially impossible. The setting up of this powerful productive unit, open to all countries willing to take part and bound ultimately to provide all the member countries with the basic elements of industrial production on the same terms, will lay a true foundation for their economic unification. (Emphasis added)

In one step, two major issues were set aside by Schuman – the narrow concept of sovereignty and national interest. What EU is today as a major trading partner of the rest of the world and a developmental model that is worthy of emulation, was possible by eschewing both these issues through enlightened political action. A similar initiative by the political leaderships of South Asia is the most urgent need of the hour. As such the concept of sovereignty and nationhood for purely political purposes like predominance of state has undergone huge change due to the emergence of International Law Regime and a proactive UN. The ability of national governments to address all challenges for development within domestic capabilities is no more feasible in a world that is increasingly interdependent. Providing a peaceful and stable environment which is fundamental to growth also depends on the stability of regime and policy continuity in the neighborhood.

South Asia, as distinct from other regions of the world, barring Western Europe, has a unique historical bond that cuts across the geographical, religious and linguistic divides that prevail in the region. We feel that this real connecting thread is the basis for cooperation that must be maximized by countries in the region. The inter people and inter-governmental structures for convergence are already in place. It is convergence of political intent that needs to be forged in South Asia in order to make sustainable development a reality for the millions that live in these lands.

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KEY TERMS AND DEFINITIONS

Climate Change: Refers to the change in weather patterns induced by ecological and environmental degradation.

Colonial Economy: Refers to the economic system formulated by the British to draw upon the natural resources of the Indian Subcontinent.

Conservation: Refers to preservation of natural environment, its protection and management by government institutions or community of people.

Ecology: Refers to the interaction between organisms and their environment. In this chapter the term is used in specific reference to the relationship between man and environment for sustenance of livelihoods and agriculture.

Environment: Refers to the natural environment encompassing all living things in it in any region of the earth.

Environmental Economics: Refers broadly to the products and services derived from natural environment.

Environmental Governance: Refers to the institutional framework for management of natural resources, and control of access to them for public and private exploitation.

Governance: Refers to the system of institutions that regulate how citizens interact with their environment.

Panchayat: Panchayat is a body of five elected representatives from the local population who form the local government at village level in India. The term is also in use in Bangladesh and Pakistan. Panchayats as local governance bodies have existed in the subcontinent for over two millennia. Panchayati Raj Institution (PRI) as they are called denotes the local governance structure established under the 73rd Amendment Bill and now prevalent across India in all villages.

Political Economy: Refers to the political and institutional control of economic activities. In this chapter, specifically refers to such control on access to natural resources.

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Raj: This Hindustani word denotes government.

Regional Cooperation: Regional cooperation refers to the political and institutional mechanisms that countries in a general geographical region devise to find and strengthen common interests as well as promoting their national interests, through mutual cooperation and dialogue.

South Asia: Refers to the Indian subcontinent consisting of all eight countries in the region, without any specific reference to any one particular country.

Sustainable Development: Refers to the pragmatic exploitation of natural resources carefully balancing the need for conservation, sustainable livelihoods and developmental projects for larger public good.

Sustainable Livelihood: Refers to the consistency with which a poor citizen can continue to draw life support resources from the natural environment in which he lives without excessively degrading it either by his own actions or actions induced by developmental or industrial activities undertaken by government or private bodies.

ENDNOTES

1 The phrase is attributed to Benjamin Disraeli, the British prime minister from 1874 to 1881. He called India "the brightest jewel in the crown". In 1876, Queen Victoria was proclaimed Empress of India, and British monarchs retained the title until 1947.

2 Land Revenue includes revenue from forest produce including sale of timber

3 Para 5 at Page 3 of the Budget Speech by Transport Member on 27 February 1947. Accessed on 27 May 2014 at the Ministry of Railways official website at: http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1,304,366,539,1287

4 for the full text, please see http://saarc-sec.org/SAARC-Charter/5/

5 The term NTFP, non-timber forest product, is widely used by FAO to denote everything from timber to fuel wood.

6 Environmental economics has existed as a discipline for more than 50 years, but its value has been recognized globally only since the 1992 Earth Summit in Rio de Janeiro. The need for an economic perspective was signaled by the summit's chair, Maurice Strong, who said, "We came into the conference believing it was about the environment; we left realizing it was about the economy."

7 (AIR 1978 SC 597)

8 AIR 1988 SC 2187

9 AIR 1987 SC 1086

10 AIR 1993 Ker 1

11 AIR 1954 SC 220

12 AIR 1985 SC 652

13 AIR 1988 SC 1037

14 (1996) 5 SCC 647

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Chapter 48
Citizen Science and Its Role in Sustainable Development:
Status, Trends, Issues, and Opportunities

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ABSTRACT

The chapter aims to analyse the role of citizen science in sustainable development, including case studies implementation, with specific focus on its suitability of citizen science in environmental sustainability. The authors structured this chapter in five sections: Background; Main focus; Solutions and recommendations for designing and executing citizen science initiatives; Future research directions with thoughts on the future role of citizen science; and Conclusion. In section of main focus, first, the authors reviewed the state of citizen science in sustainable development and explored the potential of citizen science for environmental research and governance. Second, authors identified and elaborated the core components that support the role of citizen science and demonstrated the practical approach to realize its objective. Third, using several citizens' observatories studies from various regions in Europe and within diverse environmental fields, authors highlighted the lessons learned, and reflected on major outcomes, challenges and opportunities.

INTRODUCTION

Participation of the public in scientific and action research, independently or in cooperation with scientists, is often referred to as 'citizen science' (Hand, 2010). Additional terms, such as 'crowd science', 'crowd-sourced science', 'civic science', or 'networked science' may be viewed as synonyms (Hand, 2010). Citizen science itself can be said to have existed since the very start of scientific practice, where it has developed in many different guises. As the internet continues to proliferate in the world, new tools like social media, mobile devices and mobile sensors are becoming the norm (Lanfranchi, Wrigley, Ire-

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son, Ciravegna, & Wehn de Montalvo, 2013)). Lately, it has been witnessed a global increase of citizen science projects and citizens engaging in projects as amateur researchers, as sensors, as advocates and even watchdogs (Haklay, 2015). Further, crowdsourcing methods, data processing and visualization technologies are developing rapidly, leading to a wide range of new opportunities for public participation in a compelling range of topics (Buytaert et al., 2014). As an example, it can be seen that a tremendous increase of environmental observation activities in this area, i.e., various citizens' observatories that encompass different models of citizen science and span a diverse range of subjects (e.g., biodiversity, water, air, climate change, agriculture, disaster, etc.), empowering average people to monitor their environment, collectively generate scientific data and support environmental risk response (Liu, Kobernus, Broday, & Bartonova, 2014).

The objective of this chapter is to analyze the role of citizen science in sustainable development, including case studies in citizen science implementation, with specific focus on the suitability of citizen science in environmental sustainability. It comprises the following five sections: Background; Main focus of the chapter; Solutions and recommendations for designing and executing citizen science initiatives that help inform and create environmental action, based on evidence, sound science and citizens' needs; Future research directions with thoughts on the future role of citizen science; and The Conclusion. In the section, 'Main Focus', the authors have divided it into the following substructure:

1. First, the authors reviewed the state of citizen science in sustainable development and explored the potential of citizen science to complement more traditional ways of scientific data collection and knowledge generation for environmental research and governance;
2. Second, the authors identified and elaborated the core components that support the role of citizen science and demonstrated a practical approach to realize its objective of environmental sustainability;
3. Third, using several citizens' observatories case studies from various regions in Europe and within diverse environmental fields, the authors highlighted the lessons learned, and reflected on major outcomes, challenges and opportunities in the integration of environmental-oriented citizen science within environmental management, the role of scientific knowledge in the decision-making process, and the potential contestation to established community institutions posed by the co-generation of knowledge.

BACKGROUND

Citizen participation with environmental science has a long history, before it was termed 'citizen science' (Roy, 2012). In fact, until the late 19th century, there were no professional scientists as it is well known them today (Kight, 2012; Miller-Rushing, Primack, & Bonney, 2012). Research was typically undertaken by amateurs, often Gentlemen of Leisure or men of the cloth (Miller-Rushing et al., 2012). Charles Darwin, for example, was not a trained scientist (Kight, 2012; Dillon, 2014). Likewise, the Swedish botanist and physicist, Linnaeus, was not only a Lutheran minister for a period, but worked with a wide network of citizen volunteers who sent samples to him, a not uncommon practice (Scyphers et al., 2015). One could argue that he exemplifies the very nature of citizen science. However, these men were at the pinnacle of the scientific community, so it might be somewhat disingenuous to claim they were amateurs. Nonetheless, citizen science was an activity that many average citizens engaged in at

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the avocational, or hobby level. Long before social media made citizen science accessible to the wider population in the digital age, amateurs found a way, adopting the participatory science model to their circumstances.

The first 'modern' large scale citizen participation began in 1999, at the University of Berkeley, California, where data from radio telescopes was analyzed using computers that otherwise would have been idle (Korpela et al., 2011). These computers belonged to citizens who simply wanted to be part of something, and by contributing their computer's CPUs, they helped crunch data. And as budgets become increasingly tight within research communities, alternative solutions to data gathering were needed and the Internet and mobile technologies provided the answer. The development of communication technologies offered many new avenues for citizens to contribute in a number of ways. Personal perceptions, comments, and even using the phone itself as a mobile sensor, all have a place. Such is the popularity of participatory sensing now that it has become a relatively common component to many projects and research studies (Lanfranchi et al., 2013). You can find active citizen participation in a wide range of topics, where people provide data on biodiversity, land use, weather, personal health, perception of cleanliness of buildings, and so much more (Liu et al., 2014).

The need to have a comprehensive understanding of environmental integrity, including function and structure, is often confounded by a lack of, or inadequate and incomplete, data and monitoring initiatives by professional scientists and government agencies. To fill the void, non-professionals and citizen organizations have emerged the world over to track trends and to work towards effective and meaningful planning, management, and stewardship (Conrad & Hilchey, 2011). This is especially facilitated by the innovative tools and ICT. For example, with the appearance of new low-cost sensor technologies, monitoring the environment is now, in a literal way, in everyone's hands (Liu et al., 2014; Kobernus et al., 2015). Novel sensor technologies open the opportunity to monitor the environment at spatial resolutions not possible to achieve with traditional monitoring systems (Liu, Skjetne, & Kobernus, 2013). Citizens can now contribute to monitor the environment in a direct and meaningful manner.

Formally, the role of citizen science has been defined as research co-design/co-creation, the systematic collection and analysis of data, development of technology, testing of natural phenomena, and the dissemination of these activities together with scientists on a primarily avocational basis (Hand, 2010). In recent years, citizen science has been viewed as an increasingly essential tool to support and promote community-based environmental governance, as it attempts to provide citizens with a voice and accountability in the future of sustainability research (Liu et al., 2014). Obviously, citizen science enables a more active role for citizens concerning understanding the environment, since citizens are traditionally considered as 'consumers' of information services at the very end of the information chain and not as 'data providers'. However, it is no longer sufficient to develop and provide passive lists of environmental indices or reports to inform citizens about changes in their environment. There is a need to engage citizens to find out how they can inform the community, and to empower citizens to improve their own health and well-being through actively making informed choices via citizen science activities and outcomes. Involving citizens at the local level by developing knowledge pools can help create an atmosphere of active participation and generate a sustainable movement that can build over time. Citizens have expectations to interact and participate in the decision-making processes, and to be engaged in a dialogue about their communities, preferences and future (Liu et al., 2012a). According to sociological research, the recent increase in pro-active participants of social IT media, with a particular

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focus on environmental issues, results from a shift from materialism to post-materialism where more and more people are showing increasing interest in a renewable and sustainable life style, which is the key objective of environmental governance and lies at the heart of 'sustainable development' (Salonen & Åhlberg, 2013; Liu et al., 2014).

'Sustainable development' is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Citizen science is crucial in bridging the gap between environmental governance and the public, and can play a key role in sustainable development (Liu et al., 2014). However, there is no globally agreed and understood definition of 'environmental governance' and it can be interpreted in many different ways. In principle, environmental governance comprises the rules, practices, policies and institutions that shape how humans interact with their environment (UNEP, 2009). It can refer to the processes of decision-making involved in the control and management of the environment for the purpose of attaining environmentally-sustainable development. Good environmental governance takes into account the role of all actors that impact the environment, from governments to Non-Governmental Organizations (NGOs), the private sector and civil society, the individual and citizen groups. Cooperation between actors is critical to achieving effective governance that can help us move towards a more sustainable future. In this context, the key aspect of citizen science is the direct involvement of ordinary citizens, and not just that of scientists/professionals. This can be in data collection as well as harnessing the citizens' collective intelligence, i.e., the distributed information, experience and knowledge embodied within individuals and communities. This will help to bridge gaps that many areas of environmental management are still suffering from. Namely, citizen science should enable citizens' participation in environmental monitoring in order to contribute to environmental governance by providing relevant data and information that can help decision-makers make sound decisions. This can be advanced by providing citizens with a voice and supporting them with information on their environment, consequently raising their awareness and leading to higher levels of involvement. This reveals key components that underpin the core objectives of citizen science in sustainable development, i.e., raising citizens' awareness and consciousness, enabling dialogue and supporting data exchange/knowledge sharing amongst citizens, scientists, policy/decision makers, and other stakeholders (Liu et al., 2014). These three components of citizen science can explain the major links between citizen science and environmental governance, and in fact are the three pillars that comprise citizen science enabling it to support environmental governance (Kobernus et al., 2015). In the context of citizen science's contribution to environmental governance, it is important to recognize that citizens are not a monolithic group, all alike. There are stakeholders/user groups including individuals or groups of volunteers, scientists, government authorities, emergency services, etc. Hence, various actors in citizen science have different behaviors, intentions, interrelations, agendas, interests, as well as influence, resources and power on decision-making and political processes. Moreover, there are a number of questions about its potential as a democratizing force in environmental policy and management (Fore, Paulsen, & O'Laughlin, 2001; Liu et al., 2014). However, given the many contending conceptions within democratic theory (e.g., direct, representative, participatory, minimal, deliberative, aggregative, etc.), it should be noted that this aspect is a complex subject with no "one size fits all" solution. Nevertheless, citizen science has shown its potential to address issues of environmental equity and sustainability, and to improve social justice and responsibility, which is directly linked to the principles and treaties on sustainable development, including economic development, social development and environmental protection.

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MAIN FOCUS OF THE CHAPTER

Status and Trends of Citizen Science in Sustainable Development

Due to the increasing significance, utility and function of citizen science for environmental research, governance and practice (Conrad & Hilchey, 2011; Roy et al., 2012), a review of existing citizen science projects ranging from small one-off local surveys to large-scale long-term programs by focusing on its status and trends including consensus, divergence and gaps is presented here. In order to comprehensively review the state of citizen science in academic journal articles, the authors reviewed citizens' observatories in varying environmental and social contexts. A review of the vast academic-and non-academic-based literature from around the globe indicates (Grossberndt & Liu, 2016):

1. For Professionals: Lack of funding and staffing for environmental monitoring; For governments: more environmental monitoring data and stakeholders needed for decision-making processes. These have led to an increase in the use of amateur scientists around the globe.
2. There are differences in the monitoring intent in different parts of the world. In parts of Europe (particularly in Britain), many of the citizen science initiatives focus on collecting data about species and habitats, whereas there is a predominance of monitoring efforts on ecosystem functions and environmental quality in North America.
3. The issue of monitoring interest often transcends government boundaries, and many NGOs responsible for cross-state, cross-province, or cross-country concerns have increased their use of citizen science.
4. Citizen science relationships with academic institutions and universities have increased, perhaps due to their capacity to provide training, lab facilities, free space, and funding.

This review is not intended to be inclusive of all types of citizen science initiatives, especially given the enormous proliferation of citizen science activities (e.g., there are more than 1,100 active and searchable global citizen science projects listed on SciStarter (Wikipedia, 2016)), but instead is representative of a variety of citizen science campaigns across the globe. Citizen science activities can differ in focus, approach or technique. The review indicates that many citizen science initiative focus on monitoring water quality, birds count, butterflies, mosquitoes, wildlife, air quality, algae, amphibians, plants, fish, worms, odors, and ice (Grossberndt & Liu, 2016).

In addition, citizen science initiatives have engaged both the commodity-based monitoring (e.g., resource fishery, resource forestry, etc.) and non-commodity-based monitoring (e.g., recreational fishery, monitoring water quality, monitoring air quality, etc.) (Grossberndt & Liu, 2016). Commodity-based monitoring deals with issues of economic as well as social and environmental importance. Non-commodity-based monitoring focuses on issues that may not seem to be directly economically important.

Citizen science initiatives also differ in the types of monitoring activities the organization undertakes (Grossberndt & Liu, 2016). Citizen science monitoring activities include many different types of assessment of the environment:

1. Status assessment (e.g., air quality status);
2. Impact assessment (e.g., effect of air pollution);
3. Adaptive management (e.g., managing based upon monitoring).

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Citizen science monitoring activities also include different aspects of the environment monitored (Grossberndt & Liu, 2016):

1. Environmental composition (e.g., air, water, soil, etc.);
2. Structure (e.g., environmental analysis, key pollutants, etc.); and
3. Processes (e.g., linking human health with environmental problem). Process-based monitoring is suggested as being most desirable in many studies.

Furthermore, in a context of sustainable development, almost by definition (Bastiaensen et al., 2005), the poorer people will have difficulty to voice their concerns and even more to articulate them to (scientific) outsiders. So more often than otherwise, it therefore be expected that participative citizen science will address more main stream concerns of the local majority, or even of small dominant local elites (Buytaert et al., 2014). But in view of the post-research application of scientific findings, this usually has the advantage to facilitate rallying more and more relevant local support to implement recommendations through social action, while evidently risking to bypass critical concerns of disadvantaged groups and even to contribute to the deepening of their dispossession and exclusion. This constitutes a tricky, but often unavoidable dilemma in the implementation of citizen science, and requires a careful analysis of the social interface between the citizen science practices and the learning and struggle in local political arenas. By no means, however, does this dilemma reduce the potential contribution that science and citizen science can make to local bricolage toward better governance (Buytaert et al., 2014).

According to Buytaert et al. (2014), despite being an intrinsic part of the scientific discovery and knowledge generation process, the concept and potential of citizen science in itself only recently received increasing scientific attention. New technological developments are supporting novel and more efficient methods for data collection and processing, visualization and communication. These opportunities make reflecting upon the challenges and opportunities of citizen science, especially in a context of managing natural resources and leveraging them for human well-being, timely and relevant. This is particularly the case for water resources, which is often one of the most fundamental ecosystem services and a significant bottleneck for sustainable development and poverty alleviation. Their review of technologies reveals a large potential for increasing involvement of citizens in data collection because of the availability of inexpensive, robust and highly automated sensors, and the possibility to combine them with powerful environmental models to create rich and interactive visualization methods (Buytaert, Dewulf, De Bièvre, Clark, & Hannah, 2016). In the fields of hydrology and water resource management, Buytaert et al., (2014) highlighted that citizen science has the potential of being more inclusive methods to generate knowledge on improved uses of ecosystem services that supports sustainable development and improves human well-being. Their discussion focuses particularly on:

- The motivation and level of engagement by the non-scientists.
- The type of data monitored, and potential for participatory modelling and knowledge exchange.
- The legitimacy of the generated knowledge.
- The sustainability of the citizen science activity.
- Potential uptake in decision making/resource governance.

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Core Components of Citizen Science and Its Practical Approach

In recent years, there has been a boom in citizen science projects, which allow members of the public to play an active part in monitoring and recording their environment across the globe. The increase in the prevalence of citizen science globally has been mirrored by a growth in the number of variables that are monitored, the number of monitoring locations and the different types of participating citizens (Liu et al., 2014; Kobernus et al., 2015; Grossberndt & Liu, 2016). This calls for a more integrated approach to handle the emerging complexities involved in this field (Liu et al., 2012b); but before this can be achieved, it is essential to establish a common foundation for citizen science and their usage. There are many aspects related to a citizen science project. One view is that its essence is a process that involves environmental monitoring, information gathering, data management and analysis, assessment and reporting systems. Hence, it requires the development of novel monitoring technologies and of advanced data management strategies to capture, analyze and survey the data, thus facilitating their exploitation for policy and society (Liu et al., 2014; Kobernus et al., 2015). Practically, there are many challenges in implementing the citizen science approach, such as ensuring effective citizens' participation, dealing with data privacy, accounting for ethical and security requirements, and taking into account data standards, quality and reliability. These concerns all need to be addressed in a concerted way to provide a stable, reliable and scalable citizen science program. On the other hand, the citizen science approach carries the promise of increasing public awareness for risks in their environment, which has a corollary economic value, and enhancing data acquisition at low or no cost (Liu et al., 2014; Kobernus et al., 2015).

Type of Citizen Science

Citizen science does not only serve scientific purposes, but also decision-making, since the collected data can contribute to informed policy-making. In addition, citizens can benefit by addressing the environmental issues that affect them directly in the context of participatory decision-making. In this way, the value of lay knowledge should not be underestimated (Science Communication Unit, University of the West of England, 2013). According to Haklay (2015), the following three policy dimensions can be distinguished:

1. Level of geography;
2. Policy domains; and
3. Level of engagement and type of citizen science activity.

Citizen science initiatives can influence policy decisions in a specific geographical area, i.e., local, regional, national and international. Usually, problems that affect people directly, lead to more engagement since people are both more aware and concerned (Haklay, 2015). This potential can be used to build upon observation activities through citizen science initiatives. Local citizen science is often linked to environmental activism and supports community management by working towards effective and meaningful management planning, management and stewardship (Conrad & Hilchey, 2011). Local citizen science can also apply the so-called community-based monitoring approach (CBM). CBM describes a process where concerned citizens, public authorities and further stakeholders collaborate to monitor, track and respond to issues that arise from common community concerns (Whitelaw, Vaughan, Craig, & Atkinson, 2003).

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Environmental issues are very complex and would actually require additional resources. Thus, there is an increasing need for communities to fall back on citizen science approaches (or CBM respectively) and include different stakeholders with their diverse knowledge and experience into the decision-making processes (Conrad & Daoust, 2008). In addition to the decision-making bodies' saving time and money, the societal benefits of CBM will be creating environmental democracy, social capital, and increase in scientific literacy and inclusion in local issues (Conrad & Hilchey, 2011).

Policy areas can be manifold and partially overlapping. For example, city-scale infrastructure contains public transport, environmental quality, education, infrastructure and public health. Thus, cities can be a canvas for a potpourri of local monitoring activities, originating from different concerns but using the accumulated data to see the bigger picture (Grossberndt & Liu, 2016). Moving citizen science projects to regional, national or even international level is likely to meet even more challenges than there already are. Since bottom-up initiatives usually dispose of limited budgets only, it will be less likely to find community science approaches with an active involvement of citizens in all parts of the participation cycle, i.e., citizens will rather only be asked to share observations or viewpoints on certain issues. Nevertheless, national and even international initiatives including citizen science are possible and do exist. Projects funded by the European Commission (EC) and formation of international organizations like the European Citizen Science Association (ECSA) provide frameworks for national initiatives and NGOs to create synergies to promote citizen science on a larger scale and call on international institutions such as the European Environmental Agency (EEA) to promote citizen participation also at an international level (Haklay, 2015).

However, how can people actually be involved in citizen science? Haklay (2015) distinguished different levels of engagement within citizen science. As it can be seen, these categories resemble those participation levels presented earlier in this chapter. The first level is called passive sensing and describes a process where information is collected without any effort on the participants' part through their own devices. Volunteer computing is a method where participants allow scientists to use their unused computing resources on, e.g., their PC or smartphone for complex computer models while the device is not in use. The next level, volunteer thinking makes use of the citizens' cognitive abilities not used during passive leisure activities, e.g., people contribute by recognizing patterns while watching TV. The obtained data will then be further used in scientific projects. Environmental and ecological observations describe the traditional form of citizen science, where volunteers monitor and/or observe their personal environment, often based on protocols that are designed by scientists. In participatory sensing activities, the citizens are more actively involved in designing both data collection and analysis. The last activity type can be summarized as civic/community science. In this bottom-up approach, the participants can choose their level of engagement and can even be involved in the analysis and interpretation of the results and their publication/utilization. This level of engagement does not necessarily require the involvement of scientists (Grossberndt & Liu, 2016).

Citizen science initiatives should be tailored to match both interest and skills of the participants. This is crucial in order to develop successful initiatives. Although motivations vary widely, the authors find that enjoyment and enthusiasm for the goals of the initiative are two of the main drivers. As known from other research areas, the feeling of control over the scientific process can also lead to long-lived engagement (Roy et al., 2012).

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Citizen Science Framework

Overall, citizen science is based on a general framework linking citizens and scientists together, allowing the implementation of a more comprehensive scientific approach. The framework can address a particular question, tests hypotheses with appropriate data collected from a well-designed protocol, allow the interpretation and understanding of new results and can help to derive and spread original educational outputs (Kobernus et al., 2015).

To establish a citizen science program and to make it useful for society, there is a need for researchers to collaborate with citizens, citizen groups and their representatives, and with the representatives of the local authorities, to identify interests and needs (Liu et al., 2014). In a citizen science program, all parties shall be encouraged to be engaged as active participants, to create knowledge of the environmental situation in a participatory manner and to contribute to dealing with the situation (Landranchi et al., 2013). One of the main aspects of a citizen science program is the need to effectively address citizens participation in data collection, data interpretation and information delivery. According to Liu et al. (2014), this can be expressed as the following set of five sequential aspects that underlie the citizen science skeleton and support effective citizen participation (Figure 1):

a. Citizens' participation in identifying what citizens want and what a citizen science program can offer to provide information and knowledge in response to public concerns. This is achieved mainly by a dialogue among the stakeholders;
b. Citizens' participation in exploration of what products and services a citizen science program can provide for the citizens. This involves systematizing and structuring citizens-created content to make it appealing for use by citizens during their normal daily life;
c. Recruiting and retaining citizens to participate in and contribute to environmental governance: further clarify the purpose, scope and expected impact of the citizen science program, identify motivations that will promote citizens to contribute to and take part in the citizen science activities, and encourage public participation in data collection and interpretation;
d. Obtaining public participation in the relevant decision making and/or in changing their related personal priorities and behavior by gaining access to environmental data, knowledge and experience, and by using tools that can support citizens to report or upload their objective/subjective observations, inference and concerns;
e. Supplying tools to access/receive timely information on the relevant environmental issues in a manner that is both easily understood and useful to the users.

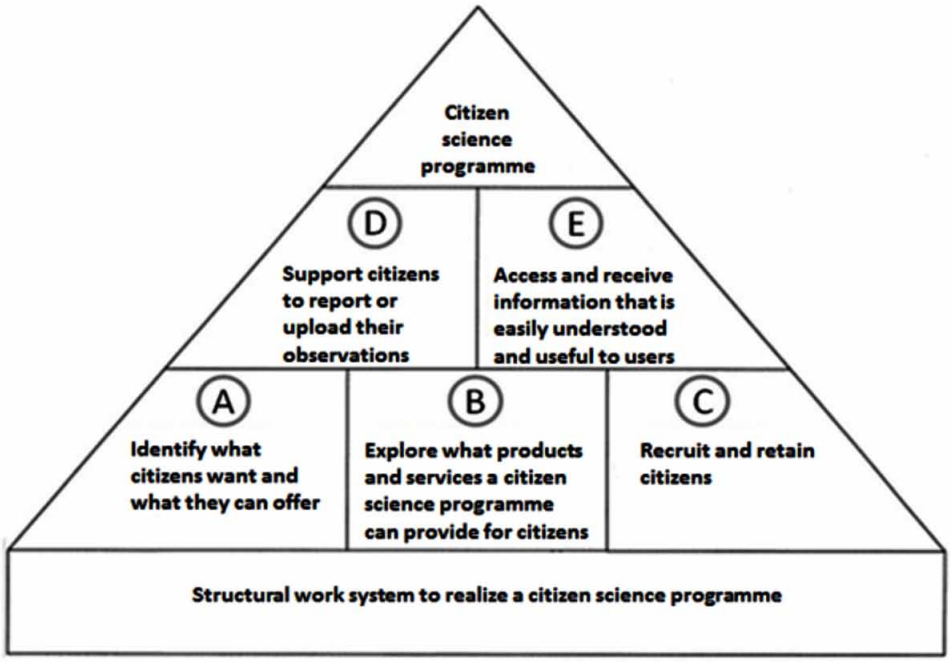
Among critical factors of success, the simplicity of each component of the framework, the structure of the scheme, the regular feedback of results to participants and a good communications strategy are crucial. Moreover, for long-term projects, the sustainability of the framework (often demanding sources of funding and people with permanent positions) should be carefully thought through (Devictor, Whittaker, & Beltrame, 2010).

Citizen Science Model in Practice

A key concept in the operation of citizen science program is the idea of a campaign that specifies stakeholders' concerns by defining the types of data that need to be collected and by describing the goal,

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Figure 1. Sequential aspects of a citizen science program



expected feedback and analysis outcomes in terms of maps, statistical results, etc. The raison d'être of the observatory then is to "run and orchestrate" a campaign in order to assure that sufficient data is gathered, both qualitatively and quantitatively, and to enable non-expert stakeholders to define, monitor and analyze campaigns in a way understandable to them (D'Hondt, Zaman, Philips, Boix, & De Meuter, 2014; Zaman et al., 2014).

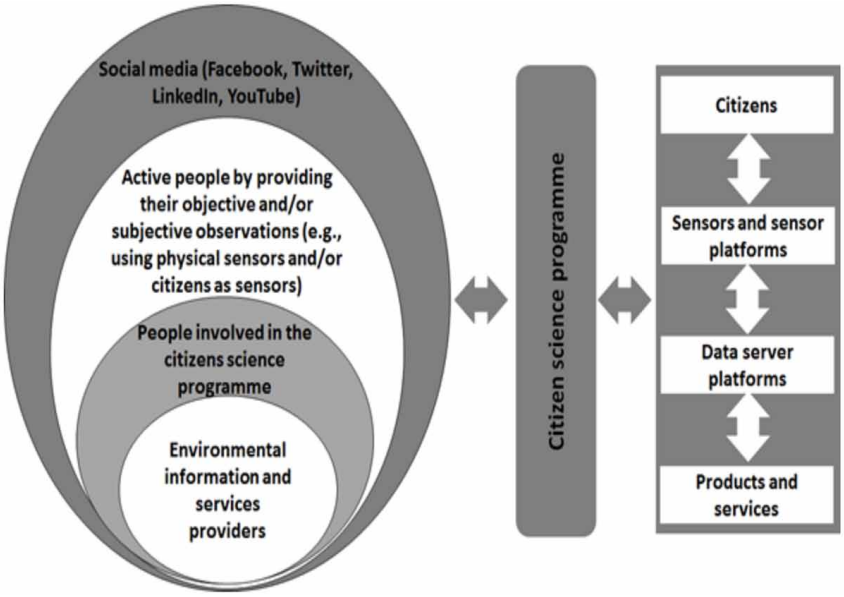
Figure 2 illustrates a common model of citizen science program: A set of concentric circles that are characterized by different types of information needs and of information gathered and shared (left part). The circles represent different types of stakeholders: environmental information and services providers and people actively involved in citizen science program (e.g., public, researchers, policy-makers, small and medium-sized enterprises (SMEs), etc.). In addition, the circles also represent different tools that different stakeholders may use to provide their observations and share their data and information, e.g., innovative low-cost physical sensors, citizens as sensors, and social media, etc. The aim of the citizen science approach is to support all stakeholders by designing various tools and applications that support co-participation (Landranchi et al., 2013).

In addition to the different stakeholders and the way to engage such stakeholders, Figure 2 also illustrates the four core components of the data flow model in various citizen science projects (right part):

1. **Citizens:** Different types of stakeholders, including the general public;
2. **Monitoring Tools and its Platforms:** Technologies for environmental monitoring (i.e., smartphone, low-cost monitoring tools and its platforms);
3. **Data Server Platforms:** Information and communication technologies (e.g., web-featured service);

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Figure 2. A common citizen-science model in practice



4. **Products and Services:** Information products and services, i.e., mobile apps, web applications, social media networks, public environmental survey, etc.

The first three components (citizens, monitoring tools and its platforms, data server platforms) are the main elements of participatory sensing, reflecting the concept of communities or other groups of people contributing information in the form of data and knowledge (Dua, Bulusu, Feng, & Hu, 2009). The fourth component (products and services), linked to the usage of obtained data and knowledge, is designed and expected to be used by various stakeholders for different purposes. These components can be considered as the four pillars that support various citizen science programs in practice (Engelken-Jorge et al., 2014; Liu et al., 2014). They relate to the stakeholders' experience, expertise and expectations and are clearly important. Within these four pillars, various actors may use the tools or instruments to produce raw data that leads to a range of new products or services as well (Lanfranchi et al., 2013; Liu et al., 2014). Here, the authors present a common model of citizen science program which is being been translated into practice in several existing citizen science projects, i.e., Citclops, CITI-SENSE, Citi-Sense-MOB, Cobweb, EVERYAWARE, Omniscientis and WeSenseIt. All of these projects put an emphasis on delivering highly innovative technologies to support citizens, communities and authorities by getting 'near real-time' and/or 'up-to-date' data about environmental conditions (e.g., air quality, water quality, etc.) and situations (e.g., flooding), while respecting the different information needs and actions respond. On a technical level, these projects consists of a combination of crowdsourcing and custom applications designed to empower and foster participation with the objective of creating an enriched information and knowledge base to facilitate decision making while increasing opportunities for citizen engagement in their community (Ciravegna, Huwald, Lanfranchi, & Wehn de Montalvo, 2013; Lanfranchi et al., 2013; Liu et al., 2014). These projects base data capture on one or several of the following tools:

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1. A set of innovative low cost sensors for monitoring environment that are designed and can be used directly by both professionals and citizens alike;
2. A set of public environmental perception surveys ("citizens as sensors") designed to be used by citizen participants;
3. Tools that enable the exploitation of the citizens' collective intelligence through crowdsourcing (e.g., Volunteered Geographic Information (VGI)) and social media platforms (e.g., Facebook page, Twitter account) analysis.

Challenges Met and Lessons Learned from Existing Citizen Science Activities

Citizen science initiatives require strict data management. Since most of the citizen science initiatives take place outside organizational frameworks, special efforts have to be made to guarantee the quality of the obtained data. This can be reached through either controlling the quality of data during their acquisition or subsequently after their acquisition by comparing them with reference data (Goodchild & Li, 2012). The first approach requires the introduction into and training of data collection and/or interpretation methods. Here, participants receive instructions and guidelines (e.g., provision of standardized equipment, instruction sheets, online training, etc.) on the use of the measuring device and how to collect data. In the case of VGI, a certain quality assurance is guaranteed when several participants deliver the same GPS (Global Positioning System) coordinates for the same object. In some occasions, some participants can also be asked to monitor and validate the data collected by participants with less experience, as for example in bird watching activities or monitoring of invasive species. Another example is Wikipedia, where a group of individuals with special rights acts as moderators or gatekeepers to avoid vandalism, remove copyrighted materials and resolving conflicts. In other occasions, it can be valuable to use existing knowledge of citizens to evaluate the validity of the data from volunteers (Grossberndt & Liu, 2016). For example, by using existing knowledge about the fauna in Norway, it is very unlikely that a giraffe will be spotted in the streets of Oslo, Norway (Goodchild & Li 2012, Haklay, 2015).

Next to data issues, there are a number of further challenges for the implementation of public participation. In their review of citizen science and community-based initiatives, Conrad & Hilchey (2011) provided a list of challenges of community-based monitoring. Apart from data issues mentioned above, these challenges include:

1. Lack of interest of the volunteers;
2. Lack of opportunities for networking;
3. Funding difficulties;
4. The participants, inability to get access to appropriate information and expertise;
5. Insufficient experimental design;
6. Utility of community-based monitoring data for, e.g., decision-making.

Another aspect that it is needed to bear in mind is the fact that even though international agencies, such as the EEA, promote approaches of inclusive governance processes, this does not mean that this advice is followed automatically on national, regional or even the local level. Not only the willingness, but also the readiness of decision-makers has to be taken into consideration when designing and implementing any participative initiative. In this context, it should also be mentioned that even if the

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participative process has been carried out successfully, it should strive to translate the prepared work into action (Litke & Day, 1998).

Although the usage of the citizen science concept is becoming a more common practice for environmental management, challenges still exist regarding how to deal with the quality of the data collected as well as how to use it for environmental policy (Tennessee Water Resources Research Center, University of Tennessee 2004; Goeschl & Jürgens, 2012).

Such challenges suggest that the following areas should receive careful consideration (Liu et al., 2014):

1. **Data Quality (i.e., Accuracy and Uncertainty):** Especially when comparing crowd-sourced and reference data;
2. **Data Privacy and Security**: Sharing of data and information requires strong ethical and security considerations;
3. **Data Interpretation**: Qualitative indicators such as "quality of life", "well-being", "happiness", etc., should be developed in parallel with more quantitative indicators that are based not only on individual perception, but on an integrated sensor network;
4. **Systematization and Structuring of Citizens-Created Content and Feedback:** Establishing a viable model(s) to support decisions and empower the public (Engelken-Jorge et al., 2014);
5. **Involving and Maintaining a Broad Spectrum of Society**: Implementing various location-specific and target group-tailored tools in recruiting and sustaining citizens' participation in environmental monitoring (Fernandez-Gimenez, Ballard, & Sturtevant, 2008).

In practice, various citizen science programs all share a similar structure, yet in the current status, constructing a new citizen science program for a new type of campaign (e.g., air pollution, mobility patterns of users of public transportation, biodiversity, climate change, etc.) requires that all software infrastructure to be rebuilt from scratch (Liu et al., 2014). The lack of a systematic, easy and reusable methods for setting up new citizen science programs and for defining new campaigns poses an unsurmountable hurdle for communities and organizations as they usually lack the specific technical ICT-skills and programming knowledge to create the necessary server infrastructure and mobile applications. This often forces these organizations to opt for a non-technological approach (i.e., pen and paper) or to spend big chunks of their restricted budget on external ICT-consultants (D'Hondt et al., 2014; Zaman et al., 2014).

SOLUTIONS AND RECOMMENDATIONS

Citizen science has showed its potential to help meet the demands of monitoring the environment. There are several guides exist in the field of biodiversity monitoring, for example, Guide to citizen science (Tweddle, Robinson, Pocock, & Roy, 2012), Choosing and using citizen science (Pocock, Chapman, Sheppard, & Roy, 2014), Guide to running a bioblitz 2.0 (Robinson, Tweddle, Postles, West, & Sewell, 2013), User's guide for evaluating learning outcomes from citizen science (Phillips, Ferguson, Minarchek, Porticella, & Bonney, 2014). However, a generic guide that can offer the scientific community advice on how to develop, implement and evaluate citizen science projects including how to get the most out of citizen science projects in the environmental filed is needed.

In order to ensure a usable citizen science program and to maintain citizens in a citizen science project in practice, Liu et al. (2014) addressed the following development needs:

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1. The need to adequately promote the citizen science platform and tools for raising awareness, recruiting and sustaining citizens' participation;
2. The need of a good understanding of citizens' demographics in order to develop the citizen science platform to meet their needs, especially as they change;
3. The need to build a long lasting infrastructure that uses open standards, is easily exploitable through an open Application Programming Interface (API), can be widely accessed, extended and maintained, and is seen as a generic environmental enabler rather than a project specific outcome;
4. The need to address and evaluate Citizens' Voice (Citizen' Views on certain environmental issues and its related environmental actions) and government Accountability (i.e., governments that can be held accountable for their environmental action) in the social and political context in which citizen science programs are embedded (Rocha Menocal & Sharma, 2008; Fernandez-Gimenez et al., 2008), to actively promote the Citizens' Voice and Accountability concepts as important dimensions of good environmental governance (Rocha Menocal & Sharma, 2008), to address citizen science potential role to influence environmental equity and to improve social justice (Kamar, Hacker, & Horvitz, 2012);
5. The need to develop particular channels and mechanisms that can underpin the sound environmental-social-political actions in which citizen science programs are addressed, in a manner that facilitates citizens to influence environmental governing priorities and processes;
6. The need to explore and further develop technologies, which deal with data collection and analysis by building necessary technical capacity and overcoming the 'digital divide' for environmental monitoring, data exchange, visualizing and communicating results back to the broader users (Rocha Menocal & Sharma, 2008; Brabham, 2009), managing and analyzing increasing data volumes, variety and velocity (Zikopoulos, Eaton, & Zikopoulos, 2011); reducing measurement uncertainties; developing reliable and fast Quality Assurance/Quality Control (QA/QC) tools that can work in real-time; and increasing need for interdisciplinary use of data, integration of different types of data.

FUTURE RESEARCH DIRECTIONS

The rapid diffusion of ICTs during the past decades has facilitated the process of data collection and sharing by the public and has resulted in the formation of more and more online environmental citizen observatory networks. There is no doubt that the increasing trend of citizen science programs has the potential to enhance the spatial and temporal resolution of current data streams from terrestrial and areal sensors, as well as being the best approach to increase citizen's environmental awareness.

One of the challenges is defining what is and what not citizen science is. However, due to the boom of citizen science programs that are currently been seeing, there is a need for having a clear global picture, in order to monitor the rapid growth of such initiatives, to catalogue and analyze differences and to synchronize already ongoing activities (Cobweb project, 2016; Ibercivis, 2016). The basic concept is to understand who is doing what and where.

In addition, there is also a need to understand how citizen science is changing the relationship between science and society. Therefore, a set of tools, metrics, shall be further developed and used. Among

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others, techniques from both humanities and social networks analysis shall be developed and used, to explore whether the key stakeholders are properly engaged or not, and if there is interactive information exchange amongst the key stakeholders within any citizen science program.

Citizen science is a growing worldwide phenomenon thanks in large part to the evolving new technologies that connect people easily and effectively with the scientific community (ECSA, 2016). There is a need to explore what types of new technologies can become a useful tool for citizens to play a more active role in sustainable development, which citizens can contribute valuable information that can be used to develop and deliver policies, improve understanding and respond to many of the challenges facing society today. Furthermore, methods for analyzing and sharing citizen science tools and data are also required (Cobweb project, 2016). There is a need to identify the major requirements for citizen science project repositories and their relation to existing citizen science platforms (Cobweb project, 2016).

Methods for maximizing the value of citizen science data, including data accessibility, availability and quality in support of the sustainable development goals, are also required (Grossberndt & Liu, 2016). Citizen science has evolved over the past four decades. Recent projects place more emphasis on scientifically sound practices and measurable goals for public education. Modern citizen science differs from its historical forms primarily in the access to, and subsequent scale of, public participation. This is, in large part, due to new technology, which is credited as one of the main drivers of the recent explosion of citizen science activity.

There is an emerging trend that indicates that research will focus on cross-cutting computational topics such as optimization, dynamical models, big data, machine learning, and citizen science, applied to sustainability challenges. Advances in computational sustainability will lead, for example, to novel strategies for helping citizens to improve their quality of life.

So far, assistance from the general public is often limited to data collection, as in classical citizen science. Moreover, whether and how people actually perceive the educational outputs of citizen science programs is generally lacking and needs to be addressed more in the future citizen science studies.

In fact, citizen science programs vary from top-down to more bottom-up approaches, depending on how people are involved. Devictor, Whittaker, & Beltrame (2010) argued that such participative citizen science approaches could be even more effective in promoting positive reconnections between the general public and conservation issues. Assessing how citizen science programs are perceived by citizens themselves would also offer opportunities to initiate more challenging levels of participation, and help develop stimulating connections between scientists, authorities and the general public (Devictor et al., 2010).

The authors do believe in the near future, citizen scientists could thus not only help to set surveys and scientific investigations, but also become the best allies of managers and stakeholders in the fields of environmental sustainability. Involving citizen participants directly in monitoring and active management of environmental issues can generate very powerful management efforts, leading to positive, cumulative and measurable impacts on environmental governance.

Although it is increasingly recognized that environmental governance, informed by local knowledge and citizen observations, may be a better option than top-down environmental protection restrictions, a practical means to implement protection strategies using citizen science as a social process is still largely missing (Devictor et al., 2010). In this context, citizen science could be of great help to promote environmental sustainability based on local environmental knowledge in several socio-economic contexts (i.e., not limited to the most developed countries).

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CONCLUSION

With this chapter, the authors have provided insight into a topic that creates ambivalent feelings for many, i.e., citizen science in sustainable development. Based on the information from literature and practice, it can be seen that during the last years, policy-makers are beginning to value citizen science approaches as an important tool in their decision-making process. The fact that issues related to environment and health are usually complex and uncertain calls for a paradigm shift in these methods. Integrating knowledge and experience of different citizen groups and other stakeholders will help authorities in their decision-making process.

Citizen science plays a positive role in environmental sustainability. A review of relevant citizen science projects shows that the involvement of volunteers offers high value to research, policy and practice. Two major gaps were identified:

1. A need to compare and contrast the success of citizen science activities which present sound evidence of citizen scientists influencing positive environmental changes in the local environment they monitor;
2. More case studies showing usage of citizen science data by decision-makers, or the barriers to linkages and how these might be overcome.

If new research focuses on these gaps, and on the difference of opinions that exist, the researchers will have a much better understanding of the environmental, social, economic, ecological and cultural benefits of the citizen science role in sustainable development.

As it is well known, not one approach fits all. The choice of both participants and participation methods are always context-dependent and require a thorough preparation phase. Thus, time and personnel resources are crucial preconditions. Additionally, the authors see a need in fostering bottom-up approaches to a larger degree. In this context, the authors see citizen science as an increasingly essential tool for public participation in environmental monitoring. This approach assists citizens in observing and understanding environmental related problems, as well as reporting and commenting on them by help of advanced ICTs.

The authors discovered that different ongoing citizen science related programs in the environmental domain share a common model that is significantly relevant for the outcome of sustainable development. It consists of the following elements:

1. Citizens are playing an active role in observing environment by using novel monitoring-technologies and citizen as monitor approach;
2. Unique virtual places are created to gather and share data from a variety of sources;
3. Extraction and making use of relevant citizens-related data and providing multimodal services for citizens, communities and authorities;
4. Raising citizens' environmental awareness to form a strong public voice; and
5. Enabling dialogue among citizens, researchers, policy-makers and other stakeholders.

In addition, the review reached a number of conclusions about the value of data collected by volunteers:

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1. The development of technologies was "revolutionizing citizen science", for example through online recording and smartphone apps;
2. Data quality could be excellent, but was not fully recognized by all researchers or policy-makers;
3. It is a cost-effective way of collecting environmental data;
4. There was potential to make considerably more use of citizen science that currently was the case.

To be successful in a citizen science program, the authors recommend the following sequential steps:

1. Identifying what citizens want and what citizens can offer;
2. Exploring what products and services a citizen science program can provide for the citizens;
3. Recruiting and retaining citizens to participate in and contribute to environmental governance;
4. Providing tools that support citizens to report their observations, inference and concerns; and
5. Supplying tools to access/receive timely information on the environment in a manner that is both easily understood and useful.

With these elements in mind, a successful performance and sustainable implementation should be possible.

Citizen science programs are geographically explicit, standardized and cover large spatial and/or temporal scales. Although citizen science is not a panacea, the development of citizen science programs should be increased and encouraged in the future as they can both be highly valuable for environmental sustainability and promote the reconnection between people and nature and more generally between people and science. Yet, although their number has increased in some countries (specifically the USA and UK) during the last decade, they remain relatively rare in others.

Moreover, the strength of citizen science programs directly relies on the curiosity and pleasure of the volunteers to learn and observe things that they have never noticed in their most familiar places.

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KEY TERMS AND DEFINITIONS

Citizen Engagement: The encouragement of the general public to become involved in the political process and the issues that affect the community.

Citizen Observatory: The citizens' own observations and understanding of environmentally related problems and in particularly as reporting and commenting on them.

Citizen Science: A form of research collaboration involving members of the public in scientific research projects to address real-world problems.

Environmental Governance: A concept in political ecology and environmental policy that advocates sustainability (sustainable development) as the supreme consideration for managing all human activities—political, social and economic.

Information and Communications Technology (ICT): An extended term for information technology (IT) which stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

Sustainable Development: The development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Volunteered Geographical Information (VGI): The harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals.

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Chapter 49
Romanian Rural Tourism in the Context of Sustainable Development

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ABSTRACT

Tourism, in all its activities, is dependent on the environment, and by exploiting its resources, products are created, creating a significant added value. But all this must take into account the rational use of natural resources with risk of depletion or degradation and the ability to achieve a decent standard of living for future generations, with an equitable distribution of general or specific revenue. Based on these considerations, the aim of this chapter is to assess the evolution of touristic infrastructure both in time and in terms of regional distribution. To estimate the tourism supply of Romanian rural tourism accommodation, the main statistical indicators used were the number of agro tourist boarding houses, the existing accommodation capacity, and the accommodation capacity in operation, their territorial concentration, and the way in which the results are strategic levers in the regional development of Romania.

INTRODUCTION

Competitiveness of rural tourism, on background process development sustainability can shape and analysis from a basic element of rural touristic supply: accommodation. In relation to the location and services, rural tourism units can be competitive success of a tourist destination.

Given the economic and social changes faced by Romania, while, there have been changes in the classification of tourism facilities that operate rural tourism, which justifies the existence of the macro-

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distributed data, regions of development and counties from 2000 to 2012, provided by NIS (Tempo-one line).

The conceptions of researchers and analysts have changed over time from negative opinions, which had consider rural tourism as a weak producer of value-added, to the positive one, which consider it as a important value-added creator.

The decrease in revenues from agriculture, increasing interest in sustainable development, the increasing efforts of local institutions to develop rural communities have created prerequisites of increased competitiveness of rural tourism destinations.

In this context, there has been a significant change in the market rural, characterized by a growing concern for health and the environment, which led to a significant increase in demand for accommodation and standards for this type of tourism, emphasizing the phenomenon of sustainability and attenuating seasonality (European Commission, 2000).

In the year 2013, EUROSTAT study (European Commission, 2013) results show that in predominantly rural regions across Europe, the share of services in regional GDP was lower (64.8%) in 2010, to predominantly urban regions (78, 6%) and the mixed regions.

Except Netherlands and Romania (46.8%) in almost all European countries, services that include tourism contributed with more than half of the value-added in the region predominantly rural. However, within Europe, it was determined that 32.2% of the total number of beds in all collective accommodation establishments are placed in the regions predominantly rural, which represent more than a third.

The objectives of this chapter is to evaluate the evolutions and the regional distribution of number of the agro tourist boarding houses (ATBH), existing accommodation capacity (EAC), and accommodation capacity in operation (ACO), their territorial concentration and specific modality in which the results are strategic levers in the regional development of Romania.

In the research methodology based on theoretical statements as guiding principles were used methods and techniques, ordering processes, correlation and processing information taken from official data provided by the National Institute for Statistics of Romania.

BACKGROUND: SUSTAINABILITY, SIGNIFICANT ELEMENT OF THE COMPETITIVENESS OF RURAL TOURISM

The competitiveness as a complex concept is viewed and analyzed globally, but also in terms of each component separately, considering the financial, human and organizational aspects. Regarding to this concept (Kotler, 2001) seats that it can be represented by the degree to which a nation, in a free and fair market conditions can produce goods and services that pass test of international markets, while managing to maintain and increase the real income of its citizens. National competitiveness is the result of competitive interdependence manifested at regional, local or company level.

In tourism, competitiveness can be approached from economically through the capacity of destination or of travel company to be more profitable in the tourist market. For a tourist destination, the competitiveness can be shaped by factors such as: attractions and tourist resources, support factors harmonized with other resources, favourizing conditions, demand conditions, tourism destination management, planning and development, policy implemented for raising the standard of effectiveness and profitability at international level.

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Tourism enterprise competitiveness is analyzed mainly through tourism products, targeting innovation, diversification, renewal and quality, client positioning the background first.

This context creates the potential market highlighting the necessity of competitive tourism products in the contemporary period, given the living conditions conducted under stress spectrum and pollution are increasingly oriented towards ecological and biodiversity plan.

Currently, the trend in Europe is the evolution of rural tourism which is constantly expanding, with all of crises manifested but under spectrum of storage, conservation, and regeneration of all resources involved in shaping competitive rural tourism products.

Emptaz-Collomb (2009) highlight that the concern of rural communities and institutions regarding environmental conservation has led over time to a specific approach to sustainable development. However, specific events constitute result of intertwining elements of demographic, social, cultural, economic and environmental factors.

The promotion of rural tourism type is a significant factor towards the development of poorer regions economic recovery, mainly of tourism opportunities, which can improve the living conditions of local people in those regions.

Studies conducted by Mehta and Kellert (1998), and Walpole and Goodwin (2000 and 2002) showed that the attitude towards interdependence between tourism and environmental conservation is direct but rather weak (European Commission, 2013). However, reveals that the over the past 15 years numerous studies have been conducted predominantly oriented towards interdependence revenues from tourism and conservation support environment. The study carried out by Walpole and Goodwin (2002) ended with the conclusion that poor countries with poor material and financial situation negatively influence support activities and environmental preservation.

World Commission on Environment and Development (1987, p.41) has defined sustainable development in their report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Michael Lemonick (2009) in his article „Top 10 Myths about Sustainability", was referring to the second myths („Sustainability is all about the environment")**,** quotes Anthony Cortese, founder and president of the organization for sustainable education "Second Nature", who said: "The economy is a wholly owned subsidiary of the biosphere. The biosphere provides everything that makes life possible, assimilates our waste or converts it back into something we can use".

World Conference on the Environment in Rio de Janeiro in 1992, paid special attention to the concept of sustainability, which involves establishing a balance between economic growth, environmental protection and finding alternative resources, defined as "the quality of a anthropogenic activities to take place without exhausting available resources without destroying the environment, so without compromising the ability to meet the needs of future generations"(Popa s.a, 2009; dexonline.ro).

At the microeconomic level, sustainable tourism development is the focus on technological developments and institutional change, touristic accommodation structures in harmony with increasing current capabilities and future ones and to meet human needs and aspirations towards recreation, restoration and spend nice time in line with the observance of ecological management. As early as the end of XX century, Welford (1997) highlighted some principles of sustainable development among which: integrated management, preventive and proactive behavior, continuous improvement, consumer information, caution, crisis strategies, contribution to the collective effort, social and environmental responsibility to the community.

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Basically, sustainability is a much deeper, being linked not only to activities involving the conservation and regeneration of natural resources and other components as well as the organization of sustainable holidays, which explains further involvement in rural tourism products of the competitiveness manifested the rural tourism.

ROMANIAN RURAL TOURISM: PRESENT AND PERSPECTIVES

Measuring the Rural Touristic Supply in Terms of Sustainability

The territorial structural analyzes is based on Nomenclature of Units for Territorial Statistics (NUTS) developed by the Statistical Office of the European Union (EUROSTAT) and included in the REGIO database under NUTS territorial units which are hierarchically structured on three levels: NUTS 1 (97 regions), NUTS 2 (271 regions) and NUTS 3 (1303 regions). In Romania, following their accession to the EU, the three NUTS levels have the following structure (Table 1): NUTS 1-4 macro, NUTS 2-8 regions and NUTS 3 - counties in each region. (Regulation EC No 176/2008, Regulation EC No 1059/2003).

Given that information (the statistics data series) which are processed and interpreted are taken from NIS (NIS, 2012) end EUROSTAT (2014), we consider that it is useful to present short definitions of them.

- *Agro tourist boarding houses* are accommodation structure, for temporary tourists' installation, located in rural areas, with the capability to provide their meals and specific activities of this type of environment. It is expressed in number of units
- *Existing rural touristic accommodation capacity* represents the number of the seats available by agro tourist boarding houses in order to tourist accommodation.
- *Rural touristic accommodation capacity in operation* is a statistical indicator which assessment offer accommodation, representing the number of seats offered by agro tourist boarding house in relation to the number of days of their operation in a predetermined period. It is expressed in number of place-days.

Table 1. Romania's territorial units according to NUTS

NUTS 1	NUTS 2	NUTS 3
Macro 1	North-West	Bihor, Bistriţa-Năsăud, Cluj, Maramureş, Satu Mare, Sălaj
	Center	Alba, Braşov, Covasna, Harghita, Mureş, Sibiu
Macro 2	North - East	Bacău, Botoşani, Iaşi, Neamţ, Suceava, Vaslui
	South-East	Brăila, Buzău, Constanţa, Galaţi, Tulcea, Vrancea
Macro 3	South -Muntenia	Argeş, Călăraşi, Dâmboviţa, Giurgiu, Ialomiţa, Prahova, Teleorman
	Bucureşti-Iflov	Bucureşti, Ilfov
Macro 4	South-WestOltenia	Dolj, Gorj, Mehedinţi, Olt, Vâlcea
	West	Arad, Caraş-Severin, Hunedoara, Timiş

Source: Regulation No 176/2008 of the European Parliament and of the Council

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Context created by information taken about three indicators measuring the supply of rural tourism accommodation, allowed the application of specific indicators of structural analysis (relative sizes of the structure), dynamic indicators (average indicators) and indicators involved in the methods establish specific degree of concentration, Gini-Struck coefficient of concentration, trapezoidal method to calculate the Gini index of concentration (Ţiţan, 2012), and diversification - value Agresti (Jaba, 2002).

Struck concentration coefficient is the corrected form of the Gini coefficient and is determined independently of the number of categories considered, across time and space permitting comparability of the results, being expressed by the relation:

$$C_s = \sqrt{\frac{n\sum g_i^2 - 1}{n-1}} \in [0;1] \quad (1)$$

In view of the rigorous evaluation as in the research, the trapezoidal method was applied to calculate the Gini concentration index. This takes into account the determination of the concentration using surface concentration value (with respect to the surface of trapezoids formed on the ranges of variation of the characteristic X) by applying the relation:

$$I_G = 1 - \sum_{i-1}^{N} s_i^2 \in \left[0;1-\frac{1}{N}\right] \quad (2)$$

where:

$n = \sum n_i$ – counties number (40 countries);

q_i – share of accumulated global values up to the same level x_i

f_i – share of herds (n_i) in total collectivity ($\sum n_i$)corresponding to the level x_i of X (in the case of research: the number of agro tourist boarding houses, the number of places or the accommodation capacity in operation).

Also, diversification indicators occupy a significant place in the survey. An important role in this analysis, had diversification index, found in the specialized literature under the name of value Agresti, determined by the relation (Agresti, 1990, p.24):

$$V_s = 1 - \sum_{i-1}^{N} s_i^2 \in \left[0;1-\frac{1}{N}\right] \quad (3)$$

The maximum value is set at 0.8 by the relation: $1-\frac{1}{N}$, where N represents the number of categories (groups). In the study, as a result of the previous processing five groups were established for each characteristic (Table 2).

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Supply tourist accommodation in rural areas of Romania has recorded a general upward trend since 2000, although during the global financial crisis has shown a slight decline, with the effects recorded in 2009-2011.

The increasing of the number of tourist accommodation units in 2012 compared to 2011 was significant compared with the trends from previous years. Meanwhile, the accommodation capacity, so the number of accommodation provided by rural touristic accommodation establishments registered a continuous growth, including in the financial crisis, when maintained, however, positive.

The real challenge lies in shaping management decisions imposing sustainability as a priority of running rural tourism activities with the need to maintain and reuse natural resources in rural areas and component elements that make up the rural touristic supply.

Applying research methodology outlined above constitutes a context for future economic modeling approaches through Bayesian econometrics, bringing together the interests of various groups of researchers in economics and adjacent, such as specialists in the tourism trade, services, marketing (Simionescu, 2013)

The Accommodation Supply of Rural Tourism in the Context of Sustainable Development Trend

Sustainable development of rural tourism accommodation supply manifests interrelated with the milestones for the development and sustainability of rural communities. Is the action plan are intertwined influence of public authorities with the management strategies applied by rural touristic accommodation.

The study of rural tourism accommodation supply in Romania was started by analyzing the evolution of the three main indicators definite above (number of agro tourist boarding houses, existing rural accommodation capacity and rural accommodation capacity in operation) both at general level (the Romanian territory) and regional level.

During 2000 - 2012 the number of agro tourist boarding houses (Figure 1) increased about 3.92 times from 400 registered in 2000 to 1569 agro tourist boarding houses in 2012, the annual average being 12.06%. In the period preceding the economic crisis their number increased continuously but with different rhythms being distinguished three periods of approximately linear growth:

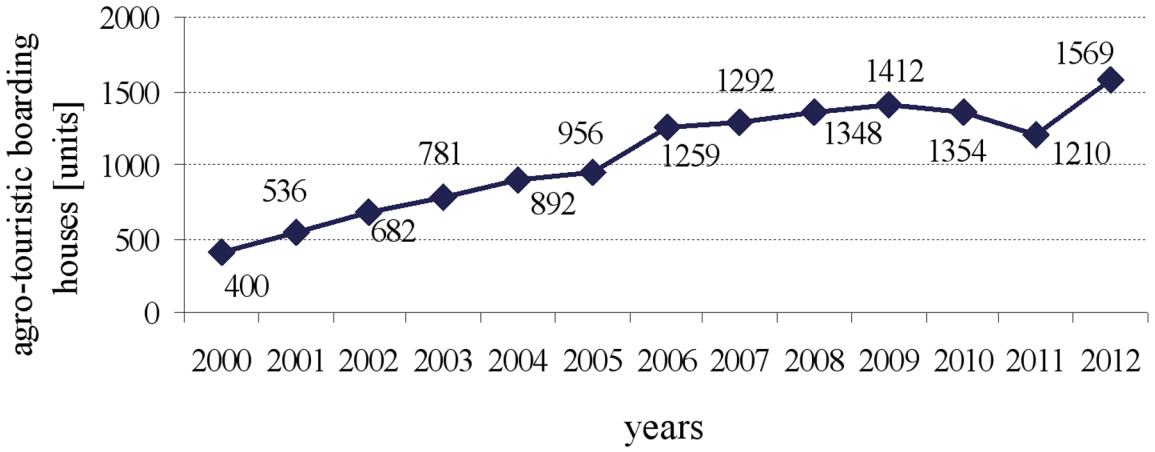
Table 2. The way of distributing of counties in the five groups in relation to each measuring indicator of the supply of rural tourism accommodation

Number of Agro Tourist Boarding Houses	Existing Accommodation Capacity (Places)	Accommodation Capacity in Operation (Places-Days)
0 - 55	0- 882	0-307187
55 - 110	882 - 1764	307187 - 614374
110 - 165	1764 - 2646	614374 - 921561
165 - 220	2646 - 3528	921561 - 1228748
220 - 275	3528 - 4410	1228748 - 1535935

Note: The lower limit included within

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Figure 1. Evolution of the agro tourist boarding houses in Romania during 2000-2012
Source: authors own computation based on NIS (2013)



- The period 2000-2005 in which the average annual increase was 111.2 agro tourist boarding houses, the annual average being 19.04% with 7.34 percentage points above the annual average of the period 2000-2012,
- The period 2005-2006 have been recorded no less than 303 agro tourist boarding houses (an increase of 31.69%)
- The period 2006-2009, in which the trend of growth continues, but with an average annual increase of only 52 agro tourist boarding houses, the annual average being 3.90%, with 8.16 percentage points below the average.

Triggering the economic crisis in 2008 had a negative impact on the supply of accommodation places in the period 2009 to 2011, in which coming out of tourist circuit, a total of 202 agro tourist boarding houses, out of whom 144 in the period 1010-2011 (in the first two years of decline, the number of agro tourist boarding houses fell by 14.3%). Year 2012 brings a revival of rural tourism, at least in terms of the supply of accommodations, in the period 2011 to 2012 the number of agro tourist boarding houses increasing by 29.67%.

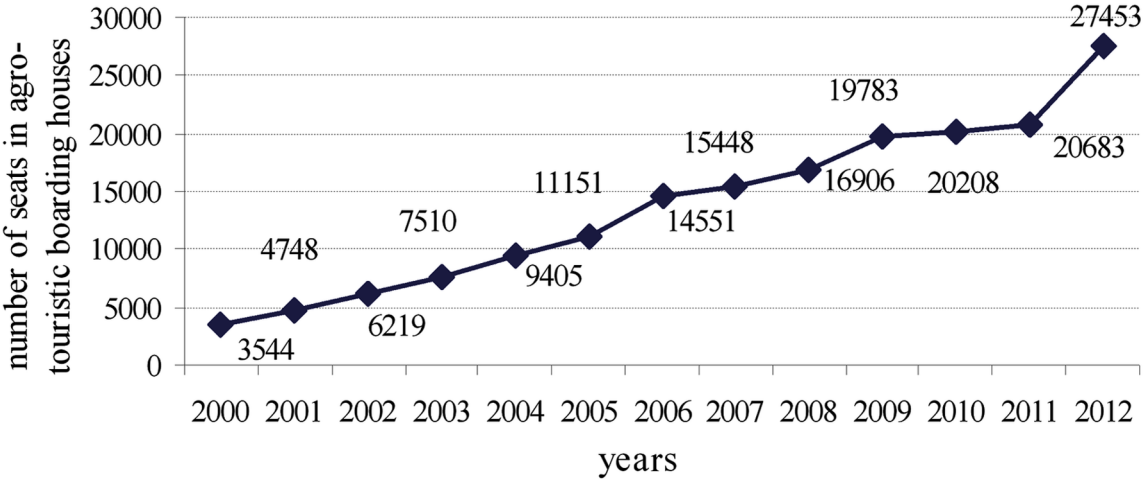
In the eight regions of development of Romania the number of agro tourist boarding houses is significantly different. Of these, the Centre region, number of agro tourist boarding houses is two times higher than in the North - West region, which is from this point of view, on place the second. Note that these two regions of development make up the Macro 1, comprising the counties of Transylvania.

Very close, in terms of number of agro tourist boarding houses, changing alternatively with North-West, the second and third places, there is the North-East region which has also a rich cultural, natural and historical heritage. In these three regions there are over 70% of total agro tourist boarding houses.

Evolution of existing accommodation capacity, represented by the number of seats in agro tourist boarding houses in Romania, is highlighted by the chronogram shown in Figure 2. Its upward trend is evident. Throughout the period under review, the average absolute increase is approximately 1992 places per year, while the relative increase is 18.60% per year.

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Figure 2. Evolution of existing accommodation capacity in agro tourist boarding houses, in Romania, in the period 2000-2012
Source: Authors own computation based on NIS (2013)



In the period preceding the economic crisis, the number of the accommodation places in agro tourist boarding houses shows an evolution similar to that recorded by the number of agro tourist boarding houses: In the period 2000-2005 the average annual rate was 27.77%, with 7.17 percentage points above the annual average of the period 2000 - 2012, in 2005-2006 the number of accommodation places increased by 30.49%, and in the period 2006-2009 the average annual rate was 10.78%, with 7.82 percentage points below the average for the period 2000-2012.

Although the economic crisis has led to decrease in the number of agro tourist boarding houses from 1412 in 2009 to 1210 in 2011, the supply of accommodation places continued to rise, from 19783 in 2009 to 20683 places in 2011 (an increase of 4.55%). Year 2012 brings a recovery of the supply of places in agro tourist boarding houses, their number being with 32.73% higher than in 2011.

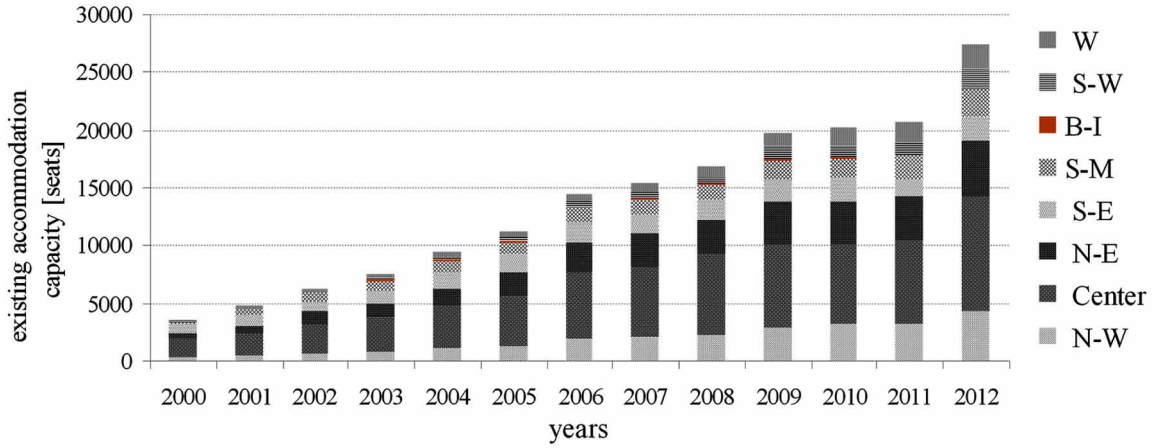
Analyzing the evolution of the number of agro tourist boarding houses and of the accommodation places provided by them, it appears that, in the period, increased from an average of 8.83 accommodation places per agro tourist boarding houses share reported in 2000 to 18.86 accommodation places per agro tourist boarding houses in 2012. This is highlighted by the annual growth rates of the two indicators. Except for 2006, which compared to 2005, annual growth in the number of agro tourist boarding houses overtake annual growth rate of accommodation places (31.69% vs. 30.49%) throughout the period, annual growth in the number of accommodation places was higher than the annual growth of the number of agro tourist boarding house, the biggest difference, 12.99 percentage points being recorded in 2009.

Also, an important conclusion is that the economic crisis has affected to a much greater extent, agro tourist boarding houses with small accommodation capacities compared to those with higher capacities. This conclusion is underlined by the fact that although in the crisis period the number of agro tourist boarding houses fell by 202, the number of accommodation capacity increased, during the same period, with 900 seats.

Through an analysis of existing accommodation capacity of agro tourist boarding houses, by regions of development of Romania (Figure 3) results, as expected, given the distribution of them by regions of development analyzed above that, throughout the period of analysis, most of accommodations are sup-

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Figure 3. Evolution of the existing accommodation capacity in agro tourist boarding houses by regions of development of Romania, in the period 2000-2012
Source: authors own computation based on NIS (2013)



plyed to agro tourist boarding houses from the Center region. After the Center region, on second place since 2002, is North-East region, followed by the North-West region.

Regarding the rhythms of evolution of existing accommodation capacity per regions of development for the period 2009 - 2012, the situation is slightly different. The West region in 2010 recorded the highest growth (25%) and, although in the coming years is surpassed by growth rate of the South-Muntenia (23% in 2011) and South East (24% 2012), during the economic crisis existing accommodation capacity in agro tourist boarding houses in the West region increased by 75.97%. Note that the West region is the only region that, during the economic crisis, showed only positive values of the growth rate of existing accommodation capacity in agro tourist boarding houses.

The accommodation capacity in operation (places-days) in agro tourist boarding houses in Romania, in the period 2000-2012, both across the country and by regions of development had a similar evolution to the evolution of existing accommodation capacity across the country, respectively, by regions of development.

Thus, as in the existing accommodation capacity, the annual growth rates of accommodation capacity in operation in 2010 have been positive only in the West (22.09%), North-West (14.35%) and South-Muntenia (4.21%). In 2012, relative to 2009, in the West region, the accommodation capacity in operation doubles (204.72%). Also significant values are recorded in the South-WestOltenia (167.27%), Centre (162.78%), South-East (132.14%), North-West (131.57%) and North-East (130.37%).

Territorial Structural Developments on Rural Touristic Supply

Studying supply Romanian rural tourism accommodation begins with analysis of the evolution of existing accommodation capacity and accommodation capacity in operation as the most representatives at both general (the Romanian territory) and particular, that from the eight macro-regions.

A structural analysis of the supply of Romanian rural tourism accommodation in the eight regions of development more clearly highlights regional differences, thus allowing the shaping of strategic insights attenuation and sustainable development territorial disparities.

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Agro tourist boarding houses structural hierarchy of the eight regions of development of Romania has changed slightly from year to year. In 2000-2012 period the trend of decreasing percentage in Central region (with the strong concentration of the total agro tourist boarding houses: from 60.60% in 2000) in favor of the other regions, so that will arrive in 2012, as territorial distribution of agro tourist boarding houses in this region corresponds to only 37.86%.

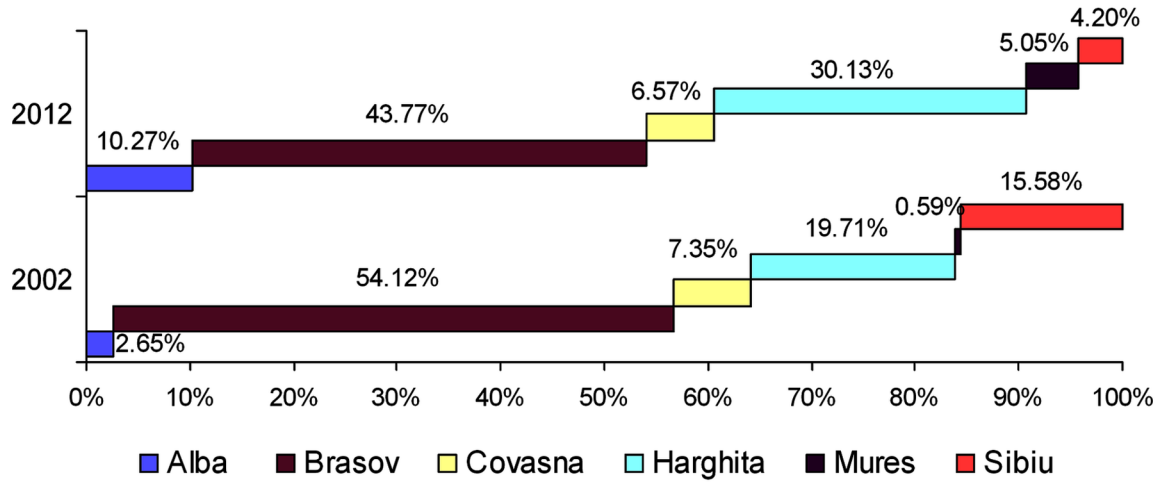
Justification situation is reported primarily in civilization, the mentality and attitude of the local community in practicing rural tourism, the implementation of appropriate policies and strategic management level. However, positive results following the establishment of agro tourist boarding houses and practicing this form of tourism are highlighted and by a detailed analysis of the distribution of their structural components counties (Alba, Brasov, Covasna, Harghita, Mures and Sibiu).

Since in Covasna and Mures were recorded hostels established in 2001 and 2002 for a clearer reflection of the situation of structural distribution of tourist hostel, comparing the 2002 with structure in in 2012, established for rural tourist pensions counties. The results (Figures 4) showed significant increases in percentage points in 2012 compared to 2002 in Alba, Harghita and Mures, while for other counties (Brasov holder of more than half of all agro tourist boarding houses, Sibiu and Covasna) are indicated only by a few percentage points decrease insignificant given the suggestive supply tourist accommodation rural county.

North Est Region, ranked second on the structural hierarchical scale of agro tourist boarding houses throughout the period 2000-2012, will determine shares varied between 11.19% in 2001 and 18.43% in 2011. In this region NE, rural touristic pensions operated from 2000 until 2005 in the territory of Bacau, Iasi, Neamt, Suceava, Vaslui in 2005 and 2011 and Botosani county area, leading to a comparative analysis of the structural set at 2012 to 2005 (considering less suggestive comparison of 2012 versus 2011).

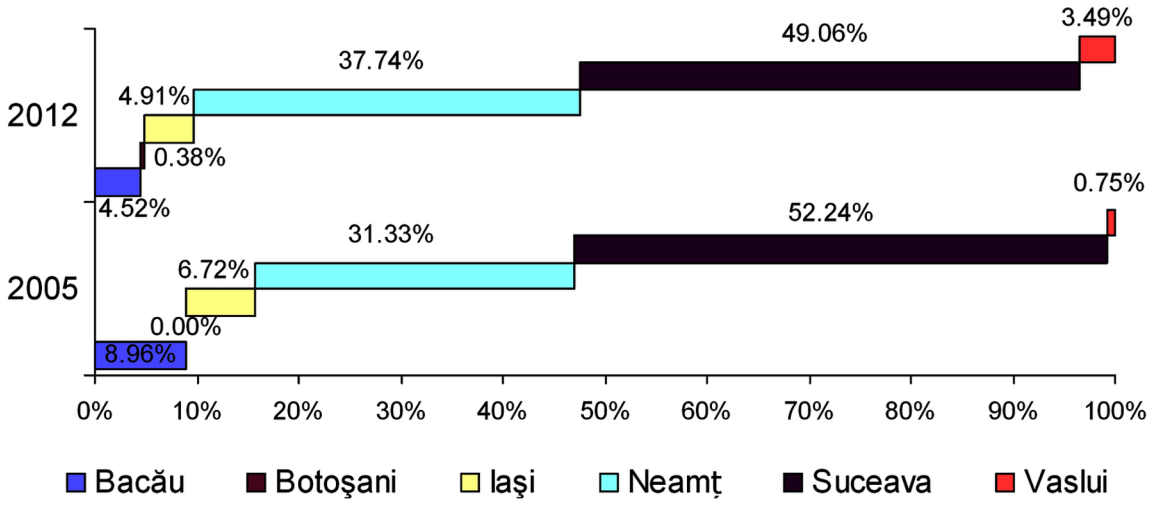
Comparative graphical representation (Figure 5) show a significant tiebreaker for Suceava (with the 52.24% in 2005 and 49.06% in 2012) and Neamt (from 31.33% in 2005 to 37.74% in 2012) in the supply of rural touristic accommodation given, primarily, to the rich natural, historical and cultural potential, and policy maintenance, recovery and transmission of cultural values and ethno-historical folklore they have. A significant potential for rural touristic supply Iasi and Bacau counties of, although in 2012

Figure 4. Structure of agro tourist boarding houses counties of Centre region in 2002 and 2012
Source: Authors own computation based on NIS (2013)



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Figure 5. Structure of agro tourist boarding houses in North Est region in 2002 and 2012
Source: Authors own computation based on NIS (2013)



compared to 2005 as a division of the supply of accommodation known process of reducing by 1.81 and 4.44 percentage points respectively.

These counties are the foundation of sustainable development of rural tourism through the nature, material, spiritual and human reserve, features that propagate as in spectrum of conservation and reclamation involved in the inestimable value of this type of tourism.

Vaslui County granted in 2005, particular attention to developing of rural tourism, which noted the increase of 2.74 percentage points in 2012 compared to their establishment.

Throughout the period of analysis, 2000-2012, is maintained also North West region as occupies the third place in the ranking of tourist agro tourist boarding houses structural rural regions of Romania, the shares varying from 8.75% in 2000 and 19.65% in 2010.

In 2000, rural tourism is run mainly in Maramureş (which holds throughout the analysis, the largest number of rural agro tourist boarding houses)and then Cluj, Sălaj, Satu-Mare, as reported in 2002 to establish a rural tourist hostels in Bihor county, and in 2004 in Bistriţa-Năsăud, which provide opportunities for comparative structural analysis in 2012 compared to 2004.

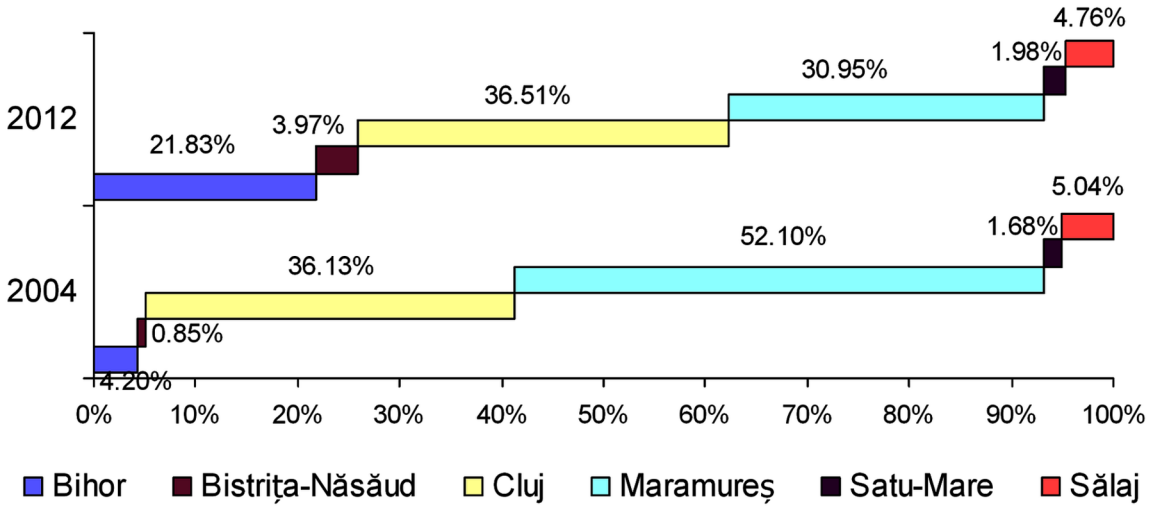
Natural and cultural potential of inestimable value is found in the county of Maramureş creating opportunity for tourism also rural tourism especially, justifying the existence of many rural agro tourist boarding houses in the area, although with the passing years, the whole region NW share of their corresponding total is reduced with the 21.15 percentage points in 2005 compared to 2012.

Strategic policies, management of rural communities and private entrepreneurs led to the establishment of more rural accommodation also tourist facilities in other counties in the region, and to increase tourist activity in those areas (especially in Bihor county where there is a significant increase with the 17.63 percentage points in 2012 compared to 2004), except Sălaj county, where the interest for practicing this type of tourism has decreased in recent years, as evidenced by reducing by 0.28 percentage points in 2012 compared to 2004.

Regions South-East and the South-Muntenia are in constant competition to occupy third and fourth place, which led to a constantly changing of the hierarchy placement. Thus, in the process of setting up

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Figure 6. Structure of agro tourist boarding houses in counties of North West region in 2002 and 2012
Source: Authors own computation based on NIS (2013)



or dissolution of agro tourist boarding houses during 2000-2012 led to fluctuations percentage between 6.73% (2009) and 9.51% (2001) for the region South-East, and between 6,75% (2000) and 10.99% (2004) to the other region.

In 2000, South-East region rural touristic accommodation supply is mainly based on the number of rural pensions in Vrancea, Constanţa, Tulcea, Buzău rural boarding representing 36.36%, 33.34%, 24.24% and 6 06%. In 2012 not only that there is a rural tourist facility in Braila county approved but are defined and structural changes towards increasing the Buzau County with the 41.13 percentage points, while for all other counties registers discounts: 4.02 percentage points for Tulcea, Vrancea with the 12.76 percentage points and 25.47 percentage points for Constanta.

The potential of these counties is quite low (except the counties of Tulcea and Constanţa), which requires a significant strategic directions for action modeling and managerial carried out in local communities in order to harmonize them at regional level backed towards sustainable development.

Rural tourist supply of the region South-Muntenia contribute to the practice of rural tourism primarily through extremely rich environment, natural and human, that Prahova, Arges and Dâmboviţa counties have. It is, in this way, the essence of rural tourism activities in this region, which runs through rural touristic accommodation in hostels representing 44.45%, 33.33% and 22.22% of those registered in the region in 2000. In 2003 rural tourism establishments are certified Ialomita and Giurgiu county and in 2011 in Teleorman. In 2012 compared to 2003 will be recorded increases by several percentage points for Arges, Dâmboviţa, Ialomiţa and Teleoman, Prahova and Calaraşi recorded discounts, while Giurgiu will remains again without registered rural tourist activity, while no longer functional agro tourist boarding houses are recorded.

South-Muntenia region is a region that has a great tourism potential area, therefore it is very important at this level to establish clear lines of action regarding the implementation of rural tourism activities, especially that natural environment in Arges, Dâmboviţa and Prahova can be a foundation of sustainable development of this type of tourism.

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Two regions (South-West and West) compete for supremacy in the hierarchy but only for 5th and 6th place. For agro tourist boarding houses in total, each corresponding number establish the time of percentages ranging from 1.00% (2000) and 6, 88% in 2012, corresponding to the South-west region and between 1.75% in 2000 and 7.14% in 2012 to W.

Rural tourist hostels from South-West region are found in Gorj and Valcea in 2000, two areas with significant natural and human potential, which opened broad prospects for practicing rural tourism.

In 2002 established rural tourism facilities in Dolj County, and in 2004 Mehedinti allowing structural stability at this year leading to a comparison with the structural situation of agro tourist boarding houses since 2012 (in 2011 there is an approved facility in Olt County). Thus, Vîlcea, Dolj and Mehedinti counties face an increase in 2012 compared to 2004 by 1.41, 1.56, 9.88 percentage points respectively, while registered in Gorj county compared to other counties, a reduction of 12 85 percentage points.

Given that Valcea relies most on extensive natural potential, directions of rural tourism development must find alternatives that lead to attraction of funds and creation of a diversified anthropogenic potential, enabling sustainable development of this type of tourism.

Caras-Severin, Arad and Hunedoara counties represent the West region and in 2000, includes some rural touristic accommodations that enable the practice of this form of tourism. In 2001, there are 25 units in Timis county, across the region, at that time, represented 64.10% of the total, the remaining percentages belonging to the other three counties. The structural situation changes in the year 2012 when Timişul lose significant percentage (51.6) in favor of other counties, Hunedoara county recording increase of 10.05 percentage points, Arad County with 15.63 percentage points and 25.92 percentage points Caras-Severin.

The attitude of communities, the level of civilization are significant advantages towards raising the standard of sustainable development of rural tourism which should adequately modeled and targeted tourism market requirements

For the last BI ranked, which corresponds to a significant number of small rural agro tourist boarding houses, the supply compared to other regions have established share between 0.13% (2012) and 0.74% (2008). Conditions and context of rural touristic supply (small area compared to the other regions, lowland area, bordering the capital of Romania), led to the placement of this area in the last step but a strategic organization and managerial adequate and sustained strategy can lead to significant insights rural development in terms of tourism supply and sustainable development with it.

The many agro tourist boarding houses in Central region leads to a large number of places supplied, aspect which shapes the possibility of getting of the first place in the ranking of the structural capacity of existing rural touristic accommodation in Romania. Figure 7 highlights the oscillatory trend of diminishing percent on accommodation supplied, ranging from 45.68% in 2000 and 36.69% in 2012.

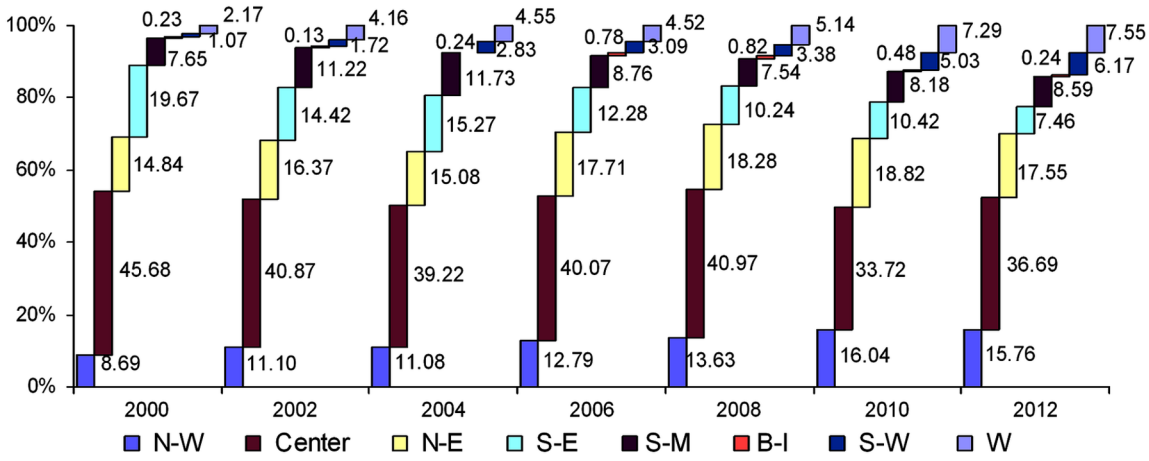
Regarding shares established through agro tourist boarding houses places supplied in each region in their total in Romania, there is a competition for the entire period of analysis (2000-2012) between the NE and SE regions. The contest for second and third place led to a changing each hierarchy placement, thus establishing percentage fluctuations during 2000-2012, ranging between 14.66% (2001) and 19.64% (2011) for the region North-West and between 6.70% (2011) and 19.67% (2000) for the South-East. region.

Dispute fourth and fifth places is given between North-West region, which corresponds to a percentage range between 8.69% - 15.76% (in 2000 and 2012 respectively), and South-Muntenia with a percentage distribution between a minimum of 7.54% set in 2008 and a maximum of 11.73% recorded in 2004.

The same two regions (South-West and West) compete for 5th and 6th place, in the supply of accommodation in the areas referred to all places Romanian agro tourist boarding houses. Structural percent-

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Figure 7. Tourist accommodation capacity current structure, on regions of development of Romania, during 2000-2012
Source: authors own computation based on NIS (2013)



ages established are close in value to those established for agro tourist boarding houses: between 1.07% (2000) and 6.17 in 2012 for the South-West region, ie the region of West between 2.17% in 2000 and 7.82% in 2011.

As might be expected, the last class is still BI, which corresponds to an insignificant number of places in rural touristic pensions compared to the total number of all regions is only 0.13% (2002) and 0.82% (2008).

The same trend of structural changes, as if the number of agro tourist boarding houses, there is the case of accommodation capacity in operation, showing small deviations from the percentage values for the indicator: established number of seats supplied by rural tourism in the eight regions of development of Romania.

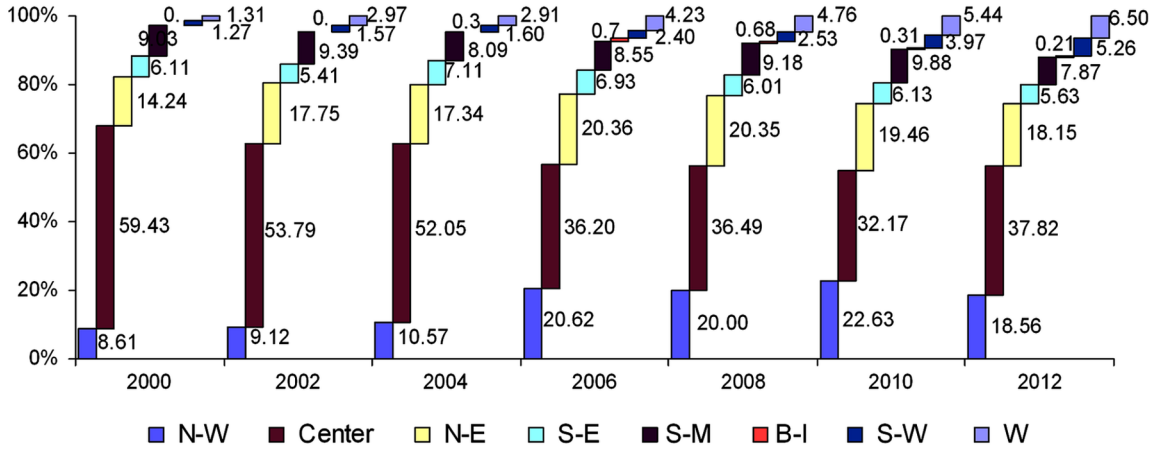
Figure 8. clearly highlights the structural developments established for accommodation capacity in operation corresponding to agro tourist boarding houses allocated in the eight regions of development of Romania.

Distribution of structural hierarchy of accommodation capacity in operation regions of development of Romania, with highs and lows percentage of the corresponding oscillation is as follows:

- First place occupied by the Central region with decreasing shares fluctuating between 59.43% (2000) and 32.17% (2012);
- Second and third place is occupied when the North-East region, when the North-West during 2000-2012 percentages ranging between 14.24% (2000) and 20.36% (2006) for North-East region and between 8 61% (2000) and 20.63% (2010) for the North-West region;
- Fourth and fifth place is disputed between regions and South-Muntenia with percentages varying between 5.33% in 2003 and 7.21% in 2005 for the first region, respectively the second between 9.03% and 10.51% recorded in the years 2000 and 2003;
- Sixth and seventh places are allocated alternatively be region West or to the South-West between 1.31% (2000) and 6.66% (2011) returning tourist accommodation capacity of the region W of

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Figure 8. Structure of accommodation capacity in operation on developing regions of Romania, during 2000-2012
Source: authors own computation based on NIS (2013)



the total of the corresponding pensions in Romania rural tourism, and between 1.27% (2000) and 5.26% (2012) for the South-West;

- Last place belongs to region BI with percentages ranging from 0.01% (2000-2002) to 0.71% (2006).

Accommodation capacity analysis of agro tourist boarding houses presented in detail on county, highlighted the similarities and disparities that are manifesting in relation to the distribution of agro tourist boarding houses on counties and regions of development.

Concentration and Regional Diversification of Rural Touristic Accommodation Supply

Results of the analysis of the indicators of rural touristic supply are the premises to study the concentration and territorial diversification manifested in Romania.

Quantification of territorial disparities is based on various methods known in the literature by using indicators such as: coefficient (index) Gini, Theil index Hoover index or Palma report or different percentiles reports, Lorenz curve, coefficient of variation, Hirschman index or Kolm report.

The applicability of these indicators is to adapt over time and space and different areas. Thus, targeting tourism literature are found Gini concentration ratios applied to predict the impact of the field and its role in foreshadowing flexible policies for developing tourist regions.

Julie Jie Wen and Corazon Sinha (2009) have analyzed the spatial distribution of tourism in China using Gini coefficient..Also, Miloš Bigovic used Gini coefficients to measure the concentration seasonal tourism in Montenegro, study highlighting the existence of a strong and consistent seasonality in this region (Bigovic, 2011).

However, the literature in the field presents Papakonstantinidis Leonidas, from quantifying income inequality, by applying the Gini indexes in the methodology to forecast the impact of tourism and development policy formulation in two of the most important tourist regions of Greece (Papakonstantinidis, 2012)

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The study of the evolution of the three indicators and their corresponding structural fluctuations, on regions of development and counties in the period 2000-2012, led to obtain an overview of the Romanian tourism supply of accommodation. Trend changes, in time and space, has created framework necessary for the analysis of regional concentration and diversification of rural touristic supply in Romania, in order to shape a clearer image of the level of development of rural tourism relative to Romania's regional development strategy.

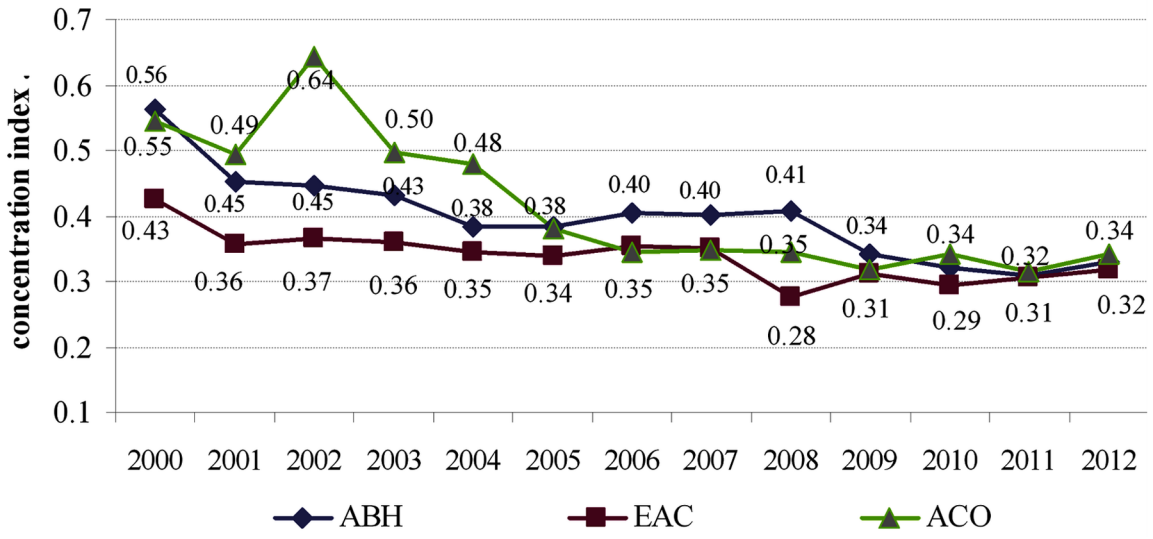
A first way of analyzing the territorial concentration of Romanian rural touristic supply is to determine the Struck concentration coefficients, at territorial development level, in the regions of Romania, whose evolution in the period 2000-2012 is shown in Figure 9.

The number of agro tourist boarding houses, at the level of each region, has allowed determination of structural coefficients, from which the coefficients were calculated annual Struck concentration. Thus, it resulted that, during 2000-2012, the concentration of the geographical spread fluctuated from year to year, as a whole, resulted a trend of reduction from a maximum of 0.5626 in 2000, to a minimum of 0.3085 in 2011.

The same trend of reduced of territorial distribution concentration was identified at Romania level, both existing accommodation capacity and the accommodation capacity in operation, as follows:

- Data on existing accommodation capacity of agro tourist boarding houses by regions of development have concluded to a concentration high enough, between a maximum of 0.426 in 2000 and 0.277 minimum in 2008;
- Significant fluctuations due to territorial distribution of accommodation capacity in operation, led to variations of the coefficient of concentration from a maximum of 0.644 in 2002, and a minimum of 0.313 in 2009.

Figure 9. Evolution of Struck territorial concentration coefficients of rural touristic supply during 2000-2012
Source: authors own computation based on NIS (2013)



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In the whole, in Romania, compared to territorial regions of development, the rural touristic accommodation supply tends to a uniform territorial distribution, the concentration decreasing significantly in the period 2000-2012. The manifested trends was determined both by the intense and accelerated development of rural tourism since 1990, implicitly and after 2000, when it placed increasing emphasis on active and direct contact between man and nature in the context of high-level manifestation of pollution and stress, as well as by the particularities of this kind of tourism, which creates financial advantages over the others, in the crisis triggered and manifested after 2008.

For a more detailed analysis of regional concentration, starting from distributions of the number of agro tourist boarding house, of the existing accommodation capacity and of the accommodation capacity in operation by county, by applying the trapezoidal method were determined Gini concentration indices, respectively indices of diversification (Agresti value), the of 2012.

In the year 2012, the distribution of the number of counties by agro tourist boarding houses in Romania shows that, out of the 40 counties, in the majority (72.50%) were between 0 and 54 agro tourist boarding houses, in 20% were between 55 and 109 agro tourist boarding houses, while only in 7.5% of their total there are more than 109 agro tourist boarding houses (by 2.5% for each of the following three ranges of values 110-164, 165-219, respectively, 220-274 agro tourist boarding houses). Corresponding to this distribution, was resulted in a low concentration level, and highlighted by the value of 0.368 of concentration index. The same conclusion is underlined by Agresti value 0.4326 (corresponding to the distribution of the number agro tourist boarding houses by counties) led in relation to the maximum value (0.8). So the inequality between counties in terms of the number of agro tourist boarding houses is reduced.

Distribution of counties by existing accommodation capacity of agro tourist boarding houses in Romania in 2012 follows the number of agro tourist boarding houses in the sense that:

- 75.00% of all counties have existing accommodation capacity between 0 and 881 places;
- 17.50% of all counties have existing accommodation capacity between 882 and 1761 places;
- 7.50% of all counties have accommodation capacities over 1761 places (by 2.5% for each of the following three ranges of values 1764-2645, 2646-3527, respectively, 3528-4409 places)

Given the distribution of counties in groups by existing accommodation capacity supplied by agro tourist boarding houses, using the same method, resulted in a concentration index value of 0.6291 which indicate a significant concentration of existing accommodation capacity in counties of Romania. This can lead to disparities and therefore requires the application of appropriate mitigation strategies, with positive effects on the performance of rural tourism activities and tourism in general. On the other hand the value Agresti is 0.5051 and compared with the maximum value of 0.8, highlights the existence of disparity and widening trend of concentration.

Considering the territorial distribution of the values of the third indicator which characterizing the supply of rural touristic accommodation, was determined the distribution of counties by accommodation capacity in operation in agro tourist boarding houses in Romania in 2012, resulting:

- 77.50% of all counties have accommodation capacity in operation between 0 and 307186 places-days;
- 15.60% of all counties have accommodation capacity in operation between 307187 and 614373 places-days;

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- 7.50% of all counties have accommodation capacity in operation over 614373 places-days (by 2.5% for each of the following three ranges of values 614374-921560, 921561-1228747, respectively, 1228748-1535935 places-days).

Starting from these, has result for concentrated index the value 0.3605 indicating a low concentration degree of accommodation capacity in operation of agro tourist boarding houses from Romania. Also, since Agresti value is 0.3751, it follows that there is a low degree of diversification in relation to the maximum value of 0.8, the disparities between counties in terms of accommodation capacity in operation of agro tourist boarding houses is lower than the others' two indicators analyzed.

In general, given the indicators those characterize the rural touristic supply, in the year 2012, resulted a breakdown in counties with a relatively low concentration, of the number of rural tourism and accommodation capacity in operation. The exception is existing accommodation capacity, which has a county distribution, not very favorable for future work of the Romanian tourism, requiring measures to mitigate of regional disparities.

The same "pattern" fall and the results of diversification indicator for number of hostels and accommodation capacity in operation, which shows a reduced disparity between counties, which means a distribution that tends toward uniformity, and that would allow maintaining a certain level the policies imposed by the regional development strategies for these two indicators, while for the existing accommodation capacity should be approached another development strategy.

FUTURE RESEARCH DIRECTIONS

The results of structural analysis on region, and of agro tourist boarding houses within the counties of the eight regions, indicates the distribution of the supply of the tourist accommodation area, and the degree of exploitation of tourism potential available to each. In this context it may establish implementing strategic measures, recovery and development of rural tourism potential which to run on the background of sustainability process

The National Strategy for Regional Development, which was outlined and applied on Regional Development Plans and the National Strategic Reference Framework 2007-2013, rural touristic accommodation supply analysis outlines the sustainable development level of this type of tourism and the possibilities that are foreseen in this direction.

In this context it is necessary that decisions and policies implemented through regional development strategies for development of agro tourist boarding houses and of accommodation capacity in operation to be performed within the same limits and coordinated. Regarding existing accommodation capacity, resulted a pronounced inequality in the territorial distribution of its, requiring the development and implementation of specific policies.

Currently, the basic element in the reform process, aimed at future territorial planning in Romania it is applied Strategic Concept of Territorial Development, Romania 2030 (www.mdrt.ro, 2013). It has the overall objective, affirmation process of the continental regional identity, of its role in the region, increasing spatial cohesion, the competitiveness and sustainable development of Romania that lead to ensuring Romania's integration into EU structures.

The Ministries policy advice to programs and strategies could affect tourism (Stănciulescu, 2006). So, established strategies must lead to the outline of the substantiation of territorial development, sup-

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porting balanced development of Romania. This context created can stimulate partnerships, associations or collaborations at local, regional, and inter-institutional agreement, to promote and implement regional strategic projects.

Integrated territorial development perspective aims to establish and implement modality to use national potential with the aim eliminate development gaps. In this framework can be placed in the future and development of regional rural touristic supply, outlining a research direction to follow the effects of Romania's regional development strategies.

In relation to determining the degree of territorial concentration of Romanian rural touristic supply is required in the future adoption of strategies for mitigating regional disparities manifested positive impact on economic growth both in the rural communities that especially in Romania, all under the spectrum sustainable rural resources.

CONCLUSION

The study includes the analysis of assessment results of the trend, across time and space, of the number of agro tourist boarding houses, the existing accommodation capacity and the accommodation capacity in operation as well as the results of determination of the territorial concentration of these indicators, which can be a start point to develop and implement strategic decisions in the regional development of Romania.

Regarding to the accommodation supply of rural tourism in the context of sustainable development trend we conclude that, after 2000, when it put more emphasis on the practice of rural tourism as a result of changes in contemporary human life is impressive, the development process, fairly sustained of supply of rural tourism accommodation. This trend is the result of the support at national, regional and local level through the application of regional development strategies based on the one hand per funds that were needed in this direction, as well as maintaining a balance regional supply that not affect human communities in these areas.

The same time, the analysis of the indicators reflecting the supply of rural tourism accommodation through its peculiarities revealed that the economic crisis has had a relatively small impact, which occurred mainly in the first year after its onset, in 5 of the 8 regions of development in Romania, where, except for the Bucharest-Ilfov region, the decrease rates ranging from 0.38% in the Northeast region, and 10.06% in the South-WestOltenia. But, on the existing accommodation capacity of agro tourist boarding houses in the Bucharest-Ilfov, the impact of economic crisis was significantly (-41.69% in 2010, and still -21.38% in 2011), so in 2012 the accommodation capacity in operation has halved (44.54%) than the one registered in 2009.

The evolution of rural touristic supply in each development region has known increases and decreases in the values of evaluation indicators of rural tourist during the entire period of analysis 2000-2012. The study results show that the highest average growth rates for each indicator were recorded in the regions of development South-West Oltenia and West (average increases ranging between 25.99% and 37.23%), while lowest increases average were recorded in South-East development region, at the indicator the number of agro tourist boarding houses, and at existing accommodation capacity (with average rates of 7.77% and 9.39%), and in the Center region, at the indicator the accommodation capacity in operation (15.13%).

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The disparities between regions with high natural supply and with low natural supply are more obvious among counties in the developing regions. Significant to note is that these disparities are still quite low, being due mainly to features of rural touristic supply (traditions, culture, history of rural localities), as confirmed by the results of the concentration coefficients Struck, the indices of concentration Gini, and the diversification-value Agresti.

The rural touristic potential, specific to each development region, form the reference framework in regional development strategies. Starting on these can be established opportunities targeted to local and regional economic growth, as the result of exploitation of natural, cultural and historic potential for the decrease of the disparities between rural areas intended for tourism.

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KEY TERMS AND DEFINITIONS

Agro Tourist Boarding Houses: Accommodation structure, for temporary tourists' installation, located in rural areas, with the capability to provide their meals and specific activities of this type of environment.

Existing Rural Touristic Accommodation Capacity: The number of seats available by agro tourist boarding houses in order to tourist accommodation.

Regional Concentration: Targeting mainly towards a region of the distribution of activities or elements that characterize an industry such as tourism.

Regions of Development: Territorial units established at national level as a result of an agreement between the county and local governments, given certain characteristics, officially established with purpose of developing and implementing strategies or development funds.

Rural Tourism: Is that form of tourism in which tourism services and activities take place in rural areas where there is prominent, the interdependence of the three basic elements still: nature, community, and traditional food.

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Rural Touristic Accommodation Capacity in Operation: Statistical indicator assessment offer accommodation, representing the number of seats offered by agro tourist boarding house in relation to the number of days of their operation in a predetermined period.

Sustainable Development: Conducting activities aimed at progress, but having regard to saving resources and protecting the natural environment so that future generations can dispose of them in their turn.

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Chapter 50
Sustainability Campaigns and Consumer Involvement:
Effects of Altruism, Locus of Control, and Long-Term Orientation

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ABSTRACT

The main aim of this chapter is to find out the effects of NGO campaigns on consumers in terms of attitude and behavior and discover any relationship between this effect and sustainable personality factors such as altruism, locus of control, and long-term orientation. A survey is conducted with 177 consumers who reside in Turkey for at least two years that are older than 18 years. Experimented with two popular environmental NGO campaigns, results reveal clearly that altruistic personality trait has a positive effect on consumers in terms of behavior. Locus of control and long-term orientation are not correlated with environmental behavior and attitude of consumers. In addition, only age is positively correlated with consumer behavior in one of the campaigns. Demographics are not found to be sufficient to explain consumer behavior in environmental campaigns.

INTRODUCTION

The importance of sustainability is relatively a new apprehension in developing economies (Mazlum, 2004). Awareness for sustainability problems are mostly created by the efforts of non-governmental organizations (NGOs). This article aims to find out how NGO sustainability campaigns affect behavioristic patterns of Turkish consumers. Most of the prior research reveals findings from developed countries. The current study is conducted in Turkey, a country of an important emerging market. Its rapid industrialization and concerted efforts towards modernization make it a significant context for observing the developments of sustainable consumption.

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While there are numerous examples to NGO initiatives for sustainability in Turkey, the effectiveness and cause effect relationships of these initiatives are not clearly comprehended. What are the reasons behind successful ones and unsuccessful ones? What are the best ways to increase consumer involvement in such initiatives? These are some of the many questions to be explored in order to understand consumer behavior and achieve more success in future developments.

The communication characteristics of a sustainability campaign that is derived by an NGO clearly play an important role in accomplishment of it. However, consumer behavior also play an important role to undertsand the underlying attributes of a successful campaign. This article aims to understand consumer personality and involvement in sustainability campaigns in terms of attitude and behavior. The correlation between personality factors of altruism, locus of control and long-term orientation and sustainability campaign attitude and behavior are investigated. The results of the research can give insight to create more successful campaigns in future.

BACKGROUND

Although the definition of sustainable development is discussed to be vague; it has different definitions in different contexts and changed over time since Brundtland Commission defined it in 1987 (Redclift, 2005). Established by the United Nations, Brundtland Comission united countries to define a map for the global environmental concerns. The comission released a report in 1987 which defined "sustainable development" and considered as the first definition of the sustainability concept. In his article, Redclift examines the development and evolution of sustainability concept from Brundtland Report's definition onward. Accoring to Redclift, by 2000s, sustainability concept refers to development of the world we live, by not only concerning the present time but also considering future generations. It has environmental, social and economic aspects which aim to achieve sustainability in all of them. Sustainable development involves governments, NGOs, corporations and consumers. In addition, since sustainable development is a broader subject which involves global problems, there is a need for managing sustainability globally.

The sustainable development concept has influenced the corporations with increasing Corporate Social Responsibility (CSR) engagements. Many business organizations are formed to support contributions of corporations to sustainable development (Smith, 2003). Some of the widespread organizations include World Business Council for Sustainable Development (WBCSD), International Business Leaders Forum (IBLF), Business for Social Responsibility (BSR) and Business in the Community (BITC). The CSR activities of firms have affected the consumers in terms of attitude and purchasing behavior in sustainability issues (Becker-Olsen et al., 2006).

Non-governmental organizations (NGOs) – another actor of sustainable development - play a significant role in political life and political changes in developing economies (Clarke, 1998). In his research, Clarke has analyzed NGOs and people organizations (Pos) in developing economies located mostly in Asia and Latin America. According to him, the recognition of NGOs and their involvement in socio-economic programs initiated after the recession in 1980. Many examples from India, Brazil, Bangladesh, Chile, Philippines, Malaysia and Thailand show that there is a correlation between political change and proliferation of NGOs and POs. The significant roles of NGOs are highly visible in promoting economic development and mobilizing broadly-based popular support for the governments. The democratization role of NGOs is ambiguous but yet it is significant that NGOs and POs strengthen civil society and the institutionalization between the society and the state. As much as for the developed world, the influential

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importance of NGOs cannot be underestimated in developing countries since their role in politics and economy is substantial.

Wade's study on developing countries' strategies states that although NGOs have little impact on social and political strategies; they are still effective in starting out initiatives (Wade, 2003). Another study about developing economies state that "bridging organizations" is very important in social and economic development and NGOs are one of the main bridges that function as intermediary mechanisms (Brown, 1991). Examples of such "bridges" are proven as initiators of CSR activities (Becker-Olsen et al., 2006) and multinational enterprise (MNE) – NGO collaborations (Dahan et al., 2010).

NGOs contributions in sustainable development cannot be underestimated since there are many success stories in literature that link sustainability solutions to NGO initiatives (Vivian, 2008; Korten, 1990). Korten suggests that the goal of sustainable development can be achieved with the promotion of NGO activities. However, Vivian's article claims that although there may be a link between NGO activities and sustainable development, such correlations have not yet proven to be right. Vivian also adds that there are not yet analyses about the correlation between NGO promotions and sustainable development in a broader level but only regional case studies exists. Therefore, it is very hard to make a general statement about the contribution of NGO promotions in sustainable development. Vivian's study also shows a case study in Zimbabwe where she analyses the effects of rural development NGOs in sustainable development. Her findings indicate that NGO promotions can become effective in finding solution to environmental problems but they are no "magic bullets" that solve everything in a first and only attempt.

The Case of Turkey

Turkey is considered as a developing economy as a Third World country. Like many developing economies, Turkey was involved with sustainability issues and developed awareness towards sustainable development later than western countries. Although some participants of the Brundtland Comission were from developing economies, Turkey was not one of them. However, the environmental problems and concerns have always been on the agenda of many institutions and organizations in Turkey.

In Turkey's history, it seems that Brundtland Report has affected Turkey's policies on sustainable development and environmental problems (Mazlum, 2004). There are no strategies for sustainable development in 1970s and 1980s but only adressed environmental problems by the government. After the release of Brundtland Report (1987) and the subsequent Rio Summit (1992) Turkish government realizes the need for combining economic and environmental protection priorities in development (Mazlum, 2004). Sustainable development is introduced in five year development plans (FYDP) first time in the 6th FYDP for years 1990-1994. However, even with the 9th FYDP for 2007-2013 years, the government fails to implement policies to achieve sustainability (Ministry of Development, 2012). Ministry of Development itself even criticizes the current state and reports the failures in internalizing and implementing applications that are coherent with the sustainability policies.

The formation of NGOs is also relatively a late attempt in Turkey. Except Turkish Red Crescent (Red Cross of Turkey) there were no NGOs in Turkey until mid 1960s. NGOs that work for development of education, social life and health start to generate from 1970s onward. However, the first NGO that works for environmental development is founded in 1990 as ÇEKÜL - Foundation for the Protection and Promotion of the Environment and Cultural Heritage. As of today, Turkey has six primary NGOs that work for the solution of environmental problems.

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Third Sector Foundation of Turkey (TÜSEV) has published a report about the NGO structure in Turkey in 2011 (TÜSEV, 2011). The report is based on an international index called CIVICUS Civil Society Index (Sivil Toplum Endeksi Projesi - STEP). According to the research, the number of NGOs in respect to population and total participation level of the society is relatively very low in Turkey when compared to other 52 countries in the index. Although the major participation (either financial or voluntary based participation) in NGOs is from the younger generation (younger than 25 years old) as 21%, it is still a very low level of participation in the international index. But, the difference is mostly caused by the lack of participation of this group in political issues. Women's participation is also very low in Turkey in all three categories of NGOs; social, political, and political activist. According to the findings of the research, the socio-economic level does not affect the participation levels in NGOs.

Environmental Consumer Behavior

Environmental issues and concerns are a vital part of sustainable development since the development of the world is highly affiliated with nature and environment. The environmental concern of consumers has attracted many researchers' attention. There are numerous studies which try to find the correlated measures for environmentally concerned behavior types. Although researchers try to correlate demographic characteristics with sustainable consumer behavior, it is very hard to define a pattern for behavior and demographics in all studies. A detailed empirical study on green consumer profiles debate inadequateness of demographics to explain green consumers (Diamantopoulos et al., 2003). Their analyses include more than 130 researches about demographics and environmentally concerned behavior types. The results indicate that demographics and attitude correlate in a way where as they do not reveal correlations with knowledge and behavior. In align with this article, a research on environmental attitude and behavior confirms no significant correlation with age, income level and education but indicates a significant difference in gender and home owners vs. renters (Mainieri et al., 1997). In addition, a research conducted in 1989 shows that environmental support, perception and behavior do not correlate with any demographic characteristics but rather correlate with political ideologies (Samdahl & Robertson, 1989). On the other hand, different behavior types and measures show dissimilar results in some researches. Another study on environmental consciousness and demographics indicates that although a significant pattern is hard to describe; age, income level and ethnicity are slightly correlated with consciousness (Krause, 1993). In another study, only age is found to be correlated with attitude towards environmental labels on products (D'Souza, Taghian, Lamb & Peretiatko, 2007). Research conducted in different cultures may also reveal dissimilar results. Contrary to many western researches mentioned above, a research conducted in Egypt indicates that men are more concerned than women in environmental issues (Mostafa, 2007). However, gender does not reveal any significant difference in environmental knowledge and attitude. Although it is very hard to define a global demographic pattern for environmental consumer behavior, demographics are still used for profiling cluster of consumer groups in terms of quality and price expectancies for environmental products (D'Souza, Taghian & Khosla, 2007).

Other than demographics, researchers have tried to find out correlations with other behavioral patterns to justify environmental consumer behavior. A recent case study for cloth diapers in Malaysia seeks to find a relation between environmental values and green purchase intention and attitude. The findings suggest that environmental consequences do not have a significant effect on attitude and purchase intention but, conservation has a positive effect on attitude (Ramayah, Lee & Mohamad, 2010). Another study

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has found out that locus of control and alienation have a significant effect on ecological concerns where as only race and income correlates among demographic characteristics (Schwepker & Cornwell, 1991).

The characteristics of environmentally concerned consumers have also been on the agenda of Turkey. Young generations are found to be even more sensitive about environmental issues (Erdoğan, 2009). Erdoğan's research among 1295 undergraduate students from four different universities in Turkey aims to measure the New Environmental Paradigm (NEP) scale which is constructed by Dunlap et al. in 2000. The results show that 56% of university students hold pro-NEP views; a high agreement to NEP's environmental statements. However, 25% of students hold pro-DSP views which states that they mostly disagree with the NEP statements. Although the disagreement level is also high, the author suggests that cultural and historical differences among populations cause different interpretations and misunderstandings of statements. Another research with a younger profile (6th, 7th, 8th & 10th grade students) in Turkey indicates that both gender and school type (private vs. public) affects the environmental attitude of students (Tuncer et al., 2005).

Furthermore, recent researches have conducted that Turkish consumers have a tendency to be more sensitive about environmental problems. A research among 1000 residents in Istanbul has been conducted to measure the environmental sensitivity of consumers (Bodur and Sarıgöllü, 2005). The findings of the research show that less educated and poor income consumers tend to have less sensitivity and concerns in environmental issues. However, the research shows that there is no difference in sensitivity to environmental problems regards to age and gender. Other than demographics, locus of control, a personality trait, was also measured and found out that active concerned consumers are to have internal locus of control where as passive concerned have external locus of control traits. However, strong effects of locus of control in environmental concern were not significant. On the other hand, the classification built by the authors indicate that there are more than active concerned (30%) and passive concerned (43%) than there are unconcerned (27%) consumers.

Locus of control is found to be explanatory in defining environmental consumer behavior in many researches which some of them are mentioned above. Locus of control is the belief in people whether they can control their lives (internal locus of control) or environmental factors control their lives which they cannot influence (external locus of control). LoC was developed by Rotter in 1954 and adapted to Turkish by Dağ in 1991 (Rotter, 1954; Dağ, 1991). People with external locus of control believe that they have none or less control on their lives and they cannot have an impact on the events surrounding them. External LoC people usually do not engage in environmentally concerned behavior since they think that they cannot have an impact on the consequences. Dağ's research in 1991 among 532 students revealed LoC mean value of 10.37 with 1-21 range. Females believed slightly more in external LoC rather than males.

Long-term orientation is another personality trait that may be used of explaining environmental consumer behavior. Long-term orientation is defined as "fostering virtues oriented towards future rewards" (Hofstede Centre, 2012). Long-term oriented people believe that context, time and situation matter in finding the truth. They can adapt traditions easily when conditions change. The opposite side, short-term oriented people are more conservative in traditions, want to achieve quick rewards as results of their actions and saving for future is not common among them. LTO was added to original Hofstede dimensions on culture in 1988 (Hofstede & Bond, 1988; Hofstede, 1991). Long-term oriented people's anticipation for the future rewards can make them behave more environmentally concerned in certain situations or as a reaction to NGO campaigns. Since it is relatively a more recent dimension, there are no widespread researches on long-term orientation of Turkish culture.

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Altruism may also be linked with environmental consciousness and behavior. Altruism is the opposite of selfishness and doing good to others without expecting any rewards. Rushton et al.'s "Self-Report Altruism Scale" is used to measure altruism personality trait (Rushton et al., 1981). The self-report altruism scale is found to be significantly and positively related with social responsibility (Rushton et al., 1981). As the altruism trait level increases, people's social responsibility increases. A study in Turkey found that as people tend to believe more in internal locus of control, their altruism and courtesy levels also increased (Basım & Şeşen, 2006).

In order to overcome the challenges in environmental problems for sustainable development, consumers' mindsets have to be changed. The changes in consumer behavior and attitude are the main research areas for many scholars. If the reason behind attitudes and behaviors are explained, then there is a chance for influencing other consumers as well to make them contribute to the environmental problems world faces today. The intermediary and bridging functions of NGOs in developing countries cannot be underestimated. Although NGO participations are low in Turkey, there has not been any research conducted to measure the participation levels in particular with *NGO campaigns*. This article aims to research the effects of particular NGO campaigns on consumer behavior with respect to personality traits in Turkey.

A CASE FROM TURKEY: CONSUMER INVOLVEMENT IN SUSTAINABILITY CAMPAIGNS

The Research

In 2013, a research has been conducted in Turkey to understand consumer behavior in terms of attitude, behavior and learning as a response to NGO campaigns in sustainability. Sustainability campaigns of NGOs which were active in years 2010-2012 in Turkey were selected as independent variables of the research. Personality traits of altruism, long-term orientation and locus of control were chosen to understand the relation between NGO campaigns and their effects on consumer behavior.

Hypotheses

H1: Since it is relatively a more recent dimension, there are no widespread researches on long-term orientation of Turkish culture. Long-term oriented people's anticipation for the future rewards can make them behave more environmentally concerned in certain situations or as a reaction to NGO campaigns. Therefore;

$H1_a$: Long-term oriented consumers will show more positive behavior towards the sustainable NGO campaigns in terms of attitude.

$H1_b$: Long-term oriented consumers will show more positive behavior towards the sustainable NGO campaigns in terms of behavior.

H2: The self-report altruism scale is found to be significantly and positively related with social responsibility (Rushton et al., 1981). If as the altruism trait level increases, people's social responsibility increases, altruistic people's behavior in response to environmental NGO campaigns should also be positively correlated. Therefore;

$H2_a$: Altruistic consumers will show more positive behavior towards the sustainable NGO campaigns in terms of attitude.

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$H2_b$: Altruistic consumers will show more positive behavior towards the sustainable NGO campaigns in terms of behavior.

H3: People with external locus of control believe that they have none or less control on their lives and they cannot have an impact on the events surrounding them. External LoC people would not engage in environmentally concerned behavior since they think that they cannot have an impact on the consequences. Therefore;

$H3_a$: Internal locus of control oriented consumers will show more positive behavior towards the sustainable NGO campaigns in terms of attitude.

$H3_b$: Internal locus of control oriented consumers will show more positive behavior towards the sustainable NGO campaigns in terms of behavior.

H4: Demographics are found to be insufficient to explain environmentally concerned behaviors of consumers (Diamantopoulos et al., 2003). But still, attitude of consumers are somehow correlated with education (Bodur & Sarıgöllü, 2005) and most researches find a difference in attitudes of gender types (Mainieri et al., 1997; Mostafa, 2007; Tuncer et al., 2005). Therefore;

$H4_a$: Demographics will have a correlation with attitude of consumers but not with behavior.

Method

An exploratory research is conducted to list all widespread NGO campaigns in Turkey. The results show that there were 24 campaigns that were initiated by NGOs and reached significant number of people in terms of their media activities in recent years. Among these campaigns 11 of them reflect environmental concerns, 6 of them social, 4 of them educational and 3 of them are campaigns for health issues.

In order to select the NGO campaigns that have already created awareness on society, an online pilot study was conducted with 89 respondents. All of the respondents were +18 years old and residents in Turkey for at least two years. (Appendix 1) The results showed that 72% remembered an educational campaign for female students in rural areas called "Baba Beni Okula Gönder" campaign. Second most remembered campaign was an environmental campaign for recycling plastic bottle caps with 66% recalling rate. The third one was Greenpeace's environmental campaign for avoiding consumption of small sized fish with 50% recalling rate.

The most recalled educational campaign was eliminated because it was not directly related with environmental concerns and did not have a direct effect on consumer behavior. Two environmental campaigns (Plastic Caps and Greenpeace's Fish campaigns) were selected to conduct further research.

An online study for measuring personality factors (i.e. locus of control, long-term orientation and altruism) and behavior towards campaigns was conducted with 177 respondents. Locus of control was measured with Rotter's scale which was adapted to Turkish by Dağ in 1991. Long-term orientation was measured with Hofstede's original LTO survey module developed in 1994. Altruism was measured with Rushton's Self-report Altruism Scale and translated to Turkish. It is structured with 20 questions on a five level Likert scale asking participants how often they have accomplished specific actions. (Appendix 2) Participants were asked to identify the two NGO campaigns that were selected and if they did not recall any of them, they were directed to the demographics questions. They were only asked questions about the campaigns which they were able to identify.

Participants' knowledge about the campaigns, their attitude towards the campaigns and behavioral outcomes were reported in a five level Likert scale.

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The link for the online survey was emailed to the participants and asked to share it with their contact lists. The survey was also shared on social media platforms.

Campaigns

Plastic Caps Campaign

Plastics caps campaign is a simple recycling campaign which people send the plastics bottle caps they collect to a certain address and caps are sold to recycling firms. The money established from these transactions is used for buying a wheelchair for the needy. The unusual characteristic about this environmental campaign is that it is not really an NGO campaign. It is an initiative started by a group of academicians in Ege University Dentistry Faculty in İzmir, Turkey. It has started in 2011 and with mass media's interest in the campaign; it became widespread in a very short time. Due to its organizational structure it may be called People's Organization (PO) but this initiative was never a sub-group of an NGO. Unfortunately the campaign ended in the beginning of 2013 due to problems with the logistics, recycling suppliers and Dean of the dentistry faculty. In two years time, the campaign collected 280 tonnes of plastic bottle caps and transported 2,039 wheelchairs to needy disabled people. With a rough calculation made, the campaign received 19,178 bottle caps per day in two years time. Plastic caps campaign is probably one of the most participated environmental campaign in Turkey.

Greenpeace Fish Campaign

The campaign has a catchy title in Turkish called "Seninki Kaç Santim?" meaning "How long is yours?" The campaign first started in social media in 2010. In a very short time Greenpeace collected 700,000 signatures and started applying to governmental units to ban fishing small sized fish. The intense interest in social media also drew mass media's attention to the campaign. By 2012, Greenpeace achieved great success by changing some laws on fishing. The secondary aim of the campaign was to create awareness among public. The awareness was surely achieved since 50% of the pilot study respondents recalled the campaign but this study will also measure if it has achieved learning on consumer behavior. Today, the campaign still continues with a less active approach.

Measures

Long-Term Orientation

Hofstede's LTO calculation is revised in 1999. The old calculation designed in 1994 contained 4 questions and the results could range from minimum -198 to maximum 302. The revised version of LTO contains 2 questions and the results can range from minimum -40 to maximum 120. Both versions of LTO is measured in this research and found out that old and new versions have a mean value of 54.3 and 66.2 respectively. However, the standard deviation values are high in both measurement and old and new versions have 77.3% and 33.1% CV respectively. Since the variance in the old LTO measurement is too high, new version is used in this research as LTO. The LTO value of 66.2 within -40 to 120 range can be considered as long-term oriented since the mid-value is 40. This is an indication that the sample is mostly expecting rewards in future, not conservative, and more flexible in many ways.

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Altruism

On a 0-80 scale, the mean value for the altruism is 34.75. Rushton's samples in US have a mean value between 52-57. The altruism level of the Turkish sample seems low when compared to samples in US. The least practiced actions are "helping for a stranger's car when it's broken", "doing volunteering work for a charity" and "giving a lift to a stranger." Most common actions that are performed more often are "offering the seat on a bus or a train to a stranger", "delaying an elevator and holding the door open for a stranger" and "giving directions to a stranger". The more convenient and easy to perform actions are the ones that are more often practiced by the participants. The least practiced actions are probably very hard for participants to perform since they all live in big cities.

Locus of Control

Rotter's locus of control scale contains 29 questions with each of them having two answer choices. Six of the questions are fake which constructs 0-23 range of possible scores. The mean value of the participants is 11.6. The higher the locus of control score the more external control belief arises where as the lower scores indicate internal control beliefs. Dağ's study on students has resulted in a mean value of 10.4 for locus of control (Dağ, 1991). This sample has slightly more belief in external control like luck, fate and uncontrollable events.

Sample

The population for the sampling is defined as the Turkish consumers who are older than 18 years old and reside in Turkey at least for the last two years by February 2013. Convenience sampling of 177 consumers are used for the research. The demographic characteristics of the sample are given below in Table 1.

The Results

Total of 89.2% of the participants stated that they were familiar about Plastic Caps Campaign. Their knowledge level about the campaign was asked in a 5 level Likert scale and the mean value is computed

Table 1. Demographic characteristics of the sample

Gender		**Net Income**		**Education**	
Female	66.3%	0 - 850,00 TL	6.3%	Elementary school	0.6%
Male	33.8%	851,00 - 1.500,00 TL	12.5%	High school	6.3%
		1.501,00 - 3.000,00 TL	25.0%	Undergraduate	55.6%
Age		3.001,00 - 4.500,00 TL	24.3%	Graduate	33.1%
21-30	42.8%	4.501,00 - 6.000,00 TL	13.8%	Phd or above	4.4%
31-40	42.1%	6.001,00 - 7.500,00 TL	6.2%		
41-50	6.3%	7.501,00 - 9.000,00 TL	5.6%		
50 +	8.8%	9.001,00 TL or more	6.3%		

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as 3.01. This means that majority of the campaign recognizants did not know any details about the campaign but also their knowledge was not insufficient. Attitude was measured with three questions that stated if they thought the campaign was right, if they liked the campaign and if they thought the campaign would be effective in finding a solution for the problem. The first and second attitude statements had mean values of 4.17 and 4.24 respectively which mean that majority liked the campaign and found the campaign reasonable. However, the third measure indicated a lower mean value (3.95) which indicated the campaign's ineffectiveness in finding a solution. The behavior was measured in four questions to understand whether they were trying to inform others about the campaign, collecting the bottle caps and sending them to the required address. Majority did not send the bottle caps by themselves but instead gave the caps to a collection point. The mean value of collecting bottle caps was high, 3.82, which indicated that the sample's involvement is also high. To measure further learning, when asked which recyclable products they were collecting, only 5% answered that they are not collecting any. 59% of the participants are collecting bottle caps. Glass, paper and battery are collected for recycling by 46%. Other plastics and food carton are collected by 32% and 28% respectively.

78.9% of the participants recalled the Greenpeace Fish Campaign and answered the questions related with the campaign. Their knowledge about the campaign has a mean score of 3.56 which means that majority of the participants agreed that they are informed about the campaign. Their attitude towards the campaign is higher than the plastic caps campaign but like the caps campaign, the least score in attitude is in believing the campaign will be effective in finding a solution for the problem. In both campaigns' attitude questions, this statement scores the lowest. This can be explained with the external locus of control tendency in the sample. As people will believe more in external control, they will not believe such campaigns can really be effective in finding solutions for the problems. The behavior measures of the campaign score lower than the attitude just like the plastic caps campaign. The least practiced behaviors are warning the fishmongers and restaurants that sold small sized fish according to the campaign. The involvement of the participants in consuming fish is also measured by asking them how often they eat fish. 46% stated that they consumed fish less than once in a week and 29% stated they consumed once in a week.

Although the attitude scores higher for the Greenpeace fish campaign, the environmental behavior is less likely to be practiced than the plastic caps campaign.

Pearson's correlation is conducted to understand the relations between the dependent and moderating variables. The results show that only altruism was correlated with consumer behavior when Greenpeace fish campaign was considered. The relation between altruism and consumer behavior towards the campaign is positively correlated meaning that the more altruistic people are the more they tend to participate in the environmental campaign. In addition, a positive correlation between attitude and behavior is significant. (Table 3)

Table 2. Descriptive statistics of the behavioral outcomes towards NGO campaigns

	Plastic Caps		**Greenpeace**	
	Attitude	**Behavior**	**Attitude**	**Behavior**
μ	4.12	3.35	4.29	3.07
σ	0.88	1.02	0.61	1.06
CV	21%	30%	14%	35%

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Table 3. Correlations between personality traits and consumer behavior in Greenpeace fish campaign

		LoC	Altruism	LTO	Fish Attitude	Fish Behavior
LoC	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	177				
Altruism	Pearson Correlation	.153*	1			
	Sig. (2-tailed)	.043				
	N	177	177			
LTO	Pearson Correlation	.095	.021	1		
	Sig. (2-tailed)	.206	.782			
	N	177	177	177		
Fish attitude	Pearson Correlation	-.051	-.009	-.053	1	
	Sig. (2-tailed)	.558	.914	.540		
	N	135	135	135	135	
Fish behavior	Pearson Correlation	-.091	**.258****	-.098	**.407****	1
	Sig. (2-tailed)	.292	**.003**	.256	**.000**	
	N	135	**135**	135	**135**	135

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The only significant correlation between the personality traits and consumer behavior is seen between altruism and plastic caps campaign behavior. There is a positive correlation between those which indicates that more altruistic people tend to collect and send caps and inform others more about the campaign. Less significant correlations are seen between locus of control and attitude and behavior. However, these correlations are also positive therefore they suggest that external control believers tend to show more positive attitude and behavior towards the campaign. This does not make sense since external control believers would think that their actions would not change anything or they would have no impact on environmental problems. The significant positive correlation between attitude and behavior is also seen here. (Table 4)

Only significant correlation between demographics and consumer behavior in NGO campaigns is a positive correlation between fish behavior and age (Correlation 0.280 significant at 0.01 level). Older people have a tendency to participate for the Greenpeace fish campaign. In order to explain this relation, the correlation between involvement level and age is analysed. If older people were eating fish more often than younger adults then this correlation would have been justified. However, the frequence for eating fish and age levels do not correlate. The Pearson analysis and One-way Anova tests show that there is no significant difference in age levels and fish eating habits. This means that older adults were more motivated to change their consumer behavior for the Greenpeace fish campaign.

Only one of the hypotheses was proved. Altruism was correlated with behavior for both campaigns. However, altruism was not correlated with consumer attitude towards environmental campaigns. Therefore we can only accept $H2_b$. Among the other personality traits, long-term orientation had no relation with consumer behavior on NGO campaigns ($H1_a$ and $H1_b$ rejected). Locus of control was only correlated

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Table 4. Correlations between personality traits and consumer behavior in plastic caps campaign

		LoC	Altruism	LTO	Cap attitude	Cap Behavior
LoC	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	177				
Altruism	Pearson Correlation	.153*	1			
	Sig. (2-tailed)	.043				
	N	177	177			
LTO	Pearson Correlation	.095	.021	1		
	Sig. (2-tailed)	.206	.782			
	N	177	177	177		
Cap_attitude	Pearson Correlation	.167*	.038	.112	1	
	Sig. (2-tailed)	.047	.653	.186		
	N	142	142	142	142	
Cap_behavior	Pearson Correlation	.166*	**.306****	-.013	**.529****	1
	Sig. (2-tailed)	.048	**.000**	.873	**.000**	
	N	142	**142**	142	**142**	142

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

with consumers in terms of behavior and attitude in plastic caps campaign. More research is needed to conclude about locus of control ($H3_a$ and $H3_b$) since it was not correlated at all in the other campaign. In addition, the positive attitude in correlation is suspicious since the higher scales in locus of control means people believe more in external factors than themselves as a mean to control their lives and the environment. Demographics also did not play a significant role in explaining consumer behavior. Only age was correlated with the Greenpeace fish campaign behavior. However, $H4_a$ suggested that it would be correlated with attitude but none of the demographics characteristics were correlated with attitude. Therefore we have to reject $H4_a$ too.

In addition, correlations in plastics caps campaign are more significant than in Greenpeace fish campaign. This may be due to the fact that more participants acknowledged the plastic caps campaign and therefore more data was collected in plastic caps campaign.

The limited sample size is the main obstacle of the study. Since the questionnaire was too long, many participants failed to complete it successfully. Limited number of responses led to variance problems in many of the collected data. The data was only collected online via internet which means that the sample consisted only of consumers who have access to internet.

SOLUTIONS AND RECOMMENDATIONS

In order for NGOs to achieve "bridging" function in sustainability they need to accomplish good communication with the community. This research shows the tendency to alter consumer behavior for sustainability campaigns among altruistic consumers. In order for sustainability campaigns to reach broader range of consumers the communication created may target more altruistic consumer profiles.

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If the campaigns succeed in reaching more altruistic consumers they will most probably reach more success in altering consumer behavior to participate in the campaign.

Both campaigns indicated that they were widely recognized by the consumers. However, the positive attitude in both campaigns was low when it was asked if they believed the campaign was going to be an effective solution for the problem. Although the consumers "recognized" and "liked" the campaigns, they did not fully believe that these campaigns would be a solution for the problems they were linked with. This is a major problem for NGOs to "bridge" consumers with the sustainability problems. If the consumers do not believe in the effectiveness of the campaign it will be very hard to change their mindsets and behavior for the campaign. In order to overcome this problem, any campaign should follow transparent policies and reveal all the steps taken and results achieved during the campaign. Indeed, they may need to give as much importance to communication of the campaign results as they give to the actual campaign itself.

On the other hand, the research findings indicate that NGOs does not have to put in time and effort to segment and differentiate targeted consumers according to demographical characteristics. There are no such correlations between demographics and consumer attitude and behavior in sustainability campaigns. Although this may change due to the problem the campaign is involved with or due to the environmental transformations; many previous researches have also shown the insignificance of demographics in sustainability.

FUTURE RESEARCH DIRECTIONS

The differences between the behaviors towards the two campaigns were also seen. Further research might include why consumers are responding differently to two environmental NGO campaigns. The attitude towards the fish campaign was higher than the plastic caps campaign but the behavior was not as positive as the plastic caps campaign. This may be due to the convenience and easiness of the plastic caps campaign. The learning and applying might be easier for the consumers where on the other one they had to learn sizes of the many fish which they need to be careful about. The characteristics of campaigns which affect the consumer behavior might be an interesting study to understand the reasons behind success of environmental NGO campaigns.

The growing concern for sustainability problems creates an obligation to understand consumer behavior to overcome related problems. The correlation between altruistic personality and sustainable consumer behavior leads to new research areas where altruistic behavior patterns and other correlated activities consumers tend to seek can be explored. Altruistic consumers can become the main target for many other sustainability campaigns where NGOs might need to differentiate themselves accordingly. On the contrary, there are challenges to overcome in order to attract attention of less altruistic personality types. While these two environmental campaigns in Turkey have drawn attention of altruistic consumers, ways to attract other consumers should also be researched and comprehended.

CONCLUSION

The outcomes of human civilization make sustainability policies more reasonable and acceptable each day. The universalization of sustainability policies is inevitable if one wants to see a good future ahead.

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Even though governments have started to take solid steps to implement these policies to laws and regulations, there are still many steps to be taken in everyday lives of people.

Laws and regulations mostly target industries and businesses to decrease their undesirable effects on environment. In addition, most governments that work with sustainability policies try to raise awareness among public. NGOs are also additional constitutions that function to raise awareness on public and change consumer behavior. Though the consciousness level is increasing in most societies, there should be ways to reach more people by using effective communication.

There are two important results of this research on Turkish consumers. First, personality and the lack of belief among consumers in effectiveness of sustainability campaigns serve as important variables that enhances the tendency in sustainable behavior. While altruistic people are more easily attracted by sustainability campaigns and issues, there is always a challenge for initiatives to attract other personality types. In addition, any initiative that runs a sustainability campaign has to implement a transparent policy in order to demonstrate the results of the campaign and the effect people can have on the environment.

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KEY TERMS AND DEFINITIONS

Altruism: Doing good to others without expecting any rewards, opposite of selfishness.
External Locus of Control: Belief in people that external factors are mostly in control of their lives.
Internal Locus of Control: Belief in people that they are mostly in control of their lives.

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Long-Term Orientation: Tendency to anticipate future rewards for one's actions and behavior.

Non-Governmental Organizations (NGOs): Non-profit organizations which are not established by the government.

Sustainability: Sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture.

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Section 5

Organizational and Social Implications

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Chapter 51
Promoting Healthy Lifestyle for Sustainable Development

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ABSTRACT

Economic growth, environment, and health are three significant aspects of sustainable development. Nowadays, lifestyle is increasingly evaluated as one of the most important factors influencing health. As increasing health expenditure is an important problem for sustainable development, it is essential to examine the society in terms of their health-related habits and promote healthy lifestyle to support sustainable development. In this chapter, healthy lifestyle of highly educated Istanbulites is researched. The respondents are classified into three distinct clusters according to their healthy lifestyles as "young and single individuals with low healthy lifestyle tendency." "young and middle-aged individuals consuming natural food," and "elderly, married adults leading healthy lifestyles." Afterwards, analyzing the data by ANOVA and post-hoc tests, it is found that respondents in different clusters have significantly different green consumer values and health motivations. Finally, theoretical and managerial discussions are provided and some recommendations are made for academicians and practitioners.

INTRODUCTION

1970s social marketing and green marketing schools strengthened the relation between marketing and natural environment. As the concept of sustainability became widespread, the number of consumers preferring products that won't harm the environment and their health, increased to a great extent. These consumers are sensitive about their health as well as the health of their environment. LOHAS (Lifestyle of Health and Sustainability), which is one of the latest approaches about lifestyle, brings a consumer segment who care about consumer health, environment, social justice and sustainable living (Cohen, 2010). Thus, it is impossible to take the concept of sustainability regardless from healthy lifestyle.

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As the main focus of this study is the issue of attaining sustainable development through promoting healthy lifestyle, it is important to define the consumers in terms of their health related habits. As healthy lifestyle of groups are different from each other, there is no single public health, health education and marketing approach that will be effective on all (Gould, 1988). Therefore, marketing strategies should be designed in accordance with the characteristics of the target group.

In this study, where consumers' healthy lifestyle is evaluated in connection with health motivation and green consumer values, 377 highly educated İstanbulites are examined and they are clustered into three groups according to their healthy lifestyles. The result of variance analysis and post hoc tests indicated significant differences between the level of green consumer values and health motivation of the respondents belonging to different clusters. Depending on these findings, some suggestions are made to practitioners and academicians. It is believed that, focusing on healthy lifestyle within the framework of sustainability is not a common approach and thus will add value to the literature and guide government institutions, non-profit organizations and companies who develop policies on this issue.

BACKGROUND

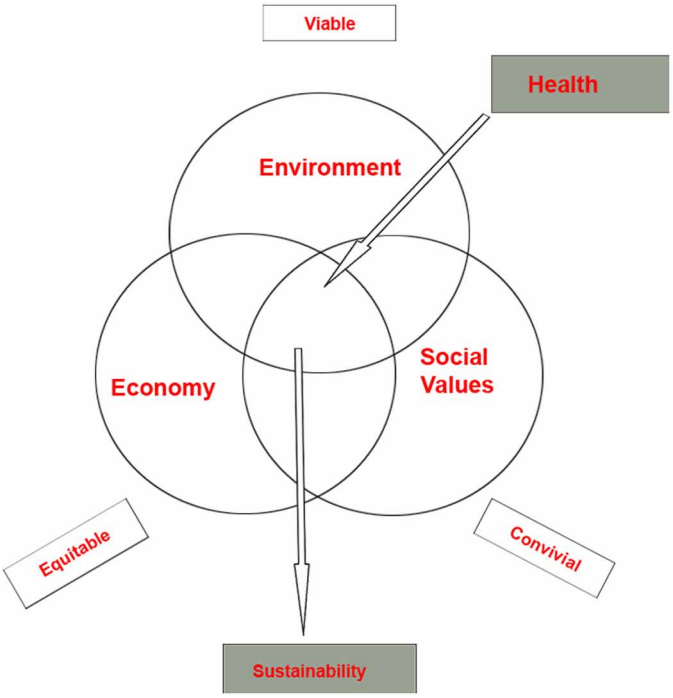
Sustainable Development

The term "sustainable development" has become an important topic for governments, institutions and individuals with the Bruntland Commission Report (Our Common Future) in 1987. *"Development is the process of improving the quality of human life"* (Our planet, our health, 1992). Sustainable development is defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Bruntland Commission, 1987). This definition is focused on human needs and the way to meet them both today and in the future. Later in 1991, the World Wide Fund for Nature, the International Union for Conservation of Nature (IUCN), and UNEP defined sustainable development from an environmental perspective as "*improving the quality of human life within the carrying capacity of supporting ecosystems*" (UNEP, 2011). Pronk and ul Hak (1992) underlines economic growth, justice and environment with their following definition: "*economic growth that provides fairness and opportunity for all the world's people, not just the privileged few, without further destroying the world's finite natural resources and carrying capacity*". These definitions show that sustainable development means much more than economic growth. Many developing countries may perform positive economic growth rates in short term, however the citizens of these countries may live in poor environmental and social conditions, or have difficulty to reach health and education services equally. So, it is obvious that economic growth alone doesn't bring sustainable development.

The concept of sustainable development is the result of the growing awareness of the global links between mounting environmental problems, socio-economic issues to do with poverty and inequality and concerns about a healthy future for humanity. Environmental problems threaten people's health, livelihoods and lives and can cause wars and threaten future generations. It crucially embraces the key issues for humanity of how to ensure lives worth living and our relation with the planet and our relations with each other (Hopwood et al., 2005).

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Figure 1. A conceptual model of sustainable development
Source: Sustainable development and health: concepts, principles and framework for action for European cities and towns (1997). European Sustainable Development and Health Series, No 1. Charles Price, Editor. Published by the WHO Regional Office for Europe, Copenhagen.



When the literature concerning sustainable development is reviewed, many articles and reports can be found. The common approach in many of them is that the term sustainable development has three main aspects. These are environmental, economic and social aspects (Figure 1) which are often considered separately, however they interact and influence each other

Health and Sustainable Development

Maybe the most important aspect in sustainable development concept is the "human capital". This perspective enables governments to invest in human capital and exploit its performance to maximum capacity. One of the ways to invest in human capital is to promote the health status (Çelik, 2011). WHO (1946) defines health as: "*..a state of complete physical, mental and social wellbeing and not merely the absence of disease and infirmity*" and positions it as one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition (IUCN, U. 1991). The global strategy for health development advocated by the WHO also implies that improving health requires action in three main areas: lifestyles, environment and the health care sector" (World Bank, 1993). The Rio Declaration's first principle also affirms that human beings are entitled to a healthy life (Health and Environment in Sustainable Development: Five Years after the Earth Summit, 1997).

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Health is also an important stimulus to other aspects of development. Healthy people are economically more productive, which increases the economic growth rate of countries; investing in health is thus one means of accelerating development (World Bank, 1993).

On the other side, increasing health expenditures has become a serious burden on economies. Health economics is the new sub-discipline of economy going back to 1960's which is a tool to find solution to increasing health expenditures and to use resources efficiently under changing demographics and patient expectations. The main factors influencing health status are socio-demographic, economic, cultural and behavioral factors, education, genetics, health services, lifestyles and environmental factors. So, promoting healthy lifestyle is closely related with health economics and sustainable development.

Healthy Lifestyle

Healthy lifestyle, as an important determinant of health status, is a factor effecting the consumers' choices as well as their activities, interests and opinions about health and healthy living. Pender (1982) defined healthy lifestyle as "*an expression of the human actualizing tendency which is directed towards sustaining or increasing the individual's level of well-being, self-actualization and personal fulfillment",* whereas Myers et.al. (2000) defined the concept as *"a way of life, oriented toward optimal health and well-being in which body, mind and spirit are integrated by the individual to live more fully within the human and natural community."* As stated in this definition, taking environmental factors as an important determinant is quite common in the literature as it is impossible to reach optimal health in an unhealthy environment. The main problem here is that, environmental factors are more difficult and sometimes more costly to intervene and control.

The Interheart study, which covered 30.000 men and women in 52 countries showed that, factors such as smoking, cholesterol level, high blood temperature, diabetes, obesity, diet, level of physical activity, alcohol consumption, emotional stress and depression are related to various lifestyle factors (Yusuf et.al, 2004). According to the estimations of World Health Organization, 70-80% of deaths in developed countries and 40-50% of deaths in less developed countries result from lifestyle related diseases (Pirinççi et. al., 2008). There are many studies showing the effect of lifestyle choices on health and long life. Such findings underline the fact that, many diseases can be prevented just by changing the lifestyle. In many countries around the world, increasing average life and health expenditure are forcing the governments toward policies to improve peoples' health and to change their lifestyles.

Promoting Healthy Lifestyle

In the US, from the beginning of 1970's, continuous efforts have been made to determine how permanent changes could be made in personal habits and lifestyles of people. In 2007, World Health Organization highlighted the importance of health promotion which includes steps like, promoting healthy lifestyle, creating suitable environments, restructuring health services and building a government health policy (Pınar et. al., 2009).

Parallel to these developments, government organizations, non-profit organizations and health educators started to use marketing techniques to make people adopt a healthy lifestyle. Nowadays, government and nonprofit organizations are regularly running social marketing campaigns on various health issues such as nutrition, physical exercise, obesity, smoking and alcohol consumption. It is essential to educate people and create awareness about health issues in order to motivate them to change their lifestyles. Kickbush

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and Payne (2003) support this view by stating that, knowledge is the main factor to stimulate the healthy lifestyle movement and in modern societies, the number of knowledgeable people are rapidly increasing.

Consumers can get basic health information from different personal, commercial, non-commercial, institutional and media channels. Media channels are printed media, electronic media and social media. Health practitioners and other health professionals provide more formal and basic health information. Kraft and Goodell (1993) stated that mass media campaigns by the government and local authorities significantly increased the awareness about the role of healthy lifestyle on preventing diseases. The most important lifestyle changes coming along with basic health information are; eating habits, regular health controls, reading the labels on packages, joining a health or healthy lifestyle club. Some other lifestyle changes coming with health information are; change in social life, sleeping habits, regular exercise and joining health exhibitions and seminars (Cangelosi et.al, 2009).

Although promoting healthy lifestyle is an important agenda, there are several obstacles to overcome. First of all, in social marketing, there is a competition between the desired and the alternative behavior (Grier and Bryant, 2005). For example, when healthy eating behavior is the case, competing behaviors are eating unhealthy food and snacks which are strongly supported by commercial advertising. Although healthy life has positive associations, some people think that it is not enjoyable and health educators are forcing people to do things which they don't want (Veenhoven, 2008). One of the most important difficulties in changing health related behaviors is the difficulty of changing habits and going out of the comfort zone.

Health Motivation

The concept of health motivation is; the consumers' being stimulated to adopt preventive health behavior (MacInnis et.al. 1991; Park and Mittal 1985), their desire to take a step and their interest in health behavior (Moorman and Matulich, 1993). The determinants of motivation include variables such as control of health behavior, self-discipline, social support and approval, value set, income, education, work status, self-respect, attractiveness and health status (Carter and Kulbok, 2002). Health motivation, which is an important determinant of health behavior plays an important role in organizing beliefs about health and various beliefs which interact with each other (Gochman, 1971). In this context, three mostly mentioned beliefs are; perceived sensitivity, perceived seriousness and perceived benefit. Perceived sensitivity is the probability to face health problems, perceived seriousness is the belief about the level of negative effects that may result from these health problems and perceived benefit is the expectation about the positive outcome of certain behaviors. High level of interaction between these three beliefs is considered to increase the possibility of adopting health behavior (Gochman, 1972). There are also findings showing that health motivation increases getting health information from the media, interaction with health professionals and the rate of going on a diet (Moorman and Matulich, 1993).

Green Consumer Values

Values, a dimension of culture, are considered to effect the consumer behavior. According to Schwartz (1994), values are guiding principles that lead individuals and social identities throughout their life. On the other hand, green consumer is the type of consumer, who tends to take into account the environmental effects of their consumption behaviors. Thus, consumers with stronger green values are inclined to make decisions consistent with sustainability (Bearden et.al., 2011). In the literature, there are also findings

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showing that people valuing ecological issues and taking risks for self-actualization with an entrepreneurial approach behave in a more ecological way (Fraj and Martinez, 2006). It is also emphasized that, people who adopt healthy lifestyles are sensitive about environmental factors as well as nutrition, physical condition and stress management (Kraft and Goodell, 1993). "For years, men have focused on economic progress to increase the level of development in their countries, but they failed to realize environmental degradation" (IMKB, 2011). However, economic sustainability depends on ecologic and social sustainability, because without a planet, there will be no economy (Charter et.al., 2002).

MAIN FOCUS OF THE ARTICLE

Issues, Controversies, Problems

It is important for marketers to explore consumers' lifestyles, values and motivations in order to determine the appropriate marketing approach to persuade the target group for adopting a healthy lifestyle. So, understanding the healthy lifestyle, green consumer values and health motivations of the consumers will enable governments and other institutions to design their health related social marketing campaigns effectively.

The objective of this study is to classify the highly educated Istanbulites according to their healthy lifestyle and to understand their characteristics regarding green values and health motivation. So the present study tests the following hypothesis:

H1: According to their healthy lifestyles, respondents will be classified in different clusters.
H2: There will be statistically significant differences between the green consumer values of the consumers in different clusters.
H3: There will be statistically significant differences between the health motivations of the consumers in different clusters,

In this study, healthy lifestyle was measured by a 13-item scale. Eleven questions of the scale were used by Gil et.al (2000) and afterwards by Chen (2011). After receiving expert opinions two additional questions were added by the authors. Health motivation was measured by the 8-item scale used by Moorman ve Matulich (1993) in their study exploring the factors effecting preventive health behavior and green consumer values are measured by a 6-item scale developed by Haws et.al (2013). For these three variables, respondents answered items using a 5-point scale. The demographic characteristics of the respondents were measured by a nominal scale.

Before collecting the data, an online pre-test was held and some wording in the survey was simplified according to the feedbacks received. As the main objective was to cover Istanbulites holding bachelor and postgraduate degree, a convenience sampling was conducted and 415 surveys were collected. From 415 surveys, 28 were eliminated due to missing answers, 10 surveys were removed due to outliers. Finally, analysis were held with 377 drop-off surveys. The collected data was analyzed with the following sequence: factor analysis, reliability tests, cluster analysis and ANOVA tests. First, factor analysis was conducted for healthy lifestyle, green values and health motivation variables. Afterwards, the reliability of the factors were evaluated by Cranach's Alpha coefficient and mean inter-item correlation values. In order to explore the ideal number of clusters, first, a hierarchical cluster analysis was conducted using

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Ward's method, afterwards k-means clustering and lastly, ANOVA test was conducted to understand whether different clusters vary in health motivation and green values.

Socio-Demographics

The sample consists of high-income and well-educated profile. 66.5% of the respondents were female. Of the respondents, 52.2% were married, 70% have bachelor degrees, and 30% have graduate degrees. In terms of age distribution, 17.9% were between 18-25, 25.4% were between 26-35, 40.4% were between 36-49 and 16.35% were over 50 years old. Of them, 13.8% had monthly income between 4.000-5.000TL, 13.8% between 5.000-7.000TL, 16.9% between 7.000-10.000TL and 14.4% had monthly income over 10.000TL.

Factor Analysis

As result of the factor analysis of healthy lifestyle variable, items were grouped in four factors with Eigenvalues more than 1 and explaining 63.16% of the variance (KMO=0,769; Bartlett's p<0,005). Due to low reliability, one factor is eliminated and the remaining three factors account for 53.8% of the variance. The reliability of the factors were measured by Cronbach's Alpha coefficient and Mean-inter-item correlation. Two factors with Alpha values over 0.6 and one factor with mean inter-item correlation value between 0.2 and 0.4 were accepted as reliable (Taylor et.al., 2003). The first factor was entitled as *balanced life* (Alpha=0.75), the second as *natural food consumption* (Alpha=0.7) and the third one as *avoidance from unhealthy food* (Alpha=0.62 and mean-inter-item correlation between 0.2 and 0.4). In Gil et.al.'s (2000) study carried out in Spain, the questions concerning exercise and taking responsibility about health were grouped under the factor "health care". However, in this study these questions were not grouped under a factor. As result of the factor analysis of health motivation variable, items were grouped in two factors with Eigenvalues more than 1 and explaining 66.5% of the variance (KMO=0,724; Bartlett's p<0,005). The first factor which expresses preventive behavior towards health problems, was entitled as *proactive health motivation* (Alpha=0.71), the second factor that points out the steps after a health problem occurs, as *reactive health motivation* (Alpha=0.77). Lastly, the green consumer values variable (Alpha=0.88) was not grouped under factors.

Cluster Analysis

Cluster analysis is an analytical technique used to create significant sub-groups from individuals and objects (Gegez, 2007). In this study, two different clustering technique was used to classify the respondents according to healthy lifestyle. Firstly, hierarchical cluster analysis was conducted using Ward's method to explore the ideal number of clusters. The results of the hierarchical cluster analysis showed that solutions with two, three and four clusters were appropriate for the study. Afterwards, k-means clustering was conducted using three of the cluster alternatives. Due to the difficulty to interpret four clusters and the lack of explanatoriness for two cluster alternative, three-cluster solution was found appropriate. ANOVA results and the mean scores that will help to describe and entitle each cluster are shown in Table 1. According to ANOVA results in Table 1, three healthy lifestyle factors significantly clustered the respondents in three different clusters ($p<0.05$). So, H1 is confirmed.

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Table 1. Healthy lifestyle mean scores for clusters

Healthy Lifestyle	Cluster 1 (n=92)	Cluster 2 (n=86)	Cluster 3 (n=199)	F ratio	Sig.
Balanced life	*3.31*	3.81	*4.08*	46.3	0.000
Natural food consumption	*2.59*	*4.15*	4.12	243.3	0.000
Avoidance from unhealthy food	*3.08*	3.03	*4.28*	238.9	0.000

It is found that the highest healthy lifestyle scores belongs to Cluster 3. Cluster 2's scores are lower that Cluster 3 except natural food consumption and higher than Cluster 1 except avoidance from unhealthy food.

Cluster 1's all mean scores are lower than Cluster 3 and also lower than Cluster 2 except avoidance from unhealthy food. In Table 2, the cluster profiles can be seen in terms of their socio-demographic characteristics. There are significant differences between the clusters in terms of age and marital status variables. Gender, education and income variables were not significantly different. It is considered that education and income variables are not distinctive since the structure of the sample is homogeneous. After analyzing three clusters in terms of healthy lifestyle and socio-demographics, the clusters are

Table 2. Socio-Demographics of the clusters

	Cluster 1 (n=92)	Cluster 2 (n=86)	Cluster 3 (n=199)	X^2 (sig.)
Age				31.660 (0.000)
18-25	*33%*	*18%*	*11%*	
26-35	*33%*	*25%*	*22%*	
36-49	*25%*	*39%*	*48%*	
50 and over	*9%*	*18%*	*19%*	
Gender				6.922 (0.140)
Female	64%	60%	71%	
Male	36%	40%	29%	
Marital Status				10.457 (0.033)
Married	*41%*	*51%*	*58%*	
Single	*59%*	*49%*	*42%*	
Education				2.610 (0.271)
Bachelor	76%	71%	67%	
Graduate	24%	29%	33%	
Monthly Income				18.070 (0.320)
2.000 TL and less	14%	8%	7%	
2.001TL-4.000TL	30%	33%	33%	
4.001TL-7.000TL	29%	34%	23%	
7.001TL and more	26%	23%	37%	

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named as "young and single individuals with low healthy lifestyle tendency", "young and middle-aged individuals consuming natural food" and "elderly, married adults leading healthy lifestyle" and each constituted 24%, 23% and 52% of the respondents respectively.

Cluster 1 (young and single individuals with low healthy lifestyle tendency): Cluster 1 which consists of 92 people, is the youngest group, with the highest single rate and the lowest healthy lifestyle score. 66% of the respondents are in 18-35 age group and 59% are single. Of this cluster, 76% have bachelor degree and 24% have graduate degree. 55% of the members have monthly income of 4.000TL and more. The highest healthy lifestyle dimension of Cluster 1 is with 3.31 mean score, balanced life. Natural food consumption dimension is, with 2.59 mean score, the lowest. Avoidance from unhealthy food dimension is, with 3.08 mean score, higher than Cluster 2 and lower than Cluster 3

Cluster 2 (young and middle-aged individuals consuming natural food): Cluster 2 consists of 86 people. 64% of the respondents are in 26-39 age group and 51% is married. Of this cluster, 71% have bachelor degree and 29% have graduate degree. 57% of the members have monthly income of 4.000TL and more. The highest healthy lifestyle dimension of Cluster 2 is with 4.15 mean score, natural food consumption. Avoidance from unhealthy food dimension is, with 3.03 mean score, the lowest. Balanced life dimension of Cluster 2, with 3.81 mean score, is higher than Cluster 1 and lower than Cluster 3.

Cluster 3 (elderly, married adults leading healthy lifestyles): Cluster 3 which consists of 199 people, is the elderly group with the highest healthy lifestyle mean scores. 67% of the respondents are over 36 years old and 58% are married. Of this cluster, 33% have graduate degree. 60% of the members have monthly income of 4.000TL and more. The highest healthy lifestyle dimension of Cluster 3 is with 4.28 mean score, avoidance from unhealthy food. Subsequently, balanced life follows it with 4.08 mean score. In both dimensions, Cluster 3 has the highest scores among the three clusters. Natural food consumption dimension is, with 4.12 mean score, higher than Cluster 1 and lower than Cluster 2.

ANOVA Test

In order to explore the significant differences between the clusters in terms of green values and health motivation, ANOVA and post-hoc tests are conducted. It is found that there are significant differences between the cluster means (F2;372) =14,586, p<0,05. Post-hoc Scheffe test shows that members of Cluster 3 have the highest green consumer values mean (M=4.21), whereas members of Cluster 1 have the lowest (M=3.79). So, H_2 is confirmed. The elderly group with the highest married rate has the highest green consumer values mean. This finding reminds Bodur and Sarıgöllü's (2005) research about Turkish consumers' attitudes and behaviors towards the environment. In their research, it was found that a number of older respondents were highly concerned about the environment mostly because they worry about the future of their grandchildren. Also, in their research held with 1.000 respondents, three distinct segments were found: active concerned, passive concerned and unconcerned. The active concerned were better educated and more affluent.

Also, significant differences are found between the different clusters' respondents' answers to proactive health motivation questions (F2;373)=18,543, p<0,05. Post-hoc Scheffe test shows that members of Cluster 3 have the highest proactive health motivation mean (M=3.78), whereas members of Cluster 1 have the lowest (M=3.19). There are also significant differences in terms of reactive health motivation means of the clusters (F2;373)=12,679 p<0,05. Post-hoc Scheffe test shows that members of Cluster 1 have the highest reactive health motivation mean (M=3.04), whereas members of Cluster 3 have the lowest (M=2.53). So, H_3 is confirmed.

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SOLUTIONS AND RECOMMENDATIONS

According to Bozkurt's (2014) study, holistic healthy lifestyle scores of Turkish people need to be developed. In this study, spiritual wellbeing score of the respondents were found to be the highest which was believed to result from the cultural characteristics of the country. Nutrition and avoiding from unhealthy food is in the middle while exercise scores are low. The holistic healthy lifestyle scores are below the desired level in many studies in the literature. It is difficult to adopt a healthy lifestyle because of habits, low awareness, time pressure, economic difficulties, consumption behaviors and negative environmental factors. However, it is important to promote healthy lifestyle in order to enhance well-being of the society and contribute to sustainable development. As stated in the beginning of this study, it is essential to define the consumers in details in order to use social marketing and supporting tools in the most effective way to promote healthy lifestyle. To promote healthy lifestyle for each segment defined in this study, some recommendations are made below.

Young and single individuals with low healthy lifestyle tendency score low in natural food consumption and avoidance from unhealthy food. This finding recalls Ergen's (2014) research, clustering Turkish consumers according to their sustainable consumption behavior. Ergen found that the youngest group consisting of students and single individuals show the lowest sustainable consumption behavior and their behaviors are not influenced by environmental knowledge. In order to persuade this group to change their habits and adopt a healthy lifestyle, marketers are advised to inform this segment about health related issues and increase their awareness. It is also found that green consumer behaviors of this segment is low while proactive health motivation is high which means they have a tendency to solve health problems when they face them. From health economics point of view, low proactive and high reactive health motivation can affect the efficiency of the labor force negatively. For a country like Turkey, which has a young population with an average age of 30.4, young people with proactive health motivation is extremely important for sustainable development. As this segment mainly includes members of generation Y, marketers are advised to take into account the characteristics of this generation while designing the marketing mix. Using entertaining messages, promoting healthy lifestyle as an increasing trend, using role models popular among this segment and effective use of social media are thought to be essential while communicating with this group. As they score low in proactive health motivation, messages to convince them take responsibility about their own health and use preventive health services are thought to be essential for marketers to communicate.

Young and middle aged individuals consuming natural food: There is an interesting contradiction about nutrition habits of this segment. Although their natural food consumption is high, their avoidance from unhealthy food is low which brings to mind that both nutritional and hedonic dimensions of nutrition are important for this group. Thus, strict messages about nutrition may not be respected within this segment and this point should be taken into account while designing the marketing messages. However this segment should still be informed about the negative effects of unhealthy food. As balanced life score is above average, messages that will stimulate this segment to take part in stress management training, leisure time activities and personal development courses are thought to be effective on them. With a high score for proactive health motivation, this segment is thought to have health insurance. So, combining the insurance packages with healthy lifestyle programs can be useful in promoting healthy lifestyle to this segment. Also focusing on green values in communication may be effective on this group.

Elderly married adults leading healthy lifestyles: Members of this segment have high scores in all dimensions of healthy lifestyle, avoiding unhealthy food being the highest. In most of the studies in the

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literature, married people score higher than singles in healthy lifestyle. In Bozkurt's (2014) study examining healthy lifestyle, the results were similar with an additional finding showing that divorced people were living healthier than singles and married people. This segment is already familiar with natural and healthy food, so they can be used as opinion leaders or health lifestyle advocates to impress other people. As their level of avoidance from unhealthy food and natural food consumption is significantly high, points of purchase and packages of nutritional food as well as health and wellness magazines can be valuable mediums to reach this segment. While communicating with this group, green values and multidimensional structure of health may be mentioned. Members of this segment score high in proactive health motivation, so they may already be using preventive health services. Social marketing campaigns targeting this segment should aim to remind the importance of living healthy and adopting healthy behaviors in various dimensions of healthy lifestyle.

It is also important to make healthy choices available for all these groups through workplace health programs. So policy makers should co-operate with and maybe support employees to motivate them design and implement such programs as a part of their human resources policies. Motivating employees to take part in these programs is an important issue to be considered for the success of these programs.

FUTURE RESEARCH DIRECTIONS

Although healthy lifestyle is an important issue for sustainable development, studies focusing on this relation is limited. So, empirical studies examining this relation can add value to the literature. It is also essential to explore the consumers to find out more about their regular activities in a day (time spent in traffic, eating and drinking, hobbies, exercise, where they shop, how they solve their health problems etc.) with in-depth interviews. Health institutions and governments should make comprehensive research in order to understand the use of preventive health services and also the barriers that should be overcome to change people's lifestyles. It is also essential to make research including other dimensions of healthy lifestyle, such as exercise and health responsibility.

In this study highly educated individuals with high income are examined. This profile is believed to be more open to receive and make use of health related messages. So people with lower education and income should also be studied in terms of their health related habits.

CONCLUSION

The starting point of this study was healthy lifestyle and sustainable development relation and how this lifestyle can be promoted among individuals with different profiles. In order to have a better understanding, healthy lifestyle is examined with green consumer values and health motivation.

One of the most effective approaches to promote healthy lifestyle is using social marketing campaigns which aim to improve health related habits of individuals to the optimal level possible within their environment. This study is believed to contribute to define the target group better and develop more effective strategies.

As Bodur and Sarıgöllü stated (2005), Turkish people are thought to be more externally controlled perhaps because of underlying characteristics such as *collectivism, shared fatalism, or spiritual beliefs*. So it is essential to convince people that they can control their health.

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Another important issue regarding the healthy lifestyle is co-operation. Authorities think that "21st Century calls for a new health system which is partnership- oriented, population health-based, and proactive rather than reactive. The health sector must serve as a guide to and be a partner in these actions so that health concerns are represented appropriately at all stages of implementation" (Health and Environment in Sustainable Development: Five Years after the Earth Summit, 1997).

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KEY TERMS AND DEFINITIONS

Cluster Analysis: Statistical analysis to classify the objects in groups according to their similarities.

Green Consumer Values: Values related to environmental concern that influence consumers' buying patterns.

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Healthy Lifestyle: Way of life enhanced with activities, interests and opinions that will help the individual reach optimal health.

Health Motivation: Being stimulated to follow health related issues and take responsibility about a person's own health.

Social Marketing: Marketing approach to promote desired behaviors in issues essential for social well-being.

Sustainable Development: Meeting human needs without sacrificing the needs of future generations.

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Chapter 52
A Fourth Wave of Education for Sustainability (EfS) in Higher Education

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ABSTRACT

Education for Sustainability (EfS) in Higher Education (HE) is described as developing through three waves. These are overviewed in this chapter and given due acknowledgement but are shown to fall short of what is needed going forward. Consequently, a fourth wave of EfS in HE is proposed. The fourth wave of EfS in HE needs to be directed at the collaborative project of constructing "sustainable universities" (Sterling, Maxey, & Luna, 2013). The concept of "neo-sustainability" (Farley & Smith, 2014) is adopted as the basis of this next wave, as is the three nested rings model of sustainability. The argument for a strategy to educate the HE educators is outlined. It is suggested that contemporary global and local sustainability issues need to become part of student engagement within all HE courses. Finally, effort needs to be exerted by HE lecturers to develop pedagogical practices that align to the aims and principles of EfS.

INTRODUCTION

The premise of this chapter is that in our society many of us are living beyond the carrying capacities of the earth's natural ecological systems. It is essential not only to change existing lifestyles, but to develop new, sustainable lifestyles. It is argued that education is the primary process for supporting the realization of the limits and the necessary changes. This chapter looks at how Education for Sustainability (EfS) is developing across the higher education (HE) sector. Three renditions or different waves of EfS in HE are identified and explained in the literature. An overview of these leads into an argument for the need for a fourth wave, with an explanation of what this next wave might look like. The major strategies for this fourth wave are a reframing and clear articulation of the concept of sustainability. It is argued that this reframing should be based on the concept of "neo–sustainability" (Farley & Smith, 2014) and

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aimed at building "the sustainable university " (Sterling, Maxey & Luna, 2013). Next, it is argued that there is also a need to reframe and add to current ideas about EfS in HE, in essence shifting the focus and concentrating on "educating the HE educators ". This educative work needs to concentrate on both (1) relevant curriculum and content, and (2) appropriately aligned pedagogical practices. However the concept of "the sustainable university" and the fourth wave of EfS in HE is very new and very much open to collaborative construction.

THE ARGUMENT

The gist of the argument is twofold. First there is a need to reframe and clarify the concept of sustainability. Second there is a need to reframe EfS in HE and concentrate on educating the educators.

The Need to Reframe Sustainability

The rise of concerns and the discourse on sustainability signify a fundamental shift in the understanding of the relationship between humanity and nature. Humanity is realizing that it is part of nature and that it depends on nature for its existence. In turn, the central concern within sustainability is that humans are living beyond the capacities of the earth's ecology systems. The world's population is living and consuming at a higher rate than what the ecological systems can re–generate and support over the long term. Central debates in sustainability focus on the use of resources, population stress, water and food security, energy, climate change, ecological balance and eco–system adaptation (Vogt, Patel–Weynarrd, Shelton, Vogt, Gordon, Mukumoto, Suntana & Roads, 2010). The subsequent conclusion derived from these debates is that current lifestyles and patterns of consumption need to change.

In short, the earth's population has outgrown the growth model. Unbridled growth is argued here to represent a mindset of abundance that favors expansion, development and growth. The mindset includes a belief that more resources exist, they just need to be found and utilized. Hence, there is a need for a counter strategy that is more attuned to current understandings. The alternative presented here is a post–abundance framing of the relationship between humanity and nature. This is a relationship based on sustainability. As Farley & Smith (2014) explain, to sustain implies maintenance, support and long–term endurance "of something", but the something which is sustained involves a value position.

Two different positions in the relationship between humanity and nature are being set out. The first concerns where we, as humanity, are at the moment. This is a position built upon the growth model, a position labeled here as reflecting an abundance mindset. The second position being presented concerns where we, as humanity, need to move. This is the preferred or desired position of living within the means and carrying capacities of global eco–systems. This is being labeled here as a post–abundance position. Throughout history, movement from abundance to a post–abundance position has often occurred through social upheaval and revolution, but in this case the movement is to occur peacefully, through education. Yet the image of the revolution helps to convey the importance of what is at stake, and the need for change. It also conveys a sense of the degree of difficulty involved and what is being asked of an educative process.

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Reframing Education for Sustainability (EfS) in Higher Education (HE)

As the United Nations Educational, Scientific and Cultural Organization (UNESCO, 1997) document *Educating for a sustainable future* (para. 38) states:

It is widely agreed that education is the most effective means that society possesses for confronting the challenges of the future. Indeed, education will shape the world of tomorrow. Progress increasingly depends upon the products of educated minds: upon research, invention, innovation and adaptation. Of course, educated minds and instincts are needed not only in laboratories and research institutes, but in every walk of life. Indeed, access to education is the sine qua non for effective participation in the life of the modern world at all levels. Education, to be certain, is not the whole answer to every problem. But education, in its broadest sense, must be a vital part of all efforts to imagine and create new relations among people and to foster greater respect for the needs of the environment.

The conclusion and main strategy put forward from the analysis of the effectiveness of Education for Sustainability (EfS) in HE up to this point, is that there is a need to "educate the educators". Educators in HE should be explicitly targeted and upskilled in EfS. Education for Sustainability (EfS) in HE needs to be embedded into each and every educator's work, much the same as Occupational Health and Safety. This may be difficult to initiate as many of these educators have deep but narrow areas of expertise and may resist spending valuable time learning and developing expertise in a new area of knowledge. But all effort in educating the HE educators will be effort well spent. HE educators have the potential to influence the students who come through their courses, many of whom will be influential people themselves in the near future. Scott, Tilbury, Sharp and Deane (2012) report that two per cent of the world's population attend higher education but more than 80 per cent of the decision makers in industry, community and politics are graduates of universities. There is a need to offer EfS to our future leaders and professionals. It has been estimated that EfS in universities has the potential of reaching 135 million students across 17,000 universities. Further, these students come and go with the cohort renewed every three years (Sterling, 2013).

Likewise, a further subset of these HE educators to be prioritized for being educated about EfS includes those who work in faculties of education as teacher educators. Using the same logic, teacher educators have the potential to influence all future teachers, and through them, all future students, across all sectors of education. To this end, resources already exist with the UNESCO project, *Teaching and Learning for a sustainable future* (last updated in 2010). This program consists of around one hundred hours of self–study, organized in 27 modules. The professional development of teachers in EfS needs to be a shared responsibility, with a dual strategy of inclusion of EfS into teacher education programs along with the option of self–study driven by the teachers themselves (Robottom, 2013). Inclusion of sustainability as a cross–curriculum requirement for all schools is one strategy that will motivate teachers to learn about and develop their own expertise in EfS.

The form of EfS that is appropriate for higher education can be categorized as being either (1) curriculum and content, or (2) pedagogical practices. Much of the emphasis has been on the latter and it is suggested that more effort needs to go into the curriculum and content. With this in mind, the first theme that needs to be included into the HE curriculum is the imperative of living within the carrying capacities of the world's ecological systems. The implication of this fundamental change needs to be taken up in some way in each and every subject taught across HE.

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Next there needs to be a clear conception of sustainability. Debates around Sustainable Development (SD) and sustainability have hampered political decision making. This field has a history of being everything to everyone and this cannot continue. This kind of ambiguity is unhelpful when trying to influence government, corporate and community policies and practices. Sustainability needs to be defined and understood as working through the needs of the environment, the economy and the social world, but these are not equally weighted: within a post–abundance framework the needs of the environment have primacy. Finally, the sustainability issues that are taken up within HE courses need to be customized to accommodate local and/or the most relevant issues and concerns to the subject area being studied.

Much of the emphasis of EfS has been placed on the pedagogical practices and those that are most appropriate for EfS in HE are those which logically align with the aims of sustainability. Principles for EfS have been stated in the Decade for Sustainable Development (DESD) and government documents. However, most of the principles can be argued as representing principles of good pedagogy rather than being specifically about EfS. Christie, Miller, Cooke and White (2013) explain that alternative pedagogies for EfS in HE focus on active, participatory, experiential learning; engage the head, the heart and the hands; involve interdisciplinary approaches; encourage holistic critical thinking; and include teaching "in place" by utilizing local knowledge and environments.

Transformative learning is commonly acknowledged throughout the EfS literature however it is argued here that most of these conceptualizations of transformative learning are about individual and personalized experiences of transformation. This is considered inadequate for the scope and scale of the change that is needed. While acknowledging that all change occurs one person at a time, social movements are a more efficient means for fostering change. An alternative conception of transformative learning that is potentially aligned to a social movement is tentatively suggested, though it is in its infancy and requires greater collaborative development. This alternative is a work in progress and for the most part develops out of the recent work of the sociologist E. O.Wright (2010).

SUSTAINABLE DEVELOPMENT AND SUSTAINABILITY: THE TERMS AND THE CONCEPTS

The assumption underpinning this section is that language is important and that terminology affects the way we understand a concept. Initially, made popular through United Nations processes and associated publications, sustainable development (SD) has not only come to mean different things over its years of use, but for many has become problematic and subsequently morphed into sustainability. Some see the two terms of sustainable development and sustainability as inter–changeable (Scott, Tilbury, Sharp & Deane, 2012), but for many others they represent very different positions (Sterling & Maxey, 2013). As flagged above, there is a debate that surrounds these definitions and terminology. Hopwood, Mellor and O'Brien (2005) conclude that "there is no such thing as a single unified philosophy of sustainable development" (p. 47). They explain that sustainable development becomes confusing when different people use the same words to mean a wide range of views and methods for moving towards sustainable development.

Vogt et al. (2010) explain that sustainable development has many different meanings. Nevertheless what the two terms have in common is that they combine concerns about the environment with those related to socio–economic issues. The emergence of sustainable development as a concept and a field of study, signifies a fundamental shift in the understanding of the relationship between humanity and

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nature. This is seen as an advance on previous centuries when, guided by a mindset of abundance, nature and aspects of the ecological system were seen merely as resources to be used and exploited by humans.

In 1983, the UN General Assembly established the World Commission on Environment and Development (WCED) also known by the name of its Norwegian Chairperson, as the Brundtland Commission. This Commission was charged with addressing concerns about the accelerating deterioration of the human environment and natural resources and the consequences of the deterioration for economic and social development. Brundtland explains that the Commission was asked "to propose long–term environmental strategies for achieving sustainable development to the year 2000 and beyond" (Brundtland, 1987, p. ix). Sustainable development (SD) has been defined by the WCED Commission report, *Our common future*, as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 43). This definition laid the foundation for inclusiveness across the many and varied interests represented on the UN General Assembly. The definition has become iconic. But by remaining in place and by being referred back to, it also encourages and allows sustainable development to become "everything to everyone". Some nations can place their emphasis on "sustainable" while others can emphasize "development".

It is broadly acknowledged that the value of the World Commission on Environment and Development definition (Brundtland, 1987) was that politically it offered something to everyone. The issues of sustainable development are global as well as local and nation states can struggle to provide effective governance beyond their own borders, hence the importance of the United Nations (UN). The UN was established in part to look at just such cross–border and global issues. However the bar can be set quite low when it comes to reaching consensus around common denominators and acceptable middle ground through the processes of the UN. This is especially the case when the consensus involves representatives from such a diverse range of constituents, with an equally diverse range of interests. The WCED definition needs to be seen in this light. Politically, it constitutes the middle ground. It continues to be important and still offers something to most people. Accordingly, it has been instrumental in bringing people with different views to sit down at the negotiating table together.

Hansson (2010) argues that the importance of *Our common future* to late twentieth–century environmental policies cannot be overstated. He explains that it had a central position at the United Nations Conference on Environment and Development (UNCED) conference in Rio de Janeiro in 1992. It laid the foundations for many of the ideas that made their way into the Agenda 21 documents (UNCED, 1992). Many of these were subsequently adopted at that conference, but the issues and debates that it raised continued to run over into environmental politics for many years afterwards. Sustainable development has been represented pictorially as the three pillars, three interlinking rings and as the sustainability compass. The model of sustainable development that has been used extensively since the World Summit on Sustainable Development in Johannesburg in 2002 is the three pillars model of sustainable development. This is depicted as three vertical columns, representing the environment, the economy and society. The columns support a horizontal beam that spans across the top of the three columns. The horizontal beam is labeled as representing sustainable development. The model of SD depicted as three interlinking rings is quite similar, in that each circle is labeled as representing the social, the economic and the environmental dimensions, with the compartment where all three intersect at once labeled as sustainability. The three rings are also said to represent the triple bottom line as explained by Elkington (1999). The criticisms leveled at these two models are that they show each of the three contributing influences as equal. The model of the sustainability compass is another model that appears throughout the literature. In many ways it is an extension of these two previous models in that it introduces a fourth

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domain into the mix, that of the political, to become: the political, the social, the natural and the economic. This is significant, as this inclusion of the political encourages readers to ask about the process of decision making and in particular, "who is making the decisions"?

UNESCO has further refined their definitions to state that "sustainable development is a vision of development that encompasses respect for all life—human and non–human—and natural resources, as well as integrating concerns such as poverty reduction, gender equality, human rights, education for all, health, human security and intercultural dialogue" (UNESCO, 2013). In this way sustainable development is said to now have four dimensions. These are society, environment, culture and economy (UNESCO, 2013). In contrast, the term sustainability is used in UN literature to reflect the longer–term goal of achieving "a more sustainable world" (UNESCO, 2013). More recently, some have brought these terms together to suggest that sustainability is the long–term goal, while sustainable development is the process or pathway for achieving it (Sterling, 2013, p. 2).

In very general terms, sustainability on its own is preferred by some to represent and acknowledge that growth and development may not provide the unrivalled strategy and appeal that it once did. In market capitalism, growth is argued as being a way to expand the economy with the intention that most will find employment and prosper. Further, the claim is made that a trickle–down effect will ensure that living conditions improve. The trickle down argument is presented as utilitarian in that it explains that this is the way to provide the most good and improvement for the most number of people. It is also happens to be a very effective way of increasing scale, turnover and subsequent profits.

Baer (2012) presents a compelling critique of this argument. Initially he draws on the eleven propositions that are used by Wright (2010) to show the contradictions within the capitalist world system. He argues that global capitalism is based on the treadmill of production and consumption leading to profit making. Such a system has a need for continuous economic expansion and to this point has been based on the use of fossil fuels. Baer (2012) argues that capitalism is at loggerheads with environmental sustainability and the causes of climate change. Instead he argues for a democratic eco–socialist world system to be built on two principles, social equity and justice, and environmental sustainability.

Joining together the terms sustainable and development as "sustainable development", is considered to represent a softer version of sustainability. This is a version that places less emphasis on sustaining the resources drawn and used from the planet's ecological systems. The concept of sustainable development originally emanated from the coalition of interests of those from Less Developing Countries (LDCs), where development is still considered a much desired and necessary goal. As noted in the WCED report, for developing countries to reach the same outputs from manufacturing as exists in westernized countries, then they need to increase their outputs by a factor of between five and ten times. Importantly, the notion of western countries reducing their outputs is not as often discussed (Farley & Smith, 2014).

At the center of this ongoing debate are challenges about the environment and equity. The key features and ideas about the environment emphasize sustainability of ecological resources, limits to growth, and the idea of the carrying capacity of these resources to sustain a growing global population (Meadows, Randers & Meadows, 2004). While the WCED saw resources from an anthropocentric position, that is, resources serving the needs of humans, with the ability to substitute resources through the use of technology, still others emphasize more systemic differences around conservation or preservation. Alongside equity, the key features in the debates concern poverty reduction, food and water security, access to healthcare and general wellbeing. Burgmann and Baer (2012) in their description of the climate justice movement, explain that the effects of environmental degradation are not shared out evenly. They discuss how some of the poorest people appear to be hardest hit by climate change, hence the call for climate justice.

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Hopwood, Mellor and O'Brien (2005) have identified and mapped three distinct versions of sustainable development. On the vertical axis they plot changes in socio–economic, wellbeing and equality concerns, starting from inequality and moving up to a position of full equality. The horizontal axis covers the priority of the environment from its beginning with no environmental concerns through techno–centered in the middle, up to eco–centered at the maximum. Next, these authors plot various reports, organizations, along with some different social movements by giving them positions on how they see these in relation to the coverage of the two axes. Some of these items are seen as taking up extreme positions; for example, neo–liberal economists are located at the intersection of the origins of the axis, where inequality and virtually no environmental concerns intersect. In contrast, deep ecologists are located at the high end of the environmental concerns but with low socio–economic wellbeing and equality concerns; socialist cornucopia are placed high on equality but with very low environmental concerns. This research by Hopwood et al. (2005) determines and locates many of these extreme positions as being outside the mainstream debate on sustainable development.

Hopwood et al. (2005) distinguish between three forms of sustainable development as ranging from "status quo", to "reform" and through to "transformation". Those in the status quo band aspire to a belief in "business as usual" and that sustainable development can be achieved within existing structures. They believe that adjustments can be made without fundamental change to society, the processes for decision–making or existing power relations. Development will occur through growth and growth will lift people out of hunger and poverty. This view entails the belief that business, private ownership of resources and markets, providing there is only minimal regulation, shall prevail. Reduction in the role of governments, sympathy for cuts in social wages, change to taxation and support for privatization are commonly stated. This viewpoint has a weak commitment to environmental sustainability, low concern for both poverty reduction and lack of equity in political power. The "business as usual" form of sustainable development reflects the abundance mindset.

Reformist models occupy the next rung up and are explained as recognizing that there are mounting problems with the environment and equity. Reformists are critical of current policies of government and business. They see the "business as usual" approach as contributing to increasing inequality, poverty, environmental degradation and world instability. They generally support capitalism but want the government to regulate market processes and provide balance. Green economists argue that the market needs modification to redress market failure and regulation to achieve ecological sustainability. The *Limits to growth* report (Meadows, Meadows, Randers & Brehren, 1972) tackled the promotion of growth head on but Brundtland rejected this notion of environmental limits in the WCED report. *Limits to growth* is seen as being strongly reformist while the WCED report is located by Hopwood et al. (2005) on the cusp between status quo (business as usual) and reform.

Those who subscribe to the transformative approaches to sustainable development see mounting problems, and believe these to be a fundamental feature of contemporary society. They see potential crises and collapse of society as possible. These are caused by the economic and power structures of society because these structures have not been set up to foster human wellbeing or environmental sustainability. This approach has a strong commitment to social equity with a view that access to livelihood, good health, resources and economic and political decision–making are connected (Hopwood et al., 2005). This perspective contains a loose coalition of eco–feminists, campaigners for anti–capitalism, anti–globalization and those working towards environmental justice. Environmental justice is aimed at social transformation that meets human needs, enhancing quality of life, economic equality, health care,

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human rights, species preservation and democracy. Bringing about such changes is considered to need major restructuring or even entirely different social orders.

EDUCATION FOR CHANGE AND EDUCATION FOR SUSTAINABILITY (EfS)

The notion of "education for sustainable development" (ESD) brings together two areas that have substantial histories with the United Nations (UN), education and sustainable development. As stated in the UNESCO (1997) publication *Educating for a sustainable future* (para. 103),

… achieving sustainability will depend ultimately on changes in behavior and lifestyles, changes which will need to be motivated by a shift in values and rooted in the cultural and moral precepts upon which behavior is predicated. Without change of this kind, even the most enlightened legislation, the cleanest technology, the most sophisticated research will not succeed in steering society towards the long–term goal of sustainability. Education in the broadest sense will by necessity play a pivotal role in bringing about the deep change required, in both tangible and intangible ways.

There are four major thrusts that support ESD and EfS which have their origins in the Agenda 21 document borne out of the UNCED conference in Rio in 1992, (UNCED, 1992). These are, to improve access to high quality education; re–orientate existing education programs; develop public understanding and awareness, and provide training. All of which remain present in most ESD and EfS initiatives. Some general principles and ideals that underpin ESD and EfS are articulated in the UNESCO (2005a) implementation document, namely, intergenerational equity, gender equity, social tolerance, poverty alleviation, environmental protection and restoration, natural resource conservation and just and peaceful societies.

In 2002, at the World Summit on Sustainable Development at Johannesburg, the United Nations adopted a resolution to designate 2005–2014 to be the Decade of Education for Sustainable Development (DESD). This reinforces the view that education is the tool for shaping a more sustainable future. The overall goal for the DESD is to integrate the principles, values and practices of SD into all aspects of education and learning. The DESD approach attempts to change traditional educational approaches to become interdisciplinary and holistic, values–based, critically reflective, multimodal, to include participatory decision–making and focus on locally relevant information (Australian Research Institute for Environment and Sustainability [ARIES] 2009: 2). Much is made in the guiding literature of the need for ESD and EfS to have local relevance and be culturally specific. Subsequently, ESD and EfS take on many different forms in different places around the world.

The key and essential characteristics of ESD though are listed by UNESCO (2005a) as, (i) based on the principles and values that underpin sustainable development; (ii) dealing with the wellbeing of all three realms of sustainability – environment, society and economy; (iii) promoting life–long learning; (iv) locally relevant and culturally appropriate; (v) based on local needs, perceptions and conditions, but acknowledging that fulfilling local needs often has international effects and consequences; (vi) engaging formal, non–formal and informal education; (vii) accommodating the evolving nature and concept of sustainability; (viii) addressing content, taking into account context, global issues and local priorities; (ix) building civil capacity for community based decision making, social tolerance, environmental stewardship, adaptable workforce and quality of life; (x) interdisciplinary; (xi) using a variety of pedagogical techniques that promote participatory learning and higher–order thinking skills.

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It is again noted that these can take many forms when they are implemented around the world in a locally relevant and culturally appropriate manner. Each country or region has to develop its own specific understandings; likewise for the concept of "Education for Sustainability" (EfS).

A LOCAL ORIENTATION TO EDUCATION FOR SUSTAINABILITY (EfS)

The Australian government developed its overall strategy paper in response to the UN DESD which it titled *Caring for our future*, and released in 2007 (Department of Environment and Heritage, 2007). This policy framework identified six themes to underpin its subsequent work. These were, communicating the concepts; basing their approach on sound research; ensuring momentum; promoting a whole of government approach; building partnerships and monitoring and evaluation. These were followed up two years later with the release of the National Action Plan called *Living sustainably* (Department of Environment, Water, Heritage and Arts [DEWHA], 2009). This plan signals a conscious shift away from ESD to the clearer notion of Education for Sustainability (EfS). EfS is acknowledged as having its origins in the environmental education of the 1970s. While it began with developing an awareness of natural ecosystems and their degradation, it has since transitioned to become equipping all people with the knowledge, skills and understanding needed to make decisions based upon consideration of environmental, social and economic implications.

This Action Plan argues that EfS aims to tackle the underlying causes of "unsustainable trends", (DEWHA, 2009, p. 8). The form of education advocated is to raise awareness initially, but also to develop capacities that enable the learner to take action and implement real change – informed, thoughtful and strategic action. The principles for this approach to EfS are explained as: transformation and change; education for all and lifelong learning; systems thinking; envisioning a better future; critical thinking and reflection; participation and partnerships for change (p. 9). Provision of EfS has also grown, facilitated variously by government departments, educational institutions at all levels, industry bodies, community groups, zoos, botanical gardens, national parks and environmental education centers.

Strategy 2 of *Living sustainably* commits to "Reorienting education systems to sustainability". This strategy covers all levels of education as it states, "the Australian government is committed to using education as a critical resource to prepare Australia for the emerging social, economic and environmental challenges of the twenty–first century. A transformative approach to education is needed, involving whole of institution engagement, innovative teaching and learning and changes to curricula (DEWHA, 2009, p. 21). The second objective set out for achieving Strategy 2 states that action needs to be taken so that "Education for sustainability is integrated into all university courses/subject areas and campuses are managed in a sustainable way".

In Australia, like numerous other countries across the globe, sustainability issues have global significance but are nationally specific. They must be tackled by global and national institutions – and yet also have their manifestations at the level of communities and individuals. Of particular importance to the discussion in this chapter, and this section on EfS, is that the recent reports from the CSIRO (Hajcowicz, Cook & Littleboy, 2012); the National Sustainability Council (NSC, 2013), the Murray Darling Basin Authority (MDBA, 2012); ClimateWorks Australia (2013, 2010); and the Intergovernmental Panel on Climate Change (IPCC) (2013), all request that the community read their reports, discuss them and consider their implications. One might react by suggesting that even asking people to read these documents is very optimistic and it is highly unlikely to occur, yet it could equally be argued that this is the

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responsibility dimension of being an active citizen living in a democracy. However, where better to have conversations on the ideas and issues being addressed in these reports than in our educational institutions and especially those dedicated to higher education. Somehow, somewhere the space must be found for consideration and discussion of these highly important twenty–first century issues.

THE THREE WAVES OF EfS IN HIGHER EDUCATION

Wals and Blewitt (2010) explain the three waves of EfS that have influenced higher education. The first wave is described as having its beginnings with the introduction of environmental education into universities in the 1970s and 80s. Courses such as Environmental Science were implemented, as were subjects like "Engineering and the environment". Students from across universities were given access to aspects of Environmental science and related issues. The issues were twentieth–century issues that had relevance to a broad range of citizens and professionals alike. In the main these subjects were about ethics, values and "education *about* sustainability".

The second wave of EfS they explain as when University administrators committed to environmental sustainability through such means as "The Talloires Declaration". This was a ten–point action plan for incorporating sustainability into teaching, research, operations and community connections. Alongside these and other early agreements came the greening of the campus initiatives that modeled energy saving and campus–based examples of ecological protection, conservation and preservation. The second wave extended EfS (EfS) beyond courses, to the university's management and through to their operations. Universities became very conscious of their ecological footprint and took to modeling energy saving, waste separation and recycling. On the curriculum and teaching side, the second wave also ushered in a different way of incorporating sustainability into teaching courses. Some argued for "a golden thread" of sustainability to run through all courses. Others started to make more use of immediate and local surroundings such as environmental walks, native flora and natural habitats. Sustainability became part of many existing courses.

The third wave of EfS is described as being a more integrated and holistic approach to EfS. The range of responses considered part of the third wave includes, universities signing the next generation of declarations; further greening and modelling of sustainability across the campuses and operations of the university; the introduction of aspects of sustainability into all courses; a change to the way that the teaching and learning occurs, (challenges to traditional university pedagogy to become more consistent or aligned with general principles of sustainability. These changes involved the introduction of more discussion, critical engagement and an increase in learner–centered learning); increased co–operation across the universities has also been advocated. This will encourage multi– and inter–disciplinary team approaches to research, and the development of community connections and partnerships.

At this stage in the development of sustainability, there has been a fundamental shift in attempting to ensure that the commitments that are made actually transpire into actions. One of the major problems and shortfalls with EfS has been the lack of impact in bringing about actual change. The UN Decade for Education for Sustainable Development (DESD) is drawing to a close. There has been ten years of concentrated effort and yet there still remains a chasm between what has been achieved, and what remains to be done (Sterling, 2013; Tilbury, 2013; UNESCO, 2005b).

Some argue that universities need to be fundamentally changed in order to align truly with the provision of higher education and sustainability. Tilbury (2013) has called for "a global rebooting of higher

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education", and other calls for transformation are common (Sterling, 2013). Brookfield (2013) a leading academic in adult education, in his discussion of transformation with respect to education and learning, explains that "transformation" is a very large word that promises a great deal. For some working in higher education, though, calls for transformation appear to overstep the mark. Universities are steeped in tradition, they are often organized around disciplines and can therefore be notoriously difficult to change. Others are adopting sustainability across the board as part of recognizing the rationality of arguments for the need to change. Clearly there is a range of responses across the various universities with regard to their degree of buy–in and take–up of EfS. For some universities the rationality angle of sustainability is imperative enough, while others are adopting sustainability as part of marketing strategies as they try to appeal to the young adult population who are potential and prospective students. The range of responses and ways of engaging with EfS within higher education are very usefully categorized through the three models of sustainable development explained by Hopwood et al. (2005) as "business as usual", reformist and transformative.

TRANSFORMATION AND EfS IN HIGHER EDUCATION

Transformative education can mean many things, as can transformative learning (Boyd & Meyers, 1988; Cranton, 1994; Cranton & Taylor 2013; Freire, 1970; Mezirow, 2012; O'Sullivan, 1999; Shor 1996). I now turn my attention to the notion of transformative learning as it applies to EfS in the context of higher education. Originally explained by Mezirow in the 1970s, transformative learning has been the subject of ongoing development and debate ever since. Mezirow's version of transformative learning is tied to critical social theory and the ideas expressed by Habermas. Mezirow's ten step model (2012) begins with the learner experiencing "a disorientating dilemma". Learners find this experience to be very confronting and one where the learner is unable to assimilate with existing understandings. Hence new frames of reference are needed and these are developed to accommodate the new experiences. This development of a new frame of reference is the transformative dimension of this form of learning.

The initiation of transformative learning by a disorientating dilemma makes this a very powerful experience. Though it is learning that is often based on experience of a unique significant event. Yet clearly, there is an ethical issue associated with educators initiating and/or facilitating disorientating dilemmas. Some adult educators consider it difficult to consciously facilitate transformative learning through a designated program or course of study. This need for learners to experience a powerful personal dilemma makes transformative learning in any educational setting highly problematic. While often cited, Mezirow's model is not the only form of transformative learning (Taylor & Cranton, 2013).

Most models of transformative learning can be criticized for being aimed primarily at bringing about deep individual change, for while this can be an effective model for social transformation, an even more efficient model is one aimed at developing social movements. Social movements are based on collective actions, and collective action shares out the work required to bring about change. Recent work by Erik Olin Wright (2010) holds out promise in this regard but the project of appropriating and applying this work as a form of transformative learning remains a work in progress. This is not Wright's intention and remains a project to be undertaken by educators to develop such an approach. It is enough to say at this point that Wright locates his sociology within emancipatory social science and that his project of "Envisioning real utopias" is divided into three sections. The first provides a diagnosis and critique of

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capitalism in late modernity. The second outlines and explains a range of alternatives as desired possibilities and exemplars, while the third section outlines a hybridized theory of transformation.

THE FOUNDATIONS OF THE FOURTH WAVE OF EfS IN HIGHER EDUCATION

At the top of the list in looking to transform the university, the staff and the learners, is the need for clarity about the key concepts being used in the discussions. These concepts cannot drive action if there is wide variance and discrepancies in what they mean. Scott et al (2012), in their report on *Turnaround Leadership for higher education institutions interested in developing their EfS* identify a need to "sharpen the focus and understanding of EfS as it applies in higher education". Meanwhile, Farley and Smith (2014) suggest that it seems like some of these key concepts and terms are being used to do too much. Time and effort spent clarifying the key concepts and how they relate to the context of universities will be effort well spent.

Farley and Smith (2014) make the point that the two key concepts of sustainable development and sustainability are not the same thing and should not be used inter–changeably. Sterling and Maxey (2013) explain how they see the differences: "sustainability is about securing economic viability, social coherence and ecological integrity at local to global scales – where these system conditions are seen as deeply co–dependent rather than as separate dynamics". One further definition is that suggested by Agyeman, Bullard and Evans (2003) in their work *Just sustainabilities*, when they venture further, and rather than presenting the three spheres as co–dependent, argue instead for the primacy of the environment and the importance of recognizing limits. They define sustainability as "the need to ensure a better life for all, now and into the future, in a just and equitable manner, while living within the limits of supporting ecosystems" (p.5). Sterling and Macey (2103) explain that "sustainable development is the journey towards these conditions" (p. 2).

Scott et al.'s (2012) basic premise for their notion of *Turnaround leadership for EfS in Higher education* is that universities are at a crossroads. They write that this is a turnaround moment where the traditional nineteenth–century didactic, fixed timetables, two–semester campus–based model of higher education is coming under increasing pressure. They point out that access to HE is broadening. HE is subject to funding cuts and student expectations are changing. There is an increasing use of ICT, and employers are looking for graduates who can manage change.

They place these changes alongside broader forces for change identified by Global University Network Innovation (GUNI), and list these as: the UN DESD and global efforts to integrate sustainability; the Rio +20 Conference in Brazil calling for universities to become models of best practice and transformation; the formal Higher Education Treaty commitment to transformational change (Higher Education Treaty Circle, 2012); and the UN establishment of a global network of Regional Centres for ESD. In Australia there is also the 2009 National Action Plan for EfS (DEWHA, 2009). Scott et al (2012) provide a summarizing comment that "higher education needs to transform itself if it is to assist societal transformation for a more sustainable future". Clearly, they are arguing that to be successful into the future, there needs to be a root and branch change of what universities do and how they do it.

Sterling (2004) argues that addressing sustainability requires a paradigm shift and the adoption of new and different epistemology. This new way of viewing knowledge refers to the need to always be cognizant of carrying capacities and limits to ecological systems. Such considerations will make some future strategies and actions possible and others, which have been popular in the past, will need to be

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abandoned. Anderson (2009a, 2009b) argues for such a shift in the field of Technical and Vocational Education and Training, and calls for a re–orientating of TVET away from its location within what Giddens has called "productivism" (Giddens, 1994) to be instead conceptualized and contextualized by the notion of "ecologism".

Blewitt (2013) criticizes EfS in higher education when he states that EfS has become tainted through accepting the capitalist mode of production as a given. EfS educators have worked within the existing system. Ball (2012) argues that best practice in education is now naturally commodified, as it is bought and sold for profit. Blewitt (2013) is very blunt when he states corporatized higher education has been charged with producing obedient neoliberal subjects (Blewitt 2013). EfS educators have been working within parameters and understandings shaped by this approach to economics.

Giroux (2002), in his work on neoliberalism and higher education, argues that when left unchallenged neoliberalism respects few boundaries based on self–restraint and the public good and is unresponsive to broader human values that are central to democratic culture (p. 431). Neoliberal economics continues to see the effects of greenhouse gas emissions as an "externality". As a contextualizing ideology and discourse, neoliberalism gives EfS in higher education a specific conceptualization. It ensures that sustainability is about photos of Vice Chancellors and Deans signing agreements, having separate bins on campus for waste separation and doing far less about advancing equity and poverty reduction. It is envisaged that to be effective, HE educators involved in the fourth wave will need to break away from this hegemony.

Blewitt (2013, p. 58) suggests that, "although higher education may not yet be a totally unconstructed cheerleader for corporate capitalism the connection between knowledge and power, learning and economic needs of the private corporations has certainly been "refreshed". Further he brings his criticism back to sustainability educators when he writes, "sustainability educators are now confronted with a serious challenge, not least because as systems thinkers working within the capitalist system, compromise, accommodation and incorporation have become their means of survival" (p. 61). But other means for contextualizing sustainability are possible – and need to be developed.

Farley and Smith (2013) argue that what is being promoted as sustainable development and sustainability represents a "faux" (false) sustainability. Instead, they argue for clarity and a reconceptualization where sustainability is about improving the social, economic and environmental conditions, not maintaining, or sustaining the damage being done. Further sustainability needs to operate within limits, with the environmental system being foundational.

To make themselves clear, Farley & Smith (2014) argue for "neo–sustainability" (or a new sustainability). Such a strategy signals the explicit choice to change direction. They define this simply as "the ability of an activity to sustain a system by improving its quality and operating within its limits" (p. 151). This is not a three pillars or a triple bottom line approach; rather, this is three concentric circles where the environment is the largest, and recognized as having primary importance. Next inside this are the social systems and then inside the social systems and dependant on the other two is the economic system. In addition they explain that neo–sustainability is based on three rules. There are natural limits to growth. The limits are dictated by the environment, and actions within any system must adhere to the carrying capacity of the earth's natural systems. As the environmental, social and economic are nested systems then actions must be based on systems thinking with multi–level and multi–domain impacts.

Transformation requires new thinking and new approaches to permeate into educational practices through the architecture and technology, to curriculum and pedagogical practices. Littledyke, Manolas and Littledyke (2013) conducted a study in three universities across three different countries. They

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found that to achieve effective EfS, there needs to be an integrated systems model for coordinating EfS which encourages distributed leadership to empower all university members to be active in sustainability practices. The system they suggest integrates structures, decision–making and governance; infrastructure and sustainable practices; and learning about and experiencing sustainability through the curriculum.

Cotton and Winter (2010) conducted small–scale surveys of educators in higher education and asked them about teaching and learning for EfS. They concluded that educators align EfS with active and participatory learning processes. They found that role plays and simulations, group discussions, stimulus activities such as initiating a discussion based on a video or newspaper clipping, debates, critical incidents, case studies, reflexive accounts, critical reading and writing, problem–based learning, fieldwork and outdoor learning and modeling of good practice were identified as active learning techniques (Cotton & Winter, 2010). Similar findings appear in the review conducted by Tilbury (2011). These pedagogical practices align with the components of EfS, such as visioning a better future, critical thinking and reflection, participation partnerships and systemic thinking, as listed in the Australian government funded guides to EfS (Australian Research Institute for Environment and Sustainability, 2009). For Thomas (2009), "the development of thinking is the critical element in education related to sustainability" (p. 246). He places thinking at the center of achieving transformative learning through the implementation of problem–based learning. There are many good case studies and exemplars of good practice in the literature demonstrating how EfS involves more active and participatory learning, encourages critical inquiry and discussion, is interdisciplinary and supports the students in exploring value positions. There is also strong research evidence to the contrary – that shows that the pedagogical practices associated with EfS may be less commonly implemented than what might be thought.

A study by Christie, Miller, Cooke and White (2013) starts with a review of literature and acknowledges that alternative pedagogies for EfS focus on active, participatory, experiential learning, engaging head, heart and hands, interdisciplinary approaches, holistic critical thinking and teaching "in place" by utilizing local environments. Teachers are considered facilitators rather than directors. The teaching and learning processes are explained as being more open and democratic. In their study, these researchers received responses to their questionnaire from 1819 academics or 6 per cent of the entire academic workforce from across Australian universities. The majority of respondents from non–environmental disciplines (71.9%, n= 701) indicated that they did not teach EfS "at all". While there were some differences across the range of disciplines the majority indicated that they did not teach EfS "at all" (71.3% – 78.9%). Where respondents did say they taught EfS they indicated that it was through "passing comments" or "just a few times across the semester". For those who taught EfS, second, following the use of passing comments, the most used method was through the use of critical thinking which they reported as doing only a few times throughout the semester. Discussions and case studies were the third and fourth most used teaching methods associated with EfS.

The view of lectures as a didactic, one–way transmission and a boring way to learn was not a view shared by Australian academics, with most explaining that they used interactive lecture formats dispersing a mix of questions and brief response exercises within the lecture. These researchers concluded from their study that academics rarely employed teaching methods that are based on the interactive and student–led pedagogies which have been advocated for EfS within the literature, such as problem–based learning and place–based education" (p. 403). Interestingly, respondents reported using the same teaching methods when they taught EfS as when they were not. This study establishes that distinctive EfS pedagogies are not being practiced by Australian academics (Christie et al., 2013, p. 403) and that EfS is not yet being widely practiced in university classrooms across the disciplines (Christie et al., 2013. P. 405).

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From this study it is clear that the pedagogies for EfS are not yet happening at the level of the teaching and the learning and therefore as educators we are not yet where we need to be. This is "business as usual" and a long way off matching the big ideals of transformative education and transformative learning. As Leihy and Salazar (2011) argue "each university will produce its own kind of EfS, there is not a one–size–fits–all formula for all university settings" (p.vi). They note that all institutions will need to invest in academic development to meet their commitments to EfS. Consequently, for EfS to reach its much–needed potential, much more effort must go into educating the HE educators.

CONCLUSION

EfS is a strategy that has been initiated to bring about much needed change. It is the use of education to challenge and facilitate movement from practices and behaviors associated with a mindset of abundance to those associated with post–abundance. It is about developing the appropriate knowledge and understanding but it also about doing things differently. A Decade of Education for Sustainable Development has been used to re–orientate systems of education to sustainability. The DESD has also supported a third wave of EfS in higher education and, along with its own achievements, this work has made what needs to be done next that much clearer. Higher education is thought to be experiencing particular pressures to change – potentially "a turnaround moment". The strategies of the fourth wave need to take up this turnaround moment. This involves basing EfS on a tighter understanding of sustainability based on what Farley and Smith (2014) call "neo–sustainability" and the three nested circles that give primacy to the environment. The focus on educating the HE educators needs to occur and EfS needs to be part of each and every HE educator's job. There is a need to continue to develop curriculum and content. This should involve a range of global issues along with local customization, and a range of contemporary reports should be utilized for inclusion creatively and where appropriate, as course content.

Consideration of the pedagogical practices aligned with EfS may even need to involve rethinking the architecture of the HE teaching spaces. However there appears to be a discrepancy in the research findings. Reports of good practice and successful exemplars being presented as case studies (Bartlett & Chase, 2013; Jones, Selby & Sterling, 2010) are at loggerheads with findings from a large scale Australian study of HE. The research by Christie et al (2013) provides contrast to the international case studies, where the Australian academics were found to use the same teaching methods with minimal active learning and participation, whether they were teaching EfS or not. In regard to EfS, this signals that there is much still left to do.

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KEY TERMS AND DEFINITIONS

Education for Sustainability (EfS): Education that is aimed at bringing about sustainability through developing the knowledge, skills and understanding needed to make decisions based upon consideration of environmental, social and economic implications.

Education for Sustainable Development (ESD): The initial program of education aimed at bringing about sustainable development.

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Neo-Sustainability: A new conceptualization of sustainability that encapsulates the embedded model of sustainability that privileges and sees the environment as primary. This is defined as the ability of an activity to sustain a system by improving its quality and operating within its limits.

Sustainability: The need to ensure a better life for all, now and into the future, in a just and equitable manner while living within the limits of the supporting ecosystems.

The Decade of Education for Sustainable Development (DESD): The decade from 2005 - 2014 was designated by the United Nations at the 2002 World Summit on Sustainable Development at Johannesburg as 'the decade of education for sustainable development'.

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Chapter 53
Environmental and Economic Impacts of Wave Energy:
Some Public Policy Recommendations for Implementation in Turkey

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ABSTRACT

The wave energy is one of the most important renewable energy sources and it has many advantages compared to other renewable energies. First, it is more reliable. Second, the cost of wave energy is competitive with other sources when it is used as a primary power source. Third, its energy density and deployment potential are higher than the wind and solar energy. Fourth, the wave energy has minor negative environmental impacts and production amount of the wave energy is more predictable. In the study, the applications of wave energy production are discussed in European Union countries in which have started to operate wave energy, recently. It is also tried to evaluate the feasibility of wave energy production opportunities in Turkey. As a result of the study, it can be said that the Black Sea has the highest wave energy potential in Turkey. Industrial production of wave energy actualized by fiscal incentives and this may lead to many social benefits such as increasing employment, reducing external dependency and diminishing greenhouse gases emission.

INTRODUCTION

The fossil fuels were used as the main energy source in many countries after the industrial revolution because they are affordable and easily accessible. The issues of global warming and climate change came to the fore and the harmful environmental effects of fossil fuels have begun to be discuss in most countries. In this context, countries have tended to use less environmentally damaging resources to

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reduce greenhouse gas emissions. Renewable energy sources such as solar, wind, geothermal, biomass, wave and tidal energy are defined as energy that comes from resources that are naturally replenished.

Wave energy is unlimited, clean, and environmentally friendly. Moreover, it does not destroy favorable agricultural areas. Hence, many countries are interested in it. Also, wave energy has reduced dependence on foreign energy sources. This kind of energy is new and has a growing importance in other renewable energy sources. The wave energy has many advantages compared to other renewable energy sources. For example, electricity power extraction from wave energy is continuous 90% of the day, but that ratio is 20% for the wind energy and 30% for the solar energy.

In Turkey, there is no industrial electricity generation from wave energy. Due to geographical location, Turkey has high wave energy potential. There is less study about the wave energy resources in Turkey in the literature. This study is expected to contribute to the literature by discussing the issue of electricity generation from wave energy in Turkey.

The study is organized as follows. In the first section, renewable energy sources are defined and wave energy is presented. Besides, wave energy has been compared with other energy sources and the cost of wave energy is clarified. In the second section, the environmental and economic impacts of wave energy are discussed and the problems of externalities are investigated. In the third section, the situation of wave energy is unfolded in the European Union (EU) member states. In the fourth section, the status of wave energy and wave energy potential for Turkey are evaluated. The fiscal policy recommendations for implementation of wave energy in Turkey are also noted. The study is completed with a conclusion and recommendations.

THE RISING TREND OF RENEWABLE ENERGY RESOURCES: WAVE ENERGY

Climate change is one of the great challenges of the 21st century. The United Nations Framework Convention on Climate Change (UNFCCC) define *climate change* as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". It is obvious that "a low-carbon energy revolution" (IEA, 2009, p. 45) is required in an effort to achieve climate change mitigation. Increased gas emissions accelerated after the Second World War has started to change the Earth's climate. The environment has been exposed to negative impacts due to exploiting of industrialized countries' insatiably and welfare increase and use of the resources has increased among developed and developing countries (Chichilnisky, 1997, p. 467).

World energy consumption has been rapidly increasing and it is estimated to rise considerably over the next decades. It is known that fossil fuel resources have a fundamental role in meeting rising energy demands across the globe. It is further known that fossil fuels are shown to be contributing to the global climate change so virulently. Global climate change and energy security concerns constitute two central issues in today's world energy policies.

The International Energy Agency define renewable energy as "the energy derived from natural processes that are replenished at a faster rate than they are consumed" and clarifies geothermal, hydropower, bioenergy, solar photovoltaic, solar power and wind and marine (tide and wave) energy as renewable (IEA, 2015, p. 2). However solar, wind and wave energy and other renewable energy sources are replenished and not exhausted. As they constantly renew themselves, destocking cannot happen.

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Renewable energy is shown as a shining solution to the problems of climate change and energy security. Renewable energy sources can make a contribution to economic and social development, to energy access and to a sustainable energy supply and can help reduce the negative impacts of energy provision on the environment and human health. Renewable energy can play a significant role in meeting energy requirements in a local and industrial level to reach sustainable development. According to Karaca and Erdoğdu (2012), renewable energy resources have great energy potential for regional and rural development through creating employment opportunities and strengthening domestic industry. Renewable energy sources have less or negligible environmental impacts and they offer a variety of energy sources with more flexible options for usage when compared with energy sources. Renewable energy sources new economic opportunities can help create and provide energy access to billions of people still living without modern energy services.

Comparison to Other Renewable Energies: Why Wave Energy?

Generating energy from waves has been an attractive research area for many years. The idea of converting energy of ocean surface waves into useful energy forms is not new; nowadays, as the negative effects of fossil fuels increase and fear of extinction of fossil fuels also increases and, accordingly, external dependency problem of economies becomes more critical, it has led to increased interest in renewable energy sources in wave energy.

Ocean energy is new compared with other renewable energy sources.IEA (2015) specifies five different ocean energy technologies under development aimed to extract energy from the oceans: tidal power, tidal (marine) currents, wave power, temperature gradients and salinity gradients. The most common energy originated from the ocean energy is wave and tidal.

MacKay (2009) declared that "sun makes wind and wind makes waves". Most of the sunlight hits the surface of the Earth and it warms the oceans. The warmed water warms the air above and then generates water vapor. As warm air rises, cooler air moves in to fill the void. In fact, wind is second-hand solar energy. As wind rushes across open water, it generates waves. Thereby, waves are third-hand solar energy.

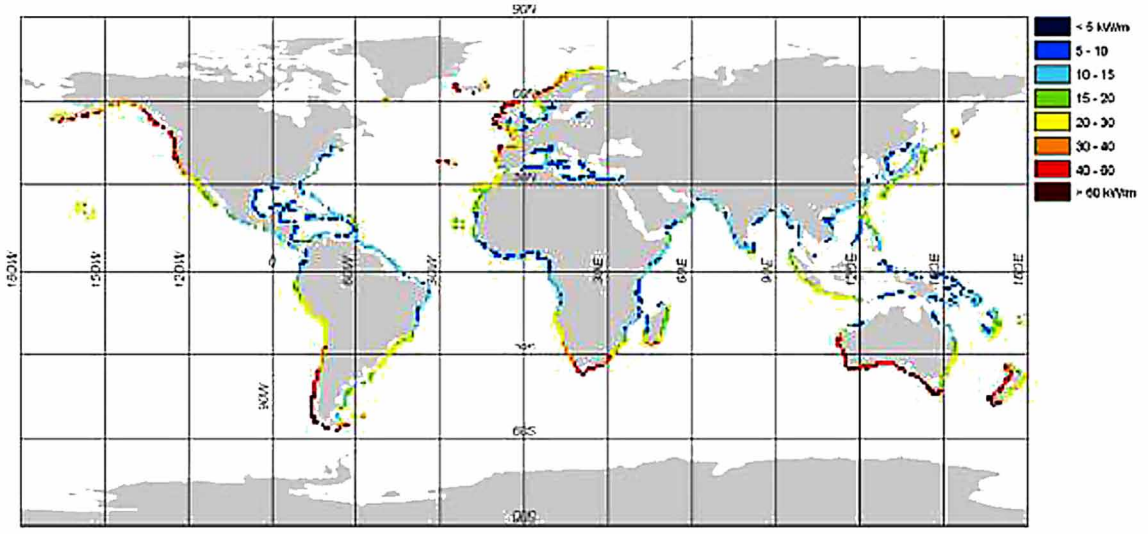
When wind blows across the sea surface, it transfers energy to the waves. This energy transfer provides a convenient and natural concentration of wind energy in the water near the free surface. Created waves can travel thousands of kilometers with little energy loss. The energy fluxes occurring in deep sea waves can be very large. The power of a wave is proportional to the square of the amplitude and to the period of the motion (Clement *et al*., 2002, p. 408).

Wave energy is found in nature just like other renewable energy sources. It is sustainable and, on the contrary, fossil fuels do not emit greenhouse gases. Thereby, it is "clean" energy sources. Wave power offers the form of ocean energy with the highest deployment potential in European waters, which is related to a global potential 30 times higher than tidal energy (Magagna & Uihlein, 2015, p. 31).

World Energy Outlook (2012) states that electricity generating marine energy, including wave and tidal power, is expected to increase to 60 TWh in 2035 (IEA, 2012, p. 230).Wave energy power is enormous and more reliable than other renewable resources such as solar and wind energy because its density 2–3 kW/m^{2}is greater the wind 0.4–0.6 kW/m^2 and the solar 0.1– 0.2 kW/m^2 (Lopezandreu *et al.,* 2013, p. 414).Global wave energy resources are estimated at 17 TW h/year (Lund, 2007, p. 920).Annual net wave power worldwide is shown in Figure 1.

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Figure 1. Annual net wave power worldwide
Source: Copyright from Mork et al. (2010).



**For a more accurate representation see the electronic version.*

According to Figure 1, the largest power levels occur on the western coasts. In Europe, the largest waves occur in Scotland and Ireland. In America, the largest waves occur in Oregon, British Columbia and Alaska; in the Southern Hemisphere, it is Chile, South Africa, Australia and New Zealand.

Vining and Muetze (2009) suggested there is about 8000–80,000 TWh/yr or 1–10 TW of wave energy in the oceans; thus, it provides more available energy sources per square meter than either wind or solar energy. Table 1 shows the capital cost comparison with renewable energy sources. According to Table 1, wave energy comes after wind and solar energy.

Table 2 illustrates the operating cost comparison with power sources, respectively. Table 2 clarifies that wave energy has costs comparable with the other energy sources. As a result, the cost of wave energy is competitive with other sources when it is used as a primary power source.

Levelized electricity costs for electricity generation by renewable and nonrenewable technologies are shown in Table 3. Marine resources consist of tidal streams and wave technology. In this group, wave energy is less costly than tidal energy. Further, wave energy may compete with other energy sources.

Wave energy offers significant benefits over other renewable energy sources. These are (Fadaeenejad *et al.,* 2014, p. 346):

Table 1. Capital cost comparison with renewable energy sources

Energy Source	Cost as Primary Source (100MW)	Cost as Secondary Source (1MW)
Coal Plants	1,500-3,500	-
Fuel Cells	-	5,000
Wind/Solar	4,000	8,000
Wave	2,300	6,200

Source: Viningand Muetze (2009).
Not: In 2001 Dollars per Kilowatt

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Table 2. Operating cost comparison with power sources

Energy Source	Cost as Primary Source (100MW)	Costs as Secondary Source (1MW)
Solar	10-15	25-50
Diesel	-	12-100
Wind	5-6	10
Fossil Fuel	3-5	-
Wave	3-4	7-10

Source: Vining and Muetze (2009).
Not: In 2001 Cents per Kilowatt

Table 3. Levellized[1] electricity costs (in Europe Cent, kWh) for electricity generation by the renewable and non-renewable technology

Source	Technology	Current Costs	Expected Future Costs beyond 2020
Coal	Grid supply	3-5	-
Gas	Combined cycle	2-4	-
Fossil Fuels	Average	8-10	-
Nuclear		4-6	3-5
Solar	Thermal electricity	12-18	4-10
Geothermal	Electricity	2-10	1-8
	Heat	0,5-5,0	0,5-5,0
Wind	Onshore	3-5	2-3
	Offshore	6-10	2-5
Marine	Tidal stream	8-15	8-15
	Wave	8-20	5-7
Biomass	Electricity	5-15	4-10
	Heat	1-5	1-5
Biofuels	Ethanol	3-9	2-4
Hydro	Large scale	2-8	2-8
	Small scale	4-10	3-10

Source: Owen. (2006).
Note: Capital costs decrease moderately with technical process. It may be offset by an increase in the real price of fossil fuels. So its expected future costs are not known exactly.

- Wave energy has the highest energy density;
- Wave energy has minor negative environmental impacts;
- Wave energy is predictable;
- Wave energy satisfies electricity demand changes;
- Electricity power extraction from wave energy is continuous 90% of the day, but that ratio is 20% and 30% for wind and solar energy.

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Wave Energy Converter (WEC) Technologies and Their Classification

Recently, increasing demand for energy has inspired acceleration for the development of wave energy around the world, which will lead to further development of wave energy converters (WECs) or wave farms. In the wave energy generating systems, there is a mechanism that changes the motion of the water into electricity (Copping *et al.,* 2014, p. 5).

WECs are different from wind turbines. An offshore wind farm's capital expenditure spent on electrical infrastructure is between 20% and 25%. Thus, the ratio is expected to be the same with wave energy. It may have various peaks in the average ratio in the same area. Thus, WECs must tackle resources with a high peak-to-average ratio. For instance, if WEC has a rating of 1MW and a capacity factor of 30%, the average annual output would be 300 kW. If the same WEC had the same average annual output but a capacity factor of 10%, WEC would have a peak rating of 3 MW (Sharkey *et al.,* 2013, p. 58).

According to Lok *et al.* (2014) despite irregular waves, WEC's average energy power output is predicted within 11%. In this study, irregular waves are defined as frequencies less than 3 hz and wave heights bigger than 30mm.

Allan *et al.,*(2011)claimed that the levelized costs of wave generation are £190/MWh. Trust (2006) found that the long-term learning rate in cost of energy for wave energy converters is possibly between 10% and 15%. Wave technology construction cost means first production models of between £1700/kW and £4300/kW. Furthermore, they estimated that £3622/kW for wave lines. They also suggested component costs for wave generation in the United Kingdom (Table 4), along with costs used for 1 MW wave generation.

Astariz & Iglesias (2015) submitted that the costs of wave energy (especially offshore wave energy farms) are divided into five categories. The main costs and rate in a wave energy plant areas follows: preparation costs about 0.26%; initial investment about 34.68%; replacement costs 24.81%; operations and maintenance costs about 40.19% and decommissioning costs about 0.07%.Yumurtacı & Bekiroğlu (2005) claimed that the installation cost of wave energy is about 1200–2000 $/kW, the unit energy cost range of wave energy is 2.70–3.60 cent/kwh and the yield of wave energy is 91%.

Table 4. Component costs used for 1 MW wave generation

	Total (£000s)	**%**
Onshore transmission and grid upgrade	36.22	1
Undersea cables	181.12	5
Spread mooring	362.24	10
Power conversion module	1847.44	51
Concrete structures	724.88	20
Construction facilities	144.88	4
Installation	144.88	4
Construction management	181.12	5
Total	**3622.44**	**100**

Source: Allan et al. (2011).
Note: Variables in 2006 prices, £000s and % of total costs.

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THE ENVIRONMENTAL AND ECONOMIC IMPACTS OF WAVE ENERGY: THE ISSUE OF EXTERNALITIES

This part of the study will examine the environmental and economic impacts of wave energy. Also, the issue of externalities in wave energy technology is evaluated.

Environmental Impacts of Wave Energy

Water is the most concentrated source of renewable energy on Earth. Wave energy is a type of solar energy. Wave energy has many advantages: stable resource, predictability, low visual impact and no fuel input or carbon emissions or price volatility (Klure, 2007, p. 5).

WECs practices are limited; for this reason, its effects on habitats is not known exactly. So, the installation site must be chosen carefully; otherwise, it may affect fishing and other uses of the sea. Langhamer et al. (2010) suggested that WECs environmental effects typically emerge in the five-year period after construction. Fridandoeni *et al.* (2011) claimed that WECs had only small direct impacts on the benthic community. All wet renewable energy devices represent a significant and clear resource and have potential to deliver low carbon energy.

According to Fadaeenejad *et al.* (2014) wave energy application in offshore islands would have positive impacts on the tourism industry because, in these islands, there would be successful sustainable development and maintain high-quality environment. The Electricity Innovation Institute (2004) also suggested that the sheltered water behind WECs may ensure attraction to some water sports: for instance, scuba diving and canoeing. Thus, WECs have important and positive impacts on recreation and tourism. When wave energy converters are established in the sea, the efficient agricultural area will not disappear. Also, Bedard (2007) claimed that, because of deployment, operations, maintenance and decommissioning, wave energy would be one of the most environmental-friendly electricity-generation technologies.

There are those who argue the negative impacts of wave energy. Copping *et al.* (2014) stated that the underwater sound from the installation and operation of wave energy converters (WECs) could harm marine animals. However, WECs would constitute approximately 3%–15% of incident wave energy. Thus, this decrease will cause wave shoaling and sediment transport (Leeney *et al.,* 2014, p. 14).

Wave energy has positive and negative environmental impacts. Table 5 summarizes the environmental impacts of wave energy devices.

Table 5. Environmental effects of WECs

The Type of Environmental Impact	The Rate of Impact
Land Use	Weak
Construction and Maintenance	Weak
Coastal Erosion	Weak or Medium
Fish	Weak
Noise	Weak

Source: Fadaeenejad et al. (2014).

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Environmental impacts of wave power generation are similar in many ways to those of offshore wind power generation. These include (Gill, 2005, p. 611; Leeney *et al.,* 2014:, p. 14; Electricity Innovation Institute, 2004, p. 3; McMurray, 2007, p. 25):

- Ecological-based mitigation;
- Noise and visual appearences;
- Alteration of currents and waves;
- Coastal sedimentary interaction;
- Emission of electromagnetic field;
- Recreation and tourism.

Emissions Benefits of Wave Energy

In recent years, because of increasing emphasis on global climate change, governments have tended to reduce the emission of greenhouse gases. Thus, governments have begun to prefer renewable energy sources. Wave energy is considered as an alternative to wind energy.

Fossil fuels emit several pollutants linked to environmental problems such as acid rain, urban ozone and global climate change. Wave energy is represented by social benefits over traditional fossil fuel generation options. These social benefits of wave energy include (Bedard, 2007, p. 48):

- Providing a new, environmental friendly and easily assimilated grid;
- Avoiding plague so many infrastructure projects;
- Reducing dependence on imported energy supplies and the risk of future fossil fuel price volatility;
- Reducing emissions of greenhouse gases;
- Promoting local job creation and economic development.

Subsequently, wave energy devices do not produce gases harmful to environment when they operate electricity production. Wave energy technology could help to reduce the emission of these gases.

Economic and Socio Economic Impacts of Wave Energy

Bedard (2007) submitted that wave energy is an emerging technology; thus, its economic opportunities are important. The minor investment by governments could stimulate the energy industry to increase economic output and employment. Furthermore, compared with wind and solar energy, wave energy is potentially more easily assimilated into the grid. According to EPRI estimates, U.S. wave resource potential could be associated with 6.5% of 2004 U.S. national electricity energy demand (Bedard, 2007, p. 44).

Wave energy ensures substantial contribution to an affordable electricity price in the long run. A country's high dependence of fossil fuel imports leads to energy diversity. Thus, they have considered renewable energy sources such as wind, wave, etc. This also may increase domestic energy supplies. Among these renewable energies, wave energy increases demand for local added value. However, an economic least-cost option is an important market barrier for wave energy (Sorensen & Naef, 2008, p. 27).

Table 6 summarizes the drivers and barriers related to wave energy. Consequently, wave energy technology stimulates employment (especially, it ensures local job creation), economic development and output. Wave energy has a significant potential for positive economic impact and job creation. Based on

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Table 6. Summary of drivers and barriers related to wave energy

Driver	Onshore	Offshore
Guaranteeing Economically Viable Prices	S.P.D.	S.P.D.
Guaranteeing Security of Supply	S.P.D.	S.P.D.
Climate Protection	S.P.D.	S.P.D.
Enforced Direct Market Support	S.P.D.	S.P.D.
Research and Development (R&D) Spending	P.D.	P.D.
Very High Potentials Worldwide	P.D./ S.I	S.P.D.
Sea Use Competition	S.I.D.	I.D. / S.I
Aiming at Conflict Neutral Technologies	P.D.	P.D.
Increasing Demand for Local Added Value	P.D.	P.D.
Potential for Technology Export from Europe	P.D.	P.D.
Short-term Objective of Least Costs of Electricity	I.D.	S.I.D.
Preferring Non-Intermittent Electricity Suppliers	P.D.	P.D.
Advanced Side Applications and Side Products	S.P.D.	S.P.D.
Restricted Production Capacities	S.I.D.	S.I.D.
Development in Perception and Network Building	P.D.	P.D.

Source: Sorensen and Naef (2008).

Note: S.P.D.: Strong Pushing Driver; P.D.: Pushing Driver; S.I.D.: Strong Inhibiting Driver; I.D.: Inhibiting Driver; S.I.: Small Impact or Unclear Influence.

projections for installed capacity, by 2020, the wave energy sector will generate over 4000 jobs and, by 2050, these numbers will increase to 264,323 jobs (WAVEPLAM, 2010, p. 9).

Leeney *et al.* (2014) suggested that wave energy's potential impact on fisheries and fish habitats are evaluated within the socioeconomic category. The closing of a wave energy area may enhance fishing activities. It may provide fish breeding and growing. Thus, this could have spillover impacts onto other areas. These devices may help recuperate ethnic regions.

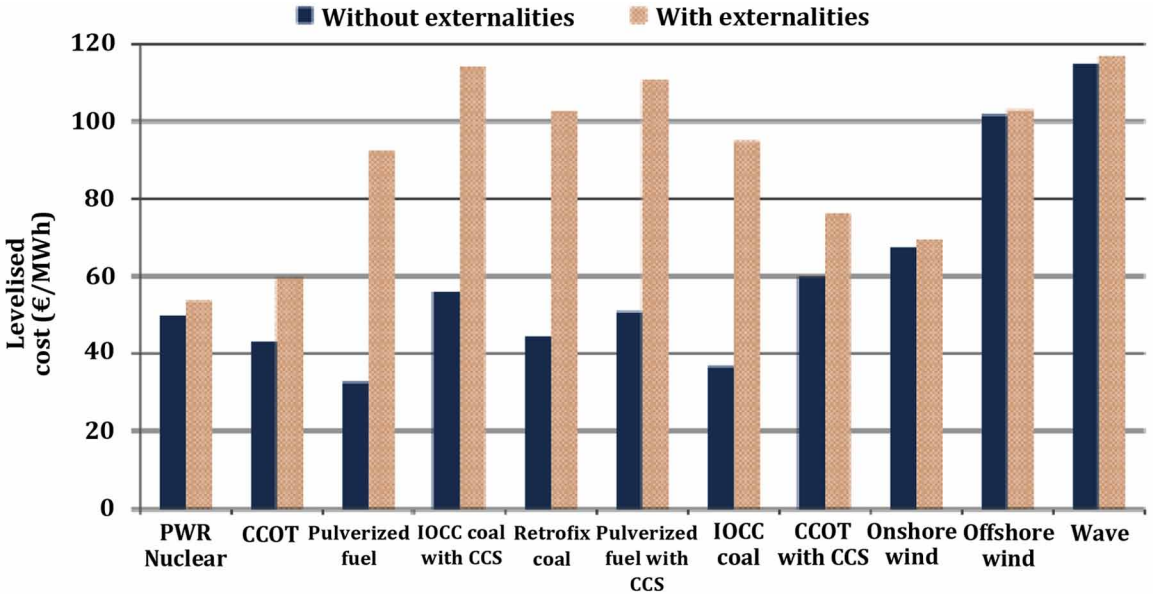
Accounting Some Externalities

Energy production has positive and negative impacts that must be considered in the total energy cost. This issue is known in the literature as externalities. Renewable energy sources have had a minor environmental impact due to minor externalities (Bedard, 2007, p. 48). In order to determine energy costs, externalities should be internalized. Therefore, the positive and negative impacts of energy production must be determined. For instance, carbon emissions in wave energy are estimated at about 6 gCO2/kWh, but the rate for conventional energy sources are about 250 gCO2/kWh. Thus, decline of 244 gCO2/kWh would be achieved by wave energy production. This should be included in the energy price of wave energy production. Furthermore, wave energy production supplies new jobs and these positive externalities should be considered separately. Figure 2 demonstrates the externalities in which technology is the most viable (Astariz & Iglesias, 2015, p. 7348).

Owen (2006) emphasized that the environmental externalities of energy production could be divided into two net costs categories:

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Figure 2. Levelized cost of different energy technologies including external costs
Source: Copyright from Astariz &Iglesias. (2015).



- Costs of the damage caused to health and environment by emissions of pollutants,
- Costs resulting from the impact of climate change. Thus, the argument of "polluter pays principle" would be to internalize as many of the externalities of energy generation in theory as possible (Owen, 2006, p. 636).

When considering wave energy installation, it also should be discussed with stakeholders. Potential negative externalities could be avoided or minimized (Bedard, 2007, p. 47).

WAVE ENERGY IN EUROPE: ITS GROWING ROLE IN RENEWABLE ENERGY POLICIES

The European Commission has identified the goal of a resilient Energy Union. A fundamental transformation of Europe's energy system will be required to achieve this goal. Renewable energy is essential to ensure this transformation. Moreover, it makes a contribution to all of the Energy Union's objectives: the delivery of security of supply, a transition to a sustainable energy system with reduced greenhouse gas emissions, industrial development leading to grow then jobs and lower energy costs for the EU economy (European Commission, 2015a, p. 2).

The Renewable Energy Directive adopted in 2009 establishes an overall policy for the production and promotion of energy from renewable sources in the European Union. It requires the EU to carry out at least 20% of its total energy needs with renewable energy by 2020. All EU countries also must guarantee that at least 10% of their transport fuels come from renewable sources by 2020 (European Commission, 2009, p. 1). The achievement of these 2020 targets cannot be met only with a single renewable source,

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but a variety of renewable energy sources should be used simultaneously. Diversification of the energy mix is a major policy driver for renewables (IEA, 2015, p. 1).

The European Commission formed an initiative called Blue Growth to further benefit from the potential of oceans, seas and coasts. Blue Growth is the long-term strategy of the European Union. The aim of this strategy is to completely support sustainable growth in the marine and maritime sectors. Oceans and seas are drivers for the European economy and they have a great potential, which can be used productively for innovation and growth. Blue Growth focus areas are blue energy, aquaculture, maritime, coastal and cruise tourism, marine mineral resources and blue biotechnology (European Commission, 2015b, p. 1). EU's blue economy, including all economic sea-based activities, presents 5.4 million jobs and a gross added value of just under €500 billion per year. Seventy-five percent of Europe's external trade and 37% of trade within the EU is sea borne and most of (not all) this activity is intensive around Europe's coasts (European Commission, 2012, p. 3).

The European Union is considered for test sites for developed or partially funded wave energy by local governments. To promote wave energy development in the European Union, the Marine Renewable Commercialization Fund (MRCF) for Wave First Array Support Programme was founded. The fund was made available when wave energy Technologies would not have been able to supply the needs for UK MEAD (The United Kingdom Marine Energy Array Demonstrator) funding. The purpose of this schedule is to fund projects that should help wave energy technology to improve its commercialization (Magagna &Uihlein, 2015, p. 39).

European industry in the global ocean energy market is currently strong. Many EU member states have researched wave energy and a number have had wave energy devices in their waters. A great number of developers have invested in wave energy R&D and creating projects. Whereas more than 100 wave energy developers were declared in 2011, EMEC declared that, for the time being, there are 254 wave energy developers all around the world. About 45% of wave energy developers are presently based or are developing projects in the EU (EMEC, 2015, p. 1; Magagna & Uihlein, 2015, p. 36).

The most convenient zones to use wave energy technologies in Europe are across the Atlantic Arc, the stretch of coastline facing the Atlantic Ocean. Other areas also have potential for future developments, but they submit limited resources compared with the Atlantic Ocean. 10 countries have been chosen as high potential areas for the development of wave and tidal energy (marine) energy technology: the United Kingdom, France, Portugal, Ireland, Spain, Denmark and Norway. Some of the strongest currents the world over are found around Orkney, PentlandFirthand Anglesey in the United Kingdom (Magagna & Uihlein, 2014, p. 31; Corsatea & Magagna, 2013, p. 8). Another report prepared by the Marine Institute and Sustainable Energy Ireland expressed that "Europe's accessible wave power resource is calculated to be of the order of 320,000 MW with the highest resource available on Earth west of Ireland" (SEAI, 2005, p. 2).

Table 7 shows the estimation of total contribution expected from ocean, wave, tidal and offshore wind. These predictions reflect the 2020 targets of selected EU member countries.

Some EU member states have wave power installed capacity: for example, 4.3 MW in UK; 0.15 MW in Sweden; 0.25 in Denmark; and 0.7 MW in Portugal. Sweden has several developers of wave energy; one of them is Seabased, the world's largest wave energy plant, at about 10 MW. The first MW was enabled during 2013 and the remaining 9 MW during 2014.It has been considered that approximately 400 units will be deployed on the Swedish west coast. Commercial delivery is expected from 2015. At an estimated cost of energy of €5 cents per kWh, it will be commercially viable without any subsidies. The prototype of wave energy has been tested in Denmark. These prototypes are made up of 39 kW energy

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Table 7. Estimation of total contribution expected from ocean, wave, tidal and offshore wind to meet the 2020 targets (MW)

Member State	Source	2010	2013	2014	2015	2017	2020
France	Ocean, Wave, Tidal	240	271	287	302	333	380
	Offshore Wind	5542	8512	9572	2667	4000	6000
Ireland	Ocean, Wave, Tidal	0	0	0	0	13	75
	Offshore Wind	0	0	0	0	125	500
Portugal	Ocean, Wave, Tidal	5	10	35	60	100	250
	Offshore Wind	0	0	0	25	25	75
Spain	Ocean, Wave, Tidal	0	0	0	0	30	100
	Offshore Wind	0	0	50	150	1000	3000
UK	Ocean, Wave, Tidal	0	0	0	0	400	1300
	Offshore Wind	1390	3470	4450	5500	8310	12,990

Source: O'Hagan et al. (2015).

power (Ernst& Young, 2013, p. 4). The United Kingdom is a global leader in wave energy and wave energy devices. In the United Kingdom, there were 31 WECs under development in 2007. In 2012, 14 wave devices totaling 3.6 MW were deployed for testing. Therefore, increasing the commercial visibility of the WECs needs to be commercially viable with financial subsidies (Lok *et al.,* 2014, p. 2). Ireland and Portugal aimed to achieve at least 500 MW energy from wave energy by 2020. Portugal wants to be a market leader in wave energy technology. Therefore, Portugal supports wave energy projects and has implemented tariffs and policies for this energy source (Dalton *et al.,* 2009, p. 4).

The United Kingdom has ensured revenue support with the renewable energy obligation credits method for wave energy industry. The renewable energy obligation credits price is nearly £0.045. In the United Kingdom, the incentives for wave energy are two renewable energy obligation credits on top of the market price (£0.09/kWh). However, Ireland has a program of tax relief of corporate investment for wave energy (Dalton *et al.,* 2009, p. 3). There was the Wave Hub Project, which was launched in 2010 off the northern coast of Cornwall in England. The Wave Hub Project is proposed to set up a wave farm demonstration and assessment site off the coast (Drew *et al.,* 2009, p. 892).

Wide scale wave energy technologies will be further developed and commercialized. Therefore, governments should give priority to national support programs and national innovation systems. On the other hand, firms that are related to wave energy may consider that foreign opportunities as an entrepreneurial strategy to overcome capital barriers. Companies do not only search for subsidies but also national innovation systems. Thus, policymakers should take an active stand to support the development of the wave energy industry (Løvdal & Neumann, 2011, p. 1094).

Vining and Muetze (2009) asserted that the most common incentives for wave energy are as follows;

- **Property Sales Tax Reduction:** These take part in indirect cash incentives. The property tax affects wave energy developers; thus, by reducing these taxes, wave energy can be promoted.
- **Project Loan Guarantees:** These incentives take part in low-cost debt financing incentives. They are an alternative to subsidized loans. This helps wave energy to obtain credit for financing.

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Andor and Voss (2014) analyzed the optimal promotion instruments and policies for all the renewable energy. Furthermore, the optimal promotion schemes are the demand independent fixed feed in tariffs, which are popular in many countries. If positive externalities arise from the production and installation of wave energy capacity generation based instruments, then feed-in tariffs are suboptimal. Instead, the optimal promotion scheme for wave energy is a capacity subsidy. This subsidy is equivalent to the externality that would maximize welfare.

For example, early R&D activities in the wave energy sector of the past decade relied on significant private investment, with some grant support from EU institutions and member states. Governments have recognized that the wave energy sectors can be major players in meeting EU energy targets, security and jobs. Thus, the United Kingdom has revealed financial subsidies for public grants and private equity of technology push and market pull mechanisms such as feed-in tariffs. This has attracted significant investment in UK companies and test centers from across Europe. Ireland has put capital and revenue subsidy programs to develop wave energy market activities. In Ireland, this subsidy has generated the opportunity to secure grants from the European Commission's Horizon 2020 program. This subsidy mechanism has been assisting EU member states to set the appropriate tariffs to suit domestic aims, market conditions and progress on cost reduction for wave energy technology. These incentives have pulled down the cost curve without penalizing progress (SI Ocean, 2014, p. 19).

WAVE ENERGY STATUS AND OPPORTUNITIES IN TURKEY

There is no industrial electricity generation from wave energy in Turkey. But wave energy potential has a significant potential in renewable energy sources. Furthermore, wave energy is economical and is waiting for further evaluation. Therefore, generation of electricity from wave energy issues should be discussed. Few studies in the literature are related to wave energy in Turkey. Mostly, these studies discuss wave energy potential and identify the best areas for wave energy in Turkey. In this part of the study, we consider briefly the wave energy potential in Turkey. Then, we discuss public policy and incentives for wave energy.

In Turkey, especially in the Aegean Sea and the Mediterranean with the wind potential of about 4–17 kW/m annual average, sea waves are emerging as the most appropriate place for the production of wave energy. The best place between Izmir and Antalya region will benefit from wave energy. However, the area between Dalaman-Finike is suitable for the generation of electricity from wave energy; too. Regional average wave intensity in Turkey is shown in Table 8 (Sağlam & Uyar, 2005, p. 3; Alptekin, 2014, p. 22). According to Table 8, wave energy potential regions in Turkey are İzmir-Antalya, Aegean Sea, Mediterranean, Black Sea and Marmara.

The total coastline of Turkey is 8210 cm. In other words, it is assumed that one fifth of coastline can be used to obtain energy from sea waves. Thus, the wave energy technical potential is estimated to be 18.5 billion kWh, which is approximately 13% of Turkey energy needs. Thus, wave energy is higher than expected. Moreover, Uygur *et al.* (2004) assumed that, because of wave formation, the Black Sea region is the most fertile area. They also claim that earthquakes increase the average wave height and this situation makes a direct impact on wave power capacity.

Sağlam and Uyar (2005) suggested that only a small-scale wave converter can be producing approximately at least 10 TWh/year energy. This rate is between the annual 4–7 kW/m water wave power. This

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Table 8. Wave energy potential in Turkey

Region	Power
Black Sea	1,96-4,22 kWh/m
Marmara Sea	0,31-0,69 kWh/m
Aegean Sea	2,86-8,75 kWh/m
Mediterranean	2,59-8,26 kWh/m
İzmir-Antalya	3,91-12,05 kWh/m

Source: Sağlam and Uyar (2005).

is 12.5% of the hydropower potential of Turkey. Sağlam and Uyar (2005) also claim that Kalkan is the best area of wave energy; Kalkan has about 6.6–7.6 kW/m wave power density.

The best places conceived to generate wave energy are west of the Black Sea, north of Bosporus, southwest of the Aegean Sea and between Marmaris and Finike. These waters are considered to be suitable for initial experiments. Thus, investors should prefer these areas (Sağlam & Uyar, 2005, p. 4; Alptekin, 2014, p. 22). According to Özdamar (2000), the average wave power of Çeşme is changing between 7.16–39.66 kW/m. This rate is considerably higher than the average for the Çeşme. Additionally, the average wave power of the Black Sea would be expected to be higher than Çeşme (Örer *et al.,* 2003, p. 4).

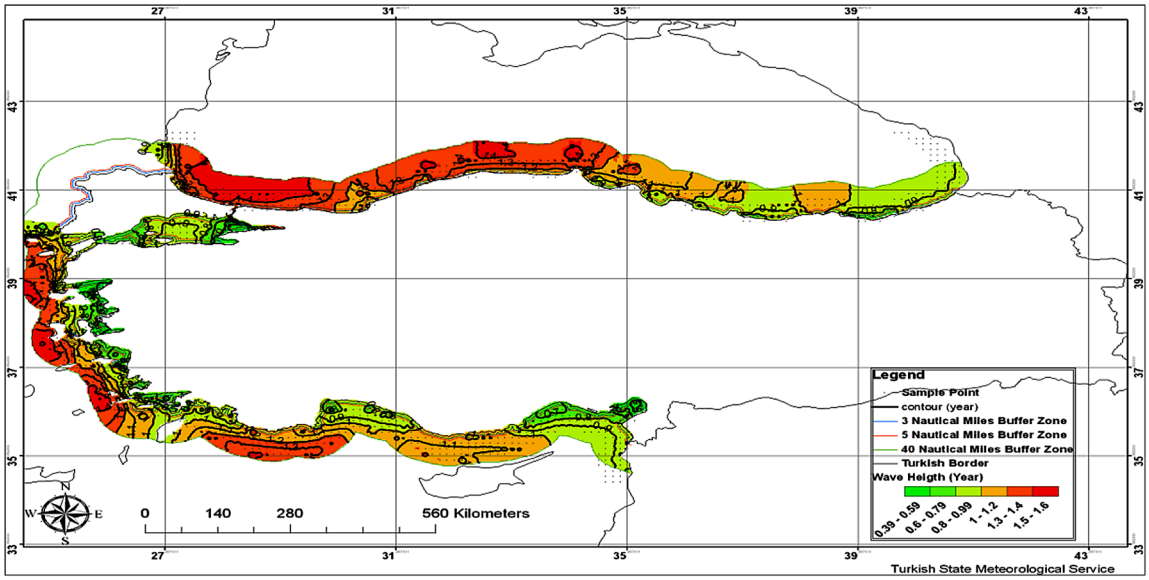
Güngör (2013) assumed that 33% of the Mediterranean coastal strip (not suitable for tourism field) could produce electricity from wave electricity generation. This could supply 20% of electricity needs of the Mediterranean region. The platform, which will generate electricity from wave energy, should be built in the Tisan, Boğusak, Kumköy and Özlü regions. Such a wave energy platform may provide a contribution of around $200 million to the regional economy. With these systems, energy can be provided to consumers at 5 cents and when producing wave energy, the cost of energy can be calculated as follows: 3 cents for the repayment of the investment, 1 cent for the maintenance and costs and other 1 cent for profit. The cost of a 3 megawatt wave energy platform can be around $5.9 million.

With cooperation of the National Boron Research Institute (BOREN), the General Directorate of Turkish Electro mechanics Industry (TEMSAN) launched the Electricity Generation from Wave Energy project in 2008. This project carried out the design of a system that converts electrical energy to the movement of sea waves. Wave energy production system field test studies were performed in Karasu-Sakarya. It takes about 20 days at the end of the fieldwork. Eventually, 5 kWh electricity production per day had been successfully realized. If industrial production in the project of designing the wave energy systems is carried out, electricity demand in the residential area of Turkey's coast can be met by wave energy, which is a clean, limitless energy source and environmental friendly. Boron magnets, which are used in wave energy systems, will increase domestic boron consumption, thus adding value and creating employment opportunities which will contribute to the national economy (Press Release, www.boren.gov.tr).

Generation of electricity from wave energy for determining the Karasu district is shown in Figures 3 and 4, respectively. Figure 3 illustrates that annual period; the probabilities of occurrence in areas of wave height are at least 10%. Figure 4 shows the annual average wave height map. Figure 3 and 4 also state that the Black Sea is the best region for wave energy. In other words, Kırklareli, Istanbul, Kocaeli, Sakarya, Düzce, Zonguldak, Bartın, Kastamonuand Sinop are suitable for wave energy. Moreover, the coast of the Aegean Sea is suitable for electricity generation from wave energy.

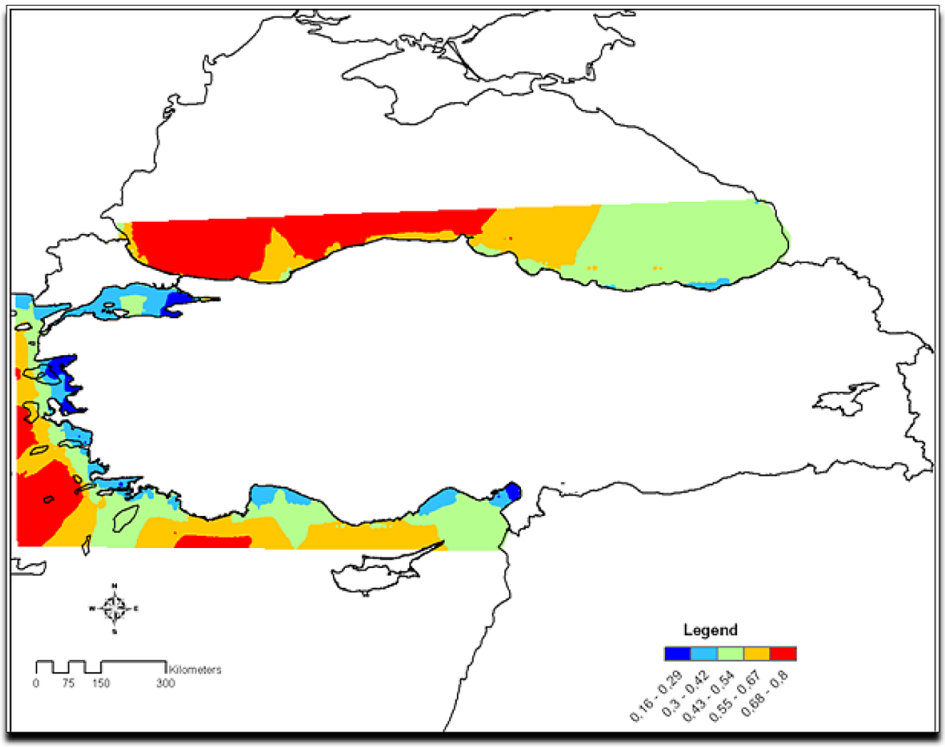
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Figure 3. Annual periods: The probabilities of occurrence in areas of wave height at least 10%
Source: Turkish State Meteorological Service, http://www.mgm.gov.tr/
Note: Wave height in red region is above 1,5m; Bosphorus output 1,4m, Off the Sinop 1,4m, Agean 1,6m.



**For a more accurate representation see the electronic version.*

Figure 4. Annual average wave height map
Source: Turkish State Meteorological Service, http://www.mgm.gov.tr/



**For a more accurate representation see the electronic version.*

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Electricity generation from wave energy is not only for corporate alliances but also for individual initiatives in Turkey. For example, an engineer, Çoktan from Turkey, started a model working in "the Black Sea Ereğli" district in 2004. Çoktan appealed for support to his project. But, the project was ended due to financial problems (Çoktan, 2009, p. 1). Another engineer, Güneş from Turkey, created a domestic device to generate electricity from sea waves. He did his first work in the Akçakoca district in Turkey in 2011; he generated 1.5 kWh electricity. However, Güneş could not get support to increase the device's capacity (www.enerjienstitusu.com).

There is also the legal infrastructure related to renewable energy in Turkey. The 4628 Electricity Market Law was enacted in Turkey in 2001. This law generated two policies and precautions related to renewables. First, the law has reduced costs associated with reducing total license fees or the license for construction and renewable energy facilities are exempt from license fees for the first eight years following the completion date. Second, the Turkish Electricity Transmission Company (TEIAS) and distribution companies are required to give priority status for renewable facility system connections. Turkey has enacted its first special law on renewable energy in 2005 (Law Number 5346).

The Renewable Energy Law No 5346 regarding Renewable Energy Resources for the Generation of Electric Energy is dated 10 May 2005. In this law, renewable energy resources are defined and some incentives are introduced. Renewable energy resources are within the scope of this law. Electrical energy generation resources suitable for wind, solar, geothermal, biomass, biogas (including landfill gas), wave, current and tidal energy resources together with hydraulic generation plants either canal or run of river type or with a reservoir area of less than 15 square kilometers. The law is applicable for a period of 10 years for production licenses subject to the RES support mechanism that are or will be commissioned as from 18.5.2005 when this law was enacted, until 31.12.2015. The feed-in tariff is provided in the rate of prices specified in the schedule of the law for 10 years (Law Number 5346).

A feed-in tariff in Turkey has a relatively low rate and is given in a limited time when compared with other countries. Thus, investors have preferred not to invest or prefer to sell their products in the spot market. Changes made in the law (Law Number 5346) in 2010: tariffs have been differentiated according to the type of technology. Payment of premiums has been brought by law. This payment is for projects using domestic technology during the first five years (Acar *et al.,* 2015, p. 12-13). The incentives have been increased by the 5627 Energy Efficiency Law enacted in 2007 and by the changes in the 5784 Electricity Market Law in 2008. Finally, the 6446 Electricity Market Law and the Regulations for Licensing and Supporting of Renewable Energy Resources based on the 6446 Law were introduced in 2013.

Correspondingly, the EU directive in the field of renewable energy, the Renewable Energy Action Plan, has been prepared by the Republic of Turkey Ministry of Energy and Natural Resources: Renewable Energy General Directorate for the period of 2013–2023.As stated in this action plan, Turkey is aimed to meet at least 30% of total electricity demand with the renewable energy by 2023. It is planned that 10% of the requirements of the transportation sector will be met by renewable energy by 2023. Turkey aims to reduce by at least 20% energy intensity, namely, the amount of energy consumed per unit GDP in the year 2023 (MENR, 2014, p. 10).

Renewable energy investments are subsidized within the scope of the General Investment Incentive Plan. Exemption of value added tax and customs duty and income tax withholding supports are ensured providing investment should be in the district[2] (6th District) which would gain the highest support in Turkey. Financial support, including the licensing process and allocation and electricity purchase issues and other supports are prescribed for the purpose of development and facilitating operation of renewable

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energy projects (Acar *et al.,* 2015, p. 13). But this subsidy should be extended to the districts that are appropriated for generating electricity from wave energy. Because, apart from the 6. district, all other districts include a county that is suitable for wave energy. Therefore, it should be applied as an exception to the wave energy subsidy in the General Investment Incentive Plan.

An annual license fee is charged according to installation power of facilities from the production facilities producing electricity in the scope of license regulations in Turkey. Energy production facilities from renewable sources are exempt from the license fee for the first eight years. In later years, they will pay 10% of specified value (Eser & Polat, 2015, p. 219).In addition, while license applications are assessed, applications of the facilities making production from renewable resources have been given priority by the (EMRA, 2013, p.5346 article 6/C).In other respects, renewable energy production facilities that have installed power under the 500 kWh have no obligation to obtain a license and establish a company. However, facilities can buy and sell their products with the support of the feed-in tariff to the energy distribution companies (Delolite, 2011, p. 27).

Wave energy is solely mentioned as a type of renewable resource. In the laws and regulations about electricity production from renewable energy, currently there are no licensed operations in Turkey that generate electricity from wave energy. But, according to Figures 3 and 4, industrial production of wave energy can be carried out in Turkey. Turkey has great potential and the work of obtaining electricity from wave energy in Turkey has gained momentum in recent years.

All attempts had to stop because sufficient support could not be provided. Renewable energy projects that are subject to R&D should be supported by governments or private and/or state-owned institutions. Turkey needs to significantly increase the annual wave energy R&D budgets. Besides one of the barriers of entrepreneurs is that financial support is usually given after spending. Providing flexibility should be useful in this area.

Furthermore, governments can consider public and private sector partnerships. Due to the impact of neoliberal currents, many countries have tended to public and private sector partnerships mostly to ensure the sustainability of the provision of infrastructure services or to provide services to the public. Public and private sector partnerships are seen especially in areas such as transport, energy, infrastructure, public safety, waste management and water distribution. To the development of wave energy, public and private sector partnerships can be considered as an alternative.

Government incentives vary according to the maturity of the market. Investments incentives are more appropriate for the immature markets such as the wave energy market and for the new technologies being developed (Delolite, 2011, p. 10). Investments related to renewable energy resources in Turkey are mostly ensured by the private sector. Stimulation of these investments, renewable energy resources are made possible with the assistance given by the government of production and consumption (Karaca & Erdoğdu, 2012, p. 23). The consistency and relevance of different policy and economic instruments are important for investment in Turkey. A framework of consistent financial support, capital grants, clear consenting procedures and timely grid access will create the secure investment environment the industry to grow. One of the steps for the government is to set Renewable Portfolio Standards (RPS) requiring utilities to ensure a certain percentage of electricity from renewable sources in coming years. Therefore, RPS might gradually become more important drivers of the wave energy industries than are tax subsidies (Erdoğdu & Karaca, 2014, p. 82).

However, governments can grant some incentives for wave energy in Turkey. These incentives may be market push, market pull, indirect and direct cash assistance, low-cost debt financing and customer

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choice. Moreover, governments should grant tax incentives: for example, excise duty, value added tax, energy tax exemptions. This type of tax incentives may increase wave energy demand. If the investment subsidy in wave energy is given priority, it can increase wave energy projects.

CONCLUSION AND POLICY RECOMMENDATIONS

Renewable energy sources are defined as energy that comes from resources that are naturally replenished. Renewable energy sources are composed of solar, wind, geothermal, biomass, wave, and tidal energy. Acceded to Kyoto Protocol, many countries are trying to get a big share from renewable energies. Turkey is no different in this respect and is following developments in wave energy all over the world.

Incentives for fossil fuels make renewable energy resources relatively costly. Through encouragement, renewable energy should become competitive with fossil fuels. Turkey should revise its national energy policy. Thus, more investment in clean and inexhaustible energy must be provided in Turkey, which is rich in terms of renewable energy.

With technological improvements and additional public support for the early stage of development, the ocean energy sector can develop a similar scale as off shore wind over time. Ocean energy currently is an infant industry, in which wave and tidal stream technologies are relatively less developed than other technologies.

The cost of wave energy is competitive with other sources when it is used as a primary power source. Wave energy has the highest energy density, minor negative environmental impacts, it is predictable, and it satisfies electricity demand changes. There is no need for fuel to produce electricity from wave energy and it does not create pollution in the stage of energy production. Operating and maintenance costs are very low. When compared with wind, the wind loses its power within a few minutes, but a wave can move thousands of miles.

The wave energy generating system transforms the motion of the water into electricity. Wave energy generating is known as wave energy devices (WEC). In other words, wave energy devices have many advantages. For example, it is a stable resource; it has low visual impact and no fuel input or carbon emissions or price volatility.

Wave energy ensures a substantial contribution to affordable electricity prices in the long run. Also, wave energy may increase domestic energy supplies and it may help to reduce current account deficits. According to the Turkish Statistical Institute data, the proportion of imports covered by exports averaged 64.1% in the period of 2000–2014. This is reported as 65.1% for 2014. In order to avoid energy imports and energy dependence and also to provide energy supply security, renewable energy sources, especially with the high capacity wave energy, should be further addressed. Hence, it will reduce external dependence comparatively in its production.

Furthermore, wave energy increases demand for local added value. Wave energy production creates new job areas. It may contribute to regional development and the tourism sector. The manufacturing, transportation, installation, operation and maintenance of wave energy facilities will generate revenue and employment. Thus, these positive externalities should be considered. It has also few or negligible negative externalities. However, its potential negative externalities could be avoided or minimized. These issues also should be discussed with stakeholders.

Although a few attempts and experiences exist, there is no industrial electricity generation from wave energy in Turkey. However, Turkey has potential due to its geographical location and it has capacity

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and experience to raise and develop a wave energy industry. It is suggested that the Black Sea is the best region for wave energy. In other words, Kırklareli, Istanbul, Kocaeli, Sakarya, Düzce, Zonguldak, Bartın, Kastamonu and Sinop are suitable for wave energy. Moreover, the Aegean Sea coast is suitable for electricity generation from wave energy in Turkey.

Industrial production of wave energy can be carried out in Turkey. Thus, wave energy should be encouraged. For this, governments first should increase R&D expenditures; wave energy converter projects also should be supported in this stage. Furthermore, governments can consider public and private sector partnerships. A variety of incentives can be implemented to provide financial support for wave energy. The incentives given for coal mining and production still have a significant size in Turkey. The incentives for fossil fuels make renewable energy resources relatively costly. Fossil fuel subsidies should be phased out gradually. Doing so may increase investment for wave energy and other renewable energy resources.

One of the most important fiscal policy instruments of a government is taxation. The incentive can be provided through tax reduction aimed at wave energy production. Reduction of the rate of corporation income tax to ensure getting into the market of wave energy production may be accomplished. Furthermore, national and/or international standards for wave energy devices can be developed. Thus, governments may provide incentives for electricity production from wave energy in Turkey. The government can establish capital grant investment subsidies. These financial incentives would increase demand for wave energy and could raise projects that are related to wave energy. The power of wave movements in the seas should be evaluated by establishing wave power plants; thus, it will contribute to the energy needs of Turkey. Consequently, incentives may promote industrial electricity generation from wave energy in Turkey.

Building successful policymaking for wave energy, thus establishing policy goals, is needed. The Republic of Turkey's Ministry of Energy and Natural Resources should establish a wave energy strategy group and it should get in contact with other departments of government. This strategy group should contain policies supporting innovation and manufacturing. Turkey has had political and economic stabilization for many years. The consistency of the government policies is crucial for implementing in Turkey.

In this context, government incentives aimed at electricity production from wave energy should be selected according to the conditions and maturity of the market. It seems imperative that the government should consider more incentive mechanisms to develop the wave energy industry.

Researchers might consider the following critical points for future studies: data that are related to wave energy converters should be collected, the performance of WECs should be observed, input–output and cost benefit analysis should be done, the adverse effects of WECs should be observed and assessed and governments should promote partnership agreements with the wave energy industry. Moreover, researchers, private sector managers and policymakers should work together toward early application of wave energy. The government should prepare national support schemes for wave energy, which should include the optimizing aim of the industry.

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ENDNOTES

1 It is the ratio of total life time expenses versus total expected outputs, expressed in terms of the present value equivalent.

2 1. District include: Ankara, Antalya, Bursa, Eskişehir, İstanbul, İzmir, Kocaeli, Muğla; 2. District include: Adana, Aydın, Bolu, Çanakkale, Denizli, Edirne, Isparta, Kayseri, Kırklareli, Konya, Sakarya, Tekirdağ, Yalova; 3. District include: Balıkesir, Bilecik, Burdur, Gaziantep, Karabük, Karaman, Manisa, Mersin, Samsun, Trabzon, Uşak, Zonguldak; 4. District include: Afyonkarahisar, Amasya, Artvin, Bartın, Çorum, Düzce, Elazığ, Erzincan, Hatay, Kastamonu, Kırıkkale, Kırşehir, Kütahya, Malatya, Nevşehir, Rize, Sivas; 5. District include:Adıyaman, Aksaray, Bayburt, Çankırı, Erzurum, Giresun, Gümüşhane, Kahramanmaraş, Kilis, Niğde, Ordu, Osmaniye, Sinop, Tokat, Tunceli, Yozgat; 6. District include: Ağrı, Ardahan, Batman, Bingöl, Bitlis,Diyarbakır, Hakkari, Iğdır, Kars, Mardin, Muş, Siirt, Şanlıurfa, Şırnak, Van, Gökçeada, Bozcaada. For detailed information can be viewed on http://www.invest.gov.tr

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Chapter 54
Interdisciplinary Approaches to Sustainable Development in Higher Education:
A Case Study From Croatia

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ABSTRACT

This chapter aims to test the positive change in students' sustainable behavior that is expected to be found under the influence of relevant subjects. Therefore, a simple quasi-experimental design was applied to test the differences between those groups of students who have not taken the subject Pedagogy of sustainable development and those who have. Since studies for primary school and preschool teachers at the Faculty of Teacher Education, University of Rijeka, Croatia are designed for building needed competencies in future educators, the case study was expected to determine statistically significant differences between those groups of students who have taken relevant subject and those students who have not. Finally, correlation analyses were run for relationship between life satisfaction, optimism, and sustainable behavior to be analyzed. Based on previous research studies and theoretical models, it was expected to determine significant positive relationship between students' sustainable behavior and their levels of life satisfaction and optimism. Both hypotheses are confirmed in this study. All findings are discussed in this chapter within theoretical models and future study guidelines. The results confirm the usefulness of the course Pedagogy of sustainable behavior within higher education of future educators, and its influence within positive change in their sustainable behavior. Besides, the expected positive relationship of life satisfaction and optimism with sustainable behavior was confirmed and so provided a platform for creating a suggestion of implementation of the interdisciplinary course/subject of Pedagogy of Sustainable development and Positive psychology.

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INTRODUCTION

Higher education represents one of the most important segments of society, and thus those expectations that demand of it the responsibility for the organization of all those activities that lead to the better, happier and more quality life of humankind are completely justified. Highly educated young people are those who create the future, and thus their actions are not only bound to their personal responsibilities – in addition, future teachers and educators are expected to take responsibility for the future behavior of the generations of teacher they will teach. Thus, it is of exceptional importance to create study programs that will directly influence the creation of competent and responsible teachers and educators, individuals that possess a readiness for lifelong learning and a positive outlook towards themselves, others, children and the environment the life inside. However, it is also of equal importance to leave enough free room within study programs for deliberation and contemplation, i.e. studying in the truest sense of the word, in which a critical approach can be used to discuss the development of (pre) school children, their needs and interests and how to satisfy them, and how to teach them and instill in them fundamental human values with the aim of producing individuals with fulfilled, satisfied and quality levels of to achieve sustainability. This is not an easy task, and thus all institutions that are the bearers of higher education are forced to grapple with this problem in one way or another.

This chapter has two main goals – the first pertains to testing the influence of the pedagogy of sustainable development on the creation of sustainable behavior among future educators and teachers. The second goal encompasses an analysis of the connections between this manner of sustainable behavior and the fundamental concepts of positive psychology, such as optimism and life satisfaction. Our expectations are that the results of both the analyses will allow for the formation of conclusions that can serve as the bedrock for creating an interdisciplinary approach to sustainable development in higher education, one that will also implement the fundamental principles of positive psychology. It is thus evident that the importance of this topic is reflected on the possibility of creating interdisciplinary connections between sustainable behavior and a pedagogical approach to education for sustainable development with the fundamental concepts from positive psychology. The results of the research completed point towards a significant possibility of the influence of the knowledge/information obtained through courses on sustainable development and their pedagogical context for the formation of more sustainable behavior in future educators and school teachers or educational workers. When viewed in this fashion, there is a justifiable basis for deliberating options for creating interdisciplinary courses as part of the education of teachers and thus creating a more innovative approach to practice in modern higher education institutions.

The development of courses for the initial training of educators/teachers conceived in this interdisciplinary fashion – with the pedagogical principles of sustainability on one side and the principles of positive psychology on the other – represent the foundation for innovation and deliberation on the means of approaching teaching for sustainable development in education. In addition, they are focused on stimulating a more quality, satisfied and optimistic way of life that are based on the satisfaction of the needs of present and future generations through the encouragement of more sustainable ways of thinking, acting and living and their transmission to educational practice.

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HISTORICAL BACKGROUND

The National Context

Developmentally speaking, a significant number of authors from the local science and research scene have deliberated the issues of ecology, environmental education, environmental problems and the concept of sustainable development.

Already in the 1970s and 1980s, the work of a large number of authors from the field of sociology bestowed significant attention upon issues pertaining to ecology and the environment (Dizdarević, 1974, 1987; Janković, 1976; Marković, 1986; Klepac, 1988; Čulig, 1987, 1991; Stanković, 1988; Čaldarović, 1989; Cifrić, 1989; etc.) and, in particularly from the 1990s onwards, with the concept of sustainable development (Kešina 2002; Pravdić, 2003; Rogić, 2003; Lay, 2001, 2005, 2008; Uzelac, 1990, 2010.). Research on environmental views and value dates back to the 1980s, and was mostly the focus of sociologists (Cifrić & Karajić, 1998) – the interest of scholars from the area of pedagogy and other similar areas only began to grow in the late 1990s. Cifrić, for example, studied the problem of environmental awareness among youth, the problem of responsibility and the individual everyday behavior of modern man in connection with environmental modes of behavior (1997, 1998.).

Many sociological studies were conducted: Šimleša (2008/2009), *Renewable Energy Sources in Croatia*; Lay (2009/2010), *Action Plan for the Sustainable development of Gacka and the City of Otočac*; Šimleša & Lay (2011), *The Sustainable development of Croatia: Development of Croatian national interests through the prism of the concept of sustainable development* ; Čolić (2007-2011), *The Cultures of Consumerism and Sustainability: Global Challenges to the Sociocultural Development of the Republic of Croatia*; Mišetić (2011), *Social Sustainability and Processes of Urban Transformation in Croatia*. The following publications are also used in the course The Pedagogy of Sustainable development: V. Lay, (2007), Eds., *Development for the Future: Contributions to Deliberation on Croatia's Sustainable development*; Geiger Zeman & Zeman (2010), *Introduction to the Sociology of (Sustainable) Communities*); Lay & Šimleša (2012), *The National Interests of Croatia as Viewed through the Concept of Sustainable development*. We wish to stress particularly Lay's (2005) concept on the development of integrated sustainability as a criteria for sustainable development as a project/process and the process of educating (for social values) and teaching (knowledge). For Lay (2005, p. 354) "deliberating on education and teaching processes and systems aimed towards achieving integral sustainability and sustainable development in Croatia is, even today, still an innovative and isolated intellectual affair". He gives his contribution to pedagogical deliberations on integral sustainability with his proposition on ten so-called "sheaves" of general content for educating and teaching integral sustainability and sustainable development: 1. Life and the living world is a fundamental value (the theory and practice of biocentrism instead of anthropocentrism, the issue of the culture of life, health, life, individual and collective self-realization, environmental safety instead of uncertainty and unsafety – a spiritual quest for a holistic life and a sustainable world); 2. Self-determination and action (towards greater benefit) as political principles, the theory and practice of the subject (individual, group, profession, society, country, etc.) as a social actor and creator of his own life and life quality; 3. Integrate sustainability: society, the environment/nature and the economy are interdependent (theoretical and social activities in the spirit of integral sustainability; environmental sensitivity – economic vitality – social welfare is three interconnected and interdependent layers of integrated sustainability); 4. The right of citizens and civil society groups to cooperate and participate in decision making; 5. The needs and rights of the generations to

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come; 6. Diversity – biological, economic, social, cultural – as a central lifestyle value that aims towards sustainability; 7. Sustainable development and the "load capacity" of the ecosystem; 8. Quality of life and justice in the distribution of chances for achieving a quality life; 9. Education and teaching for integral sustainability and sustainable development (learning about learning - adapting the content of curricula to different age groups and various cultural profiles) and 10. The tentativeness / limited nature of current knowledge on the principles of (un)sustainability/applying caution in action.

During the past few years, a certain interdisciplinary approach to research on this topic and a departure from the narrow areas of science can be observed. There has also been an increase in the number of studies in the areas of geography (Kuvedžić, 1999), economy (Sustainable development, Innovation and the Regional Policy of the Republic of Croatia, Starc, 2007; Ham, 2009), technical sciences, naval research (Kovačić, Bošković & Favro, 2006; Šerić & Luković, 2009), and, in particular, the area of tourism, where there is a wealth of conferences, research (Bučar, Škorić & Prebežac, 2010; Vukonić, 2010; Zlatar, 2010) and study programs at all levels of higher education.

As far as we know, studies on sustainable behavior have not been conducted in the national context of Croatia as of yet. In the area of pedagogical research, the studies that have been/are being conducted are largely based on testing the views of students and educational workers. In the context of pedagogical research, it ought to be stated that local authors have been mostly dealing with the issues of changes in schools and the influence of current social developments on the role of the school today and in the future, and with the issues of the development and implementation of the concept of education for sustainable development into educational institutions, whether kindergartens, primary and secondary schools or universities. There are the works of many authors presented in a series of books titled *Lifelong Learning for Sustainable development* (international conference held in Croatia in 2008 and organized by Faculty of Teacher education in Rijeka), voles. 1., 2.,3. V. Uzelac & L. Vujičić (Eds), and other publications: Anđić (2006), *Analysis of the Condition and Vision of Teacher Training for the Environment*; Rončević, Ledić & Ćulum (2008/2009), *"I'm not sure what it is, but it is important"*; Ledić, Turk & Buchberger (2010), *Empowering Communities for Sustainable development*; Anđić (2011), *The Schools in the Promotion of Education for Sustainable development*; Rončević & Rafajac (2012*), Sustainable development – A Challenge for the University?*. The systematic examination of the views of students and their knowledge of sustainable development and the role of the faculty or university in the promotion and/or implementation of the ideas and principles of sustainable development has received fairly little attention in Croatia, with the exception of the works by Cifrić, 2005; Pravdić, 2001; Lay, 1998, 2005, 2007; Uzelac & Vujičić, 2008; Uzelac& Pejčić, 2003 (as cited in Rončević, 2010, p. 44).

Out of the existing, we wish to stress several more important studies that particularly underlined the need for an interdisciplinary approach to the education of educational workers. Important breakthroughs in the field of pedagogy have been made with the systematic and continued research from the early 1990s to the late 2000s through the studies and publications by V. Uzelac *Environmental Education and Educators/Teachers* (1989); *The Fundamentals of Environmental Education* (1990); *The Environment-Education-Educators-Teachers* (1996); *Environmental Elements in the Curricula for Future Teachers* (1999*); Children and the Environment* (1999); *Educating Students for the Environment* (2002); *Educating Teacher Trainees for the Environment* (1997-2002); *Further Educating Teacher Trainees for the Environment* (2002-2006); *Lifelong Learning for Sustainable development* (2008). Uzelac has been systematically and continually pointing towards the need for the initial and professional training of educators/teachers and students in the area of environmental education and education for sustainable development, while demanding the stronger development of environmental literacy and its implementation into the educa-

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tion system – both when it comes to formal and informal education. In her research (1999-2006), she examined the views and values of educators, teachers and students of teacher training faculties, while on the education of future educators and teachers she concludes the following: "the problem of their education is reflected in the need and necessity for finding interdisciplinary forms of work and content, and broader possibilities for organizing lessons, discussions on environmental problems, problem teaching, didactical games, research, trips, projects and other various forms of teaching" (Uzelac, 2001, p. 218). Through an analysis of all levels of the education system (from preschool to higher education) in the Republic of Croatia regarding the area of education for sustainable development in the context of lifelong learning, in her further research the author makes conclusions on the dearth of practice and education. In doing so, she alerts that its state has been to the traditional level and points towards the neglect of the intensity and extensity of changes reduced. As a significant cause of this condition, the author identifies the lack of conceptions of lifelong learning for sustainable development. "Future development will depend on the quality of work and mutual cooperation through new and higher forms of networking between various factors" (Uzelac, 2008, p. 22), which includes the influence on global movements towards sustainability on the reshaping of the local, and networking and communication at an academic, scientific, educational and research level.

In their research conducted in 2007 (2009), Rončević, Ledić & Ćulum analyzed the role of higher education institutions in the promotion of the idea of sustainable development, and presented their own results on knowledge and understanding of the concept of sustainable development, plus views and behaviors connected with some aspects of this concept. The results pointed towards significant weaknesses regarding knowledge of the concept, while the views and habits tested did not demonstrate an affinity to this area and did not acknowledge the responsibility of schools. The most important role in the promotion of sustainable development was to the dimension of politics, followed by civil groups and the media given. The research subjects concluded that "political will is the first step in the promotion of the idea of sustainable development, from where it should spread to the rest of society. Without initial action from the political level, the promotion of the idea of sustainable development is not possible" (Rončević, Ledić & Ćulum, 2009, p. 72). Borić & Jindra (2008) stress that lifelong learning for sustainable development is one of the priorities of the knowledge society. With the accession of the Republic of Croatia to the European Union, this priority will become even more significant, particularly when it comes to the training of future educational workers. Their research indicated that students of teacher training studies hold that sustainable development improves the quality of life of current and future generations, while future kindergarten educators proved to be the most informed about this topic and its implementation in practice. The study showed that, for university professors, sustainable development is still a hot topic, but not yet an adopted way of living and they fail to identify expectations for the implementation of sustainable development in their own practice. "This fact is a cause for concern, as university professors conduct undergraduate programs, through which lifelong learning for sustainable development is promoted the most efficiently, while also educating future teachers and educators and through them, indirectly, influencing the education of preschool children. The reason for this is that 'the professional training of university professors' has not been systematically organized" (Borić, Jindra & Škugor, 2008, p. 325). Still, steps forward are visible from these results, not only in educational practice but also in the initial education of future teachers and educators. The authors concluded this study with recommendations for the initiation and implementation of changes "in the higher education system, as all of its output indirectly influences the input in other parts of the education system" (Borić, Jindra & Škugor, 2008, p. 325). Study by Uzelac & Anđić (2006) has pointed towards certain flaws in the practice

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of teachers and educators and a lack of strategy, programs and materials in initial teacher education and professional training. However, newer research (Anđić, 2011) points towards significant steps forward, particularly when it comes to the values, views and perceptions of students/future educators and teachers regarding the topic of sustainable development. Unfortunately still, the professional training of teachers is rated as insufficient and lies in the hands of the teachers themselves, as self-education is its most common form. However, positive steps forward can be observed in the examples of schools that have departed from the narrow conception of sustainability through environmentally-focused work and are striving to develop more integrated forms of work that encompass the economic, political and, above all, social dimensions of sustainability. At the same time, they are also developing a vision for schools in the future whose operation will encompass a holistic approach to the implementation of education for sustainable development.

The Case Context

The first time was a course pertaining to ecology presented at the Faculty of Teacher education in Rijeka in the academic year of 2000/2001, when a course under the name of Fundamentals of Ecology was as part of the study program introduced for the initial education of teachers and educators. The same year a course of similar content, Pedagogical Ecology, was as an elective course introduced as part of the postgraduate university masters study of pedagogy at the Faculty of Arts and Social Sciences in Rijeka. At this time, our institution for the training of teachers and educators still operated under the name of the Teacher Training College in Rijeka, as it only became an autonomous faculty and began operating under its current name, the Faculty of Teacher education of the University of Rijeka, in 2006.

In addition to acquainting future primary school and preschool teachers with the basic tenets of ecology and environmental issues, the course Fundamentals of Ecology also dealt with the methodics of working in schools and kindergartens. This initial step of introducing such subject matter into study programs was, above all, thanks to one of the most important pedagogists and scholars in the Republic of Croatia, Vinka Uzelac, Ph.D made, whose work has, for many years, been focused on a pedagogical approach to environmental and sustainable education. In cooperation with the Ministry of Science, Education and Sport, she has continually been working on the promotion of this problem and its implementation in initial teacher training and professional training programs since the late 1980s and early 1990s. In this, of particular importance are her research projects approved by the Ministry – Educating Teacher Trainees for the Environment 1997-2002 and Further Educating Teacher Trainees for the Environment 2001-2006. The long-standing work of Vinka Uzelac resulted in the significant implementation of this problem at the level of the initial training and further professional training of teachers and educators in the Republic of Croatia, while also spurring interest in this topic at a regional and national level.

The course Fundamentals of Ecology was restructured and built upon in 2005, which was a change motivated by the developments in education for the environment and sustainable development at a national level. In 1997, the Republic of Croatia became one of the signatories of the Kyoto Protocol, which came into force in 2007, while an official document issued by the Ministry under the name of National Primary School Curriculum for 2006 included a separate part that pertained to education for the environment and sustainable development. Thus, this topic became an integral part of the primary education system known as environmental education and education for sustainable development.

With the enactment of the strategy for sustainable development and the UN's proclamation of the 2005-2014 as the Decade of Education for Sustainable Development, the said issues became the leit-

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motif for the construction of the courses that are part of the initial training of teachers and educators. A new course titled Pedagogical Ecology vividly illustrates this new focus on pedagogy, didactically and methodologically equipping future teachers in the implementation of content pertaining to environmental education and education for sustainable development. During this period, significant breakthroughs in research work were also made, in which a significant milestone was the largest international professional conference created under the initiative of Vinka Uzelac and organized by the Faculty of Teacher education in Rijeka with the support of the Ministry of Science, Education and Sport. This conference was in 2008 held under the name Lifelong Learning for Sustainable development and gathered a great number of researchers, scholars and practitioners that had made significant breakthroughs in this area, and who were thus able to point out both the pros and cons of the implementation of this issue at a local, regional and national level. Important steps forward in interdisciplinary research certainly contributed to the incorporation of this issue into the programs of other faculties. Among these, we particularly want to stress the following: the Faculty of Tourism and Hospitality Management, the Faculty of Economics, the Faculty of Forestry, the Faculty of Food Technology and Biotechnology. In ways that are in accordance with their study programs (sustainable development and tourism, the fundamentals of ecology, protection of the environment), there are also other faculties that are interested in environmental education and education for sustainable development. However, the development of pedagogically and psychologically rooted approaches to this problem also points towards an increase of the implementation of this topic in study programs for the initial training of teachers and educators, particularly after the introduction of the Bologna Process.

Up to the academic year of 2005/2006, courses titled Pedagogical Ecology were at the full-time and part-time study programs held in the professional training of teachers and educators at the Faculty of Teacher education in Rijeka. However, the adoption of the Bologna Declaration and the harmonization of the higher education system with its principles resulted in great changes in study programs.

This new reconstruction of course programs was with these significant changes harmonized; studies were university studies and an integrated undergraduate and graduate teacher education study transformed into and was in the academic year of 2005/2006 initiated, while alterations and additions to its program were made in 2008. During this period, an obligatory course held in this study was Pedagogical Ecology, which was in accordance with the university level of the study modernized and paid a lot of attention to the problem of sustainable development. In 2009, i.e. the academic year of 2010/2011, the first university level study of early and preschool care and education being in the Republic of Croatia began conducting. A course under the name of The Pedagogy of Sustainable development was as a regular course conducted, while the course Education for Sustainable development in Open Spaces was as an elective course conducted. During the same academic year was the teacher education study again reconstructed and changes were also made in the course of Pedagogical Ecology – its content was reconstructed and it was renamed as The Pedagogy of Sustainable development.

Courses that deal with the problem of ecology are still conducted only at the teacher training faculties of the Republic of Croatia – at the Faculty of Teacher education in Rijeka and at the faculties in Osijek, Pula, Petrinja and Zadar. At these faculties, the titles of their courses can be as indicators of their programs viewed. At the University of Juraj Dobrila in Pula, the Department for Teacher Training conducts the courses of The Fundamentals of Ecology and Pedagogical Ecology; the Petrinja branch of the Teacher education Faculty in Zagreb conducts a course known as Pedagogical Ecology, the Department for the Education of Teachers and Educators in Zadar holds the elective course Ecology, while the Gospić branch that was up to 2011 part of the Faculty of Teacher education in Rijeka conducted Pedagogical

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Ecology as a compulsory course. The Faculty of Teacher education in Osijek has the broadest selection of courses dealing with the problem of ecology/the environment/sustainable development: an elective course titled Environmental Education as a part of Natural Sciences at the integrated undergraduate and graduate teacher training study; Environmental Education in Kindergartens as an elective course at the undergraduate study of early and preschool care and education; while at the graduate level of early and preschool the compulsory courses The Pedagogy of Sustainable development, Ecology for Sustainable development and History of the Environment appear, together with an elective course titled Games in Environmental Education. It ought to be noted that professional studies have been conducted since 2005, and university studies since 2009/2010.

In addition to initiating a university level study of preschool care and education, the Faculty of Teacher education also initialized a lifelong learning program intended for educators that completed a professional level study. This lifelong learning program has been termed as a differential program for enrollment at the graduate level of preschool care and education, and comprises 7 courses that are different to the university level of the undergraduate study. Among these seven courses, a course under the name of Sustainable development in the Context of Lifelong Learning has also been included. The faculties of teacher education in Zagreb and Osijek have initiated similar differential programs, but their structure does not contain courses that deal with environmental issues/sustainable development. Since the academic year of 2012/2013, the course Education for Sustainable development has also been on offer as an elective course in the doctoral study of pedagogy at the University of Rijeka.

SETTING THE STAGE

Part 1: Sustainable Behavior

There exist several terms in literature that can be connected with the issue of behavior and its formation/influences within an ecological, sustainable context. The terminological determination of pro-environmental/environmental/sustainable forms of behavior is not simple, but a review of literature on the topic leads to the conclusion that it is limited to the views, convictions, values and certain actions of an individual that are determined by the intensity and extensity of behavior. Different types of behavior are determined through various combinations of causal factors (Stern, 2000, pp. 409-411). Stern differentiates between several types of behavior that he defines as environmentally significant: environmental activism, non-activist behavior in the public sphere, ecological behavior (environmentalism) in the private sphere and other environmentally significant forms of behavior. According to Krajhanzl (2010) environmentally relevant behavior encompasses deliberate or non-deliberate forms of behavior that involve the conscious and/or unconscious influence of the individual on the environment. In contrast to environmental behavior, pro-environmental behavior is evaluated within the social context as a protective form of environmental behavior, i.e. the application of environmentally sound and socially responsible ethics to lifestyle choices), which includes actions aimed towards the reduction of "ecological footprints" (Akpan et al., 2003, p. 7). Such behavior is also described as preservation/protection of the environment; environmentally responsible behavior, ecological behavior; environmentally destructive behavior; environmentally adverse behaviors sustainable behavior (Krajhanzl, 2010, Akpan et al., 2003, p. 7). In addition to the aforementioned, terms such as consumer behavior also appear, in which it is widely accepted that users' consumption decisions and lifestyle have a considerable effect on the

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environmental impact of a product's lifecycle (Yilmaz, 2011, p.1). Another term we wish to point out as very important for our research is the term of environmental citizenship and its three types (Liberal, Civic Republican and Post-cosmopolitan), which pertains to public and private pro-environmental behavior that is based on a conviction for participating in the enactment of sustainable policies, i.e. the active participation of citizens, and to principles and values, i.e. an approach grounded in values that stimulate pro-environmental behavior (Dobson, 2003, 2010; Huckle, 2008,).

Huckle's conception of environmental citizenship (2008) expands on the idea of the sustainable citizen and individual, which presupposes the development of competencies based on the *head, heart, hand and spirit* approach. Huckle differentiates between *head competencies* that presuppose environmental knowledge, the abilities of systematic thinking, creative problem solving and applying ethically approaching new situations, and the ability of estimating the influences of human technologies and actions and the long-term consequences of decisions. *Heart competencies* encompass a deep sensitivity that does not only pertain to caring for the welfare of the Earth and the environment, but also to empathy and the ability to view things from multiple angles, possessing a commitment to equality, justice and respect for all people, and the skill of creating, managing and maintaining communities. *Hand competencies* encompass the ability of applying environmental knowledge to practice, making environmentally-conscious decisions, possessing practical skills for the creation of means (tools), objects and procedures needed by the community, the ability to estimate and adapt the use of energy and other resources and the capability of turning convictions into practical and efficient actions. *Spirit competencies* pertain to a sense of wonder, a deep respect for and feeling of connection with the natural world and the ability of invoking these feelings. The distinguishing features of this approach lie in the fact that the development of *head, heart, hand and spirit competencies* are focused on the development of the individual and a citizen that will possess the *ability to design and maintain sustainable societies* (Anđić, 2011, p. 75 as cited in Huckle, 1994, Huckle, 2008).

The focus of our work are those types of sustainable behavior that, according to Najera, presuppose the following: "a set of effective, deliberate, and anticipated actions aimed at accepting responsibility for conservation and preservation of physical and cultural resources. These resources include integrity of animal and plant species, as well as individual and social well-being, and safety of present and future human generations" (Najera, 2010, p.29.). Najera extrapolated this definition by modifying Corral-Verdugo and Pinheiro's definition from 2004 and grounding it in her own sociopsychological model.

Research on environmental and pro-environmental behavior and the internal and external factors that stimulate/participate in/influence their formation is the long-standing research focus of many sciences. Steg and Vlek (2009) point towards the existence of 4 important research areas within a systematic approach for the stimulation of pro-environmental behavior. These are: 1. the research areas that study the selection, evaluation of behavior; 2. research areas focused on the identification of factors that determine behavior (motivational factors and contextual factors); 3. research areas focused on interventions for stimulating pro-environmental behavior (informative strategies, structural strategies) and 4. research areas focused on evaluation (of the success of interventions).

In the research conducted heretofore, of particular prominence are psychological, social, economic and pedagogical studies. Many approaches, theories, concepts and models were structured that attempted to explain and determine the characteristics and/or factors that influence the formation of such behaviors. Table 1 presents a short overview of some of the theories and behavior models that we have included in our research.

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Table 1. The Theories and behavior models overview

Factors		Model/Theory in Explaining Behaviour
Norms -Values - Beliefs – Attitudes (motivation, fear)		Norm Activation Theory, Schwartz, S. (1977) Theory of Reasoned Action, Fishbein, M. & Ajzen, I. (1975) Health Belief Model, Rosenstock, I. (1974) Protection Motivation Theory, Rogers, R.W. (1975, revision, 1983) Universal values theory, Schwartz, S. (1994) Schematic Causal Model of Environmental Concern Stern, P. et al's (1995) Values Beliefs Norms Theory, Stern, P. et al's (1999) Model of Ecological behavior as a function of environmental attitude extended by responsibility feelings, Kaiser, F. et al's (1999)
Agency - Efficacy -Control		Theory of Self Efficacy, Bandura, A. (1977) Theory of Planned Behavior, Ajzen, I. (1986) Model of Pro-Environmental Behavior, Kolmuss, A. & Agyeman, J. (2002)
Socio-psychological models		
Internal factors External factors	Values, Attitudes, Norms, Motivation, Needs, Knowledge (different forms), Emotional Involvement (Feelings, Fear, Happines) Infrastructure, Political, Social, Cultural factors, Economic situation, Technology etc.	The Needs Opportunity Ability model, Gatersleben, B. &Vlek, C. (1998)
		Ecological behavior as a function of environmental attitude extended by responsibility feelings, Kaiser, F. et al's (1999)
		Model of Pro-Environmental Behavior, Kollmuss, A. & Agyeman, J. (2002)
		Modelling social behavior with the sociopsychological simulation approach, Moser, H.J. (2004)
		Theory of Interpersonal Behavior, Jackson, T. (2005)
		Community-based social marketing model, McKenzie- Mohr, D. (2008)
		The concept of affinity towards diversity, Corral-Verdugo, V., Mireles-Acosta, J., Tapia-Fonllem, C. & Fraijo-Sing, B. (2009).
		Sociopychological model of sustainable behavior, Najera, M.J. (2010)

As is evident from this table, certain theories and models have grounded their starting points in either the external or the internal factors that explain pro-environmental/environmental/sustainable forms of behavior. Sociopsychological models mostly encompass both of these factors. Our focus is on Najera's model (2010). This model is in several important theories that attempt to explain and examine sustainable behavior grounded, significant for our research and case that we build upon it. Two key elements serve as a starting point of the model: values and responsibilities. The point of departure for explaining the values in the model is on Schwarz's theory of universal values (1994) based. This theory is rooted in the view that values differ among themselves primarily according to the type of motivational goal they are focused on. For Schwartz, values are conscious goals that reflect the three universal demands of human existence: biological needs, the need for coordinated social interaction and the need for surviving and functioning in a group. Based on the aforementioned, he developed a typology of different value contents, i.e. 10 related motivational goals for which he claims to be of universal character, which he proved with his research in 13 countries around the world (Schwartz, 1996). He presented the content of the ten motivational types of values through 56 specific values, which he depicted on a circular structure of 4 fundamental value categories he grouped them in: *openness to change opposite to conservation* and *self-transcendence opposite to self-enhancement*. At the same time, Schwartz's universal values are in significant connection with the topics and values promoted by education for sustainable development. Schwartz's universal values are: Self-Direction (Independent thought and action; choosing, creating,

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exploring), Stimulation (Excitement, novelty, and challenge in life), Hedonism (Pleasure and sensuous gratification for oneself), Achievement (Personal success through demonstrating competence according to social standards), Power (Social status and prestige, control or dominance over people and resources), Security (Safety, harmony, and stability of society, of relationships, and of self), Conformity (Restraint of actions, inclinations, and impulses likely to upset or harm others and violate social expectations or norms), Tradition (Respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide the self), Benevolence, Preserving and enhancing the welfare of those with whom one is in frequent personal contact (the 'in-group') and Universalism (Understanding, appreciation, tolerance, and protection for the welfare of all people and for nature) (Schwartz, 1994). The values and topics of key importance to the concept of sustainable development and education for sustainable development are: human rights, health promotion, sustainable production and consumption, gender equality, information and communication technology, rural transformation, and intercultural understanding and peace (adapted from Najera, 2010, p. 58, p. 60). Because of this, Najera created a foundation for examining values through a questionnaire that tested the sustainable behavior of students of two universities.

Schwartz's norm activation theory (1977), i.e. Stern's adaptation (1999) of this theory and its modification of it within the context of the VBN theory (Stern, 1999), together with the adoption of the scale of the NEP (new environmental paradigm) comprise the foundation of Najera's sociopsychological model (2010). In his adaptation of Schwartz's theory, Stern includes the VBN (value-beliefs-norm, Stern, 1999.) theory and the theory of environmental values (the presupposition that there are three different value orientation orientations that are likely to motivate pro-environmental behavior – egoistic, altruistic and biosphere-related, Schwartz, 1977). The connection between values and environmentalism, whose mediators are also particular convictions, is an important part of the foundation of this theory. Information that shapes convictions can influence pro-environmental personal norms and represent a predisposition for taking pro-environmental action (Stern, 2000, p. 414). Environmentally-aware intentions represent only one of the factors that influence behavior, and usually not the most important one. According to Stern, variables can be grouped into 4 factor types: 1. factors that encompass norms, convictions and values, but also other factors, e.g. pro-environmental intentions. Stern describes the aforementioned as attitudinal factors; 2. factors that encompass interpersonal influences such as convincing and modeling, which he terms contextual forces; 3. factors that encompass knowledge and skills involved with certain actions, which he terms personal abilities and 4. factors encompassing the last type of causal variables – habit or routine (Stern, 2000, p. 417). Different types of grouped causal variables are dominant in different types of pro-environmental behavior, depending on the behavior in question (Stern 2000, p. 417, as cited in Gardner and Stern, 1996; Stern, 2000). In further elaborations of the sociopsychological model, two fundamental terms distinguish themselves: awareness of consequences and the ascription of responsibility. According to Huckle (2006, p. 20) the ethics of sustainability encompass the term of values, while the foundation of the concept of education for sustainable development comprises reexamination and taking responsibility for oneself, others, things done or left undone, the past, the present and the future (Huckle, 2006). The ethics of sustainability presuppose 5 dimensions of sustainable development (the economic, environmental, social, cultural and personal dimensions), while the aim is to create a balance between all five. This includes the continued reaffirmation of democratic values such as freedom, equality, human rights, rationality and balancing between the interests of the global population, future generations and the rest of the environment. The author stresses the sense of general responsibility that emanates from the connection between the local and global and the role of the citizen and individual. For Huckle, responsibility is of a global and collective nature but is, at the same time, also local and

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individual, in which "Everyone shares responsibility for the present and future well-being of the human family and the larger living world" (Huckle, 2008, p. 3). The question of responsibility is the central issue in S. Schwartz's norm activation theory (1977).

The foundation for the stimulation/activation of personal moral norms for the initialization pro-environmental forms of behavior or participation in them is awareness of one's own actions and the actions of others, together with the acceptance of personal responsibility and the responsibility of those who are responsible for certain consequences. Prior to this was the NEP scale developed by Dunlop and Van Liere (based on the sociological approach of the so-called New ecological paradigm scale, it comprised 15 particles in 1978 and was revised later), which measured the worldviews of citizens. It comprises a set of 15 particles grouped into three categories that pertain to harmony with nature, the restriction of development and man's domination of nature. However, further examination of this scale proves the existence of two or even more dimensions and a scale consisting of only 12 particles (Dunlop, Van Liere, Mertig & Jones, 2000, p. 430). In the last thirty years or so, this scale has also been reduced to 5, 6, 7, 8 or 10 item(s) (Hawcroft & Milfont, 2010). The authors, however, suggest the unidimensional, i.e. single-variable use of the scale (Dunlop, Van Liere, Mertig & Jones, 2000,p. 431).

The part of Gardner's multiple intelligence theory (2011) pertaining to interpersonal and intrapersonal intelligence is a constitutive part of this model and is based on the principles of emotional intelligence. Interpersonal and intrapersonal intelligence are analyzed through the 5 psychological dimensions of sustainability, based on the instrument for measuring emotional intelligence.

Emotional intelligence was first defined by Salovey & Mayer (1990) as the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions. In 2000 Mayer, Caruso & Salovey, revised the initial definition to include the capacity to perceive emotions, assimilate emotion-related feelings, understand the information of these emotions and manage them. They adopted the theoretical foothold for their conception of emotional intelligence from Gardner and Sternberg, who developed two intelligence theories - Gardner's model of multiple (independent) intelligences (1983) and Sternberg's triarchic theory of intelligence, i.e. practical intelligence (1985, 1990, 1999). Gardner distinguishes between seven basic forms of intelligence: musical bodily-kinesthetic, logical-mathematical, linguistic, spatial and social (interpersonal and intrapersonal). With time, he expanded his theory to encompass naturalist intelligence, existentialist intelligence (the intelligence that leads human beings to pose big 'existential questions'), and pedagogical intelligence (the intelligence that enables human beings to convey knowledge and skills to other human beings who have varying degrees of knowledge) (Gardner, 2011). According to Gardner, interpersonal intelligence is defined as the ability of identifying, understanding, acknowledging and communicating with others depending on their various needs, moods, temperaments, desires, views and motivations. In other words, it presupposes a relationship, interaction with and focus on other people. Intrapersonal orientation is a focus on oneself, and is defined as the ability to create a correct and reliable cognitive model of one's own person and abilities and to use this model to successfully function in life (Gardner et al.,1999).

This model uses the theory of emotional intelligence, i.e. instrument for measuring emotional intelligence developed by Boyatzis et al. (2000, 2002, 2004). It is based on an integrated concept of emotional intelligence that encompasses personality structure, activity theory and job performance. Goleman (1998) defined emotional competence as "a learned capability based on emotional intelligence which results in outstanding performance at work". In other words, if a competency is an "underlying characteristic of

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the person that leads to or causes effective or superior performance" (Boyatzis, 1982) then the competency of emotional intelligence is the ability to recognize, understand and use emotional information on oneself and others, which stimulates a more efficient or superior performance. This definition is further expanded in the manner that emotional intelligence represents a set of competencies or abilities by the virtue of which a person is: a) self-aware; b) self-managing; c) socially aware; d) manages his relationships with others. In this, among the competencies pertaining to emotional intelligence are: a) The Self-awareness Cluster included Emotional Self-Awareness, Accurate Self-assessment, and Self-confidence; b) The Self-Management Cluster included Emotional Self-control, Achievement, Initiative, Transparency, Adaptability, and Optimism; c) The Social Awareness Cluster included Empathy, Service Orientation, and Organizational Awareness; d) The Relationship Management Cluster included Inspirational Leadership, Influence, Conflict Management, Change Catalyst, Developing Others, Teamwork and Collaboration.

In their study (2004) Corral-Verdugo &Pinheiro give an overview of relevant research and differentiate between the terms of sustainability, pro-environmental and sustainable behavior. Based on their research, they differentiate between different types of sustainable behavior. In addition, they stress that not all forms of behavior that stimulate a high level of environmental welfare are, at the same time, also useless in an economic, political and social sense. The study pointed towards the need for the categorization of sustainable behaviors, in which it is clear that they apply psychological criteria for individual and group behaviors. The authors set the condition that, in the determination of levels of sustainable forms of behavior, an interdisciplinary approach ought to be involved, as it is possible to recognize social, economic, political and environmental influences in their determination. In other words, the authors include economic, political, social and environmental factors among the predictors of pro-sustainable behavior. In light of the aforementioned aspects, the authors define sustainable behavior as a set of efficient and intentional actions that are necessary for the preservation of natural resources (which includes both animal and plant species) and for the individual and social benefit of both current and future generations (Corral-Verdugo & Pinheiro, 2004, p. 10). In the continuation of their conceptualization of sustainable forms of behavior, Corral-Verdugo & Pinheiro (2004) dissect the mental characteristics involved in sustainable behavior and name them the psychological dimensions of sustainability. Sustainable behavior should be in accordance with at least five psychological characteristics, which are identified as: 1) effectiveness, 2) deliberation, 3) anticipation, 4) solidarity and 5) austerity. Efficiency presupposes responsibility at work or a responsibility regarding demands in a physical and social sense, while deliberation means that behavior must occur with the purpose or special intention of preserving the environment and promoting the welfare of all living creatures. Anticipation means that, although the behavior is completed on time, the individual separates himself for a moment and projects his behavior in the future, which is the time that this behavior is focused on. Solidarity manifests itself as a set of trends and actions through which the individual is engaged in an altruistic care for others. Austerity opens the need for the implementation of a lifestyle that is restricted to those goods and natural resources that are a necessity. According to these authors, it is necessary to determine the behavioral dimensions of sustainability at a psychological level, and they propose these initial five dimensions. According to the results of research and the model presented, the presence of an integrative construct can be identified; however, there is still room for other scholars to add new dimensions and offer alternative explanation models. The given model's purpose is integrating the coherent and inclusive explanations of sustainability, in which the psychological component is with other dimensions integrated (Corral-Verdugo & Pinheiro, 2004, p. 22).

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Part 2: Positive Psychology and Sustainable Behavior

Research on environmental and pro-environment behaviors, both external and internal, and the factors that encourage, participate and influence their formation have been a longstanding focus of research in psychology. There are a number of structured theories, concepts and models that attempt to explain the characteristics of such behavior. As has been described earlier, this chapter focuses on the socio-psychological model by Najera (2010), based on which we constructed the questionnaire that was used in this study. An interdisciplinary approach is evident in the value categories, which include the core values of the concept of ESD, but also in the concept of responsibility that is crucial. Value systems and responsibility, among other things; represent a very important part of those human virtues (Peterson & Seligman, 2004) that are studied within positive psychology. Human virtues as positive personality characteristics are crucial in positive psychology research. Responsibility was first as one of the fifteen Roman virtues emphasized and, since then, it has been described and measured as part of the Gallup talents classification (Clifton, Anderson & Schreiner, 2006). Other human virtues such as independence, humanity, social justice, etc. are described in all three models of human virtues: Gallups' talents classification, VIA classification (Peterson & Seligman, 2004) and Forty developmental advantages (Rijavec, Miljković & Brdar, 2008). Individuals whose human virtues are better developed show more life satisfaction (Park, Peterson & Seligman, 2004) and optimism (Kashdanm, Pelham, Lang, Hoza, Jacob, Jennings, Blumenthal & Gnagy, 2002). Therefore, we can logically expect to find significant positive correlations between sustainable behavior, which consists of human values, and life satisfaction and optimism. Positive personality characteristics are significantly positively correlated with positive thinking (optimism) and this, in the end, resulted in a person highly satisfied with his/her life.

Furthermore, dimensions of sustainability form the basis for the explanation of the possible models of the SD concept, and include models that attempt to explain its complexity with the use of a psychological approach (Kumar, 2005; Selby, 2007). According to O'Brien (2012), there is a significant basis for an interdisciplinary approach to the implementation of the concepts of ESD, sustainable happiness, well-being and positive psychology. The results of our study suggest an extension of this approach to pedagogical issues and the fundamental structure the course PSD. The concept of sustainable happiness was by O'Brien (2012) developed, who emphasized that it was indispensible for building and increasing the quality of life and described it as "happiness that contributes to individual well-being, the well-being of the community and/or global well-being without exploiting other people, the environment or future generations." The Concept of ESD ought to include the concept of sustainable happiness because it is an integral part of a sustainable future, and of the need to expand research that examines the relationship/connection between environmental sustainability, quality of life and life satisfaction. Positive psychology possesses potential as a means by which sustainable happiness and well-being could be enhanced and understood in the context of ESD. Sustainable happiness and well-being are an integral part of the concept of ESD, therefore it is necessary to consider them in this context. Consequently, graduate programs for early and preschool education include the course Positive psychology (Tatalović Vorkapić & Vujičić, 2013), and we believe it will find an important place within the new reconstruction of the study program for teacher education. When it comes to the inevitable connection between positive psychology and the pedagogy of sustainable development, the second part of this chapter will be grounded in the empirical links between optimism, life satisfaction and sustainable behavior, which we expect to determine through our examination of students of the Faculty of Teacher education in Rijeka. According to Scheier and Carver (1985), optimism is the general expectation that good rather than bad things will occur in our

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lives (dispositional optimism), while life satisfaction variable is operationalized as the general cognitive evaluation of the satisfaction with life in students ((Diener, Emmons, Larsen & Griffin, 1985). Within this research, we expect to find significant positive correlations between optimism, life satisfaction, and sustainable behavior among future preschool and primary school teachers. Based on the findings of this research, could be future guidelines for creating an interdisciplinary course that encompasses the main principles of the pedagogy of sustainable development and the tenets of positive psychology created.

CASE DESCRIPTION

Part 1: Education As Predictor of Sustainable Behavior

Education is, in both its formal and informal manifestations, according to article 36 of Agenda 21 indispensable and vital for achieving environmental and ethical awareness, values and views that are in accordance with sustainable development and the efficient participation of the public in decision making. Education is a significant predictor and/or mediator of proenvironmental/environmental/ sustainable forms of behavior, to which many studies are testament. Research results testify that education is an important predictor /mediator of pro-environmental/environmental/sustainable forms of behavior (Hawthorne & Alabaster, 1999). However, in contrast with the aforementioned, important studies were conducted that indicated that formal knowledge and information are by themselves not sufficient to stimulate changes in behavior or influence the formation of desirable forms of behavior (Schahn, 1993; Gardner & Stern, 1996; McKenzie-Mohr, 2000; Stern 2000; Kaiser & Fuhrer, 2003; Nolet 2009; Finger 2010). Hawthorne & Alabaster (1999, p. 40) claim that "environmental citizens are not produced merely by education, but by a whole range of factors with which education may interact". According to these authors, the other significant predictors of sustainable behavior are: emotionality, which presupposes development through the emotional aspect of learning, religious affiliation, social class, a sense of personal success and personal responsibility.

Pol's model (2000) examines the theoretical assumption that environmental behavior is always under the influence of four important factors (depending on the case and the weight of each factor). The factors that he terms as spheres of sustainability are: the sphere of information and rationality, the sphere of emotiveness, the sphere of functionality and the sphere of social influence. In 2007 in a study conducted on students of three universities, he also added a fifth sphere that he termed manifested environmental behavior. The results of his study indicated that information and knowledge are not a guarantee for coherent and harmonious behavior. An Education in itself does also not imply pro-environmental habits or forms of behavior. On the grounds of this research, the author brought into question the sustainability model, i.e. the type of education applied at universities heretofore.

Education influences the formation of environmental views and pro-environmental forms of behavior, for the longer the education, the more comprehensive the knowledge on issues pertaining to the environment – however, this does also not have to necessarily presuppose an increase in pro-environmental behavior (Kollmuss & Agyeman, 2002, p. 248.). In other words, education is necessary, as it is a mediator, but also important are other factors that may interact with education. Akpan, Del Matto, Hunsberger, Rehbein, Rogozinski, Rosenthal & Shaw (2003) present an interesting conceptual framework for the promotion of pro-environmental behavior. This framework is grounded in the assumption that "environmental knowledge and values are positively related to pro-environmental behavior, that educational strategies

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can be used to promote environmental knowledge and that increased knowledge, in combination with training … leads to increased pro-environmental behavior, including institutional factors…" (Akpan et al., 2003, p. 8). However, the research conducted confirmed that though "environmental education can influence pro-environmental behavior change, it is by itself not sufficient to accomplish this. Adequate communication strategies that address barriers and provide incentives for change, as well strong institutional commitment and support, work together with providing education to enhance opportunities for the adoption of pro-environmental behavior" (Akpan et al., 2003, p. 34).

According to McKenzie-Mohr (2008), more conventional approaches based on advertising, comprehensive information and education are not sufficient to stimulate sustainable forms of behavior. Thus the author offers his model - community-based social marketing that consists of 5 fundamental steps: a careful selection of the behavior (s) to be promoted; identification of the barriers and benefits to the behavior, development of a strategy that addresses these barriers and benefits; pilot testing the strategy; and finally; broad scale implementation (McKenzie-Mohr, 2008, p. 1). This model allows for the further development of this technique and, according to the author, enables the identification of inner barriers, thus offering a possible framework for effective programs for both educating and informing.

When it comes to the stimulation and development of pro-environmental/environmental/ sustainable forms of behavior, researchers also preoccupied themselves with those forms of knowledge that can influence/be predictors of/mediate such forms of behavior. Studies connected with the factor of knowledge as a predictor/mediator of pro-environmental/environmental/sustainable forms of behavior pointed towards several important facts: it is not only knowledge that is a key factor/predictor/mediator of behavior, but also its manner of manifestation, i.e. the form this knowledge takes. Frisk & Larson (2011, pp. 5, 6) give an overview of some of the important theories and models that studied the connection of behavior and forms of knowledge as predictors of behavior. Through their Information Deficit Model, Kollmuss & Agyeman (2002) researched pro-environmental behavior and used declarative knowledge (Understanding of how the environmental systems function) predictor in the form of Technical information, Awareness of environmental problems and the Mechanical understanding of issues. As predictors of Responsible Environmental Behavior and proenvironmental behavior, several theories used forms of procedural knowledge (Awareness of how to undertake particular actions): Process-oriented 'how to' information (the Information Deficit Model by Kollmuss & Agyeman, 2002; Model of Responsible Environmental Behavior by Hines et al. 1986); Structural influences & limits and Situational constraints & opportunities (Value-Beliefs-Norms by Stern, 2000; Community-Based Social Marketing by McKenzie-Mohr, 2000).

In the Effectiveness knowledge domain (Views of the outcomes of different behaviors) predictors were: Personal efficacy & locus of control (Value-Beliefs-Norms Theory by Stern, 2000; the Model of Responsible Environmental Behavior by Hines et al. 1986; Fishbein and Ajzen's Theory of Reasoned Action, 1975, 1980; Community-Based Social Marketing by McKenzie-Mohr, 2000); the Perceived consequences of actions (Value-Beliefs-Norms Theory by Stern, 2000); Attitudinal evaluations of outcome (Fishbein and Ajzen's Theory of Reasoned Action, 1975, 1980; Ajzen's Theory of Planned Behavior, 1986). These models or theories tackled the research and prediction of Behavior, Responsible Environmental Behavior and Sustainable behavior. The last knowledge domain expounded by Frisk & Larson (2011, p. 6) is social knowledge (the awareness of the motives and intentions of other people or society). In this instance, as predictors of responsible environmental behavior, environmentally sustaining behavior and sustainable behavior the following were used: Ascribed responsibilities to self & others (Model of Responsible Environmental Behavior by Hines et al., 1986); Beliefs about social norms & expectations (Fishbein & Ajzen's Theory of Reasoned Action, 1975, 1980; Ajzen's Theory of Planned

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Behavior, 1986) and Perceptions & pressures conveying what is dis/approved (Community-Based Social Marketing by McKenzie-Mohr, 2000).

Studies focused on only certain forms of knowledge in the prediction of behavior most frequently yielded little or no effect. In the research conducted by Thielking & Moore (2001, p. 67) high levels of factual and conceptual knowledge proved to be significant independent predictors of environmental behavior and intentions, and of a stronger feeling of personal responsibility for the environment – but only among women. Among men, no form of knowledge proved to be a significant predictor of behavior. However, it ought to be noted that research based on differences in sex and age as predictors of pro-environmental/environmental/sustainable forms of behavior represent a separate issue that we will not be tackling in this work.

In their research of the dependence of environmental behavior on various forms of knowledge, Kaiser & Fuhrer (2003, pp. 598-613) view knowledge through three important categories: declarative (environmental) knowledge (knowledge on how the ecosystem works); procedural knowledge (action-focused knowledge aimed at the issue of how to achieve a certain goal; it presupposes behavioral options and possible courses of action, and can be differentiated further to, e.g. Sorting and avoidance knowledge etc.); effectiveness knowledge (about the relative conservations effectiveness, relevant when behavior is instrumental in optimizing a person's cost-benefit ratio) and social knowledge. According to these authors, there exist two types of social knowledge: 1. social knowledge that refers to the motives and intentions of others; socially shared or common knowledge (depends heavily on socialization and consists mainly of normative beliefs about what people think they have to do). The authors connect this type of knowledge with social norms (moral and conventional) and Ajzen & Fishbein's (1980) theory of reasoned action. In the continuation, the authors advocate the convergence of knowledge, which means that even when different forms of knowledge are already acquired, knowledge is successful in its endeavor only when different knowledge forms promote ecological behavior jointly and convergently. In their study, the authors conclude the following: different forms of knowledge have to converge towards the common ecological goal. Hence, it is not the mere amount of knowledge available that determines ecological behavior, but the strength of the convergence of this knowledge. It promotes ecological behavior more significantly than any exclusive form of knowledge alone (Kaiser & Fuhrer, 2003, p. 604). Regardless of the fact that many factors can limit/decrease the influence of knowledge on the formation of behavior, nevertheless, knowledge remains an important and highly significant predictor of ecological behavior (Kaiser & Fuhrer, 2003, p. 609).

In their study on the environmental behavior of citizens, Hungerford & Volk (1990) propose behavior changes through education for the environment. This study yielded the identification of key educational components that curricula ought to include, as they possess a significant influence on the formation of desirable forms of behavior. In addition, the authors present two teaching models, which have shown to be influential on the formation of such behavior. They stress three categories of variables (major and minor) that they presented in their model for behavior change: Entry-level Variables (prerequisite variables or at least variables that will strengthen the decision-making. The major variable in this category is environmental sensitivity that is defined as "an empathetic perspective toward the environment". Minor variables are Androgyny, knowledge of ecology and attitude toward pollution/technology/economics); Ownership Variables (environmental issues that are important at a personal level, they are critical to responsible environmental behavior, includes in-depth knowledge of the issues and personal investment). Empowerment Variables (strengthen the sense that we can change and are able to solve environmental problems to make a better world. Knowledge and skill in using environmental action strategies are the best

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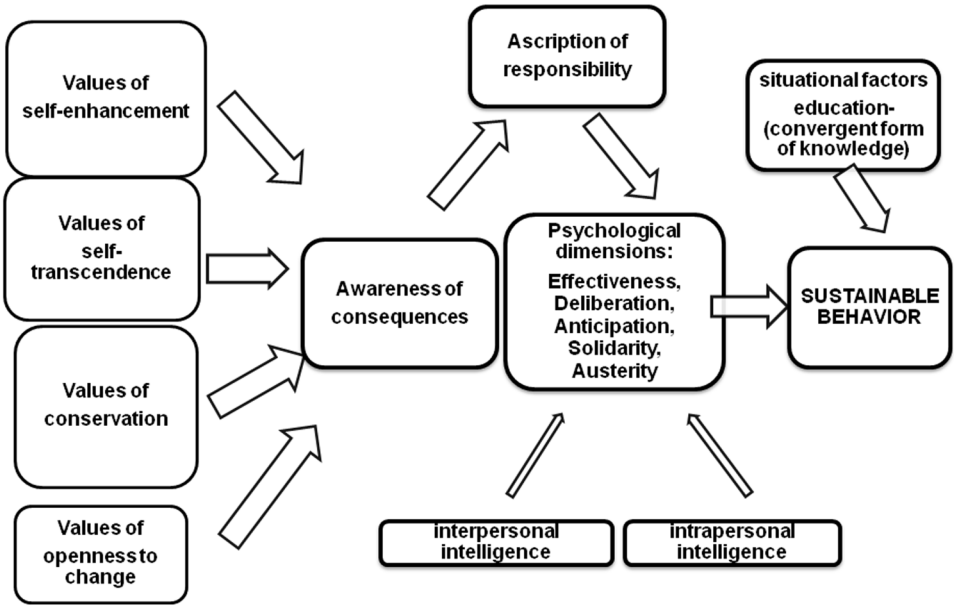
predictor of pro-environmental behavior because it brings self-confidence to help resolve environmental problems. Locus of control refers to believing in being for a certain behavior reinforced. A person with internal locus control believes that he/she will be for doing something reinforced. Intention to act is to empowerment variables related. If a person's intent is to take action, the chances of that action occurring are increased (Hungerford & Volk, 1990, pp. 8-21).

A majority of researchers point towards the need for knowledge that is able to spur the transformation at many different levels. In other words, in demand are concepts that "through the integration of knowledge domains that speak to ecological knowledge as well as social norms, beliefs about behaviors, and how-to information about specific problems and actions, aim to develop an educational approach that resonates with behavioral science and core competencies for sustainability" (Frisk & Larson, 2011, p. 3). Frisk & Larson thus propose a model of Integrating disparate fields for an interdisciplinary approach to sustainability education. This model encompasses: 1. the role of varying types of knowledge, information, and education in changing behaviors (also including broader theoretical and empirical insights about what motivates and constrains environmental actions). 2. Integration of the educational and sustainability literature (achieving sustainability competencies by particular teaching approaches, specifically focusing on transformative actions in the context of systems thinking, a future orientation, and collaborative decision making). 3. Reflection on critical challenges and opportunities for educational initiatives aimed at changing behaviors for sustainability. (Frisk &Larson, 2011, p. 3).

This work will place an emphasis on the sociopsychological model by Najera (2010), based on which we constructed a questionnaire that we applied to our research (Figure 1).

The description of the sociopsychological model that we have used in our experiment, together with the aforementioned studies, provides us with a foundation for creating hypotheses for the examination of students, i.e. future teachers/educators regarding their sustainable behavior. In this, the convergent form of knowledge we have been developing through the interdisciplinary content of the course The

Figure 1. The sociopsychological model of Najera (adapted and modified by Najera, 2010, p. 59; Anđić & Tatalović Vorkapić, 2013)



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Pedagogy of Sustainable development is a predictor – one we presume shall evoke a transformation of their values, responsibilities, awareness, actions and behavior.

Part 2: The Course *The Pedagogy of Sustainable Development* Overview

Approach and Aims

The course The Pedagogy of Sustainable development (PSD)[1] is as an obligatory course conducted in the 4th semester of the Undergraduate Study of Early and Preschool Education, and in the 8th semester of Integrated Undergraduate and Graduate Study of Primary School Teacher education (4% ECTS credits). The objectives of the course are: to develop knowledge of the general and fundamental concepts of PSD in relation to the historical and social concept of development; to encourage the development of students' critical thinking and their understanding of research breakthroughs, and to familiarize them with the theories on and approaches to the modern pedagogical conceptions of EE[2] and ESD[3].

Through the exploration and the constructivist approach of this course, students develop their abilities as reflective practitioners through the theoretical creation of lessons pertaining to sustainable development and its implementation in educational practice. By successfully completing this course, students will acquire:

- Independent research skills, an affinity for teamwork, interaction and cooperation grounded in partnership and forms of cooperative learning;
- The ability to think critically, derive logical conclusions, make connections and express relevant opinions in an argumented fashion;
- The skill of following up-to-date global information pertaining to social pedagogy and the concept of sustainable development, and using this knowledge to develop their own views and accepting responsibility for both their own lifelong learning for sustainable development and that of humanity in general.

The methods and means of stimulating general competencies encompass motivating students to actively participate in classes (both lectures and seminars) and to complete e-learning activities. Students' activities encompass asking questions, making comments and discussing at lectures; independently selecting, creating and presenting a paper; using information, communication and multimedia technology through the MUDRI e-learning interface and perusing optional literature according to their own choice. In addition, visits to exhibitions, field classes, and various forms of cooperation with social institutions, visits to Eco schools/kindergartens or educational institutions can also be organized in connection with the content of this course.

Course Content

There are three key structural units of this course program consisting of 15 substantive themes:

1. The development of man's thoughts on the environment (man – ecology – environment – SD),
2. From EE to ESD (2. Paradigmatic aspects of ESDs. 3. SD: models, dimensions, problems and perspectives - a sustainable future; 4. Values in ESD - ethics of sustainability; 5. Starting points

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and approaches to ESD as a concept - multidimensionality and development through the concept of SD to education in the UN Decade for ESD; 6. First steps in EE and SD - from EE to ESD in kindergartens and schools; 7. the theoretical and practical framework of ESD in early and preschool/primary education; 8. Children's play in the context of EE/ESD, activities in kindergartens/schools as one of the preconditions for SD; 9. Elements of the kindergarten/school curriculum that develops children's/students' sensitivity towards SD - creating a kindergarten/school environment, calendar of ESD in kindergarten/school facilities; 10. Educational projects and EE and ESD in kindergarten/school facilities; 11. Kindergarten/school management and SD; 12. A holistic approach to ESD (school/nursery as a whole, eco-and sustainable school/kindergarten);

3. 13.Lifelong learning in ESD (roles, problems and prospects in the process of lifelong learning for SD (NGOs, etc.)); 14. Model competencies of educators/teachers for ESD; 15. Analyzing one's own activities; the development of critical and analytical competences and the professional dimensions of future educators.

Competencies

The stimulation of systematic, interpersonal and instrumental competences encompasses activities that are to be performed individually or in a group during the conduct of the course (at university or via e-learning). After completing these activities, the students are expected to be able to:

- Research the problem of sustainable development both independently and in a team while making use of indirect sources such as ICT technology, and also of direct sources of knowledge on education for sustainable development that can be found in their current social context and the practice of educational institutions;
- Follow current social and pedagogical issues pertaining to the environment and sustainable development, describe, analyze, critically deliberate and express their opinion on current social issues, reflectively create and implement in practice various educational activities for preschool institutions;
- Efficiently construct the educational context, activities, projects and other forms of work needed to position the issue of education for sustainable development as an integral part of the kindergarten curriculum and of educational practice in preschool institutions;
- Independently and critically deliberate on the necessity of lifelong learning and to accept the problem of sustainable development as an inextricable part of their own future and the future of the world.

Forms of Learning and Teaching

Forms of learning, teaching and activities for stimulating specific competencies in students encompass: connecting and interpreting questions and critically and argumentatively discussing current issues pertaining to the pedagogy of sustainable development, which presupposes the skill of writing a critical essay, analysis or overview. These activities are through two work assignments conceived. The first assignment can involve: a) deliberating and constructing theoretical and practical concepts; b) describing ecological activities based on visits to educational institutions, or research through literature and ICT technology;

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c) recognizing, defining, differentiating between and augmenting the fundamental principles of sustainability through task-oriented movie watching; d) writing a critical review of a movie, exhibition or event.

Students can opt to complete the 1st assignment that pertains to visiting an exhibition, visiting a Greenpeace ship or conceiving practical activities for school or kindergarten on the basis of the theory mastered; or by analyzing a movie that thematizes the problem of ecology.

The 2nd assignment is realized by making connections between the dimensions of sustainable development, i.e. by applying the theoretical and practical concepts of sustainable development with examples of regional, local, national and /or global importance. This assignment demands a perusal and analysis of the problem selected through the lens of the social, economic, ecological, cultural and political dimensions of sustainability and their corresponding values. The aim of this assignment is to raise awareness of the interconnectedness and mutual influences of the dimensions of sustainability and the values they promote.

The 3rd assignment pertains to the development of specific competences through the planning and/or preparation of activities/project. This task involves making connections between theoretical and practical concepts and implementing them in educational practice. It is realized through the concrete creation/ construction of examples of activities or projects connected with a certain topic that can be applied as part of the educational practice of schools and kindergartens (projects on the topic of plants, animals, food, water, human rights, tolerance, natural and cultural heritage and diversity – in accordance with the topics prescribed in the curricula or kindergartens and primary schools).

This course is conducted in hybrid form – through lectures and seminars held at the faculty and through the e-learning interface of the MUDRI-system tool for e-learning. The course has been uploaded to the MUDRI with the purpose of sharing information and opinions, stimulating discussions and enabling students to ask questions and consult teachers regarding lectures, papers and other unclarities. Students can use the e-learning course to communicate with professors and other students, write a blog, participate in discussions on the forum, and create a wiki, share links and upload assignments for consultation/evaluation. Lessons are organized in a manner that enables students to make comments, share their opinions and to ask questions freely. Lessons are conducted regularly in the form of two hours of lectures and two hours of seminars held in the faculty's classrooms or through various forms of extracurricular lessons, e.g. visits to either exhibitions or important events or field classes.

MudRi is a remote learning system based on Moodle software. Moodle is an open-source system intended for the creation of electronic learning materials and conducting remote lessons. All members of the academic and school community have the right to use this system completely free of charge and are entitled to all the assistance they need regarding its use. AAI@EduHr is an infrastructure for the authentication and authorization within the science and higher education system of the Republic of Croatia. The AAI@EduHr has been technically realized through the use of distributed LDAP directories. The Faculty of Teacher education in Rijeka, as part of the AAI@EduHr directory system, issues students and staff a unique electronic identity (user account) that enables authorization and authentication. AAI@EduHr user accounts are opened automatically, and are active as long as the user is affiliated with the Faculty of Teacher education. During their application, students obtain a sheet containing the information needed for logging in to the Mudri system and its courses and to the resources and services described. Students' unique electronic identities also serve as their e-mail addresses at the domain of the Faculty of Teacher education in Rijeka (Carnet, n. d.). This remote learning system has been in use at the Faculty of Teacher education in Rijeka since the academic year of 2008/2009, and at present 50% of courses in all faculties of the University of Rijeka apply this system as a resource, teaching aid or to conduct hybrid lessons.

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As part of the hours intended for academic papers, students have the opportunity to freely select a topic pertaining to the problem of the environment/sustainable development that suits their individual interests and needs. Regardless of whether the topic of the paper is offered or freely selected by the student, before writing and presenting their work students are obliged to hand in a synopsis of their proposed paper. They must then discuss this topic with the professor during consultation hours and obtain his/her permission for the topic, form and manner of writing and presenting of the paper. Students present their papers in the way that suits them best – this can be individually, in pairs or in teams. Individual presentations make use media to expand the content of the paper, work in pairs may take the form of a workshop, while teamwork can involve discussions and debates. During introductory seminar classes, students are given the necessary information on how to present a paper. The presentation of a paper through discussion presupposes discussion as a particular form of group interaction in which members (participants) consider issues of mutual interest together, exchange views and examine the different aspects of their answers, increase knowledge and understanding, confirm or refute opinions, decisions, solutions or activities pertaining to the problem (topic) discussed. The discussion technique that will be depends on the goals set selected, the number of participants, the manner and scope in which opinions are presented, the length of preparation, the sources used etc. The number of participants must not be larger than 4 students. The presentation of a paper topic through a debate presupposes the simulation of a public discussion on the topic assigned in which two teams are confronted – one that advocates a thesis, and one that opposes it. The number of participants must not be larger than 6 students, out of which three are members of the negating team, and three members of the affirming one. The choice of topics is broad: any ecological, political, economic, social, scientific or cultural topic can be chosen that connect with the issue of sustainable development and has possible pedagogical implications for educational practice in kindergartens and schools. (see Table 2)

The evaluation of the presentation and the creation of the paper encompasses the following elements: research on the topic (4% ECTS[4]), creation of the paper according to the rules for writing papers (1%ECTS), connection with educational practice (5% ECTS), evaluation of the presentation of the paper (form of the presentation, methodical approach, tools and aids) and the participation evoked from students (0-3% ECTS). Evaluation of work on the course comprises three midterm exams (10%ECTS) and a final written (25% ECTS) and oral exam (5%ECTS).

Grounds for the Course: The National Context

The justification for a course whose content and activities stimulate the development of general and specific student competencies in this manner is in the following arguments grounded. The education system of the Republic of Croatia is determined through several official documents that give a blueprint for work, i.e. educational practice in preschool and primary education institutions. The fundamental document known as the National Curriculum Framework for Preschool Education and Compulsory Basic and Secondary Education (MSESRC, 2010)[5] defines sustainable development as an educational value and part of the general educational goals of the Republic of Croatia. The basic structure of the preschool curriculum is divided into three large sub-areas in which a child acquires competences: 1. Me (one's image of oneself), 2. Myself and others (family, other children, the social community, kindergarten and local environment), 3. The world around me (the natural and broader social environment, cultural heritage, sustainable development). In the structure of the curriculum for primary and secondary schools, environmental education and education for sustainable development is as an interdisciplinary course

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Table 2. Discussion themes/thesis options, Debate themes/thesis options, workshop themes and open (personal) choice themes/thesis for Academic years 2011 /2012; 2012 /2013

Discussion Thesis/ Themes Options	Debate Themes/ Thesis Options	Workshops Themes	Individual Presentation Themes	Open (Personal) Choice Themes/Thesis
Natural Heritage and Sustainable development	Vegetarianism (Vegetarianism is/not a healthy way of life)	Recycling	Alternative energy sources	Teletransmitter on mount Učka (local issue)
Kindergartens of the future	Genetic engineering (Genetic engineering is /not contributes to the future)	School garden	Eco or sustainable kindergartens	Illegal dumping sites (local, national and global level of issue)
Human rights (Health environment; tolerance, expression)	Cloning (Cloning is/not justified)	Eco project and how to develop it	Cultural heritage (personal choice: Island of Pag, City of Senj)	Oil spill in bay of Kaštela (local issue)
Healthy food	Globalization (Globalization promotes/is/not development)	Unformal and hidden curriculum- how to implement (promotion) activities of ESD, the role of the teacher	Basic activities of ESD in national curriculum	Dumping site Marišćina (local issue)
Eco tourism	Fur & Leather-Fashion (The use of fur and leather in fashion purposes is/not justified)	Eco activities in kindergarten /school	The need to preserve the future	Industrial hemp (global issue)
Industrial hemp	Global warming (The Global warming is/not exists)	Eco stories	Role of kindergarten teacher/primary school teacher in constructing/ implementing ESD activities in to curriculum	Initiative „For a Family“ - amending the constitution and implications for same-sex unions and their rights (national issue)
	Water (Water will be/not be the cause of future wars)	Healthy food	Natural disasters	
		Eco movies	Cultural sustainability of kindergarten/school	
		Kindergartens/ Schools in promoting sustainable communities	Media and sustainable development	
		Trafficking (guest lecturer)	Protected plant and animal species	
		Alternative energy sources	School management and sustainable development	
		Sustainable design and development-kindergarten and school design (indoor and outdoor)		

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defined. These are topics of special importance and exceptional content that are not realized through one school subject, as "the operationalization of interdisciplinary topics is one of the ways in which we can contribute to making connections between educational areas and subjects and meld them into a harmonious unit of knowledge, skills and opinions". The description of the interdisciplinary topic of Health, Safety and Preservation of the Environment is as follows (MSESRC, 2010, p. 24).

The national primary school curriculum of the Republic of the Croatia, which is the second official document that we wish to stress, defines the following: "The issue of the preservation of the environment and of sustainable development is a strategic issue for every country. It is at the center of attention of the international community and the subject of many declarations, conventions and international treaties. In order to ensure sustainable development, which presupposes a form of economic and social development that preserves the quality of the environment and uses natural resources reasonably, education is of pivotal meaning. Thorough changes are in order to alter the centuries-old collective idea on the inexhaustibility of the environment needed, changes that will contribute to improving all the violation caused by human activity. New generations must create a different stance towards the environment and develop skills and abilities that will assist them in facing inherited and newly arisen problems. Environmental education and education for sustainable development encompasses everything that surrounds us and includes the natural, social, cultural, traditional and economic aspects of the environment. As it is based on the construction of a positive value system in the individual, a frequent topic is also the internal environment, which pertains to a respect for the phenomenon of life, compassion and respect for the needs of others, satisfying one's own needs in a manner that takes care of not jeopardizing the needs of future generations and other living creatures, the creation of awareness of one's own values, strengths and possibilities and the establishment of quality relationships with other people, nature and with oneself" (MSESRC, 2006)[6]. The task of schools is to create and implement content pertaining to environmental education and education for sustainable development. Apart from being implemented through existing subjects, environmental education and education for sustainable development can be realized through extracurricular activities and other organized forms of work: integrated extracurricular lessons, days of integrated lessons in the school, environmentally-focused school projects (particularly in cooperation with the local community, professional institutions, associations and companies), the organization of debates and participation in various regional, national and international projects. Projects and programs that focus on preservation of the environment and sustainable development, such as the international programs GLOBE and SEMEP, the ECO-school project, the national program of Young Protectors of the Environment etc. give a framework for the topic and content for activities pertaining to environmental education, enable networking between schools with similar interests and allow for mutual support and an exchange of experiences. Environmental education and education for sustainable development represents a relevant part of lifelong learning. It is also desirable to involve both parents/caregivers and the local community in the realization of this program (MSESRC, 2006).

From *The Strategy For Sustainable development of the Republic of Croatia* (2009) among the principles published is also education for sustainable development. A separate chapter is devoted to social justice and cohesion, in which the following are, among other things, given as activities or measures for realizing the main goal and its corresponding concrete goals: giving special attention to the protection of childhood and the development of children, improving the quality of the entire education system and ensuring it is available to all and improving the education of teachers in the area of the Republic of Croatia through continued professional development. The chapter pertaining to the prerequisites for further development stresses 8 key challenges, out of which a society based on knowledge/education

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for sustainable development is given as the second key challenge. This chapter states that education for sustainable development should be implemented at three levels: at the level of formal education in educational institutions, at the level of informal education, and at the level of the media and processes of implementation in everyday life as a third (informal) level, while stressing the necessity of improving the quality of education at all levels as a key prerequisite. In addition to the topic of education, which is defined identically as in the UN's Decade of Education for Sustainable development (2005-2014), education for sustainable development is defined as a part of lifelong learning. The same document states that it is necessary to "alter and adapt existing curricula for all levels of formal education so that they include the principles and values of sustainability and the interdisciplinary intertwining of its three constituents to a greater extent"(Croation Parliament, 2009)[7].

The Strategy of The University of Rijeka defines completing tasks in harmony with the needs of the sustainable development of the community as part of the university's mission. The University defines itself as a research-oriented university focused on sustainable development that seeks to base its development on human resources equipped for sustainable development. It understands education for sustainable development not only as preservation of the environment, but also as a means of achieving changes in society, in which it refers to the strategy for sustainable development of the Republic of Croatia and lifelong learning, while also planning the foundation of a University Center for Sustainable development.

Grounds for the Course: The International/European Context

Among the significant documents issued in Europe in the area of pedagogy, of particular importance are:

- **The OECD competency framework** which gives a generalization and classification of key competencies for education for sustainable development at the level of general education (Stevens, 2006). Competencies in education for sustainable development are an integral part of international trends in education and have the complete support of UNESCO. Competencies and their development are defined as the priority task in a holistic, cross-curricular approach, i.e. a multidimensional (the ecological, social, political and economic aspects of sustainability), interdisciplinary and integrative concept. In the further text, the competencies stated allow for the formation of a framework of core competencies in education for sustainable development.
    1. **Subject-related competencies** encompass knowledge, facts, definitions, concepts and systems, i.e. encompass thematic areas that are rooted in the fundamental principles of sustainability and development.
    2. **Methodical competencies** encompass the skills of looking up facts, analyzing and problem solving, i.e. presupposes the didactical and methodical skills for the implementation of content and the development of the same competencies through learning material. Their importance is in the strategic approaches to teaching and learning in schools reflected.
    3. **Social competencies** encompass various forms and types of communication (internal, external, personal and interpersonal), interactive work, the public. The importance of the development of these competencies is with democratic decision-making, school management, the school's ethic and cooperation with external factors such as the pupils' families, the local community, educational institutions and supervising bodies connected.
    4. **Personal competencies** encompass those views, values and ethical principles that are subject to change under the influence of new types of learning and teaching, but with the change

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coming from inside, from the individual himself – pupils, teachers, schools as communities, the local community, society. These competencies are particularly in the sensibilities of both educational workers and pupils reflected, while consequentially manifesting as a motivation for change based on the *heart-head-hands* approach, for learning, active participation and training.

Competencies classified in this manner are part of the core curriculum for the implementation of education for sustainable development in kindergartens/schools.

- **The dynamic model for the development of ESD competencies in teacher education (2008)** that was developed as part of the *COMENIUS, SOCRATES* and *EU* projects. It is considered one of the most important educational frameworks created on European soil. Future programs for the education and professional training of primary school teachers should be towards the development of professional and general competencies directed.
- **Professional competencies** represent the area of the professional dimension in which the teacher is not as a "instructor" but as an individual perceived, that has complex interactions with his pupils, his colleagues and his environment. The teacher is no longer considered a mere transmitter of knowledge, but a member of an institution that possesses a collective focus regarding the ways in which all members of an institution (in this case, an educational institution, i.e. school) learn and develop, with all of them involved in a dynamic society that demands facing issues pertaining to sustainability. For all these levels, teachers require specific competencies such as a value system and ethics, action, knowledge, emotions and systematic deliberation on future learning processes, both local and global, which also includes the development of general competencies.
- **General competencies** are connected with the professional domain, and include, as the first competency, the development of *communication* (both internal and external), *envisioning* or *reflection* as the process of transforming educational processes and the foundation for the construction of sustainable schools, with particular emphasis on action research. Action research represents a key tool for the realization of these processes. The third competency is *networking* and encompasses connections with workers in other schools and the exchange of cooperation, experiences and materials. Competencies thus defined ought to be developed through the initial education of teachers and their further professional training, which can be modified in accordance with geographical factors, the status of the school and the education and work experience of teachers in order to achieve higher levels of competency, qualification and knowledge in the development of a holistic approach to education for sustainable development in schools.

According to the Tuning project (2006), competences are as a dynamic set of personal characteristics defined (knowledge and insights, cognitive and practical skills, and values and views) that is the result of the processes of education at a certain level. They are in an integrative approach grounded, in which individual possibilities are the dynamic combination of characteristics as that enable a competent performance or are part of the final product of the educational process viewed. They also encompass three types of knowledge: knowledge and understanding (theoretical knowledge of an academic area, the capacity for cognizance and understanding), 3. knowledge on how to act (the practical application of knowledge in certain situations) and 3. knowledge on how to be (values as an integral part of acknowledging and living with others in a social context). Within the Tuning project, competences represent a blend of these characteristics, in which knowledge and its application, views, skills and responsibilities take into

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consideration to describe the level at which an individual is prepared to use them. (Tuning, 2006, p. 5). Tuning distinguishes between three types of general or generic competencies:

- **Instrumental Competences:** Cognitive abilities, methodological abilities, technological abilities and linguistic abilities; the ability of analysis and synthesis, organization and planning skills; basic general knowledge; oral and written communication in the mother tongue; knowledge of a second language; basic math skills; information management skills (the ability to acknowledge and analyze information from different sources); problem solving and decision making
- **Interpersonal Competencies:** Individual abilities like social skills (social interaction and cooperation); being critical and self-critical; teamwork; interpersonal skills; the ability to work in an interdisciplinary team; the ability of communicating with experts in other areas; accepting diversity and multiculturalism; the ability of working in an international environment and acting ethically
- **Systemic Competences:** abilities and skills concerning whole systems (combination of understanding, sensibility and knowledge; prior acquisition of instrumental and interpersonal competences required); the ability to apply knowledge in practice, research skills; learning skills; the ability to adapt to new situations; the ability to create new ideas (creativity); leadership; understanding the culture and customs of other countries; the ability to work independently (autonomy); creating and managing projects; taking initiative and possessing an entrepreneurial spirit; awareness of quality (culture of quality); a desire for success.

The teachers at the University are obliged to create the syllabi for their courses based on the indicators described in the Tuning project (2006).

Part 3: Research Aim, Problems and Hypothesis

The main aim of this study was to analyze the effect of the course The Pedagogy of Sustainable development on sustainable behavior in students enrolled in Faculty of Teacher education, and to explore the relationship between students' sustainable behavior and their optimism and life satisfaction.

This aim encompassed the following problem questions:

Table 3. Levels of Learning competences

Level	Description of learning competence
1.	Accepting to be guided through learning
2.	Seeking to be guided through learning
3.	Taking responsibility for one's own learning
4.	Expressing an orientation on the self in learning
5.	Valuing one's own learning and recognizing the need for further learning
6.	Consistently valuing one's own learning and identifying the need for learning
7.	Possessing learning autonomy and having a good understanding of learning processes
8.	Developing new ideas or processes and having a very good understanding of learning processes

(University of Rijeka (2007). *Strategy 2007–2013.* Appendix of Figure 1.13)

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1. Is there any difference in sustainable behavior (as measured through four dimensions: human values, awareness of consequences (AC), ascription of responsibility (AR) and intra-personal and inter-personal intelligences) between the group of students who completed the course and those who had not (control group)?;
2. What is the relationship between students' sustainable behavior (as measured through four dimensions: human values, awareness of consequences (AC), ascription of responsibility (AR) and intra-personal and inter-personal intelligences) and their optimism and satisfaction with life?

The following hypotheses were formed based on these questions, previous studies and relevant theoretical models:

1. Since the course The Pedagogy of Sustainable development has the goal to encourage the development of critical thinking about sustainability in students' lives (among other things) it significant differences are expected between the experimental and control groups. In other words, we expect to find significantly higher levels of all four dimensions within sustainable behavior in students who have completed The Pedagogy of Sustainable development when compared to those who had not.
2. In connection with recent studies on sustainable happiness, we expect to determine a significant positive correlation between sustainable behavior (all four dimensions) and optimism and life satisfaction in the total sample of students.

Methods

Participants

A total of 126 subjects (M=20.94 years, SD=1.75, range: 18-27) participated in this study. The sample consisted of undergraduate students (three of them were male students) from Faculty of Teacher education of the University in Rijeka, Croatia. Sixty-three of them were enrolled in the second year of study program Early and Preschool Education and Care (M=19. 68 years, SD=1. 23, range: 18-25), and sixty-three of them were enrolled in the fourth year of study program Primary Teacher education (M=22. 19 years, SD=1. 22, range: 21-27). Sixty-four students (31 of them were enrolled at Early and Preschool Education and Care and 33 of them were enrolled in Primary Teacher education) attended the course The Pedagogy of Sustainable development (experimental group). The average age of students in the experimental group was M=21. 28 years, SD=1. 52, range: 19-27). Sixty-two students (32 of them were enrolled at Early and Preschool Education and Care and 30 of them were enrolled in Primary Teacher education) had not completed the course (control group). The average age of students in the control group was M=20. 58 years, SD=1. 91, range: 18-25).

Measurement

For the measurement of sustainable behavior, a Croatian adaptation of the *"Questionnaire on Sustainable behavior"* (Nájera, 2010)[8] has been applied. This questionnaire measures: a) human values (21 items) according to Schwartz's ten value categories (HV), b) subjects' activations and responsibilities determined by their moral norms (two subscales: each subscale comprising 9 items – awareness of consequences

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(AC) and ascription of responsibility (AR) and c) intra- and inter-personal intelligence (comprising 20 items, INT). This questionnaire of self-assessment satisfied has already satisfied psychometric properties (validity, reliability) in prior research (Anđić & Tatalović Vorkapić, in press), which has been confirmed in this study, as well: in the first measurement (rHV=0.773; rAC=0.881; rAR=0.823; rINT=0.745) and in the second measurement (rHV=0.801; rAC=0.859; rAR=0.849; rINT=0.668). In the first and the third subscales, participants answered by choosing between one of the answers from the Likert scale given (1-strongly agree; 2-somewhat agree; 3-undecided; 4-somewhat disagree; 5-strongly disagree). In the second subscale, subjects answered by choosing between one out of three answers (1-very serious problem; 2-somewhat serious problem; 3-no serious problem), and in the fourth subscale by choosing one out of five answers (1-never; 2-rarely; 3-sometimes; 4-often; 5-consistently). The sample item from the first subscale of human values was: "Responsible"; from the second subscale of awareness of consequences it was: "Do you think that the destruction of rainforests will be a problem for the country as a whole?"; from the third subscale of Ascription of responsibility it was: "Business and industry should reduce their emissions to help prevent climate change."; and from the fourth subscale of intra- and interpersonal intelligence it was: "Keeping your promises". A Kolmogorov-Smirnov test showed that there was a significant difference in the distribution of the results in the second subscale of awareness of consequences between the first measurement (K-Sz=1.790, p=0.003) and the second measurement (K-Sz=1.890, p=0.002). In addition, there were no significant differences between the distribution results of the other three subscales and normal distribution, i.e. the first and second measurement.

- **Life Satisfaction Scale** (Diener, Emmons, Larsen & Griffin, 1985).This questionnaire consists of 5 items that were used to give a cognitive assessment of life satisfaction. The scale has been translated to Croatian adapted to our country (Rijavec, Miljković & Brdar, 2008), and showed one-factor structure. Participants in this study are assessed through their answers on a Likert scale of 5 degrees (from 1-strongly disagree, to 5-strongly agree). The total score was calculated by adding up the estimates for all items, with a higher score reflecting a higher estimate of life satisfaction. An example of one item is: *"I am satisfied with my life*." The scale has satisfactory psychometric properties, as indicated by the Cronbach's alpha reliability coefficients in the first (r = 0.817) and the second measurement (r=0.846) of this study. Similar reliability levels were obtained in previous studies on Croatian samples (Brdar &Anić, 2010; Brkić & Rijavec, 2011; Kararić et al., 2012). A Kolmogorov-Smirnov test showed that there were significant differences between the distribution of results on life satisfaction subscale and normal distribution only in the first measurement (K-Sz=1. 429, p=0. 034).
- **Life Orientation Test (LOT)** (Scheier & Carver, 1985). This questionnaire consisted of 6 items that were used to measure dispositional optimism. The participants are assessed by answering on a Likert scale of 5 degrees (from 1-I disagree a lot, to 5-I agree a lot). The total score was by adding up the estimates for all items calculated, with a higher score reflecting greater dispositional optimism. An example of an item: *"Overall, I expect more good things to happen to me than bad."*. The scale was adapted to our language in previous studies that had shown satisfactory psychometric properties (Rijavec, Miljković & Brdar, 2008). This study determined the Cronbach's alpha in the first (r = 0.722) and the second measurement (r=0.752). A Kolmogorov-Smirnov test showed that there was no significant difference between the distribution of results regard in optimism and normal distribution, in either the first or the second measurement.

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Procedure

Prior to examination, approval for collecting data was from the directorate of Faculty of Teacher education obtained. The questionnaire described was applied at the beginning of spring semester (1st measurement) and at the end of the same semester of the academic year of 2011/2012 (2nd measurement) in the experimental group, and at the beginning of the winter semester (1st measurement) and at the end of the same semester of academic year or of 2012/2013 (2nd measurement) in the control group. Therefore, measurement took place two times in both groups. Subjects participated in the study voluntarily and anonymously, and they received course credit for their participation in the study. Filling out the questionnaire took about 10-15 minutes at each measurement time.

After informing students about general aim of this research, the following instructions were given to them: "Sustainable behavior is evaluated through this questionnaire in accordance with the following definition: a set of effective, deliberate, and anticipated actions aimed at accepting responsibility for the conservation and preservation of physical and cultural resources. These resources include the integrity of animal and plant species, as well as individual and social well-being, and the safety of present and future human generations. In this study, we kindly ask you for your opinions on these items in the context of sustainable behavior. Therefore, please read all the items carefully and assess the extent to which you agree with each of them by circling one of the following numbers: 1, 2,3,4,5. Thank you very much for your cooperation."

After the collection of the data was completed, it was statistically processed through: a reliability analysis of all analyzed variables, descriptive analysis, t-tests on paired samples for all four sustainable behavior dimensions and correlational analysis between sustainable behavior and students' satisfaction with life and optimism. The statistical program SPSS 18.0 was used.

Results

Overall, the results confirmed our first hypothesis, which stated that the course The Pedagogy of Sustainable development would significantly influence positive changes in the students' sustainable behavior. In other words, a statistically significant difference in sustainable behavior was determined between the control and the experimental group. This result vividly demonstrates the usefulness of content pertaining to sustainable development in the training of Croatian primary and preschool teachers, and implicates the importance of sustainable behavior in other professions.

In Table 4 and Figure 2, means and standard deviations could be observed in the experimental group in all four dimensions of sustainable behavior in the first and second measurement. Besides descriptive statistics, results from t-test for paired samples and their significant levels could be seen, too. As it was expected, the findings confirmed higher levels of sustainable behavior after students have attended subject course Pedagogy of Sustainable development.

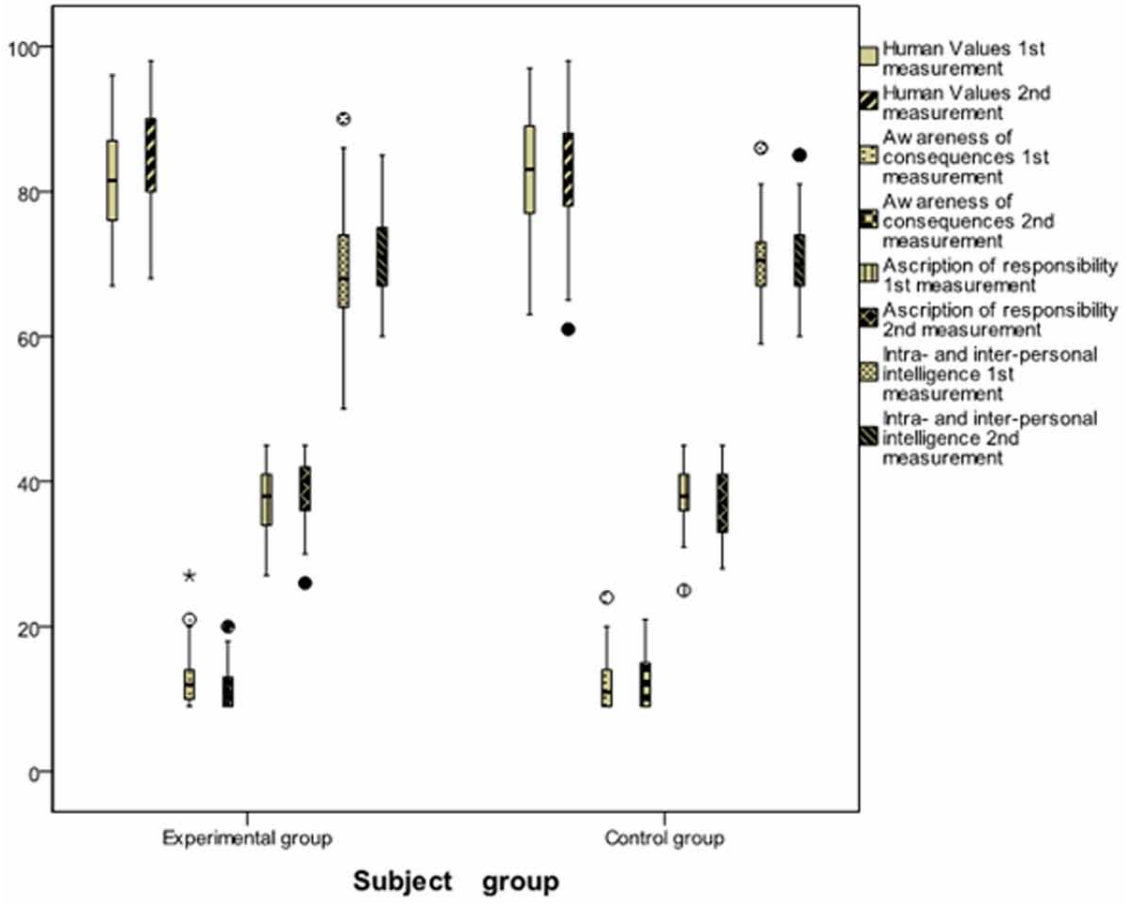
Their results at three subscales were significantly higher in the second measurement: at the Human Values subscale, Ascription of responsibility subscale and Intra- and inter-personal intelligence subscale. In those cases, higher results meant higher levels of human values, ascription of responsibility subscale and intra- and inter-personal intelligence, while in the case of awareness of consequences lower result meant higher levels of that awareness. Therefore, students showed significant results' decline only at Awareness of consequences subscale. This means that awareness of consequences was significantly higher in the second measurement, what was expected, too.

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Table 4. Descriptive statistics, t-tests for paired samples and their significance levels for four dimensions on the questionnaire on sustainable behavior: human values, awareness of consequences, ascription of responsibility and intra- and inter-personal intelligence in the experimental group

Four dimensions of Sustainable behavior in both measurements		Mean	Standard Deviation	t-test for paired samples	p
Human values	1st measurement	81.625	6.713	-4.788	**.000**
	2nd measurement	84.938	6.948		
Awareness of consequences	1st measurement	12.594	3.449	2.613	**.011**
	2nd measurement	11.375	2.597		
Ascription of responsibility	1st measurement	37.109	4.557	-2.808	**.007**
	2nd measurement	38.766	4.078		
Intra- and inter-personal intelligence	1st measurement	69.031	7.191	-3.171	**.002**
	2nd measurement	71.062	5.497		

Figure 2. Boxplot of four dimensions on the questionnaire on sustainable behavior: human values, awareness of consequences, ascription of responsibility and intra- and inter-personal intelligence in the control group in experimental and control group



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In addition, as it was expected, participants from the control group (who did not complete the same course or a similar one) did not demonstrate any significant changes in all four dimensions of sustainable behavior. Table 5 and Figure 2 show the means and standard deviations for the control group in all four dimensions of sustainable behavior in the first and second measurement. It was determined that the most stable dimension of sustainable behavior was human values, where the same mean was determined in both measurements. Even though they had a somewhat smaller stability, no significant changes in all other three dimensions of sustainable behavior were determined. These findings in the control group of subjects definitely showed that prior significant changes in experimental group could be ascribed to the influence of completing the course The Pedagogy of Sustainable development.

The Pearson correlation coefficients (r) between the four dimensions of sustainable behavior: Human values, Awareness of consequences, Ascription of responsibility and Intra- and inter-personal intelligence in the control group and students' optimism and life satisfaction in the first measurement (upper diagonal) and in the second measurement (lower diagonal) are displayed in Table 6. Overall, the correlation analysis of sustainable behavior and students' optimism and life satisfaction showed significant relationships, as expected. It was determined that students who showed higher levels of human values also showed higher levels of optimism and life satisfaction. These significant positive correlations between human values and optimism and life satisfaction were determined in both measurements. A similar relationship was determined between intra- and inter-personal intelligence and optimism and life satisfaction – students with higher levels of intra- and inter-personal intelligence also showed significantly higher levels of optimism and life satisfaction. This relationship is stronger in the second measurement. According to these two dimensions of sustainable behavior, it can be concluded that they showed demonstrated an expected correlation with optimism and life satisfaction. In contrast, awareness of consequences and ascription of responsibility did not show any significant correlation with optimism and life satisfaction.

Discussion

The results of our research indicate towards and corroborate our initial hypothesis that education/ knowledge is a mediator and/or predictor of sustainable behavior. After actively participating in the course, the

Table 5. Descriptive statistics, t-tests for paired samples and their significance levels for the four dimensions on the Questionnaire on Sustainable behavior: Human values, Awareness of consequences, Ascription of responsibility and Intra- and inter-personal intelligence in the control group

Four dimensions of Sustainable behavior in both measurements		Mean	Standard Deviation	t-test for paired samples	p
Human values	1st measurement	82.621	7.499	0.000	1.000
	2nd measurement	82.621	7.885		
Awareness of consequences	1st measurement	12.017	3.343	-1.614	.112
	2nd measurement	12.621	3.508		
Ascription of responsibility	1st measurement	38.086	4.084	1.400	.167
	2nd measurement	37.328	5.000		
Intra- and inter-personal intelligence	1st measurement	70.534	5.020	-.719	.475
	2nd measurement	70.983	5.243		

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Table 6. The Pearson correlation coefficients (r) between the four dimensions of sustainable behavior: Human values, Awareness of consequences, Ascription of responsibility and Intra- and inter-personal intelligence in the control group and students' optimism and life satisfaction in the first measurement (upper diagonal) and in the second measurement (lower diagonal)

Four dimensions of Sustainable behavior, Optimism and Life Satisfaction	Human values	Awareness of consequences	Ascription of responsibility	Intra- and inter-personal intelligence	Optimism	Life satisfaction
Human values	1.00	-0.044	**0.385****	**0.529****	**0.377****	**0.363****
Awareness of consequences	-0.169	1.00	**-0.366****	-0.110	0.044	0.134
Ascription of responsibility	**0.398****	**-0.559****	1.00	**0.263****	-0.002	0.007
Intra- and inter-personal intelligence	**0.530****	-0.108	**0.349****	1.00	0.105	**0.239****
Optimism	**0.480****	-0.009	0.132	**0.266****	1.00	**0.488****
Life satisfaction	**0.542****	0.058	0.068	**0.274****	**0.559****	1.00

(*p<.05; **p<.01)

students from the experimental group demonstrated significantly higher evaluations when it comes to values, responsibility, awareness and intelligence, which confirms the first hypothesis. The results also indicated that, regarding the students in the control group, statistically significant differences between the first and second measurement were not obtained in those 4 dimensions of sustainable behavior, which indicates that the changes observed in the experimental group can be ascribed solely to the influence of the course. If changes in the control group had been ascertained, then the changes in the experimental group could not be ascribed exclusively to the course. Such a result, holistically speaking, indicates that an interdisciplinary course that demands a psychological and pedagogical approach to the dissemination of knowledge, including the development and stimulation of the generic / subject-related, systematic, interpersonal and instrumental competencies through various forms of knowledge and teaching and learning methods, created the foundation for the transformation of existing forms of behavior into a more sustainable behavior. The need for interdisciplinary cooperation is a prominent part of the view of many scholars who acknowledge the interdisciplinary context of both sustainable development itself and education for sustainable development. The values of education for sustainable development are not only an environmental nature and of are not just an issue of behavior in the psychological sense, but also technological, economic and sociocultural problems (Van Liere & Dunlap 1980, Messick & Brewer, 1983, Guagnano, Stern &Dietz, 1995 et al. as cited in Clark, Kotchen & Moore, 2002, pp. 237-239, Brekke, Kipperberg & Nyborg, 2010).

However, the concept of sustainable development as a value system is the axis of the development of more sustainable forms of behavior and the achievement of a more sustainable future. This is an education that strives towards the development of human abilities and an ethics of responsibility, to alter our relationship towards those social processes that have proven to be harmful and to instill a respect for other individuals and species (Rakić & Vukušić, 2010, p. 790). In accordance with the interdisciplinary context of our research, this work places an emphasis on the psychological and pedagogical aspects of sustainable behavior as applied to the context of implementation of education for sustainable development at the level of higher education (Pol, 2000, 2007.). An example of such a convergence of knowledge is

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reflected in those forms of work within the course The Pedagogy of Sustainable development that are rooted in the view that *"It is not the amount of knowledge available that determines ecological behavior but the strength of the convergence of different forms of knowledge"* (Kaiser & Fuhrer, 2003, p. 604). The course also encompassed a historical perspective, terminological definitions and individual and group tasks that were on the clarification of the notion of values and responsibility focused. Individual work and work in a pair/team allows for both the identification and clarification of these terms and their transmission to everyday life and educational practice. The Croatian sociologist Cifrić (2002, p. 80) stressed two important demands for studies on sustainability: interdisciplinarity and research focus. He stresses two prerequisites for interdisciplinarity: terminological clarity and a consensus on their use. The second demands pertaining to the research focus as, according to the author, studies should encompass concrete social problems such as lifestyles, values and environmental problems, but also be able to deliberate on power and the influence of the various actors in current processes. They also have to be self-reflective. The clarification of terms, terminology and terminological discrepancies between various research areas, the evolution of the concept from environmental education to education for sustainable development and lifelong learning strategies are important prerequisites for the conceptualization of both explicit and implicit educational reflections and methodical approaches in the practice of educators and teachers. Huckle's (2006) stance towards the personal dimension of sustainability as an area of the problem of the ethics of sustainability is a constituent part of interdisciplinary and holistic deliberations on values and responsibilities, which also includes the concept of sustainable development and its educational manifestation. In other words, the holistic perspective offered by the model of sustainable development both gives the student an opportunity to reflect and self-reflect on his own values, responsibilities and actions in his everyday life and his student (professional) life.

Research results indicate that students in the experimental group demonstrated significantly larger statistical steps forward when it comes to the area of Schwartz's universal values, which also includes the values of education for sustainable development and particles that are in opposition to them. Values are a category that is difficult to change, and from the studies conducted heretofore, it is evident that they have been a frequent subject of research, as has been their influence on the formation of behavior. Support for this can be in many studies found, for example, those by Inglehart (1977-1997) in which he attempted to prove the connection between value systems and socioeconomic systems. For this author, an increase in care for the environment occurs as the consequence of a paradigm shift[9]. The issue of value change is rooted in the stance on shifting from a materialistic towards a post-materialistic paradigm, i.e. from a modern to a postmodern paradigm (1997). In this, Inglehart sides with those multiple authors that hold changes/shifts/improvements of paradigm as important for the development of education for sustainable development. Value changes, particularly as viewed in the context of social and cultural values, were the focus of many researchers. Maslow's hierarchy of needs, for example, stresses that people progress through a succession of levels of need until eventually they become more interested in–or more free to pursue–personal development and self-actualization. With his S-curve, Salk (1981) underlines the existence of two epochs whose values are diametrically opposite. Tibbs (2011) gives us an overview of the aforementioned models and debates on changes in the social and cultural spheres and the conversion of values that support sustainability. The author stresses Ray's (Tibbs, 2011, p. 19 as cited in Ray, 2008, p. 1) view on defining values as *"people's most important life priorities, the basis for what they actually do, what they want to accomplish, and how they want to be"*. Viewed in this fashion, this definition of values is also in our research and in the items in our questionnaire reflected.

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The research overview and empirical study by Abdul Rashid and Abdul Wahid (2012) proves that employees that are actively involved with environmental activities at the workplace would also show a similar inclination toward performing pro-environmental behavior at home. These authors stressed two important factors that influence the positive spillover pro-environmental behavior: Organizational Factors (organizational climate according to environmental management system has three dimensions: clarity of goals; Trainings and teamwork) and Family Factors (family cohesion and family support). Thus, the explanation of these results is rooted in the fact that a value change occurred in our students, one that was the result of the influence of the course content and the teaching methods that questioned from the very beginning each student regarding the following issues – who they are, what they want to achieve and what kind of people they want to be. In other words, if we connect the issue of values in the course content with the issue of personal values, the greater the possibility for making connections between goals and achieving them, (Năftănăilă, 2010, p. 836) – or, in our case, for attaining more sustainable forms of behavior.

Deliberations on the values of sustainable development through their four dimensions (UNESCO, 1997) in an everyday context, at both the local and personal level, offer the possibility of achieving identification in this manner and provide the foundation for altering one's own value system. Through tasks conceived in this manner, students have the opportunity to transform their own values and spot common goals in their own lives, how to transmit them into the local and global level, and while also learning how to think in a more innovative fashion. Reexamining one's own views, values and responsibilities is a constituent part of this task and enable students to notice different perspectives and view things from a different angle, to observe problems from a personal, local or global level and to arrive to the crux of the problem in a holistic fashion. The selection of task problems is free and personal, which at the same time indicates a hierarchy of personal values, and how informed are students regarding current social, political, environmental, economic and other issues in a local and global context.

Also connected with the idea of values is the idea of responsibility, which completes the self-image of the individual. According to Stern, Dietz, Abel, Guagnagno & Kalof (1999) in their Theory of Support for Social Movements with which they explain 4 types of environmental behaviors (Environmental Activism, Environmental Citizenship, Policy Support and Private-Sphere Behaviors), the values that support the New Ecological Paradigm (altruistic, egoistic, traditional, openness to change) lead towards an awareness of consequences, the ascription of responsibility and the formation of proenvironmental personal norms. Thus, deliberation on responsibility in the context of work on the course is through reflection on one's own values and by improving awareness of the consequences of one's own actions and the actions of others realized. This explains the results obtained through our research.

An indispensable part of such work is involving those aspects of work that are rooted in inter- and intra- personal intelligence as measured with the particles used for the measurement of emotional intelligence. The results obtained regarding the measurement of awareness of environmental problems and interpersonal and intrapersonal intelligence as viewed through the 5 psychological dimensions of sustainability indicate statistically significant differences that are in favor of the experimental group of students. According to Najera (2010, p. 57), Gardner's multiple intelligence was the subject of some criticism in its application in the context of education. Najera stresses the following: *"However, this theory holds that: 1) multiple intelligences act on a value system whereby students with a diversity of abilities can learn and succeed; 2) that learning is exciting, and that hard work by teachers is necessary; 3) that the exchange of constructive suggestions and formal and informal ideas embedded in the curriculum and the*

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evaluation of educational activities are valid for the students, as well as for the broader culture, 4) that the arts may be employed in order to develop people's abilities and comprehension within and across disciplines, and 5) that multiple intelligences are means to fostering high quality student work. These features are highly pursued in education for sustainability" (Najera, 2010, p. 10). On the other hand, we can also partially locate an explanation of our results in this paragraph: the course content directly stimulates students to interact with others, reflect and self-respect on their views and the views, perspectives, values and behaviors of others. Every student freely selects the topic of his/her task and paper and also the manner in which he/she desires to present it. Certainly, these demands for the professor to be prepared and to introduce the students to the topic of sustainability, while stimulating their interest and motivation regarding issues of personal, local and/or global importance. However, further implications of such a manner of teaching and developing competencies within the educational practice of teachers/educators are in the students themselves manifested.

Smith (2002) stresses that students will be happier studying issues that are directly relevant to their lives, and students that engage in issues that are directly pertinent in their own lives, that are directly related to their communities and important to the adults that surround them, will most likely find their school experience more enjoyable, engaging and valuable. The inclusion of such topics and the creation of educational activities, games and projects enables students to connect the issue of sustainability with their own environment, and also to identify better with sustainability issues in other areas as an increase in their awareness on the cause-and-effect relationships between their own actions and those of others and in their level of sensitivity has occurred.

In close relation to the 5 psychological dimensions of sustainability, the results of the research indicate positive steps forward regarding taking responsibility, deliberating on purposeful behavior now and in the future and on the causes and consequences of one's own behavior and the behavior of others, altruism towards others and the implementation of more sustainable ways of life. These results could be compared with those results obtained in the evaluation of optimism and life satisfaction, and positive relation between pro-environmental behavior and well-being (Venhoeven, Bolderdijk & Steg, 2013). The study hypothesis were set according to previously described theoretical models and empirical findings, such are those from research by Tapia-Fonllem, Corral-Verdugo, Fraijo-Sing, B. & Durón-Ramos (2013), that determined significant correlations between environmental emotions, affinity towards diversity and sustainable happiness. Related to that, we also expected to determine significant correlation between sustainable behavior (all four dimensions) and optimism and life satisfaction in the total sample of students. Nevertheless, our hypothesis have been confirmed partially, considering that the obtained significant positive correlation with optimism and life satisfaction was determined only in relation to two dimensions of sustainable behavior: human values and intelligence.

Such results were to be expected, since these are personality traits that are closely connected with the measured dispositional optimism, and thus also life satisfaction. In contrast to this, awareness and responsibility are less stable convictions and are subject to change, which can be the reason for their lack of correlation with optimism and life satisfaction. Research on optimism shows that people who demonstrate high levels of optimism are more likely to use stress-confronting and problem-solving skills, while being less likely to use evasion and avoidance of a task (Scheier, Weintraub & Carver, 1986; Carver, Scheier &Weintraub 1989; Rand 2009). This is also with a confrontation with environmental and sustainability issues connected, as the concept of education for sustainable development demands learning and teaching problem-solving skills, decision making, viewing issues from different angles etc. Weber's study (2012)

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indicated that optimism is significantly correlated with general environmental behavior. However, it has not been ascertained that more optimistic people will act in a more environmentally-aware/sustainable way, but that they will be more likely to participate in environmental behavior.

CURRENT CHALLENGES FACING THE ORGANIZATION

Current challenges facing our organization including the following issues:

- Implementing and developing new forms of convergent knowledge in the course – as results have shown there are significant changes in sustainable behavior of our students- these changes must take long term effects. Education and convergent forms of knowledge are predictors of these changes and must be further developed and improved.
- Conducting the empirical study researches about/ of competencies especially in education for sustainable development – planned research and team project (in autumn - winter 2013/2014): that includes a variety of competencies, constructing an instrument, interdisciplinary approach (psychological, didactics, pedagogy, methodology) in building and conducting the research (including other universities)
- Competencies issues- competencies and methods needed for strengthening in learning and teaching in this course, as its development in other interdisciplinary courses;
- Constructing the frame for specific competencies and new innovative ways to develop them;
- Enhancing students in studying more interdisciplinary approaches trough selection of discussions and debate themes/thesis of local, regional, national and global issues;
- Securing students motivation and interest trough continually monitoring events and new literature, enhancing their questions, thinking, team project building and its presentations on teaching and practice trough the course.

SOLUTIONS AND RECOMMENDATIONS

According to Steiner & Posch (2006), the concept of sustainable development can give a normative framework for the introduction of innovations. These authors also hold that innovators in the introduction and integration of the problem of sustainability into higher education face dynamic non-linear phenomena and complex situations. Due to these reasons, we should identify the possibilities that emanate from sustainable behavior with the purpose of developing strategies and concrete action plans for stimulating development in the direction of sustainable development. This potential has been recognized by educational institutions long ago, as has the stimulus for transformation based on the ten-item plan of the Tallioires Declaration (1990), created by presidents, rectors, and vice chancellors of universities/ institutions of higher learning for a sustainable future. This plan stresses the pivotal role of the university as an institution that educates, explores, shapes policies and exchange information, while defining the action plan for universities all around the world regarding the implementation of sustainable development. One of these items pertains to cooperation/collaboration through interdisciplinary approaches, which involves convening all university workers, administrators and practitioners that deal with this topic to develop an

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interdisciplinary approach to curricula, research, initiatives, operations and other activities that support an ecologically sustainable future.

We recognized the implications of one such approach in the guidelines presented by O' Brien (2012, p. 1199)[10], which are grounded in UNESCO's determinants for reorienting teacher education for sustainability and the implementation of positive psychology and the concept of sustainable happiness and welfare, as they offer us a framework that directly reflects the course The Pedagogy of Sustainable development.

Those are also possible solutions and recommendations for further interdisciplinary course development. The first guideline in the area of reorienting teacher education for sustainability (according to Unesco, 2005) encompasses coursework on sustainability for student teachers that involves interdisciplinarity and the availability of material on local and global sustainability issues. In the area of positive education and sustainable happiness it introduces student teachers to research in positive psychology and its relevance to their school and community and the subjects they will teach; the encouragement of systems thinking to integrate sustainability with positive; the influence of student well-being on learning; how individual well-being is interconnected with community well-being and the well-being of the natural environment.

Connections with the course Pedagogy of Sustainable development are evident through content aimed at introducing students to the fundamental terms within ecology – the development of man's thought on the environment up to the 20th century (interdisciplinarity, holism); familiarization with the terminology and definitions pertaining to the concept of sustainable development (its early development and its contemporary models) and the concept of education for sustainable development. In this area, students are acquainted with research results through: an international overview of research trends in the area of formal, informal and non-formal education; an overview of environmental education and education for sustainable development projects in European, Asian and North American countries, an overview of national reports on the identification of implicit and explicit criteria; support to eco-schools that incorporates sustainability principles and actions in whole school and a comparative analysis of national reports and criteria for eco-schools, i.e. on the eco-school development processes in 13 world countries (Mayer &Mogensen, 2005). Current local research. The area of values and responsibility within the concept – giving examples for individual and team student work and thematizing content in an integrative fashion that presupposes a diverse approach to the problem of values within the dimensions of sustainable development. Observing the model of sustainable development through dimensions (biophysical/ ecological, economic, sociocultural and political) and the values on which they are based and which they promote. Different concepts, values and educational topics pertaining to sustainable development are reflected upon, discussed and observed through the lens of this model. Particular emphasis is placed on a methodical approach to the implementation of environmental education and education for sustainable development that includes implementation through official educational documents and a curricular approach. The tasks are: to make connections, interpret questions and critically argument the problem of the pedagogy of sustainable development (Writing a critical essay, analysis or review – assignment 1). Papers: debates, discussions and workshops.

The second guideline for the reorientation of education towards sustainability presupposes the demonstration of pedagogical techniques that foster higher-order thinking skills, support decision-making, involve participatory learning and stimulate the formulation of questions; in connection with positive education and sustainable happiness it presupposes a critique of existing pedagogical techniques in order to determine how they contribute to or detract from teacher and student well-being, a discussion of the well-being of teachers, stress prevention and management and of model teaching practices and assessments that contribute to well-being.

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We connect these guidelines with the course content that encompasses the area of the development of environmental education into education for sustainable development. A methodical approach; orienting oneself towards, within and for the environment; elements of the curriculum; implementation through play and activities (the creation of eco-games and activities, aspects in the formation of environmentally-conscious games and activities, sources of direct and indirect reality, projects. This also includes the creation of academic papers: debates, discussions and workshops.

The third guideline for reorienting teacher education encompasses (O' Brien, 2012, p. 1199) an emphasis on the role of the citizenry in the sustainable community (the demand for active participation and decision-making in the classroom and curriculum), while in the area of positive psychology and sustainable happiness it presupposes creating opportunities for student teachers to apply positive psychology to classroom management, teaching practice and assessment strategies

The connections between this guideline and our course include deliberation on values and responsibilities – presenting examples through the individual and teamwork of students. Methodical approach – sustainable educational institution – holistic approaches to the implementation of education for sustainable development into kindergartens and schools. Evaluation and self-evaluation are/as an integral part of the holistic approach. Tasks for students involve: planning and/or preparing activities/projects, writing and presenting papers: debates, discussions, workshops.

The fourth guideline towards reorienting teacher education for sustainability presupposes discussions on social equity (e.g. gender, racial, ethnic, and generational) and identifying the ways in which the local community exhibits social tolerance, societal intolerance, equity, and discrimination; in the area of positive psychology it includes the incorporation of emerging research on social equity and well-being.

The connections between this guideline and our course encompass the area of values and responsibility within the concept – presenting examples through the individual and teamwork of students. Tasks: to make connections, interpret questions and critically argument contemporary issues within the pedagogy of sustainable development (Writing a critical essay, analysis or review).

The fifth guideline towards the reorienting of education towards sustainability encompasses analyzing of the mandated curriculum that they will be teaching and identifying topics and themes related to sustainability and those that are linked to local sustainability issues. In the area of positive education and happiness, a similar topic appears – guiding and leading student teachers to analyze the mandated curriculum they will be taught to identify topics and themes related to the individual, community and global well-being (particularly health education)

The implications of these guidelines pertain to the content encompassed by the curricular approach: an analysis of official educational documents. Every paper must include a chapter that pertains to implications or explicit work in education – the kindergarten or school. Tasks for students: planning and/or preparing activities/projects.

The sixth guideline towards the reorientation of teacher education for sustainability pertains to providing student teachers with opportunities to explore their own values and attitudes towards local sustainability problems and those of the surrounding region; while in the area of positive education and sustainable happiness it implies providing opportunities for student teachers to apply positive psychology both personally and professionally, assisting student teachers to explore their views of happiness and well-being, developing a "happiness literacy" regarding the factors that influence them and their values about happiness, encouraging critical analysis of current education practice, including program delivery, how schools are built etc.) (O' Brien, 2012, p. 1199).

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The connection of these guidelines with the course Pedagogy of Sustainable development encompasses deliberation on personal, local and global problems in the context of values and responsibilities - presenting examples through the individual and teamwork of students, the ethics of sustainability, modern childhood, strategies of lifelong learning for sustainable development, the curricular approach: an analysis of official educational documents and the design of schools and kindergartens.

The seventh guideline towards the reorientation of teacher education is on promoting understanding of global sustainability in order to encourage critical thinking and decision-making that influence personal lifestyle and economic choices focused. This guideline logically follows the previous and they can be implemented together. The guidelines for the implementation of positive education and sustainable happiness presuppose providing opportunities for student teachers to apply sustainable happiness both personally and professionally (synthesizing positive psychology with sustainability) and encouraging student teachers to think critically about the role of education for sustainable happiness and well-being.

Its implications are related to the course content given previously and encompass content on values and responsibility - presenting examples through the individual and teamwork of students; a curricular approach – holistic approaches to the implementation of education for sustainable development into kindergartens and schools. It also includes the following content: evaluation and self-evaluation as an integral part of the holistic approach; strategies of lifelong learning for sustainable development and familiarizing students with teacher competency models regarding education for sustainable development. Tasks for students: to make connections, interpret questions and critically argument contemporary issues within the pedagogy of sustainable development (Writing a critical essay, analysis or review - model of sustainable development: dimensions of sustainability, assignment 2). Papers: debates, discussions, workshops.

The eighth and final guideline is actually a herald of the further development and formation of courses that will encompass all the aforementioned guidelines for the reorientation of teacher education for sustainability and the promotion of positive psychology/education and sustainable happiness. O' Brien (2012, p. 1199) stresses that it is necessary to develop specialized Education for Sustainable development (ESD) programs for student teachers (e.g. mini-courses) with certificates of completion, so that student teachers can include them in their resumes for seeking employment and to provide teacher education courses and professional development opportunities that apply positive psychology and sustainable happiness to education and educators.

The course program is an integral part of the compulsory study program of: the integrated undergraduate and graduate teacher training study; the undergraduate study of preschool care and education; the differential program for enrolling at the graduate level of early and preschool care, and the elective course Education for Sustainable development in Open Spaces. Bachelor's and master's theses that include connections with positive psychology and the pedagogy of sustainable development are also realized at the faculty.

Finally, we also wish to stress one limitation of our research experiment, and this is the fact that the study was on a relatively small sample conducted. Our solution and recommendation for further research is not only to further develop the implications of an interdisciplinary and integrated approach to the development and implementation of courses for the training of educational workers, but also for future research to be on larger samples conducted and with more variation in age, sex and study orientation. This would allow better insight into the relationship between certain dimensions of sustainable behavior and optimism and life satisfaction. However, the evident strong connection of values and intelligence with optimism and life satisfaction empirically proves an overlap between the fundamental terms of positive

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psychology and those from the pedagogy of sustainable development, which can serve as a basis for the creation of interdisciplinary courses that aim to develop and stimulate specific sustainability-related competencies.

Courses such as this one must include convergent forms of knowledge and enable a change of values and views, taking responsibility, reflection and self-reflection from the angle of the individual, the citizen of society, the professional employed in an educational institution and the teacher as a part of society. Such courses must equip students with competencies that will enable them to adopt the aforementioned roles and promote them at an institutional and social level.

As is stressed in Agenda 21, education is the key tool for the promotion of sustainable development, and we wish to again stress that is bearers are educational workers. The model of sustainable behavior that we have applied to our research also confirms this argument and represents a foundation for the further creation and development of more inventive forms of both initial teacher education and further professional training, and for teaching and learning for sustainable development in current and future practice at both the national and global level.

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KEY TERMS AND DEFINITIONS

Education for Sustainable Development: A concept whose primary goal is the promotion and implementation of the idea of sustainable development at all levels of education, in every form of education, for every individual, community, society, including its local, regional, national and global context.

Life Satisfaction: A general cognitive evaluation of the satisfaction with life.

Optimism: The general expectation that good rather than bad things will occur in our lives (dispositional optimism).

Pedagogy of Sustainable Development: An interdisciplinary course at the Faculty of Teacher education in Rijeka. It encompasses the contents regarding pedagogical implications and implementations of education for sustainable development in primary school/preschool/kindergarten practices. It's intended to teacher students and early education/preschool teachers in developing competencies for effective practice in teaching in education for sustainable development.

Positive Psychology: A science of positive subjective experience, positive individual traits, and positive institutions promises to improve quality of life and prevent the possible pathologies.

Sustainable Behavior: Behavior that encompasses peoples' values, norms, beliefs, senses of responsibility in deliberate actions focused to providing well-being of all living beings, including present and future generations.

Teacher Students/Early Education/Preschool/Kindergarten Students: Students at the Faculty of Teacher education in Rijeka, University of Rijeka, Croatia. They are attending Integrated undergraduate and graduate study of Primary School Education and University undergraduate study of Early and Preschool Education.

ENDNOTES

1 PSD: Pedagogy of Sustainable development.

2 EE: Environmental Education.

3 ESD: Education for Sustainable development.

4 ECTS: European Credit Transfer and Accumulation System.

5 Ministry of Science, Education and Sport of Republic of Croatia (2010). National Curriculum Framework for Preschool Education and Compulsory Basic and Secondary Education. Zagreb. / online/. Retrieved November 12. 2011 from http://www.public.mzos.hr

6 Ministry of Science, Education and Sport of Republic of Croatia (2006). National Curriculum. Zagreb. Retrieved September 15, 2010 from http://www.public.mzos.hr

7 Croatian Parliament (2009). The Sustainable development Strategy of the Republic of Croatia. Narodne novine. 30(110/07). Retrived September 15, 2010 from http://www.hrpsor.hr/hrpsor/images/dokumenti/StrategijaOdrzivogRazvitkaRH_NN30_09.pdf

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[9] In Anđić (2011), this is the demand for paradigm "improvements" or "shifts", which are, according to some authors, necessary in order for us to speak of the Concept of Education for Sustainable development. According to many authors, Environmental Education is defined as a part of the modern paradigm, while Education for Sustainable development is considered a part of the postmodern paradigm. Locally and abroad, this issue was the thematized by Cifrić, 1990; Beck, 1995; Tilbury & Waterford, 1996; Capra 1998; Sterling 2001; Raumolin 2001, 2002; Myerson 2002; Novalić, 2003; Šantić 2003; UN Commission on Sustainable development, 2009 et al.

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Chapter 55
Rule of Law: A Fundamental Pillar Enabling Sustainable Development and Reduction of Poverty in India

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ABSTRACT

The world as a whole has developed in the global dimension and has flourished with prosperity. But still one can see the hurdles in the development process. One of such impediments is poverty and the other is the environmental problems. Poverty results in violation of human rights. The rule of law is crucial and is one of the means to strengthen these hurdles. One of such escalation is on the environmental development wherein it strives for achieving sustainable development and eradication of poverty. The rule of law plays a vital role in reducing extreme poverty with emphasizing on human rights. It is the very essence and the core of Good Governance. Without the principles of the rule of law, it will not be enough to achieve sustainable development and eradication of poverty. The rule of law strengthens to provide intense legal framework. It works as an effective mechanism for the enforcement of law. Innovative methods are undertaken to aim in the enforcement of sustainable development and eradication of poverty. The paper implies on effectiveness of the rule of law in providing sustainable development policies. It analyses the legal framework in India that contributes in maintaining economic imbalances. The paper explores the role of Indian Judiciary and the classic Judgments of Supreme Court of India. Keeping in view the importance of sustainable development and eradication of poverty, the paper contributes to explore the significance of the rule of law in achieving the objective of the nation. "Development is one of the primary means of improving the environment for living, or providing food, water, sanitation and shelter, of making the deserts green and the mountains habitable" (Indira Gandhi, 1972).

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1. INTRODUCTION

The environment is a facet of every human activity. It must be protected as there are various threats and barrier. Only through sustainable development, the environment can be protected and preserved for the future generations. In the same way, the poverty, being a major challenge in a global aspect, needs its eradication for the human development. Reduction of poverty, being one of the biggest challenges in the world, is not only a developmental goal but it is an incredible challenge for a country. India is no exception for that. The fundamental precepts of human rights are violated due to poverty. Environmental protection and reduction of poverty are integral aspects of the developmental process. The extent and the depth of poverty may be linked to sustainable development in the same way as environmental degradation. The poverty may have significant repercussions for sustainable development through their linkages with social sustainability (Naushad Ali Azad, 2004). In this perspective, Rule of law, as one of the special features of good governance stand as a pillar for the growth and development of a country. It must be effective to provide conformity and enforcement mechanisms of environmental sustainability policies to achieve sustainable development.

2. PERSPECTIVES OF RULE OF LAW

The governance structure of the country is founded on the principles of democracy, equality and the principles of the rule of law (N.K. Uberoi, 2003). An outlook of A. V. Dicey's evaluation on the principle of rule of law embraces three ideals: 1) the absence of arbitrary and discretionary power on the part of government; 2) every man is subject to the ordinary law of the land administered by the ordinary and usual tribunals; 3) the general principles of law, the common law rules of the constitution. (Dicey, 1915)

The rule of law plays an indispensable role for sustainable development and poverty alleviation since it is the root cause for rapid economic growth. The very essence of the Rule of Law is that everyone is equal before the law and that fair justice must be conferred without fear or favour. It provides deference to constitutional supremacy and upholds human rights. "It is important to emphasize that the absence of arbitrary powers is the first essential of the Rule of Law upon which our whole constitutional system is based. In a system governed by the rule of law, discretion when conferred by upon executive authorities, must be confined within clearly defined limits" *(*Aeltemesh Rein, Advocate, Supreme Court of India v/s Union Of India And Others).

The rule of law plays a crucial role in sustaining constitutionalism and strengthening democracy in India. Indian democracy has been protected, enhanced and enriched by principles of rule of law (Dr. Singhvi L.M., 2002). It is enshrined in *Aritcle 14* of the Constitution of India that rightly said to be the "basic feature" of the constitution that cannot be destroyed even when amended under *Article 368* of the Constitution. There is a close network between the rule of law, sustainable development and eradication of poverty. Without adherence to the rule of law, there can be no sustainable development. Without the rule of law, there can be no protection and safeguard of human rights. In *Zahira Habibulla H. Sheikh v/s State of Gujarat*, the Supreme Court of India observed that, "the principles of rule of law and due process are closely linked with human rights protection…."

The outcome of the United Nations Conference well known as Earth Summit held in Rio de Janeiro, Brazil on 20-22 June, 2012 focused on the notion of sustainable development and eradication of pov-

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erty has taken firm steps on this overwhelming background by implementing policies and programmes, executing and enforcement of laws and signatory to the various International and Regional Agreements on sustainable development.

3. RULE OF LAW IN PROMOTING SUSTAINABLE DEVELOPMENT

Sustainable development has various dimensions, viz., environmental, ecological, social, economic, financial, cultural, political, and so on. Here the concept is highlighted with the environmental sustainability. Raskin (1996), have defined environmental sustainability as the capacity of unimpaired persistence and the maintenance of the ecosystems and the natural resource base into the future (Naushad Ali Azad, 2004). Sustainable development is a process of encouraging economic growth while protecting the environment and improving our quality of life without affecting the ability of future generations. The original concept of sustainable development enunciated in *Our Common Future* (the *Brundtland Report*) is of "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Honourable Justice *Brian J. Preston*, 2006). The precautionary principle, intergenerational and intragenerational equity, the conservation of biological diversity and ecological integrity, and the internalisation of environmental costs are the four fundamental elements of sustainable development. The triumph of sustainable development depends on effective functioning of the rule of law as it is a major force in the attainment of sustainability in the country.

United Nations Conference is a watershed event on environment and development, which is well known as Earth Summit held in Rio de Janeiro, Brazil on 3-14 June, 1992. *Agenda 21* is one of the Principles resulted by the conference that monitors the relationship between human rights, population, social development, women and human settlements, and the need for environmentally sustainable development. The second UN Conference, renowned to be Rio+20 held on 20-22 June, 2012 at Rio de Janeiro, Brazil, devastated the theme on sustainable development. The conference conveyed confronts of sustainable development including *Agenda 21* for its further implementation. India, through the instrument of rule of law has put its efforts in the implementation of *Agenda 21*.

3.1. Legal Framework and Role of Government

India has maintained a focus on sustainability. Significant progress has been made in major sectors like agriculture, forestry, energy, and environment. The contemporary legal regime governing the environment in India came basically in the wake of the Stockholm Conference of 1972, which required states to adopt measures to protect and improve the environment. Under this circumstance, the 42nd amendment to the *Constitution of India* was made in 1976 and thereby *Article 48A* of the Directive Principles of State Policy was incorporated that provides for the protection and improvement of the environment and the safeguarding of forests and wildlife. A Fundamental Duty was also set upon the citizens to 'protect and improve the natural environment, including forest, lakes, rivers and the wildlife, and to have compassion for living creatures' under *Article 51A (g)*. *Article 21* of the constitution provides for the Right to Life and the same has widened the interpretation by the judiciary to comprise right to clean environment. The ruling in *Maneka Gandhi v/s Union of India* made *Article 21* a residuary freedom clause. In this wave length, in *M.C. Mehta v/s Union of India,* the court has brought under the umbrella of *Article 21*, the right to clean environment (*C.M. Jariwala,* 2004).

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India has enacted various laws pertaining to environmental development. Few among them have been mentioned below:

- The *Wildlife (Protection) Act,* 1972 - A comprehensive legislation for the protection of wild animals, birds and plants and also lays down the law for the setting up of protected areas such as sanctuaries, national parks and closed areas.
- The *Water (Prevention and Control of Pollution) Act,* 1974 – Aims at the prevention and control of water pollution and of restoring the wholesomeness of water quality.
- The *Forest Conservation Act,* 1980 - Restricts and regulates the dereservation of forests or use of forest land for nonforest purposes without prior approval of central government.
- The *Air (Prevention and Control of Pollution) Act,* 1981 - Provides for the prevention, control and abatement of air pollution and explicitly states in its Preamble that the Act represents an implementation of the decisions taken at Stockholm
- The *Environment (Protection) Act*, 1986 - Protect, improve and prevent the environment, human beings, other living creatures, plants and property.
- The *Biological Diversity Act*, 2002 - Gives effect to the sovereign right of countries of origin over their genetic and biological resources and the acceptance of the need to share benefits flowing from commercial utilization of biological resources with holders of indigenous knowledge.
- The *Patents (Amendment) Act,* 2005 - Prevent misappropriation of indigenous knowledge of communities by making it nonpatentable.
- The *Forest Rights Act*, 2006 - Deals with the rights of the traditional forest dwellers.
- The *National Green Tribunal Act,* 2010 - Deals with the liability and compensation for the victims of pollution and other environmental damages.

3.2. Policies

- The National Forest Policy, 1988
- The National Conservation Strategy and Policy Statement on Environment and Development, 1992
- The Policy Statement on Abatement of Pollution,1992
- The National Agriculture Policy, 2000
- The National Population Policy, 2000
- The National Water Policy, 2002
- The National Environment Policy, 2006 shows interest in all facet of environmental development - The Policy seeks to extend the coverage and fill in gaps that exist in the light of present knowledge and accumulated experience. It does not displace, but builds on the earlier policies

3.3. Schemes and Programmes

- National Natural Resources Management System (NNRMS), 1983 was set up for optimal management of the natural resources and environment of the country using an optimal mix of remote sensing and conventional techniques.

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- Integrated Watershed Management Programme (IWMP) that intends to restore the ecological balance by preserving and developing degraded natural resources such as soil, vegetative cover and water.
- National River Conservation Plan
- Ecomark Scheme of India (ECOMARK) - Ecomark Labelling
- National Afforestation Programme - A Participatory Approach to Sustainable Development of Forests
- National Action Programme to Combat Desertification
- Grants in aid Scheme for Voluntary Agencies

3.4. Conventions

India is party to almost 35 International Conventions, Treaties and Protocolds. Some of them are as follows (Mohammad Naseem, 2011):

- The Antarctic Treaty, 1959.
- The Fund Convention, 1971
- Ramsar Convention on wetlands, 1971.
- Stockholm Declaration of the UN Conference on the Human Environment, 1972.
- The Convention on Migratory Species, 1979.
- Vienna Convention for the protection of the ozone layer, 1985.
- Montreal Protocol on substances that deplete the ozone layer, 1987.
- Basel Convention on Trans boundary Movement of Hazardous Substances, 1989.
- UN Convention on Biological Diversity, 1992.
- UN Framework Convention on Climate Change, 1992.
- UN Convention to combat Desertification, 1994.
- Kyoto Protocol, 1997.
- Rotterdam Convention on import of hazardous chemicals, 1998.
- Cartagena Protocol on Biosafety (Safe transfer, handling and use of Living Modified Organisms), 2000.

3.5. Judicial Perspective

In India, the judiciary has played a vital role in contributing to environmental development. The notion of Governance and the Rule of Law are basically intertwined and that the Judiciary, interacting with the human affairs as the final arbiter, has both the responsibility and the duty to dispense justice by upholding the Rule of Law (Lal Kurukulasuriya, 2003). Environmental jurisprudence is significant particularly in three aspects; (a) there is a new dimension given to the dormant procedural provisions on public nuisance as crime, (b) there has been rejection of traditional common law doctrines of strict liability, creating instead of absolute liability for hazardous and inherently dangerous industrial activities, (c) the past few years have witnessed the creation of what amount to a fundamental human right to a clean environment guaranteed under the Constitution of India (C. M. Abraham, 1999) . The following is a brief outline of the developments in the aspect of judicial facet.

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3.5.1. Right to Life

In N.D. Jayal v/s Union of India, the Court linked the concept of "sustainable development" with the "right to life" and observed:

…. the adherence to sustainable development principle is a sine qua non for the maintenance of the symbiotic balance between the rights to environment and development. Right to environment is a fundamental right. On the other hand, right to development is also one. Here the "right to sustainable development" cannot be singled out. Therefore the concept of "sustainable development" is to be treated as an integral part of "life" Article 21 of the Constitution of India." (A.K. Tiwari, 2006)

3.5.2. Access to Information

In *M.C. Mehta v/s Union of India and others (*WP (Civil) No. 860 of 1991), the Supreme Court of India, in response to a petitioner's request for issuing a court directive on the importance of public information in environmental matters, called on cinemas and video parlours to project environmental messages and films about environmental issues and requested that radio companies make programs on environment and pollution.

3.5.3. Precautionary Principle

When confronted with an action that sought to stop industries from discharging untreated effluent into agricultural fields, the Court in *Vellore Citizens Welfare Forum v/s Union of India,* called upon the government to create an authority that would address polluting industries. After announcing that the precautionary principle had become an international customary law, the Court recommended that the announced authority consider this principle.

3.5.4. Polluter Pays

The polluter pays principle has been recognized by the Supreme Court of India, in *Vellore Citizens Welfare Forum v/s Union of India,* held that "along with the precautionary principle - the polluter pays principle is a part of customary international law".

3.5.5. Public Trust Doctrine

In *MC Mehta v/s Kamal Nath & Ors,* the Supreme Court of India has applied the public trust doctrine in regard to natural resources and the environment.

3.5.6. Right to Clean Environment

The Supreme Court of India in *M.C. Mehta v/s Union of India* ordered the relocation of hazardous industries located near residential areas in New Delhi. The Court held that the citizens' 'right to clean environment' is in turn derived from the protection of life and liberty enumerated in Article 21. In *T. N.*

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Godavarman Thirumalpad v/s Union of India, Hygienic environment is an integral facet of the right to a healthy life and it would be impossible to live without a humane and healthy environment.

3.5.7. Promotion of Sustainable Development

The Supreme Court of India in *Narmada Bachao Andolan v/s Union of India* defined sustainable development in a case concerning to the construction of a dam which mean to "what type or extent of development can take place which can be sustained by nature / ecology with or without mitigation". In *State of Himachal Pradesh v/s Ganesh Wood Products,* the Supreme Court of India upheld the applicability and significance of the concept of sustainable development. The Court said:

Intergenerational equity means the concern for the generations to come. The present generation has no right to impede the safety and well-being of the next generation or the generation so to come thereafter.

4. RULE OF LAW IN COMBATING POVERTY: A MULTI-LEVEL CHALLENGE

Poverty is multi-dimensional involving number of parameters of human development and human empowerment. When compared to urban and rural estimates of poverty, confirms that, poverty in the rural areas is more severely entrenched (Naushad Ali Azad, 2004). The great Visionary Former President A.P.J. Abdul Kalam vision is that true of making India a developed country by 2020, not by adopting the age old theory of redistribution of income and wealth which has seized its relevance at least at present, but instead of it, we should adopt the policy of reduction of number of poor (Vimal Shankar Singh, Shweta Singh and Subraha Singh, 2010).

India, as a nation that has been actively associated with the global pursuit of sustainable development, is in exertion to achieve the objectives underlying the principles of Agenda 21 which is the central of planning in India. Since Independence, the country has paved the way towards social development through multi-faceted development planning, guided by the objectives of poverty eradication. The government, over the years has developing a number of programmes that aim at eradicating poverty (N.K. Uberoi, 2003).

The last few decades have made comprehensible progress in the field of economic growth and development. The development towards agriculture, industry, trade, infrastructure, banking and finance, investment, encouraging foreign investment, widening of international market, removing barriers to trade and commerce by eliminating controls over private sector. All these have outcome the growth rate in the Indian economy. The other direction to eradicate poverty was the implementation of policies, programmes and schemes emphasizing on health, education and women's empowerment. The government strived towards the achievement of UN Millennium Development Goals (MDGs) pertaining to poverty eradication.

4.1. Policies

- The *National Agricultural Policy (NAP)* seek to promote technically sound, economically viable, environmentally nondegrading, and socially acceptable use of country's natural resources to promote sustainable development of agriculture.

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- The *Food Security Policy* provides nutritional support to the poor through subsidized food grains and ensuring price stability.
- The *Industrial Policy Statement* of 1991 has been established to encourage entrepreneurship, develop indigenous technology through investment in research and development, bring in new technology, dismantle the license permit system, develop the capital markets and increase competitiveness for the benefit of the individual.
- The policy towards deregulation of *Foreign Direct Investment (FDI)* has played a major role in the economic growth of the country.

4.2. Programmes

- *National Food Security Mission (NFSM)* that aims to increase the production of rice by 10 million tonnes, wheat by 8 million tonnes and pulses by 2 million tones by the end of Eleventh Five Year Plan (2007-2012).
- *Rashtriya Krishi Vikaas Yojna (RKVY)* that seeks to achieve an annual growth rate of 4 percent in the agricultural sector during the Eleventh Five Year Plan (2007-12).
- The *Twenty Point Programme* was introduced in 2006. The programme is an umbrella package of social sector schemes and programmes that are administered by various Ministries and implemented by State/Union Territory Governments with the basic objectives of poverty eradication and improving the quality of life of the poor and the under privileged population of the country.

4.3. Schemes

- The Public Distribution System (PDS);
- Antyodaya Anna Yojana (AAY);
- The National Programme of Nutritional Support to Primary Education, also known as “mid day meal scheme”;
- The Integrated Child Development Services (ICDS);
- Annapurna;
- The National Old Age Pension Scheme (NOAPS);
- The National Maternity Benefit Scheme (NMBS);
- The National Family Benefit Scheme (NFBS).

4.4. Conventions

India is a signatory to a number of major International Conventions and Treaties on Human Rights and Sustainable Development.

- International Convention on the Elimination of All Forms of Racial Discrimination,1968.
- World Intellectual Property Organization (WIPO), 1975.
- International Covenant on Civil and Political Rights, 1979.
- Convention on the Rights of the Child, 1992.
- Convention on the Elimination of All Forms of Discrimination against Women, 1993
- World Trade Organization (WTO), 1995

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4.5. Legal Regime

Comprehensive and landmark legislation in reduction of poverty and enabling sustainable development.

- The pillars of sustainable development are inserted in the *fundamental rights* of the Indian Constitution. *Article 21* of the constitution provides for the Right to Life and the same has widened the interpretation by the judiciary to comprise right to food, right to livelihood, right to live with dignity and other similar rights.
- The Human Rights Act, 1993, has been enacted in protection of human rights ensures justice for all.
- *People with Disabilities Act*, 1995 and the *National Trust Act,* 1999 protect the rights of the disabled and seeks to set up a national level body to ensure the welfare of the disabled respectively.
- The *Right to Information Act*, 2005 promotes transparency and accountability in the working of public authorities.
- The *National Rural Employment Guarantee Act*, 2005 aims to provide a legal guarantee of a minimum 100 days of wage employment in a financial year to every rural household.
- *The Maintenance and Welfare of Parents and Senior Citizens Act*, 2007, protecting the rights of the senior citizen to a dignified old age.
- The *Right of Children to Free and Compulsory Education Act*, 2009, has been enacted vowing to the obligation towards the youth.

The Planning Commission, being a prime bureau, periodically estimates poverty lines by conducting research and analysis on the poverty. The Planning Commission under the Chairmanship *Suresh D. Tendulkar,* known as *Tendulkar Committee* has issued poverty line.

Table 1 shows national poverty levels. According to these estimates, poverty declined at an average rate of 0.74 percentage points per year between 1993-94 and 2004-05, and at 2.18 percentage points per year between 2004-05 and 2011-12.

It is evident that the percentage of the population in poverty has been falling consistently. The *Eleventh Five Year Plan* laid great stress on implementation of the accompanying projects and programmes. The following are some important indicators (Vivek Mehra, 2013).

- GDP growth (see Table 2) in the Eleventh Plan 2007–08 to 2011–12 was 8 per cent compared with 7.6 per cent in the Tenth Plan (2002–03 to 2006–07) and only 5.7 per cent in the Ninth Plan (1997–98 to 2001–02). The growth rate of 7.9 per cent in the Eleventh Plan period is one of the highest of any country in that period which saw two global crises.

Table 1. National poverty estimates (% below Poverty Line) 1993 – 2012 (Press Note, Planning Commission, 2013)

Year	Rural	Urban	Total
1993 – 94	50.1	31.8	45.3
2004 – 05	41.8	25.7	37.2
2009 – 10	33.8	20.9	29.8
2011 – 12	25.7	13.7	21.9

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Table 2. Gross domestic product (GDP) growth rate from 2005 to 2014 (Statista, 2014)

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
9.04%	9.53%	10%	6.9%	5.88%	10.09%	7.9%	4.9%	5.9%	6.4%

- Agricultural GDP growth accelerated in the Eleventh Plan, to an average rate of 3.7 per cent, compared with 2.4 per cent in the Tenth Plan, and 2.5 per cent in the Ninth Plan.
- The percentage of the population below the poverty line declined at the rate of 1.5 percentage points (ppt) per year in the period 2004–05 to 2009–10, twice the rate at which it declined in the previous period 1993–94 to 2004–05. (When the data for the latest NSSO survey for 2011–12 become available, it is likely that the rate of decline may be close to 2 ppt per year.)
- The rate of growth of real consumption per capita in rural areas in the period 2004–05 to 2011–12 was 3.4 per cent per year which was four times the rate in the previous period 1993–94 to 2004–05.
- The rate of unemployment declined from 8.2 per cent in 2004–05 to 6.6 per cent in 2009–10 reversing the trend observed in the earlier period when it had actually increased from 6.1 per cent in 1993–94 to 8.2 per cent in 2004–05.
- Rural real wages increased 6.8 per cent per year in the Eleventh Plan (2007–08 to 2011–12) compared to an average 1.1 per cent per year in the previous decade, led largely by the government's rural policies and initiatives.

4.6. The Goal and Target that Guide the Twelfth Five Year Plan (Vivek Mehra, 2013)

4.6.1. Economic Growth

1. Real GDP Growth Rate of 8.0 per cent.
2. Agriculture Growth Rate of 4.0 per cent.
3. Manufacturing Growth Rate of 10.0 per cent.
4. Every State must have an average growth rate in the Twelfth Plan preferably higher than that achieved in the Eleventh Plan.

4.6.2. Poverty and Employment

1. Headcount ratio of consumption poverty to be reduced by 10 percentage points over the preceding estimates by the end of Twelfth Five Year Plan.
2. Generate 50 million new work opportunities in the nonfarm sector and provide skill certification to equivalent numbers during the Twelfth Five Year Plan.

4.6.3. Environment and Sustainability

1. Increase green cover (as measured by satellite imagery) by 1 million hectare every year during the Twelfth Five Year Plan.

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2. Add 30,000 MW of renewable energy capacity in the Twelfth Plan.
3. Reduce emission intensity of GDP in line with the target of 20 per cent to 25 per cent reduction over 2005 levels by 2020.

5. ENVIRONMENTAL SUSTAINABILITY

Greening rural development is essential for ensuring the environmental sustainability of economic growth. Poverty reduction and economic growth can be sustained only if natural resources are managed on a sustainable basis. Greening rural development can stimulate rural economies, create jobs and help maintain critical ecosystem services and strengthen and strengthen climate resilience of the rural poor.

Greening rural development refers to five broad green outcomes:

- Improved natural resource conservation,
- Increased efficiency of resource use,
- Reduced negative environmental impacts,
- Strengthened climate resilience of communities, and
- Contribution to climate change mitigation.

The rationale for greening rural development emerges from the Twelfth Five Year Plan (2012-17) strategy of faster, sustainable and inclusive growth for poverty alleviation and to reduce rural poverty and ensure a better quality of life especially for the poor.

Sustainable use of environmental resources can contribute to growth and stability. Direct economic benefits from environmental policies will accrue mainly over the long term, green policies can contribute to short-term economic growth (World Bank, 2012). This strengthens the case for paying attention to environmental sustainability. Rural development schemes provide a strong opportunity to aggregate 'small initiatives' in several locations to improve natural capital on a macro scale. These self-governing institutions and their capacities will be key to greater effectiveness of regulatory and market instruments in ecosystem regeneration and improving natural capital. Natural capital or environmental resources are an important complement to such planned investment in achieving development goals (Ravi Chopra, 2012). The Planning Commission notes in its Approach Paper to the 12th Five year Plan that "economic development will be sustainable only if it is pursued in a manner which protects the environment. With acceleration of economic growth, these pressures are expected to intensify, and we therefore, need to pay greater attention to the management of water, forests and land (Planning Commission, 2011. pg 10).

Sustainable development has been embedded in the planning process of the country since the 1990s. The Ninth Five-Year Plan (1997–2002) explicitly recognized the synergy between environment, health and development and identified as one of its core objectives the need for ensuring environmental sustainability of the development process that also promote sustainability of economic growth. India's planning focuses on development that strives for improvement in the standard of living and quality of life of the people. The period after the 1992 Earth Summit saw the introduction of various government programmes and schemes to address sustainability concerns as discussed in earlier sections. A list of key programmes along with the recent budget allocation is presented in Table 3 (Ministry of Environment and Forests, Government of India, 2011).

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5.1. Expenditure on Sustainability Programmes (in INR Million) (Ministry of Environment and Forests, Government of India, 2011)

1. Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) – 401000
2. National Rural Livelihood Mission/Swarna Jayanti Gramin SwarojgarYojana (SGSY) – 26830
3. Indira Awas Yojana – 93335
4. Renewable Energy for Rural Applications – 1620
5. Renewable Energy for Urban, Industrial and Commercial Applications – 370
6. Jawahar Lal Nehru National Urban Renewal Mission (JNNURM) – 200
7. Swarna Jayanti Shahari National Rural Health Mission (NRHM) - 135402.6
8. Forest Conservation, Development and Regeneration - 567.3
9. National Afforestation and Eco-development Programme – 2530
10. Prevention and Control of Pollution – 8075

5.2. Judicial Reform

Human rights provide a framework for poverty eradication. Poverty at the same time is the cause and the consequences of the human rights violations. Applying to human rights perspective to poverty establishes a relationship between strategies to fight against poverty. The Public Interest Litigation has provided broad access to justice and judicial redress to all persons that are in a position of poverty (Maritza Formisano Prada, 2011)

The judiciary set forth in eliminating poverty and upholding the human rights by means of exerting the right to life of the citizens. The programme on "National Conference of High Courts on Poverty Eradication, Combating Social Exclusion and Advancing Social Justice: Role of Courts", organized at National Judicial Academy, Bhopal on October 24-25, 2009 aimed at the idea of social justice and alleviation of poverty, mainly focusing on Poverty related challenges (Court News, 2009).

While hearing to a Public Interest Litigation case (People's Union for Civil Liberties (PUCL) *vs*. *Union of India* and *Others),* on the right to food filed by People's Union for Civil Liberties (PUCL), the court heard the PUCL's lawyer, Colin Gonsalves, who had brought a report published in the *Hindustan Times* ("India lets grain rot instead of feeding poor", *HT*, July 26, 2010) to the court's attention. The Court held that, it was a crime to waste food in a poor country. The Court criticized Additional Solicitor General Mohan Parasaran: "If you cannot store the grain, give it to the people to eat (The Hindu, 9th August, 2010)." The right to food can be seen as an implication of the fundamental "right to life", enshrined in *Article 21* of the Constitution. *Article 21* should be read with *Articles 39(a) and 47* to understand the nature of the obligation of the State in order to ensure the effective realization of this right. *Article 39(a)* enunciated as one of the Directive Principles, fundamental in the governance of the country, requires the State to direct its policy towards securing that the citizens, men and women equally, have the right to an adequate means of livelihood. *Article 47* spells out the duty of the State to raise the level of nutrition and the standard of living of its people as a primary responsibility. An interim order focused on eight food related schemes, viz., PDS, AAY, National Programme of Nutritional Support to Primary Education (mid-day meal scheme), ICDS, Annapurna, NOAPS, NMBS and NFBS.

Essentially, the interim order converted the benefits of these eight "schemes" into legal entitlements. The government should be held accountable to what it claims to be doing to protect the right to food, i.e.

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implement these food related schemes. It also directed the government to replace monthly "dry rations" of grain with daily, cooked midday meals. The Court Orders further for:

1. Identification of BPL families,
2. Accessibility of ration shops and regular supply of grain, and
3. Permission to buy in installments

The judiciary also shines in protecting human rights. In *Coralie v/s Union Territory of Delhi*, court observed:

We think that the right to life includes the right to live with human dignity and all that goes along with it, namely, the bare necessaries of life such as adequate nutrition, clothing and shelter over the head and facilities for reading, writing and expressing one self in diverse forms, freely moving about and mixing and commingling with fellow human beings. (Brinder Pal Singh Sehgal, 2008)

The Supreme Court of India in *Anthony v/s Bihar Gold Mines Ltd.,* has interpreted *Article 21* with the principles enshrined in *Article 39(a)*. "The sweep of the right to life conferred by Article 21 is wide and far reaching.…An equally important facet of that right is the right to livelihood because, no person can live without the means of living, that is, the means of livelihood. *If the right to livelihood is not treated as a part of the constitutional right to life, the easiest way of depriving a person of his right to life would be to deprive him of his means of livelihood to the point of abrogation*. Such deprivation would not only denude the life of its effective content and meaningfulness but it would make life impossible to live…."

6. CONCLUSION AND SUGGESTION

Even though the progress has been made by the principle of the rule of law in enhancing substantial development and reduction of poverty in innovative ways, there are many manifestations of these problems such as high growth of population, the food disaster, unemployment, inequality and so on. Hence, there is a need to overcome such challenges and threats. The rule of law will exert in resolving these impediments. India is a signatory to the various International and Regional Agreements on sustainable development. Currently, the upshot of many policies, programmes, various laws, agreements and the contribution of judiciary illustrates the development of sustainability. However, vibrant judiciary is essential in furtherance to uphold the rule of law. Chief Justice, R.K.Agrawal, Madras High Court, has divulged in his speech on "Rule of Law and Access to Justice" that,

…due to a poverty 'access to justice' has remained elusive to the masses. The Government, in its welfare role, has tried to alleviate poverty through various schemes. Yet, the enforcement of these rights often requires the intervention of Courts. The role of Indian Courts ensures greater 'access to justice' through 'Public Interest Litigation' and other procedural innovations.

Nevertheless, poverty is a great threat to the political fidelity. Indeed, focus must be enhanced to greater extent for sustainable development. Efforts must be made by implementing and enforcing innovative laws. Legal reform and judicial interference is very much important for comprehensive develop-

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ment. Steps must be taken to remove barriers in the development. Struggle must be made to convene the prospective between the different policies and programmes, to avoid the leakages to ensure the fruits of the schemes that reach the beneficiaries, adoption of innovative approaches to environmental regulation and to improve the technical and managerial skill. Ultimately, the rule of law must work in progress in order to well-build the incentives and regulatory framework with relevance to reduction of poverty and sustainable development. The developmental Planning must aim at the reduction of poverty line from the grass root level. The perfection must be in overall system of the government, central, state or local bodies. Coordination is an imperative for efficient public delivery and effective functioning of the politico-administrative machinery in the country. To attain sustainability and reduction of poverty, it is thus only possible with the effective enforcement of the rule of law which is a cornerstone in upholding human rights. Certainly, the rule of law is vindicated by judicial independence.

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Chapter 56
Are University Lecturers Literate in Sustainability?

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ABSTRACT

An extensive body of knowledge exists about students and education for sustainable development; though very little can be found for educators. This chapter will review existing literature and relate how it is relevant for educators to be sustainability literate in order to promote the skill among students. A purely qualitative approach was used for this study. Eleven lecturers were interviewed in order to ascertain their level of sustainability knowledge. The interview transcripts were analysed using phenomenography. Findings indicate that built environment academics were particularly literate in sustainability matters. Recommendations as to how other institutions can assess the sustainable literacy level of educators are made.

INTRODUCTION

Sustainable development education has been the focus of much research (Pappas, 2012; Murray, 2011; Wright, 2010; Sibbel, 2009; Murray and Cotgrave, 2007; Cotgrave and Alkhaddar, 2006; Reid and Petocz, 2006; Thomas, 2004); largely due to the United Nations decade of education for sustainable development as well as the worldwide attention sustainability has been given.

The most cited definition of sustainable development comes from the United Nations World Commission on Environment and Development (WCED, 1987) Brundtland Report which states that "sustainable development seeks to make sure that developments meet the needs of the present without limiting future generations from meeting their needs". However other ways of defining it exist. The 'triple bottom line' considers sustainability in environmental, economic and social terms (Hueting and Reijnders, 2004; Murray, 2011). Whereas Faber, Jorna and van Engelen (2005, p. 5) suggested that "sustainability refers to an equilibrium between an artefact and its supporting environment, where they interact with each other

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without mutual detrimental effects". Although there are numerous definitions for sustainability, (WCED, 1987; Leal Filho, 2000; Hueting and Reijdners, 2004; Faber et al., 2005; Atkinson, 2008; Shepherd et al*.,* 2009; Murray 2011) the basic premise of all of them appear to be how sustaining the well-being of living systems can be achieved over time (Moore, 2005; Atkinson, 2008). It would therefore be safe to say that there will likely never be a universal definition for sustainability as it means different things to different people (Mann, Dall'Alba, and Radcliffe, 2007). The authors argued that a reason for that is that people's understanding is influenced by their own background, work experience, previous training and their views on political and economic aspects.

The UK government has passed legislation such as the Duty of Care which places the responsibility of appropriately disposing of waste to those that are in contact with materials, including producers and importers (Dainty and Brooke, 2004). It has also published reports such as the Office of Government Commerce which provided details as to how the construction industry can achieve sustainable procurement (OGC, 2007; Cotgrave and Kokkarinen, 2010b). Research conducted by Cotgrave and Alkhaddar (2006) found that final year students did not possess in-depth knowledge regarding environmental or sustainable issues when holding presentations on the subject. The following year Murray and Cotgrave (2007) wrote that the Sustainable Development Education Panel (SDEP) proposed that all professional bodies should incorporate sustainability in their course accreditation criteria. As observations like this have still been made even with government and professional body involvement, it emphasizes the need to educate people on sustainable development, particularly in higher education, as this is most often the last chance people have to gain full theoretical knowledge before being able to practically apply that knowledge in a job.

The influence that sustainable development education has on students has been researched as they will have the potential to endorse sustainable practices in the industry once they obtain their degree. In spite of this, the community, industry and university groups have a limited knowledge of how educators at university level understand and incorporate the concept of sustainability in their teaching (Reid and Petocz, 2006).

Studies promoting sustainable development education in students have proposed educational theories such as collaborative and transformational learning (Moore, 2005). A central tenet for collaborative learning is that students from many disciplines work together to build their knowledge and understanding on a subject matter. The assumption for this type of learning is that every discipline has something to contribute towards this production of knowledge (Moore, 2005). Transformational learning is when learning changes problematic frames of reference into ones which are more reflective, inclusive and emotionally able to change (Moore, 2005; Dirkx, Mezirow and Cranton, 2006). This means that an opinion changes once enough knowledge is gained which challenges the previous point of view that was held by an individual.

If academics are found to have a deep knowledge on sustainable issues, knowledge on collaborative and transformational learning might enable them to think of different educational tasks by which to encourage transformational learning to occur amongst their students. Not only that, but academics themselves could benefit by applying certain principles from these theories into exchanging ideas with other members of staff regarding their knowledge on sustainability as this may vary from subject to subject. As sustainable development means different things to different people, incorporating collaborative and transformational learning theories to form a new understanding of what sustainability means, particularly in the built environment, which reflects the knowledge of each academic in every discipline is needed.

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In addition to sustainable development education, sustainable literacy is another component which has been heavily researched (Thomas, 2004; Murray and Cotgrave, 2007; Fortuin and Bush, 2010; Murray, 2011). By being sustainability literate, individuals would have the right values, knowledge and skills to have a significant impact in securing the future (Murray, 2011). It is a skill that is believed to give graduates the ability to apply sustainable principles and practices in their careers after obtaining their degree and perhaps even in their personal lives. Sustainability literacy is a learning outcome that is expected to arise after successful sustainable development education. Even so, it should also be considered a skill set that is correspondingly required by educators to possess in order for students to gain it as a skill.

This chapter will attempt to address what Reid and Petocz (2006) pointed out that there is a need to understand the way in which educators themselves understand sustainability in a discipline-specific way. In this particular case study, the understanding of academics from the built environment will be explored through a qualitative research design. The objectives are to find out how sustainability literate lecturers are by having them describe in their own words how they understand sustainability as well as how they see sustainability benefitting their discipline. Academics will be asked to consider whether there are any potential barriers they see affecting the assimilation of sustainability knowledge by students.

ORGANIZATION BACKGROUND

Following a Research Assessment Exercise (RAE) conducted in 2008, the School of the Built Environment at Liverpool John Moores University (LJMU) was ranked first among post-1992 universities in the United Kingdom based on the quality of research produced (Higher Education Funding Council for England, HEFCE, 2012).

LJMU's School of the Built Environment offers undergraduate courses in seven areas which are: Architectural Technology, Building Services Engineering, Building Surveying, Civil Engineering, Construction Management, Quantity Surveying and Real Estate Management. Additionally, the school has several post-graduate programs as well as a doctoral research department. Most programs can be studied full- or part- time while in some cases distance learning is offered. Throughout all of these programs, sustainability is promoted to some extent, in a way that most appropriately addresses each course of study.

When studied full-time, most undergraduate studies last three years in UK universities. These comprise of level four for first year students, level five for second year students and level six for final year students. For the purpose of this study, academics who taught Civil Engineering students were not interviewed because Civil Engineering students did not partake in an educational intervention which followed the interviews of academics.

SETTING THE STAGE

UNESCO declared 2005-2014 to be the Decade of Education for Sustainable Development. In a similar vein, business leaders and national governments have been trying to promote sustainable practices with the help of international agreements or transparent business plans (Murray, 2011). Thus far however, the desired level of effect has not been reached as more and more sustainable development initiatives are being devised. This begs the question whether they are meant to take the place of already existing ones or whether a new approach is being implemented if older ones have not yielded expected results.

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Recognising the barriers facing consumers to making sustainable choices shifts the focus to the training of professionals who manage the resources, educate the public or design the options from which choices are made. The institution of higher education is where these professionals are trained. In fact, many argue that the higher education sector bears a significant responsibility for sustainability by virtue of its influence on society and academic freedom to explore ideas (Sibbel, 2009, p. 74; Wright, 2010; Pappas, 2012).

Barraza and Robottom (2008) noted that education for sustainable development directs educational tactics to promote, understand and implement sustainable development through bringing together seemingly discordant ideas of conservation and development. Although what Sibbel (2009) postulates is valid, the assessment of skills should be done for those who are meant to teach future professionals. Notable barriers that have been identified in incorporating sustainability into higher education are the lack of experts in sustainability (Kokkarinen and Cotgrave, 2010a). Many academics may already have other areas in which they teach and therefore do not have the time to attend training courses to update their sustainability knowledge consequently passing on information that is out of date to their students (Thomas, 2004; Velázquez, Munguía, and Sánchez, 2005; Sibbel, 2009; Kokkarinen and Cotgrave, 2010a).

Educational theories support sustainable development education by promoting collaborative learning in which students work together to build their knowledge and understanding on a subject matter (Moore, 2005). Transformational learning is another theory in which the learning of new information changes a previous frame of reference that a person has had (Moore, 2005; Dirkx et al., 2006). The focus of this theory in most cases has been to understand adult learning but it has also been used in higher education: "abstract and idealized, grounded in the nature of human communication" (Dirkx et al., 2006; Taylor, 2007; p.173). Aspects of the theory are rooted into developmental stages but most of the theory focuses on the understanding of the process of using a previous notion to devise a new or revised interpretation of meaning of an individual's experience in order to direct future action. Moore (2005) gave the example of critically reflecting on consumption patterns and production and how this knowledge may impact a persons' own consumptive behaviour.

Theories such as these are helpful in directing educational efforts to help students understand sustainability yet an area that has been overlooked has been the role that academics have in educating university students about sustainability. More importantly it raises the question as to whether they have the necessary knowledge on such a complex notion. If academics were to implement collaborative or transformational learning into teaching their students, they could make use of certain principles from these theories to improve their own knowledge on sustainability by seeking to exchange ideas and information with other colleagues.

Marton (2007) described a theory of learning which was based on a phenomenographic approach in which teachers thought critically about how they present teaching materials and what they have to do to make sure that students can easily learn from what is presented to them. Phenomenography is defined as a research method that describes the qualitatively different ways in which phenomenon is experienced, conceptualized or understood, based on an analysis of accounts of experiences as they are formed in descriptions (Hasselgren and Beach, 1997). While transformative learning uses different methods to change an individual's perspective, the content which transformational educators teach is no different from what non-transformational educators teach (Dirkx, 1998). Transformative learning can be periodic or augmentative and can involve objective or task-oriented as well as subjective (self-reflective) reframing (Dirkx et al*.,* 2006). In most cases the support from others is needed in order to fulfil subjective

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reframing (Dirkx et al., 2006). Therefore elements such as group work and having a reflective element to it may help promote transformational learning experiences. Moore (2005) pointed out that new models of interdisciplinary education promote teamwork exercises. However, she continued by stating that these aims are difficult to implement in current curricula as the focus is on marking the individual, hence making the implementation of transformative learning more difficult. Moore (2005) noted that academics have freedom in both teaching and research, yet few engage in different methods of teaching, nor do they emphasise the intended learning outcome of social change. A phenomenographic approach is particularly useful in trying to assess whether a transformative learning experience has taken place in an individual as it allows analysis of experiences that happened prior to and after the fact.

Sustainable literacy is another component that is often researched (Thomas, 2004; Murray and Cotgrave, 2007; Fortuin and Bush, 2010; Murray, 2011) and could be described as a learning outcome for sustainable development education. It is a skill that will give graduates the ability to apply sustainable principles and practices in their careers after obtaining their degree in order to move the sustainable development agenda forward. Even the United Kingdom's Sustainable Development Strategy has mentioned the need to instil this competency into professional graduates (DEFRA, 2005, p. 39), "we need to make 'sustainability literacy' a core competency for professional graduates". While it is clear that mechanisms to help students gain an understanding of sustainability are in place, there appears to be little work on the skills educators should have in order to teach sustainability effectively.

Reid and Petocz (2006) explored the kind of sustainability conceptions that academics from multiple disciplines held and what efforts they made in trying to integrate sustainability into their lesson plans. The academics that were interviewed were not from environmental science disciplines. This resulted in the conclusion that their conceptions and experiences of sustainability differed greatly from the conceptions and experiences which lecturers who are familiar with sustainability have expressed. Particularly, Reid and Petocz (2006) asserted that the range of explanations given by interviewees did not match the rhetoric that sustainability experts would use to describe sustainable development issues. Despite these findings, their work is noteworthy as it is one of the only available publications which attempted to assess the sustainability knowledge of educators-providing support to the fact that an equal, if not more attention should be paid to their capabilities and knowledge than those of students.

In order to address the lack of research regarding the role of the educator, this chapter will outline a case study which qualitatively assessed the sustainability knowledge that academic staff in LJMU had on sustainability.

CASE DESCRIPTION

Eleven academics from LJMU were interviewed using a semi-structured interview schedule. The reason why the sample size was so small is because these academics were the module or program leaders, thus having the most involvement in creating the material and choosing the topics that are covered in lectures and tutorials.

An interview schedule containing 11 questions was developed based on several articles and issues which had been identified through existing literature (Dirkx, 1998; Mezirow, 2003; Moore, 2005; Dirkx et al., 2006; Taylor, 2007; Wright, 2010). The questions intended to gain academics' understanding about sustainability, any barriers they thought would inhibit the inclusion of sustainability in the courses and

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lastly, questions regarding transformational learning were asked to see if academics believed that this would be an effective way of promoting sustainability knowledge (Taylor, 2007; Wright, 2010). Table 1 contains a selection of the questions included in the interview schedule.

Each interview lasted between 30 and 60 minutes. In the case that respondents did not understand the question that was being asked, the researcher clarified what was meant. The interviews were transcribed verbatim by a third party who specializes in transcription. The interview transcripts were checked by the authors to make sure that the audio recording coincided with what was written. This then allowed for manual qualitative analysis to take place.

In line with previous research (Moore, 2005; Mann et al., 2007), phenomenography was deemed the appropriate method to analyze the data because its origins lay in investigating learning among university students, although it has also been applied to understanding the experience of teaching; which this case study intends to convey (Hasselgren and Beach, 1997; Mann et al., 2007). "Phenomenography takes a second order approach, as it is the experiences of others rather than that of the researcher, which are the base of the investigation" (Mann et al., 2007, p. 7).

Phenomenography emerged in the 1980's in Gothenburg as a research approach that describes people's experiences. These types of experiences have covered elements such as the experience of teaching and learning as well as the ways of experiencing the learned content (Mann et al*.,* 2007). Experience is defined as non-dualistic because internal relationships exist between the participant and world (Hasselgren and Beach, 1997; Giorgi, 1999; Mann et al., 2007). It therefore does not take a positivist or objective approach which is free of human interpretation yet it does not rely on a subjectivist approach either (Mann et al., 2007). Hasselgren and Beach (1997) summarised the history of phenomenography as a method which described qualitative differences in the ways in which a phenomenon is experienced, understood or conceptualized.

Qualitative analysis often relies on an inductive approach through the use of thematic networks. Inductive, because the transcripts allow for broad generalizations to emerge from specific anecdotes rather than having to deduce what the specific conclusions were from general data (David and Sutton, 2011). Thematic networks explain the understanding of an issue by making connections between the statements that people make and the meaning they are trying to impart through conversation, or discourse (Attride-Stirling, 2001). A systematic extraction method was proposed by Attride-Stirling (2001) which firstly includes identifying basic themes which are key words immediately found in the text. This is then followed by grouping basic themes together which summarize abstract principles forming organizing themes. Finally, after the organizing themes are found, they too are regrouped to form global themes which in turn are the umbrella terms for the overall content that the interview covered.

Table 1. A selection of questions included in the interview schedule

Questions
1. What does the term sustainable/sustainable development mean to you?
3. What, if any barriers do you see preventing the module or program from engaging in sustainability initiatives?
5. Do you foresee different barriers and challenges in the future?
9. Do you think the promotion of sustainability in the construction industry (once students graduate) will be more likely to happen if the students have a transformative experience through educational interventions/increased sustainability knowledge while at university?

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The manual analytical process began by reading the transcriptions several times to become familiar with their content and to think of the transcripts as a whole set (Mann et al., 2007). Open, inductive coding (David and Sutton, 2011) was used in the first instance. Key words and phrases were highlighted from every line of dialogue that the interviewee gave and a note of it was made on paper. Once open codes had been created for each interview transcript, the notecards were grouped together where similar individual meanings were mentioned. The similarities within and differences between groups were then clarified (Mann et al., 2007). These essentially formed the organizational themes which Attride-Stirling (2001) mentioned. This was followed by a further regrouping of the themes and a description was written for each category which emerged using quotes from the transcripts to support the description of each umbrella term. Examples of these will be outlined in the solutions and recommendations section of the chapter.

Mann et al. (2007) emphasized that the first attempt of forming categories would not be final and is likely to change but it provided the researcher with a different way by which to see the data and allow for further categories to be developed. Once the final categories were identified, they were organized into a hierarchy of increased comprehensiveness. It is this hierarchical representation which is referred to researchers as the outcome space (Loughland et al*.,* 2002; Mann et al., 2007).

In order to ascertain whether the categories which the researcher came up with seemed valid, the differences were discussed with other sustainability experts for their thoughts on the logic behind the categories. The overall cohesiveness of these groupings and implications were also discussed with others demonstrating that the analysis of the data was triangulated (Kitto, Chesters, and Grbich, 2008). David and Sutton (2011, p. 637) described triangulation as "approaching the same topic from a number of different approaches. Triangulation may involve the use of more than one researcher or research team, more than one round of data collection, different types of data collection, or different theoretical frameworks". Denzin (1978 as cited in Burke Johnson, Onwuegbuzie, and Turner, 2007) considered the use more than one researcher to discuss final conclusions as investigator triangulation.

CURRENT CHALLENGES FACING THE ORGANIZATION

Construction programs are accredited by professional bodies in the United Kingdom. It is often the requirements of these professional bodies that dictates the material or subject areas that each course should focus on, so that students are able to become fully charted members once they graduate and begin work. Therefore a challenge facing not only Liverpool John Moores University, but all UK universities is the fact that the requirements set by professional bodies are vague, leaving universities to interpret and implement sustainability requirements by themselves; resulting in each university having its own way of addressing the topic, which may cause discord when students become professionals.

The Royal Institute of British Architects (RIBA) accredits architectural programs. Their validation procedure outlines that sustainability should be understood through the legal framework specifically in relation to "environmental and sustainable legislation" which are relevant to architectural design and construction (RIBA, 2011, p. 56).

The Chartered Institute of Architectural Technologists (CIAT) accredits architectural technology programs. When reviewing the benchmark statement, sustainability was only mentioned in relation to the design of the course so that the needs of industry and the profession are typically met stating that the program should "emphasise the value placed on detailed design, health and safety and production

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information, including technical regulatory factors affecting buildability, sustainability and performance" (Quality Assurance Agency, 2007, p. 2).

The Royal Institution of Chartered Surveyors (RICS) accredits real estate, building and quantity surveying courses. According to a review conducted by Murray and Cotgrave (2007), the RICS states the need to address sustainable development education but did not propose any formal requirements by which to achieve it.

The Chartered Institute of Building (CIOB) mostly accredits construction management programs. In their educational framework, the CIOB is keen to promote knowledge and awareness of sustainable design and construction to future construction professionals. For undergraduate programmes, the framework mentions environmental sustainability, but at masters level sustainability is focused on much more in depth (CIOB, 2007).

As can be seen from the statements of the above professional bodies, sustainability is mentioned; but a solution as how to achieve or promote it is not offered. The effect of this is potentially that educators of built environment courses are unable to determine what elements of sustainability they should know themselves, and pass on to their students. It is feasible that other areas also face similar problems from their respective governing bodies.

SOLUTIONS AND RECOMMENDATIONS

The results from the phenomenographic analysis revealed that academics at LJMU were very aware of sustainability and the importance of it in built environment curriculum. Analysis demonstrated that the outcome space for sustainability was understood in a hierarchy of five tiers. These were built environment and construction practices, economic and financial aspects, social aspects, usage implications and future proofing.

The hierarchy of these categories firstly reflected that all of the interviewees thought about sustainability in terms of their primary role- as built environment practitioners and educators. From the time that they have learned the core skills of their given topic areas, they have picked up sustainability knowledge and have internalized it in a way which could be practiced in their fields: *"it means inception of an idea, and planning it and building it and then maintaining it… building will last and be pleasant for people to use". "…means longevity of not just the construction or the techniques of the processes. It means a sustainable asset which will endure through its occupation".*

Secondly, LJMU lecturers saw sustainability as a possibility to enhance the financial or economic status of the construction industry either by entering new markets or adding value to property: *"Asset… ability to have an economic return for a long period of time".*

The third level related to social aspects of sustainability. Whatever is constructed, such as buildings or offices, need to benefit its occupants and society at large such as *"sustainable communities"*. They should serve a purpose for as long as possible.

Environmental aspects were mentioned in a specific way: resource use which was the fourth level in the hierarchy. Central to sustainability are three aspects: economic, environmental and social (Hueting and Reijnders, 2004; Murray, 2011). This concept was reiterated in the understanding of interviewees as they gave examples of what their respective built environment field could experience as sustainable. Such things included minimizing the use of resources, or saving them for future generations. It was implied that sustainability was an umbrella term for anything relating to environmental protection. However when

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further immersing into the transcripts this implication about resource use, energy consumption related to economic and social aspects as well. "*Safeguarding our existing resources and making the best use of our existing natural resources for the future". "Has longevity in relation to economic and functional use".*

The fifth and final category as to how lecturers understood sustainability could be summarized as future proofing. Buildings that are constructed need to reflect sustainable know-how. An implicit concern became evident from the interview transcripts as the amount of knowledge to be able to make appropriate decisions was expressed. It was mentioned that more information on sustainability would improve values and parameters. This knowledge should be used to make the correct decision for the relatively immediate benefit of present generations but also endure for the use and benefit of future generations. The Brundtland report and the famous definition was mentioned in relation to future proofing as it seeks to ensure that present and future generations have their needs met. This was also expressed by other respondents but they did not call the report by its name. Terms such as *"longevity"* resonates with this category as it was mentioned several times that buildings should last a long time.

During the interviews, none of the academics mentioned barriers which had been highlighted by previous research such as lack of experts in sustainability or lack of time or training opportunities. Instead, the barriers they identified regarded issues of knowledge and finance. Knowledge seemed to be a potential barrier. *"How much information students have had when they arrive to undertake this project"* and where will students' sustainability knowledge fit in professional practice: *"It could be that the younger people in the profession might be challenging the…more established…perceptions."*

On the whole however, economic factors were considered quite a barrier amongst all academics. These included funding, understanding financial return and its associations with sustainability and environmental protection. *"At the moment sustainability is just seen as a marketing tool and therefore the barrier with our students is making them see the link that sustainability has for enhanced asset value and improved growth in rentals and capital." "Building Surveying students have to understand that their decisions have a commercial effect as well as an environmental one. So that's always the barrier in the challenge between the two."*

Questions regarding transformational learning had to be clarified to a few of the interviewees. This was done by giving the example of students who had completely changed their mind about sustainability in a positive way after having learned more about the subject. Once this clarification was made, all academics fully understood the question. This led to eight out of eleven academics saying that transformational experiences would promote student learning, while two said no and one did not answer. A particular interviewee described witnessing transformational learning experiences and believing they are a central part of promoting learning about sustainability by stating: *"I'm absolutely positive because I've already seen it happen in a number of initiatives for the last couple of years. Just individual initiatives from staff and students who are looking for challenges in terms of their overall research project and their dissertation."*

Although only one academic mentioned a clear example of transformational experiences happening to students because they had seen it first hand, others described the kinds of methods they were using in order to promote transformational experiences such as taking them on site visits and guest lectures from practicing professionals: *"We try to bring in people from industry to help them understand and to see the application of a theory in waste management, in planning, in things like that".*

"Yes, yes that is important…the students are going to visit the BRE [Building Research Establishment] *Innovations Center at Watford. Looking specifically at the promotion and trying to give the*

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students some sort of experience in sustainability. In other words, trying to broaden their knowledge of this particular matter".

"…if you give a student an idea, let's say we take them to BRE and they see how these houses are operating…you sow the seeds, those seeds will eventually get back into industry…"

"I'm sure the students will respond in different ways… But even if it's just a small number you know that small number is replicated on RICS [Royal Institute of Chartered Surveyors] *courses across the country…"*

As the academics mentioned that they did not foresee any barriers affecting sustainability being learned by students, it could be inferred that this particular cohort of built environment academics are particularly literate in sustainability. Academics were able to describe the benefit that sustainability had in relation to their own field in quite a lot of detail. Contrary to what Reid and Petocz (2006) found, the academics who were interviewed at LJMU were very aware of sustainable issues and were able to use fairly elaborate yet specific explanations and definitions when describing their conceptions of it. Although not an environmental subject as such, it appears as though the built environment is hugely aware of its impact on nature and resource use, therefore being an appropriate subject area to promote sustainable development education.

This qualitative assessment of the level of sustainability knowledge that academics have at LJMU gave a certain degree of confidence that they have a firm grasp on the notion and are able to deliver sustainability knowledge to students in relation to their field of study. Although the decade of education for sustainable development is coming to an end, it has left a good legacy of not only what works to promote sustainable literacy among learners, but to also focus on the skill level that is needed by the educators themselves. It must be noted however, that the group of eleven academics that were interviewed was a very small sample size, and therefore the positivity that was expressed by this cohort may not be representative of the overall attitude of built environment academic staff. This may partly be due to the fact the LJMU is a supporter of the sustainability agenda and its promotion throughout the university.

FUTURE RESEARCH DIRECTIONS

The aims of this case study were met as built environment academics explained in their own words what sustainability and sustainable development mean to them and the benefit sustainability could have within their discipline. Academics were also asked about any potential barriers they felt may hinder the incorporation of sustainability into teaching but none of the barriers that had been identified through the literature review were mentioned (Thomas, 2004; Velázquez, Munguía, and Sánchez, 2005; Sibbel, 2009; Kokkarinen and Cotgrave, 2010a).

The eleven academics that were interviewed possessed a significant amount of knowledge regarding sustainable development and provided detailed anecdotes as to how sustainability was relevant in their discipline, something that Reid and Petocz (2006) did not find in their study. Academics were also very specific in the way that sustainable development had been incorporated into the courses that they taught as well.

The use of a phenomenographic approach provided a far detailed report than had this case relied upon a quantitative approach. Through the use of semi-structured interviews the experience of how built environment academics experience sustainable development and as a result, how much knowledge they

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are able to pass on to their students was identified. What is particularly remarkable is that the different ways in which sustainability was experienced was then condensed into an outcome space which described five levels of understanding that could be expected from other built environment academics (Hasselgren and Beach, 1997; Mann et al., 2007). The findings reported here could serve as a benchmark to other built environment institutions wanting to compare the knowledge possessed by their staff. In a similar vein, this process could easily be adapted to suit other disciplines that would also like to understand their level of sustainability literacy. This could be done by keeping the questions generic to gauge levels of knowledge and allowing interviewees to elaborate further if they believe they engage in sustainable practices to some extent (Reid and Petocz, 2006).

Promoting sustainable development is a chain reaction of knowledgeable educators influencing students who are likely to become sustainable construction professionals in the near future. Therefore other educational establishments may find it beneficial to take stock of the knowledge that educators possess in order to ascertain whether there is a good chance of students walking away with a sound understanding of sustainability and how to encourage sustainable development. This could be achieved by holding appropriate refresher or training courses for the level of knowledge that is lacking or needs improvement.

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Chapter 57
Energy Cost Saving Tips in Distributed Power Networks

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ABSTRACT

This chapter studies energy cost saving strategies in power networks. A prosumer is a user that not only consumes electricity, but can also produce and store electricity. Three tips are considered: distributed power network architecture, peak energy shaving with the integration of prosumers' contribution and prosumers market. The proposed distributed power network architecture reduces significantly the transmission costs and can reduce significantly the global energy cost up to 42 percent. Different types of prosumer who use self-charging renewable energy systems, are able to intelligently buy energy from, or sell it, to the power grid. Therein, prosumers interact during the purchase or sale of electric power using a double auction with negotiation mechanism. Using a two-step combined learning and optimization scheme, each prosumer can learn its optimal bidding strategy and forecast its energy production, consumption and storage. Our simulation results show that the integration of prosumers can reduce peak hour costs up to 17 percent and 6 percent for eligible prosumers.

INTRODUCTION

As energy efficiency and clean energy technologies become more common, system challenges require to rethink traditional paradigms of energy system planning and operation. Historically, central plants have been an integral part of the electric grid, in which large generating facilities are specifically located far from populated load centers. These, in turn, supply the traditional transmission and distribution grid that distributes bulk power to load centers and from there to consumers. Nowadays, distribution generation technologies have open the door to decentralized or distributed power network management systems. For

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reasons of reliability, distributed generation resources would be interconnected to the same transmission grid as central stations. Various technical and economic issues will occur in the integration of these resources into a grid. Technical problems arise in the areas of power quality, voltage stability, harmonics, reliability, protection, and control. Behavior of protective devices on the grid must be examined for all combinations of distributed and central station generation. A large scale deployment of distributed generation may affect grid-wide functions such as frequency control and allocation of reserves. As a result smart grid functions, virtual power plants and grid energy storage such as power to gas stations are added to the grid. At the energy market, Wholesale transactions (bids and offers) in electricity are typically cleared and settled by the market operator or a special-purpose independent entity charged exclusively with that function. Market operators do not clear trades but often require knowledge of the trade in order to maintain generation and load balance. The commodities within an electric market generally consist of two types: power and energy. Wholesale transactions (bids and offers) in electricity are typically cleared and settled by the market operator or a special-purpose independent entity charged exclusively with that function. Market operators do not clear trades but often require knowledge of the trade in order to maintain generation and load balance. The commodities within an electric market generally consist of two types: power and energy.

At the consumer level, there is an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. The goal of this chapter is to analyze the energy cost saving tips in centralized and decentralized power network. The chapter is structured as follow: The first section offers an introduction on power networks. It focuses on power network operation and explores different aspect of energy production, transmission and consumption in both the centralized and decentralized power approach. The section gives also a background of learning and optimization techniques used in the chapter. Then different energy saving approaches are presented from consumer incentive to renewable energy sources integration into the distributed power network. Next, we study the prosumer energy profiling in a distributed power network. Therein, prosumers interact in a distributed environment during the purchase or sale of electric power using a double auction with negotiation mechanism. Using a two-step combined learning and optimization scheme, each prosumer can learn its optimal bidding strategy and forecast its energy production, consumption and storage. The simulation results show that the integration of the prosumer in the power grid help to reduce the peak energy consumption and to lower the electricity cost for the population of prosumers. Discussions and future research directions are presented in the last part of the chapter.

BACKGROUND

Reinforcement Learning

In the field of machine learning, one way for an intelligent agent to interact dynamically with the environment from which it has no information is to use reinforcement learning techniques (Barto et al (1983)). The reinforcement learning can be subdivided into 2 steps: the choice of the action to be executed and the reward to be assigned to that action. As the agent has no exact information about the state of the environment (it depends on the behaviour of other agents involved), the choice of an action is made probabilistically, according to a distribution which depends on past experiences. The reward assigned

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to the action taken is based on the result of the interaction with the environment. The probabilities of actions are then modified in such a way to increase the long-run reward. The reinforcement learning approach is similar to the El Farol bar problem in economics and the minority game in statistical physics (Challet et al. 1997). The class of algorithms used by the authors is known as temporal difference method (Sutton, 1988). Extension of reinforcement learning to multi-agemts systems and game theoretic learning can be found in Tembine (2012).

Dynamic Programming

In mathematics and computer science, dynamic programming is a method for solving a complex problem by breaking it down into a collection of simpler sub-problems. Dynamic programming is both a mathematical optimization method and a computer programming method. In both contexts it refers to simplifying a complicated problem by breaking it down into simpler sub-problems in a recursive manner. While some decision problems cannot be taken apart this way, decisions that span several points in time do often break apart recursively; Bellman called this the Principle of Optimality (Bellman, 1952). Likewise, in computer science, a problem that can be solved optimally by breaking it into sub-problems and then recursively finding the optimal solutions to the sub-problems is said to have optimal substructure. If sub-problems can be nested recursively inside larger problems, so that dynamic programming methods are applicable, then there is a relation between the value of the larger problem and the values of the sub-problems. In the optimization literature this relationship is called the Bellman equation (Bellman, 1957).

Power Networks

The centralized power management system is currently used in many countries (Barroso et al. (2005)). The main feature of this model is that at the physical layer, the grid is designed for a one-way flow of the electricity. More precisely from the top, where the electricity is generated in large power plants and transported to local substations, to the bottom, final stage in the delivery of electricity to end users (see Figure 1).

The power grid operation can be subdivided into three main tasks:

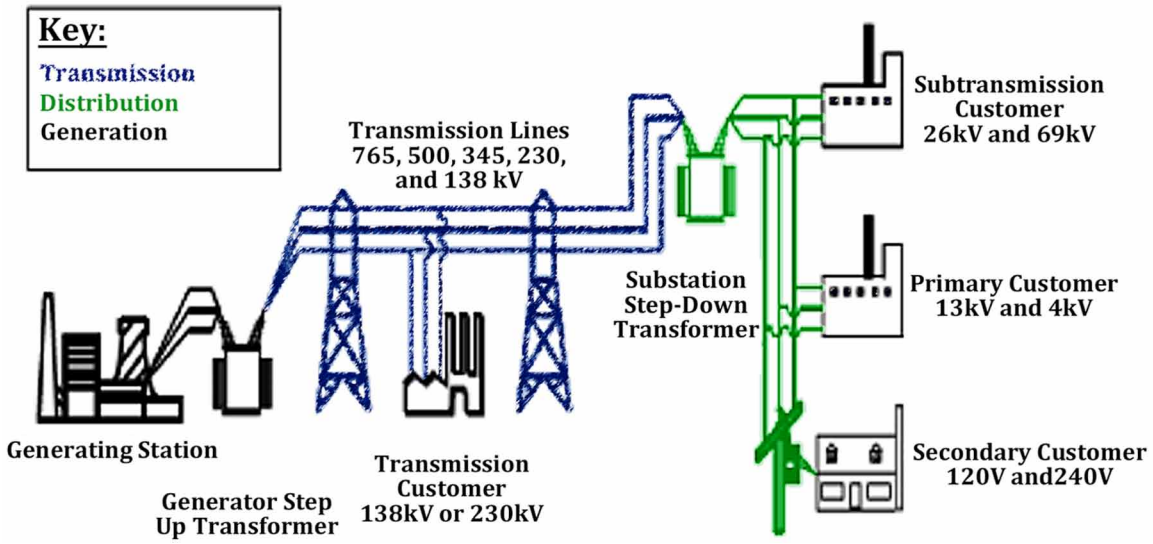
- **Centralized Power Generation:** Where electricity is produced by large size energy source generation as coal plant, nuclear plant, natural gas plant and hydroelectric plant. Generally, the electricity is produced in an extra high voltage in the order of 265 to 275 KV.
- **Power Transmission:** It is a high voltage electric transmission in the order of 110 KV or above, from generating power plants to sub-stations located near to population centers. The electricity is transmitted at high voltages to reduce the energy lost in long distance transmission and power is usually transmitted through overhead power lines.
- **Electricity Distribution:** It is the final stage in the delivery of electricity to end users or consumers. It works typically at medium voltage (less than 50 KV) and low-voltage (less than 1 KV).

Literature Review

The continuously increasing cost of the energy along with the need to reduce greenhouse gas emissions to protect the environment, have made energy efficiency one of the technological challenges of

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Figure 1. Diagram of an electric power network (New jersey OCE (2010))



our century (Chenrui, et al. 2013). Centralized power management systems need to integrate renewable energy sources in the current model (Barroso et al., 2005) in order to reduce energy cost. This recall the integration of distributed energy resources in the power grid (Sugiyama, 2014). Decentralized power networks aim at reducing power transmission losses and allow a better integration of distributed energy generation. The question is how to propose model for handling renewable energy sources penetration? (Handschin et al. (2006)) have proposed a decentralized model based on which consumer can interact during the purchase and sell of energy. Montanari et al. (2014) have extended the previous model and have proposed a prosumer approach for the energy profiling in a distributed power network.

Critics of renewable energy often cite the fact that technologies like wind and solar only produce energy when the wind is blowing or the sun is shining (Li et al., 2014). They argue that we can't effectively utilize renewable energy until appropriate energy storage technology is developed (New jersey OCE, 2010). Demand Response solutions have to be implemented in order to reduce peak energy demand in the net (Cappers et al., 2010). High demand puts pressure on the electricity grid, and outages can occur when demand exceeds available supply (Dong et al., 2014). The question in this case is show to develop models that help to stabilize this balance, minimizing the need to activate expensive fossil fuel generators that pollute the environment and spike energy prices (Jie et al., 2014).

Electric vehicles will have tremendous potential to offset portions of the environmental impacts from both the direct transportation sector and from the electricity generation sector (Tcheukam et al., 2015). From the standpoint of the electric utility grid, electric vehicles offer an opportunity to facilitate increased penetration of renewables and reduce the need for peaking generation units during the day by acting as a distributed storage and generation source (Paranjape et al., 2014). The question is how to increase the penetration of electric vehicle in many regions (Bingtao et al., 2014)?

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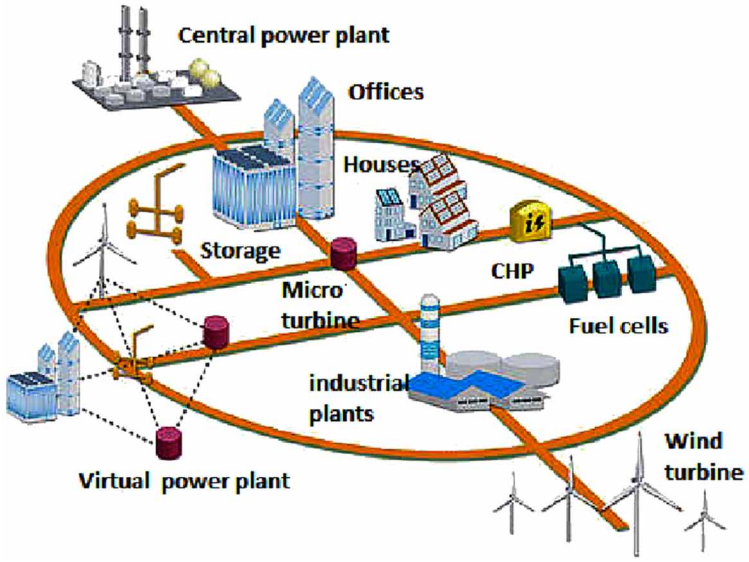
MAIN FOCUS OF THE CHAPTER

Power Network Architecture Paradigm Shift

In the new era of power network, we can distinguish between two types of electricity power management systems: the centralized (see background section) and the decentralized power management system. Decentralized power management systems will play a key role in reducing greenhouse gas emissions and increasing electricity production through alternative energy sources. The idea behind the decentralized power management system is to exploit the increasing integration of decentralized energy resources (DER) into the distribution network. DER systems are modern technologies based on solar or wind power, or on other renewable energy sources. More precisely, they are small or mid-scale power generation technologies (typically in the range of 3KW to 10 MW). However establishing clean or renewable energy sources involves the problem of adequate management for networked power sources. This is due to intermittency of renewable energy source during the electricity generation and to the fact that power consumers are in the same time power producers and vice versa. For this reason, the power network needs to be managed in a distributed way. At the physical layer, the electricity flow in this power management system focuses on the distributed generation scheme. At the power market layer, small businesses and households will be able to produce and store energy through the use of solar panels, wind turbines and combined heat and power plants. They will become prosumers. A prosumer (producer - consumer) is a user that not only consumes electricity, but can also produce and store electricity.

The operation of grid systems can be shared between central and distributed generators. Control of distributed generators such as combined heat and power plant (CHP) and micro-turbines could be aggregated to form micro-grids or 'virtual' power plants to facilitate their integration both in the physical system and in the market (see Figure 2).

Figure 2. Distributed generation in micro grids (WWF (2006))



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INCENTIVIZING CONSUMERS

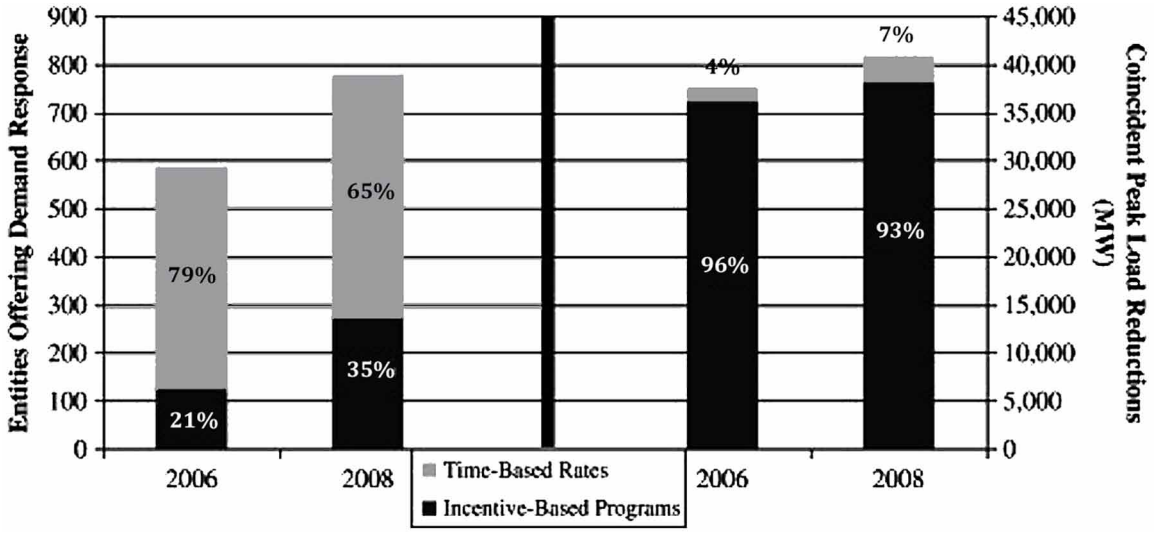
The electricity cannot be indefinitely stored and therefore the system operator need to meet the demand pattern manage the network stability. One of the main issues in the electricity sector is to balance the energy demand or to reduce peak energy consumption. Two approaches can be used to manage the problem: Demand response approach and prosumer integration approach.

Demand Response (DR)

For limitations, the electricity cannot be easily stored on a large scale. As a result, supply and demand must remain in balance in real time. Traditionally utilities have leveraged peaking power plants to increase power generation to meet demand. Demand response works from the other side of the equation – instead of adding more generation to the system, it pays energy users to reduce consumption. Utilities pay for demand response capacity because it is typically cheaper and easier to procure than traditional generation. Demand response allows energy users of all kinds to act as virtual power plants, adding stability to the grid by voluntarily lowering their demand for electricity. Participants in demand response programs get paid for providing demand response capacity.

As part of the Energy Policy Act of 2005, the U.S.A Congress directed the Federal Energy Regulatory Commission (FERC) to develop a comprehensive national assessment of the size and scope of electricity Demand Response resources and advanced metering as part of a national energy policy (Cappers et al. (2010)). In the U.S.A case, there has been a significant increase (117%) in the number of entities offering DR programs: 126 in 2006 vs. 274 in 2008 (Figure 3) and about a 10% increase in the number of entities offering dynamic pricing tariffs to retail customers.

Figure 3. Estimated size of Demand Response resources in the United States (Cappers et al. (2010))



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Prosumer Integration

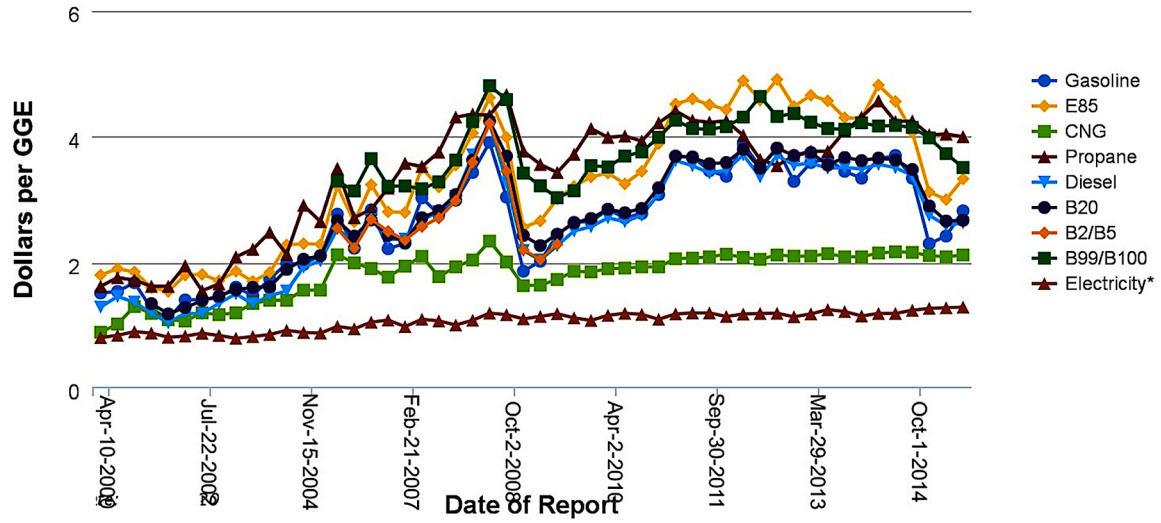
A prosumer (producer-consumer) is a user that not only consumes electricity, but can also produce and store electricity. Thanks to the penetration of renewable energy sources the efficiency of the power market depends also on the participation of a new costumer – prosumer – who is now able to play a key role in reducing peak energy demand in the traditional power grid. In order to the enable market integration of prosumers, prosumers should be able to choose the technology and size of equipment on the basis of their individual preferences, as well as the related market-driven costs and revenues. At the same time the regulatory framework should not provide incentives that lead to market distortions and negative impacts from the system perspective. The challenge of the prosumer will be to use control algorithm in order to optimize his (her) cost based on the power market condition. He will coordinate himself such as to minimize peak energy consumption in the power network while maximizing his profit.

INTEGRATION OF RENEWABLE ENERGIES

Distributed Energy Generation

Fuel prices are increasing and there is a need of alternative fuels sources for lowering the energy price and meet the demand. The electric price is very cheap compared to other energy production sources. As gasoline prices increase, alternative fuels appeal more to vehicle fleet managers and consumers (Figure 4). The electric prices are reduced by a factor of 3.4 because electric motors are 3.4 times more efficient than internal combustion engines (Alternative fuel data center (2010)). Based on the US National Average Price (April 15, 2015) the electric price is $0.12/kWh is the cheapest compare to Diesel ($3.06/gallon), Natural Gas ($2.09/GGE), Propane ($2.92/gallon) and Gasoline ($2.42/gallon). The electricity can be seen as a Vehicle Fuel and can be used to power all electric vehicles and plug-in hybrid electric vehicles.

Figure 4. Average Retail Fuel Prices in the U.S



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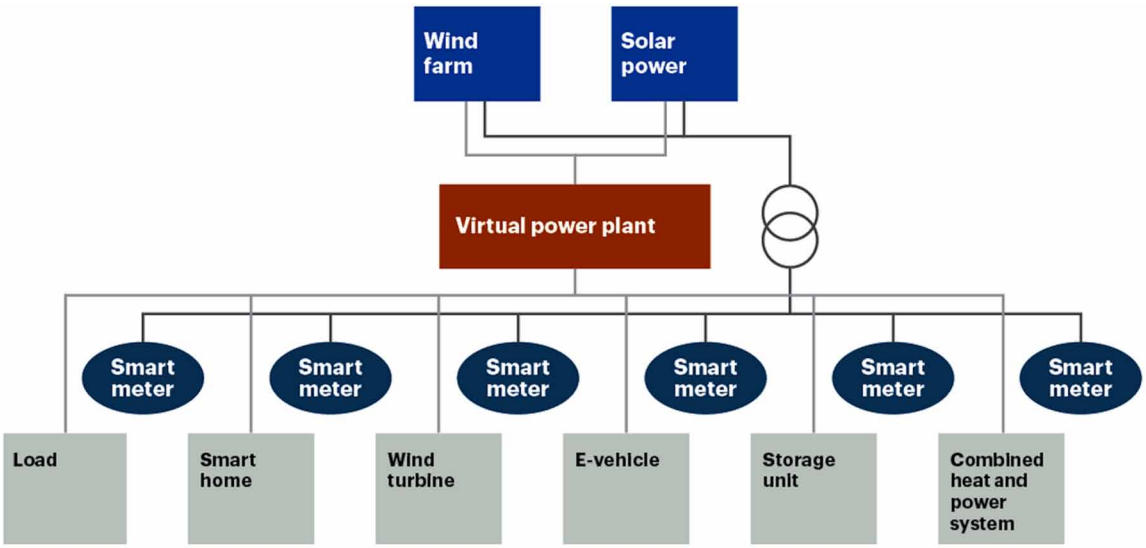
Distributed Energy systems are modern technologies based on solar, wind, geothermal, water, biomass, biofuel or other renewables energy resources (Figure 5). More precisely, they are small or mid-scale power generation technologies (typically in the range of 3KW to 10 MW). Nevertheless, the potential availability of wind, solar and biomass energy varies over time and between locations. This variation is not only caused by the resource characteristics (wind/solar regime, soil) but also by geographical (land use and land cover), techno-economic (scale, labour cost) and institutional (policy regime, legislation) factors.

The coordination of the distributed power network will require advanced metering infrastructure (AMI) and automatic metering reading (AMR). For instance new projects are arising around U.S., Europe and Asia Pacific. The aim is to propose model for addressing Smart city project (see Figure 6).

Environment Changing

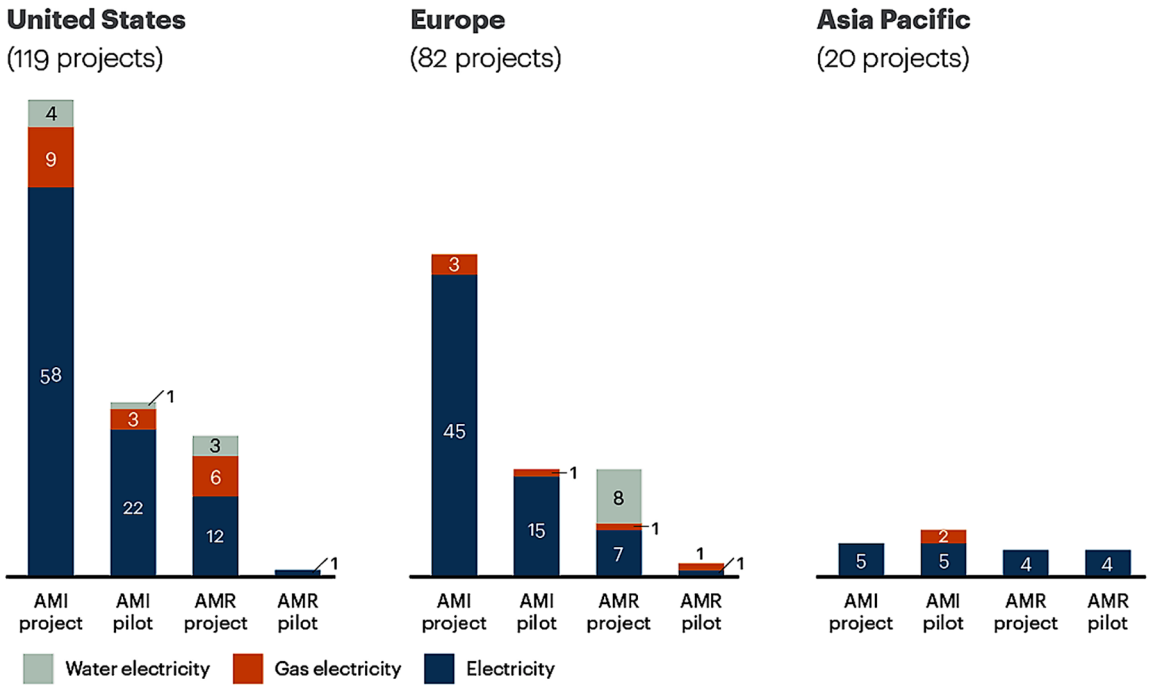
The penetration of renewable energy sources can lead to landscape ruined in many cities. Harnessing power from the wind is one of the cleanest and most sustainable ways to generate electricity as it produces no toxic pollution or global warming emissions (Sellami, 2014). Despite its vast potential of wind, there are a variety of environmental impacts associated with wind power generation that should be recognized and mitigated (Araneo, 2014). The land use impact of wind power facilities varies substantially depending on the site: wind turbines placed in flat areas typically use more land than those located in hilly areas (Awadallah et al. (2015)). Sound and visual impact are the two main public health and community concerns associated with operating wind turbines (Bashir et al. (2015)). Most of the sound generated by wind turbines is aerodynamic, caused by the movement of turbine blades through the air. There is also mechanical sound generated by the turbine itself. Overall sound levels depend on turbine design and wind speed. Likewise, the sun provides a tremendous resource for generating clean

Figure 5. Distributed generation units (ATKearner analysis (2010))



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Figure 6. Smart metering project around the world (ATKearner analysis (2010))



and sustainable electricity without toxic pollution or global warming emissions. Depending on their location, larger utility-scale solar facilities can raise concerns about land degradation and habitat loss. The total land area requirement varies depending on the technology, the topography of the site, and the intensity of the solar resource (Hartmann et al. (2013)).

PROSUMERS INTERACTION WITH THE POWER MARKET

Tradition Power Market

The use of market-based approaches in the electricity system operation continues to mature (Tcheukam, 2013). In general the electricity market is subdivided into two categories: the wholesale market and the retail sale market. These two markets interact with each other. The wholesale market involves Generator Company (GenCo), Load Service Entities (LSE) or retailer as brokers and distribution companies (DisCo) in a trading market. In the retail market, brokers forecast the aggregated resource needs of consumer and shop in the wholesale markets available to them. Moreover, the wholesale electricity market (also called Spot Electricity Market) can be subdivided into three subsequent markets:

- **The Day-Ahead Market (DA):** Which is a market finalized for the exchange of wholesale power between producers, traders and eligible customers. It takes place a day before the effective dispatch of the electricity.

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- **The Intra-Day Market (IDM):** Is an adjustment market on which operators can modify the programs established in response to the Day-Ahead Market submitting further bids on the sale or purchase. It takes place an hour before the effective dispatch of electricity.
- **The Ancillary Services Market (ASM):** Is the market where the traders make offers of availability of an increase or reduction of the power injected or withdrawn in the grid. This information is used by the transmission system operator to correct programs that violate the limits of transit, and to balance the system in real time against deviations from the program.

These three markets operate in the pool market, which is under the control of a single operator, who is normally known as Independent Market Operator (IMO). The role of the Independent Market Operator in a wholesale electricity market is to manage the security of the power system in real time and co-ordinate the supply of and demand for electricity, in a manner that avoids fluctuations in frequency or interruptions of supply.

Distributed Power Network Approach

We focus on power market models in which prosumers interact in a distributed environment during the purchase or sale of electric power. We propose a hierarchical distributed model which is based on reinforcement learning and optimization. Different types of prosumer are able to intelligently buy energy from, or sell it to, the power market. Our simulation results show that the integration of the aggregator in the power grid help to reduce the peak energy consumption and to lower the electricity cost for the population of prosumers.

We introduce a micro grid negotiation concept that enables the energy balancing in the entire power grid and we term it DIPONET. The approach is more dynamic since it provides the consumer/prosumer a more efficient way to interact in the distributed power network. The DIPONET (Tcheukam et al. (2015)) approach is based on the previous project DEZENT (Handschin et al. (2006)). The limitation of the producer/consumer in the previous project is that it only make use of reinforcement learning when buying/selling energy from/to the power market. The consumer in that approach is static in the sense that it is not able to anticipate or to delay energy consumption. Moreover at the power market layer, a negative bidding strategy used by the static producer/consumer was affecting its portfolio.

The novelty of our approach is that it combines both distributed learning and optimization to predict supply/demand and storage in a more efficient way. More specifically we use reinforcement learning to adapt prosumer's price strategy at the power market and dynamic programming to predict future outcomes. The learning accounts for the fact that the power producer/consumer will need to use his/her best strategy when buying/selling energy quantities from/to the power market. The dynamic programming approach is due to the fact that a short term optimization might not be suitable in the event that a power consumer needs to plan his/her energy consumption over a period of a day, a week or even a month.

Prosumer Planning and Adaptation Model

The power grid of interest consists of a multi-level micro-grids architecture which is subdivided into 4 levels. The first level (0.4 kV) is a low-range network covering subdivisions (a neighborhood). The second level (10 kV) is a medium-range area network covering a suburb (regional grid). The third level (110 kV) is a long distance energy transport network. Finally in the fourth level (380 kV) the electric-

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ity is produced from large power plants (coal, gas or nuclear). Power needs of prosumers are covered through alternative energy sources within the first 2 layers and additional power needs will be covered at the latest by the fourth level.

At the power market layer, we consider a multi-stage negotiation system through which the energy produced by microgrids (at various tiers) are auctioned to/by the prosumers. The balancing of demand and supply between participants is carried out through balancing group managers (BGMs) which are located in different network layers and operate in parallel on each grid. The BGM balances the supply and the demand of electricity between a producer and a consumer who have submitted a similar bid.

A prosumer in such a power grid can be viewed as user who has the ability to independently modify his/her power requirements optimizing his cost. In our model, we believe that independent planning by the prosumers may improve significantly the matching between production and consumption in the power grid. In practice, this could mean to help balancing the power market, since the price will favor low consumption/high production when the cost is high and vice versa. Moreover, our approach is not centralized and, in this sense, is different from demand side supply management. The idea is to exploit the (limited) ability of prosumers of planning in an autonomous way their consumption/production. Hence they do not sign any contract leaving the planning to others: our independent consumer planning is a local matter involving only one prosumer

Control Strategy of the Prosumer in the DIPONET Approach

The challenge of the prosumer is to make elastic the demand for, and the supply of, electricity in order to optimize its energy cost based on power market conditions and on suitable constraints on their power consumption. Prosumer strategies are concerned with two separate phases. On one hand, prosumers should compete on the DIPONET power market: they should negotiate a deal with a close partner, thus achieving a better price. On the other hand they should concentrate as much as possible their energy consumption in the periods when the prices are more convenient.

We now described the combined scheme DIPONET.

Step 1: Reinforcement learning

At the end of a negotiation, the final achieved price by the consumer is normalized according to the frame size of the negotiation. Then, the temporal difference method of Sutton is used to derive the reward of the negotiation strategy currently executed.

$$P(t+1,s) := P(t,s) + \alpha\,(r(t,s) - P(t,s)) \tag{1}$$

where $P(t,s)$ is the value of the reward associated to action s at time t, $r(t,s)$ is the reward associated to action s at time t and α is real parameter, $0 \leq \alpha \leq 1$.

Step 2: Optimization

For clarity we consider the case of a consumer. The consumer is characterized by the class of energy variation profiles (s)he can adopt during the day.

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Controllable inputs: we denote by x(t) the vector of controllable inputs of the consumer. The consumer has the ability to increase/decrease its energy consumption.

Uncontrollable inputs: the total power produced by renewable energy sources in the power grid can be less than, equal to or great than the total energy demanded in the grid and this may cause an increasing cost of the electricity in the dynamic power market.

State of the consumer: the state of the consumer is given by the level of the energy reserve R(t).

Objective function: the objective of the consumer is to minimize the electricity cost achieved at the end of the day.

$$\min (o(x(1))+q(1))c(1) + (o(x)+q(2))c(2) + \ldots + (o(x(T))+q(T))c(T) \quad (2)$$

where the minimization is over x (t), t be the time index. o(x(t)) is the additional cost paid for the transmission cost, q(t) is the amount of energy consumed at time index t and c(t) is the unitary energy cost achieved after the negotiation.

Constraints

1. Summing up all the variations from the beginning of the day to any time, we cannot exceed a lower and an upper bound of the energy reserve. This constraint accounts for available energy storage media, like electric vehicle batteries or thermic accumulations due to anticipated heating, or delayed air conditioning.

$$\forall 1 \leq t \leq T,\ 0 \leq R(0) + x(1) + \ldots\ x(T) \leq R \quad (3)$$

where R(0) is the initial energy reserve capacity and R is the maximal energy reserve capacity.

2. The sum of all the energy variations in the whole day for the consumer is zero, i.e. if in some slot the variation is positive, in some other slot it must be negative.

$$x(1) + x(2) + \ldots + x(T) = 0, \quad (4)$$

Proposed algorithm: we propose an efficient dynamic programming algorithm for planning the energy consumption/production. The control algorithm of the consumer has three inputs: (i) the definition of the class of allowed profiles Q; and (ii) the cost of a unit of energy which is the result of the negotiation in each time step of the previous day. Hereafter, the optimization problem and the proposed dynamic programming algorithm used to solve it are defined.

Let $Z(t,Y(t)): R \cup \{\infty\}, t=1,\ldots,T, 0 \leq Y(t) \leq R$ be the optimal energy costs for time step 1, . . ., T, when the final energy reserve at time t is Y(t). Here $Z(t,Y(t)) = \infty$ if energy reserve Y(t) cannot be achieved at time step t . Thus Z(0,Y(0)) (no slot has elapsed yet) is everywhere ∞ except for $Z(0,R(0)) = 0$.

$$Z(t,Y(t)) = \min_\{x(t)\} \sum (o(x(t)) + q(t))c(t),\ t= 1,\ldots T \quad (5)$$

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$$\forall k\ 1 \leq k \leq T,\ 0 \leq R(0) + \sum x(i) \leq R,\ 1 \leq i \leq k \tag{6}$$

$$R(0) + \sum x(i) = y(t)\ 1 \leq i \leq t,\ 0 \leq y(t) \leq R \tag{7}$$

Dynamic Programming

$$Z(t,Y(t)) = \min_\{x(t)\}\ Z(t-1,Y(t) - x(t)) + (o(x(t)) + q(t))c(t),\ t = 1,\ldots T \tag{8}$$

Such that $-k \leq x(t) \leq k$ and $0 \leq y(t) - x(t) \leq R$

$$Z(0,Y(0)) = \text{if } Y(0) = R(0) \text{ then } 0 \text{ else } \infty \tag{9}$$

$$Z(T,R(0)) = Z \tag{10}$$

The value of Z(t) at time t is computed sequentially in terms of $Z(t-1)$ by looking backwards for $Z(t,Y(t))$ to the optimal energy costs at slot $t - 1$ for eligible values $Y(t) - x(t)$ of the energy reserve. Finally, an optimal strategy S is any sequence

$S = (x(1), Y(1)), \ldots (x(T), R(0))$, such that the values of x(t) and of Y(t-1) are computed backwards from Y(t), t= 1,…T by letting $Y(T) = R(0)$, the final reserve being R(0). Formally: optimal strategy

$$Z(t,Y(t)) = Z(t-1,Y(t)- x(t)) + (o(x(t)) + q(t))c(t),\ t = 1,\ldots T \tag{11}$$

$$Y(t-1) = Y(t) - x(t) \tag{12}$$

$$Y(T) = R(0) \tag{13}$$

The time and space complexity of the algorithm are O(TRk) and O(TR) respectively. Where T is length of the day, R is the maximal energy variation capacity and k is the maximum energy variation level.

We compare the behavior, in terms of energy cost minimization, of a consumer in our approach with that of a consumer of the DEZENT approach

Setup: the space of the experiments is based on the available DIPONET and DEZENT simulator and on the implementation of the two types of aggregator. It depends essentially on three parameters: (i) the free market power cost, which can exhibit high or low variance: for this we chose real data from the day ahead market prices of Switzerland (date: March 9, 2013); (ii) the prosumers environment, namely heavy production or heavy consumption, in which the total amount of the electricity produced in the subnet is respectively greater than or less than, the total amount needed in the subnet. In the heavy consumption situations, the additional, needed power is made available at the large power plant level, at a price which depends on the time of the day. Analogously for the heavy production situations. In all these cases, the

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profile cost of the electricity at the global level (namely at the large power plant level) was the same for all days; (iii) the available energy reserve capacity of the virtual prosumers characterizing the aggregator is considered finite. The experiments were conducted on the NYUAD cluster at the division of Engineering laboratory, simulating a 3 days service period (see Table 1). Here the last day has been considered, since in this way transitory effects are minimized.

DIPONET vs DEZENT: in the first experiment we compare the behavior of a consumer in the DEZENT approach with that of our approach. The comparative study is based on the total cost of the electricity paid at the end of the last day. We recall that the consumer in DEZENT only make use of reinforcement learning while the consumer in the DIPONET approach uses both reinforcement learning and optimization. In Figure 7 the consumer in DEZENT (dashed curve) has spent more than the DIPONET consumer (solid curve). The saving of the DIPONET consumer is about 8,23%. This is due to the fact that the DIPONET consumer is able to anticipate or delay energy consumption thanks to its flexibility.

Aggregator models: in the second experiment comparative studies were based on the total cost of the electricity paid at the end of the last day by the consumer population and on the profit realized by the aggregators. Figure 8 synthesizes the optimal controller of the one prosumer of the centralized aggregator. The two upper curves of Figure 8 represent the unitary cost of energy as resulting from the negotiation phase at day 2 (solid curve) and at day 3 (dashed curve). The difference between the two upper curves gives an idea of the possible variations between the outcomes of different negotiations. Notice that the profile of the global energy cost and the context of competing prosumers is the same in both days. The lower dashed curve (respectively lower solid curve) represents the result of the optimization algorithm applied to the curve of day 2 (respectively of day 3). The curves plot the sum (from the beginning of the day) of the suggested variations: according to the constraints we assumed on the virtual prosumers profiles, the sum of the variation must be not greater than the aggregates reserve capacity and should end up at 0. Notice that the controller correctly suggests variations which are opposite with respect to the negotiated cost.

Table 1. Setup of the DIPONET ENVIRONMENT

Architecture	Negotiation Level: 1 BGM on Level 1: 1 Clients: 23 Producers (50−350 KW): 10 Consumers (50−300 KW): 10 Prosumers (50−300 KW): 3
Electricity price	Day duration: 60 slots (24hours) Profile cost of the electricity (free market)
prosumers environment	Producers: Gaussian distribution 1 Consumers: Gaussian distribution 2
Energy reserve	finite capacity prosumer initial level: 0
Controller	Class of consumption profiles Planning phase: optimization
Simulations	Duration: 3 days Test: non stationary environment

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Figure 7. DIPONET vs. DEZENT

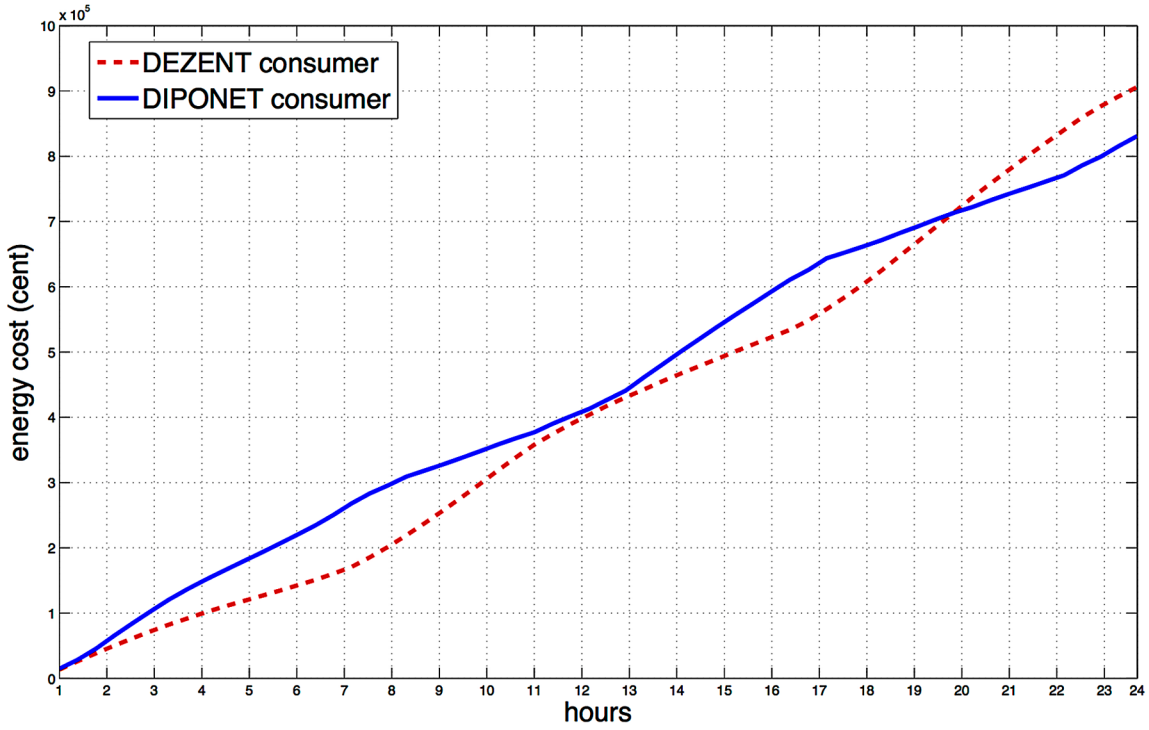
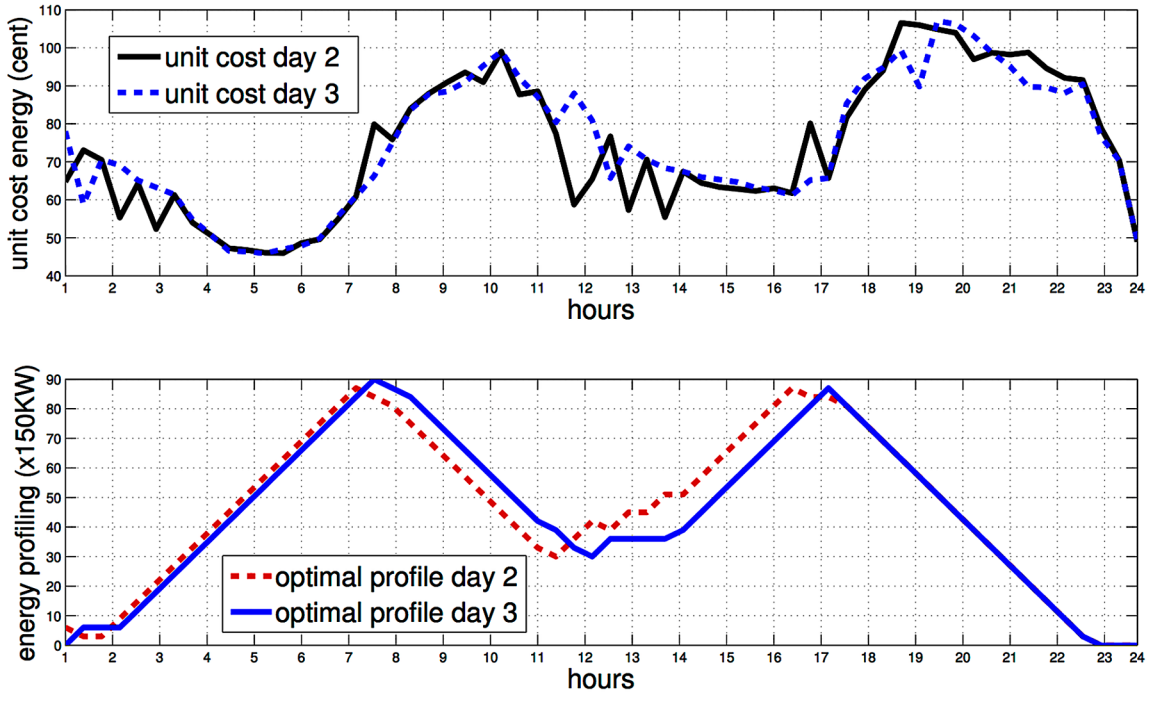


Figure 8. Optimization model of one prosumer



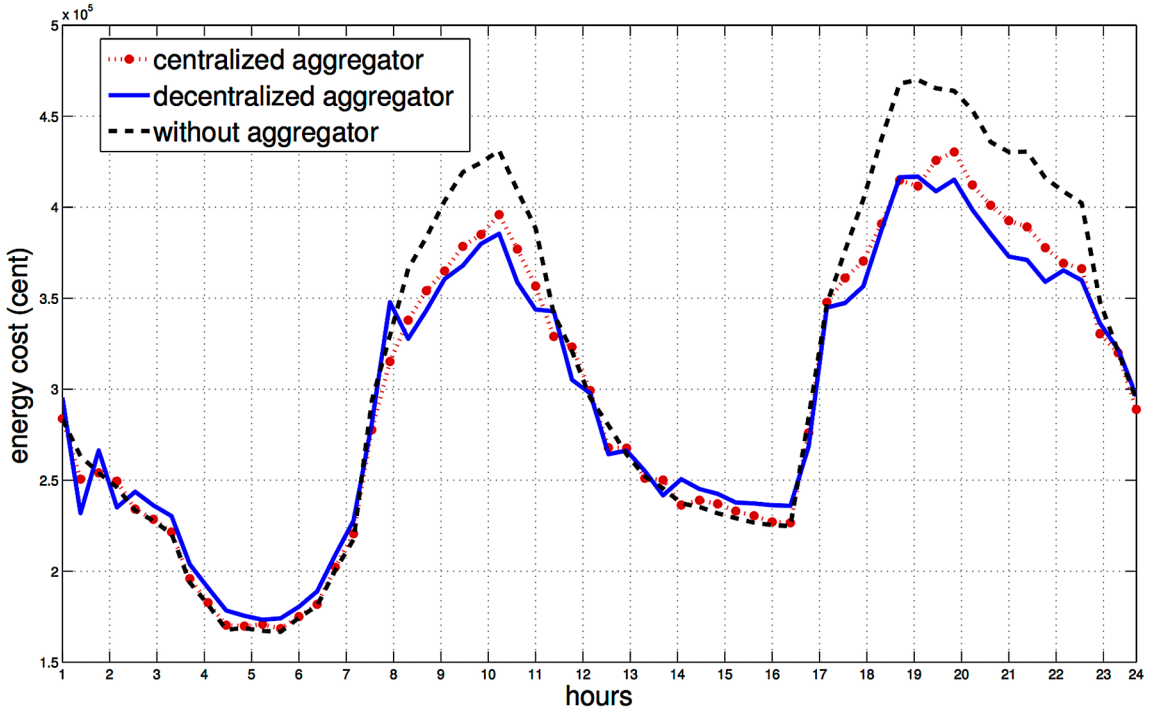
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Figure 9 reports the result of the placebo test on the behavior of the consumer population. In Figure 9, the upper dashed curve represents the energy cost achieved in each hour by the entire population when there is no aggregator in the power market. Analogously, the middle bullet curve represents the case in which the centralized aggregator is active and the lowest solid curve the case in which the decentralized aggregator is active. The observation we have is that the consumers population when the aggregator is active has spent less during peak energy consumption period.

In Figure 10, the final cost achieved at the end of day 3 by the population of consumers in which the aggregator was active (solid curve for the decentralized approach and bullet curve for the centralized approach) is less than the case in which there was no aggregator (dashed curve). This positive effect is due to the introduction of an aggregator. The two curves when the aggregator is active are overlapped and this is due to the fact the available reserve charactering the aggregators are the same in both cases. The percentage of global energy cost reduction is about 3,2%.

In Figure 11 we compare the actual profit of the two aggregator approaches. The solid curve reports the energy cost (actual profit) realized by the decentralized aggregator in the power market. The profit is given by the sum of the entire profit realized by the virtual prosumers characterizing the aggregator. Analogously, the dashed curve reports the actual profit of the centralized aggregator. The profit in the centralized case is given by the sum of energy cost achieved in every time slot. There is a remarkable difference between the two gains and the centralized aggregator exhibits a superior behavior. This is due to the fact that the centralized aggregator uses cooperative informations of virtual prosumer characterizing its portfolio. The information about the difference between the two gains of Figure 7 can be well studied if we compare the actual profit of each aggregator with its expected one.

Figure 9. Energy cost achieved by the consumer population



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Figure 10. Energy cost at the end of the day achieved by the consumer population

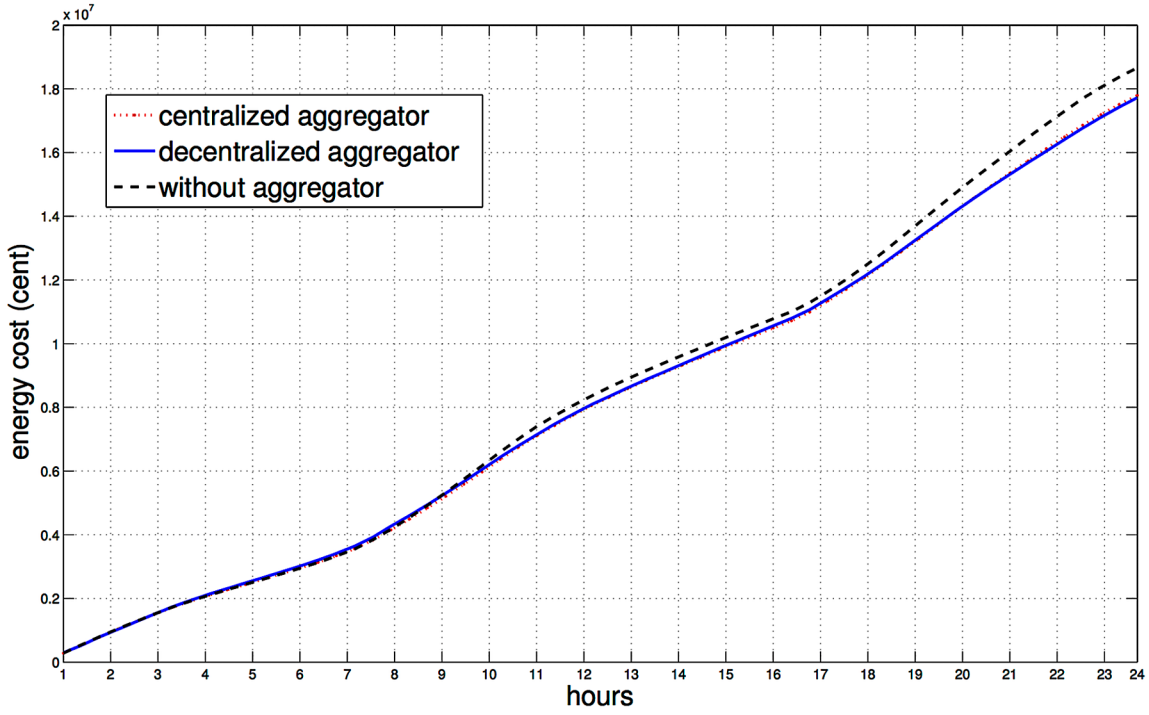
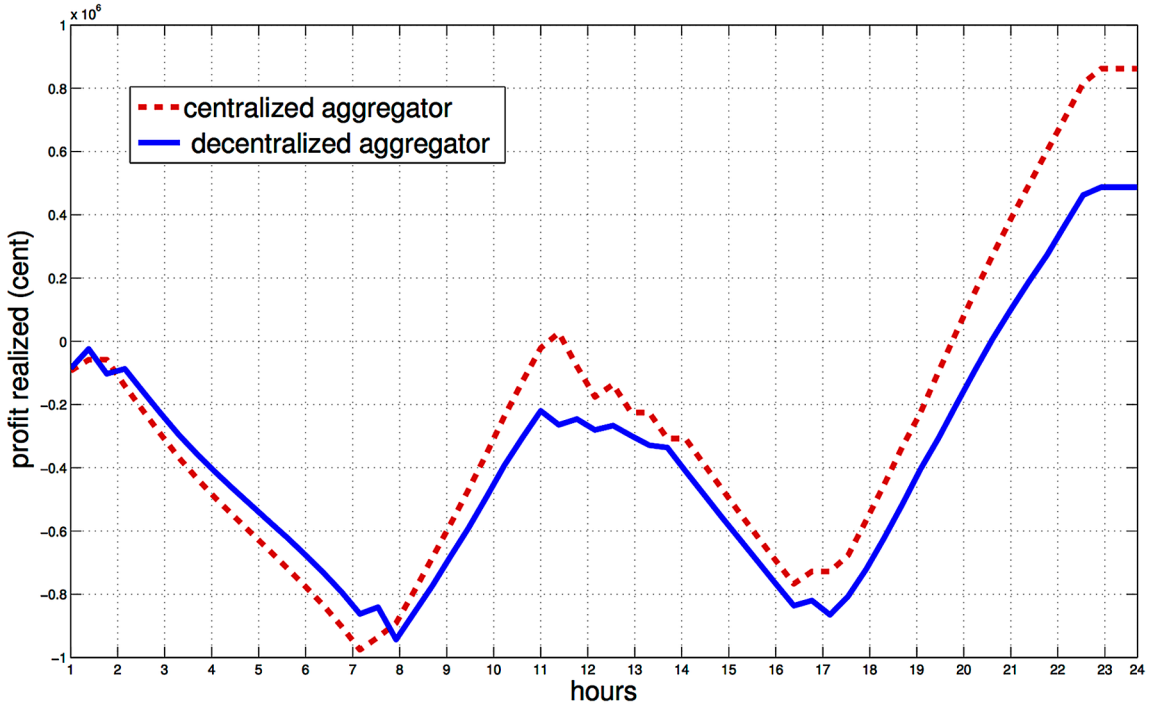


Figure 11. Aggregators: profit realized



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In Figure 12 the dashed curve represents the expected profit of the decentralized aggregator at the end of day 3. The curve is computed by assuming known in advance the energy cost. That curve has been obtained by summing up all the energy costs of the optimal profile of day 3 of the virtual prosumers.

Analogously, in Figure 13 the dashed curve represents the expected profit in the decentralized aggregator case at the end of day 3. That curve is given by the energy costs of the optimal profile of day 3 of the centralized aggregator. Notice that the difference between the expected gain and the actual gain of the aggregator in the decentralized case is greater than that of the centralized case.

SOLUTIONS AND RECOMMENDATIONS

See Table 2.

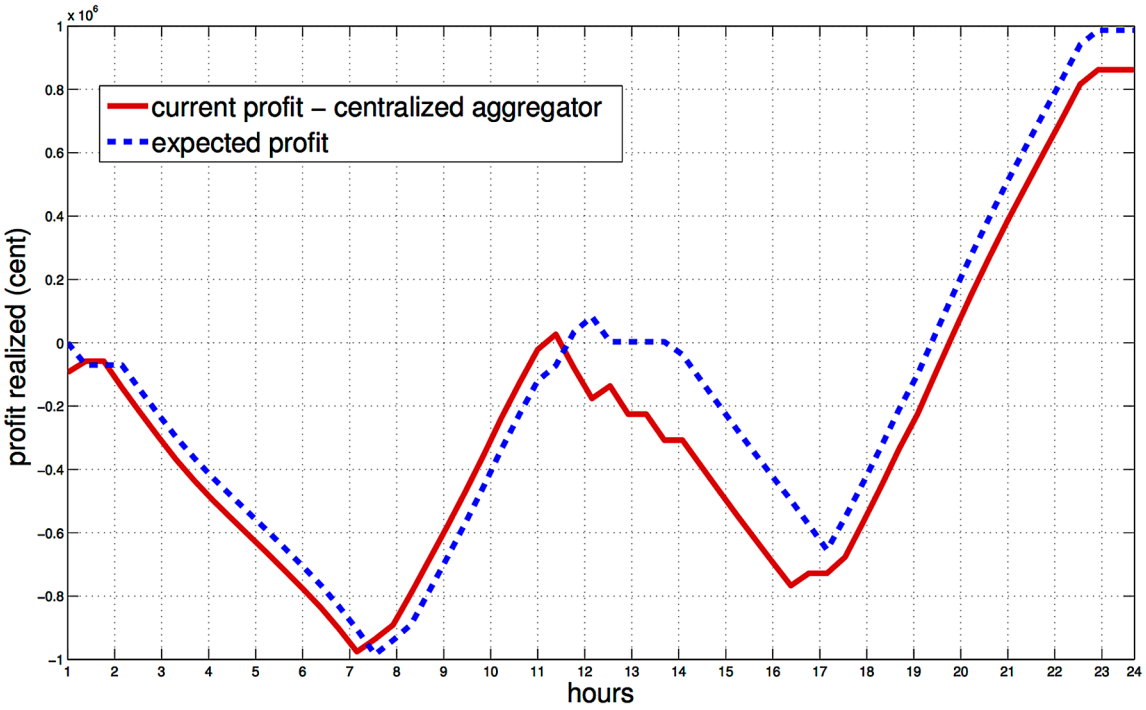
FUTURE RESEARCH DIRECTIONS

This section discusses future and emerging trends.

Combination of the Centralized and Decentralized Power Management System

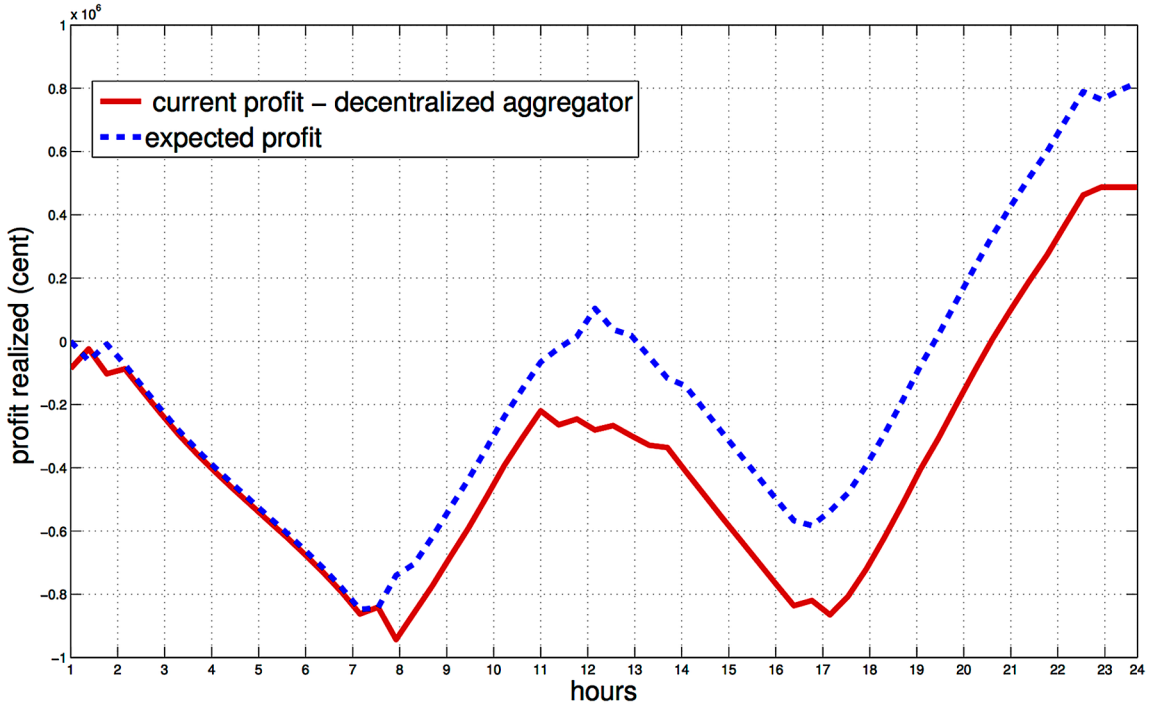
The first step is to identify the strengths and weaknesses associated with Centralized power network and Distributed power network infrastructure for the future electric grid system. There are many reasons for

Figure 12. Centralized aggregators, expected cost vs real cost



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Figure 13. Decentralized aggregators, expected cost vs real cost



considering the extent to which a planning and operation decision about centralized generation (CG) and distributed generation (DG) should be based. This will involve the development of indices for an economical scale study of DG relative to CG, and consider which is the most cost-effective to accommodate new markets. In order to assess the robustness of DG and CG under different load conditions, different indices for measuring the combination of CG/DG with respect to their capability and resilience to handling unforeseen events. This will involve development of new tools with stability measures and reliability as constraints.

Enhancing the Reliability of Power Grid: Power Quality

Today's energy availability to users is largely dependent on the resiliency of the power grid supplying the need of the consumers. Provision needs to be taken into consideration should power demand exceed power generated. In a particular region under consideration, required energy consumption increases with population. Therefore, a need arises to have a power grid expansion options during the installation of either a DG or CG systems.

As CG/DG systems continue to grow in size and capabilities, the current state of art in power system reliability is being pushed to its limit. While power engineers try as much as possible to ensure that there is constant power availability to users, considerations of some natural disasters such as earthquakes, hurricanes, tornadoes, and snow storms, continually mitigate the availability of continued power being supplied to these consumers. The question to be addressed now is: will either CG/DG or both power grids architecture be best to improve the reliability of power consumption?

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Table 2. Summary of the main focus of the chapter

	Pros	Cons
Centralized architecture	• Reliable power transmission • Top down power management • Easy power stability management.	• Power transmission cost due to joule effect. • Non penetration of Renewable energy sources • Greenhouse gas emissions
Distributed architecture	• Transmission cost reduction • Better exploitation of renewable energy sources • reduction of greenhouse gas emissions	• Two ways energy flow to be managed • Meet power demand (intermittency RES) • Power grid instability
Demand response	• Reduction of peak energy consumption • Electricity cost minimization • Grid stability management	• Consumer change behavior • Enhanced heating and cooling systems in the population
New market participant: prosumer	• Household and small businesses can also produce and stored energy • Electric vehicles penetration	• Energy profiling scheduling • New market strategies needed for small participants
Environment	• Greenhouse gas reduction • Clean energy penetration • Building for smart cities	• Landscape ruined • New technology needed for renewable energy systems recycling
Distributed energy resources (DERs)	Penetration of mid-scale technologies • Solar panel, wind farms, • Combined heat and power plant • Biomass, biofuel, geothermal, water	• High cost energy production (currently) • Intermittency of energy production • Power grid management
Centralized power market	Subdivided in three parts: • Day ahead • Intra-day (hourly) markets • Real time power market	• Do not exploit efficiently renewable energy sources •Consumer cannot directly participate to the market
Distributed power market	• Energy cost reduction • New market mechanism • Incentive strategy for prosumers • Aggregator penetration	•Mismatch between supply and demand • ICT systems need to be developed

New Form of Energy Production for Lowering Energy Cost

The production cost of the energy through alternative energy sources is still high and new technologies have to be developed for lowering the energy price in the future. Scientists will race to perfect greener sources of energy to improve the environment and reduce dependence on oil and other fossil fuels. Some predict a hydrogen economy. Others say solar is the way to go. Wilder schemes involve sky-high wind turbines or antimatter engines.

Sustainability of the Environment

Sustainable energy has two key components: renewable energy and energy efficiency. Distributed power network encompass any generation built near to a consumer's load regardless of size or energy source. The energy system lies at the core of sustainability just as balanced energy supply and demand can assist increase resource efficiency; minimize unwanted wastes thereby reducing the adverse environmental impacts of energy production. Sustainability in a power network system would thereby aim at addressing the following: energy consumption reduction, reduction of sources of energy waste, minimization of energy production pollution and minimization of life-cycle costs of renewable energy resources.

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CONCLUSION

In this chapter we have studied the energy saving tips in distributed power network. It turns out that there is a need of technology improvement, new models and algorithms for a better integration of renewable energy source in the traditional centralized power network. The question is how to efficiently combine centralized and decentralized power generations models so as to minimize the energy cost and maximize the power network stability? The answer of this question requires co-optimizing distributed generation and centralized generation in a future electric grid.

The first approach considers a centralized power network and introduces demand response strategies for reducing peak energy demand in the grid. The weak point of the approach is that the system does not exploit more renewable energy sources and there is a need to reduce greenhouse gas emissions.

The second approach is to shift from centralized power to distributed power network. Namely, integrate distributed generation in a more efficient way in the power grid and optimize the power grid operation through demand response. At this point, the authors proposed a prosumer interaction model in a distributed power network. The prosumer combines both distributed learning and optimization to predict supply/demand in a more efficient way. Simulations results showed that our approach is more efficient than the approach used in DEZENT. The learning scheme of the prosumer in our model can be extended through a CODIPAS learning model (Tembine, 2012).

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KEY TERMS AND DEFINITIONS

Auction Games: Deal with how people behave and act in auction markets.

Demand Response: Is a change in energy usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments.

Distributed Power Network: Is a power network where the energy is generated or stored in a distributed way by a variety of small, grid-connected devices referred to as distributed energy resources systems.

Energy Profiling: Is the prediction of the variation of the energy load over the time.

Game Theory: Is the study of mathematical models of conflict and cooperation between decision-makers.

Optimization: Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing or minimizing desired factors.

Power Market: Is a system enabling purchases, through bids to buy; sales, through offers to sell; and short-term trades.

Prosumers: Is a user that not only consumes electricity, but can also produce and possibly store electricity.

Renewable Energy Sources: Energy that come from resources which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat.

Strategic Learning: Learning in which decisions and outcomes depend on the strategies used by other participants.

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Chapter 58
Ecological Influences on the Evolving Planning System in Turkey

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ABSTRACT

Many developing countries' national plans and urbanization policies lack effective measures to address environmental degradation and support the sustainable use of natural resources. Sustainable urban development policies, the most important pillar of socio-economic development, have not been produced and/or integrated to the urban planning system in Turkey. Suggesting that economic growth may be equaled to wealth and welfare is only possible in environments where certain requirements are satisfied. These requirements may be enumerated as not surpassing the natural renovation capacity, minimizing pollution risks, optimal protection and preservation of non-renewable resources, use of natural resources according to protection-utilization principles. This chapter firstly addresses planning tradition in conceptual background, and analyses relationship of this convention with urban development. Secondly and final phase it addresses the ecological influences created by the urban development shaped by urban planning tradition on the environment, and presents suggestions for solution.

INTRODUCTION

The purpose of the chapter is to state the influence of the increased population growth and urbanization on the development, and role of ecological needs in Turkey's planning system in the context of impacts of population growth and rapid urbanization on the developing world. Due to lack of failure to apply proper planning policies in Turkey, and in connection therewith, lack of sustainable urban development policies, examination of urban planning system in the context of sustainable urban development poses various difficulties in terms of methodology. For this reason, in order to make a general evaluation to overcome such difficulties, in this part of the study, the planning tradition upon which the urban planning system is based and which is determined by a legal framework and formed with historical know-how

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of the system has been addressed in the first place, and evaluations have been made with regard to the relationship of this tradition with the basic paradigms of sustainable urban development. Subsequently, the impact of urban development shaped by urban planning tradition on environment has been canvassed, and criticisms and proposals have been presented.

BACKGROUND

The development of urban planning as a discipline and as an area of policy application has been accompanied by various images as to the scope, issues, concerns, and the type of activities with which the field is preoccupied. Different aspects are held by the ordinary citizen, by professionals in related disciplines, and crucially by planners themselves. This variety is not new to the profession. There is reason to believe, however, that it has increased greatly with the past decade (M. Needleman & C. Needleman 1974; Erber, 1970; Eldredge, 1967) and that it is departing fundamentally from the conventional and popular definitions associated with the field in its earlier years. In tracing the evolution of planning thought over the past two decades, the dynamics of consensus and conflict among planners, and the problems associated with circumscribing the emerging themes of planning theory are suggested to be critical to an understanding of the state-of-the-art in planning theory nowadays. Planning at this time is essentially different from planning at the turn of the century because of the increased recognition of the plurality of values in society and in the profession and because of the expanded scope of substantive area applications of planning (Galloway & Mahayni, 2007). "The diversity within the planning area raises a number of important questions concerning the present and future role of planning in urban policy making. This diversity has sprung from a number of alternative planning definitions and strategies. Policy makers concerned with decisions governing the role of planning in their organizations are having an increasingly difficult time sorting out the planning process and the field to which this process relates. This appears true for governmental officials at all levels and administrators in higher education governing academic programs in planning as well as the public at large. The field of planning as a discipline justifiably has taken pride in the eclecticism, spontaneity, and innovative thrusts that have characterized the field over the past decades" (Godschalk, 1974).

THE EVOLUTION OF PLANNING TRADITION/SYTEMS IN TURKEY

The concept of urban planning emerged in industrialized societies to solve multi-faceted urban problems brought by industry. On the other hand, urban planning followed a different route in countries like Turkey that remained behind in the industrialization process. The first zoning movements in Turkey which could be considered in the context of urban planning "were initiated to seek solutions for initial integration of pre-industrial towns with the world economy" (Tekeli, 1991). In Turkey, the urban planning system has reached the present, undergoing different stages throughout the Republican period. In this context, the evaluation of the urban planning system in Turkey has been conducted by periods which represent break points that influenced planning. Tekeli's grouping (Tekeli, 1998) has been relied upon in the determination of such periods, and 1923 - 1950 period, 1950 - 1960 period, 1960 - 1980 period and post-1980 period have been used.

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In this framework, when the first period is considered in general terms, Ankara was the first city that the Republican management considered in the planning studies as they wanted the new capital to be a modern city. Aside from this, other cities were subject to planning under existing laws. In 1933, a new law was enacted in relation to zoning, and planning was carried out in accordance with that law. In this framework, The Law on Structures and Roads Nr. 2290 guided planning activities between the years 1923 – 1950. However, because the said law was a "law of foreign origin" (Çetiner, 1984), the fact that the prepared plans only sought to specify physical formations and failed to consider socio-economic and other data sufficiently had been a significant matter of criticism.

The second period between the years 1950 – 1960 is prominent as a process when changes in several basic paradigms were experienced in the area of urban planning. Turkey switched to the multi-party system in this period which represented the post-World Ward II (WW2) era. USA introduced the policies called Marshall Plan for the recovery of European countries that were destroyed after the WW2, and these policies incredibly increased urbanization rate particularly in Turkey. With the assistance program in question, mechanization in agriculture and new employment opportunities in the cities triggered a flow of population from rural areas to urban areas, and cities started to become overpopulated. The significant rise of urban populations had a destructive effect on the urban texture which were tried in the previous periods to be shaped as widely-spread housing areas with gardens. The general housing pattern in the cities was specified as multi-story buildings with deficient infrastructure. In the same period, the shanty phenomenon emerged due to the populist and income-oriented policies of the government of the time in Turkey. In the face of all these negative developments, a new zoning law was needed, and the Zoning Law Nr. 6785 was adopted in 1956. As a result, this had been a period with an urban planning system based on comprehensive, multi-faceted researches and during which steps towards an approach that went beyond the physical formation approach of the previous period were taken. However, the most important criticism raised against this period in terms of the planning system was that the urbanization rate was ahead of the planning.

The most prominent characteristic of the 1960 – 1980 period is the 1961 Constitution that adopted the principle of social state. In this connection, the state obliged itself to meet the basic requirements of its citizens and demonstrated its influence in several areas. In addition, another important characteristic of 1961 constitution is the importance attached to the concept of planning. In this direction, the idea of planning gained respect, and enabled comprehension and inspection of the spatial dimensions of development and social change to be seen as an achievable purpose (Tekeli, 1998). In this framework, the State Planning Organization was established. This period should be considered in two/ dimensions in terms of planning. The first dimension is to create regional plans in line with the mission of DPT "to carry out necessary researches and prepare short term regional plans and programs", (Keleş, 2004) a mission specified in the law regarding the foundation of this organization and its formation and duties. The second dimension is to create a phenomenon of town planning. In this context, regional plans were made for Zonguldak, Eastern Marmara, Antalya and Cukurova in this period. Although these plans could not be put into practice entirely due to uncertainty of institutional arrangements in the implementation process, they, at least, provided great contribution to the inventory efforts for future planning. Secondly, the most prominent feature of the 1960 – 1980 period with regard to town planning is the understanding that these plans could not simply consist of physical plans and that economic and social dimensions cannot be neglected. In other words, a "comprehensive - rationalist practice of planning" (Tekeli, 1998) started to rule growth pattern in the country. In this framework, a new understanding was adopted, which "changed the plan production stage and placed emphasis on lack of researches" (Çetiner, 1984).

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Political and economic structural changes that emerged in the world since 1980s left important effect on spatial structure. In the same period, in Turkey that endeavored to integrate itself to the global capitalist system, spatial decisions subject to income policies were made within a system where market conditions ruled. While central government had weight in planning until 1985, the influence of the central government was reduced with the Zoning Law dated 1985 and number 3194, and these authorities were assigned to local governments. Thereby, with the planning studies performed by local governments, application, monitoring and inspection could not be performed sufficiently, and as a result, towns failed to preserve their spatial structures, and entered a fast phase of transformation. Subject to these developments, it is undoubted that non-renewable natural sources will be polluted and destroyed.

Today, there are important problems in regard to application of plans in Turkey, and the understanding of planned urban development is replaced by an irregular, unplanned development. The zoning law was re-assessed at different times with the purpose of preventing illegal housing, and amendments were devised.

As a result, an understanding of planning, which can be summarized as producing fragmental and temporary solutions, rather than presenting fundamental solutions for a healthy urban development, has emerged. On the other hand, according to another approach which supports this view and asserts that Turkey is far from having a planning philosophy. According to this view "it is clear that urban planning experience has been a failure in Turkey. In Turkey, plans cannot be applied for certain reasons and the plan structure occurs as a bulky and bureaucratic planning approach which has very limited effect on urban development and quite far from exhibiting flexibility" (Işık, 1994). Such a structure that fails to address spatial structure along with other dimensions and adopts a minimalist approach to planning will inevitably be shaped solely according to economy and determinant actors of economy.

ECOLOGIC EFFECTS OF ECONOMIC GROWTH ON THE URBAN ENVIRONMENT

Urban ecological systems are characterized by complex interactions among social, economic, institutional, environmental and physical geography variables. These interactions generate complex human-dominated landscapes, which significantly influence the functioning of local and global earth ecosystems and the services they provide to humans and other ecosystems on earth. Urban development fragments, isolates, transforms and degrades natural habitats; simplifies and homogenizes species composition; disrupts hydrological systems; and modifies energy flow and nutrient cycling. Urban areas also appropriate a major share of earth's carrying capacity from other regions in terms of resource input and waste sinks. Change in ecological conditions that result from human activities in urban areas finally affect human health and well-being (Alberti, 2005). The future of earth ecosystems is progressively dependent on the patterns of urban growth. Cities are growing rapidly globally. "The world's urban population has multiplied more than tenfold during the past century, from 224 million in 1900 to 2.9 billion in 1999 (United Nations [UN], 1999). It has also risen from 14 to 50 percent of total world population. In 1900, only sixteen cities had a population exceeding 1 million; by 2000, more than four hundred did. By the year 2030, more than 60 percent (4.9 billion) of the estimated world population (8.1 billion) will live in cities: 56.2 percent of the population of developing countries (3.88 billion) and 83.5 percent of that of the developed countries" (1.01 billion) (UN, 1999).

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Highly concentrated human populations cause changes in natural disturbances (i.e., more frequent flooding, air pollution) and unprecedented catastrophic disturbances. How alternative urban development patterns and environmental politics influence ecological systems along this tendency, however, is not known. Although many studies have addressed the correlation between urbanization and ecosystems (McDonnell & Pickett, 1993), few have asked directly how alternative urban patterns control the distribution of energy, materials, and organisms in urban ecosystems (Sukopp et al., 1995; Alberti, 2005). Most studies of the impacts of urbanization on environmental systems correlate changes in environmental systems with simple aggregated measures of urbanization and socio-economic indicators (e.g., human population density, percentage impervious surface).

More recently, varied disciplinary approaches have been combined to research the interactions between complex human behaviors and ecosystem function. Scientists have started to recognize that urban ecosystems consist of several interlinked subsystems— social, economic, institutional, environmental and ecologic—each representing a complex system of its own and affecting all the others at various structural and functional levels. In studying the interactions between humans and ecological processes in urban ecosystems, researchers need to consider that many socio-economic and biophysical factors work simultaneously at various levels with substantial feedback mechanisms. These complex interactions give rise to emergent phenomena whose characteristics cannot be understood by studying the properties of the socio-economic and ecological systems in isolation (Grimm et al., 2000; Pickett et al., 2000; Alberti et al., 2003).

The most important tool that helps guide urban development, urban planning plays a determinant role in the urbanization process, and the relationship between urbanization and environment expresses the entirety of acts and policies laid down by urban planning.

In this framework, the interaction between urbanization and environment can be examined under topics such as air, water and soil pollution, industrial site selection, illegal housing, historical - cultural setting, agricultural soils, forest areas, terrestrial and aquatic ecosystems and diverse ecosystems, biological diversity, intra-city transportation and other physical geography elements.

The first subject to be addressed under the pollution topic is air pollution, which can be assessed under two headings as pollutants from natural events and pollutants from artificial sources caused by human activity. Dusts dragged/blown by winds, dusts and particles emitted to the atmosphere as a result of forest fires and volcanic activities are natural sources of pollution. Besides these, sources of pollution caused by human activity include, inter alia, transportation, solid fuel, power stations, fuels used for industry and heating, and industrial processes. Air and noise pollution is widespread phenomenon in urban areas. The presence of many motor vehicles in urban areas produces noise and air pollutants such as carbon dioxide and carbon monoxide. Emissions from industrial buildings and plants such as sulphur dioxide and nitrogen oxides are very toxic and poisonous to both human beings and environment. Sources of air pollution arising from urbanization include crowded urban population, extremely dense population density, selection of habitation and industrial sites which are not appropriate to urban topography and meteorological conditions, and urban heating systems and urban transportation (Haq, 2011). The most typical examples in Turkey for air pollution caused by inappropriate site selection that do not suit urban topography and meteorological conditions are Ankara, Bursa, Konya and Yozgat. In these cities, air pollution occurs as a result of discharge of the flue gases of thermal power plants without proper treatment, and flue gases created by use of low-quality coals for heating in downtown Bursa and rural settlement areas and exhaust emissions from vehicles. Subject to natural thresholds created by urban geomorphologic structure and dominant wind direction, polluted air mass remains suspended over the

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urban center, and affects water sources and vegetation adversely with inversion and acid rains. It is seen that development plans made in such cities are unsuccessful in preventing air pollution.

Besides, comparing with rural areas, differences and diversity in solar input, rainfall pattern, temperature and microclimatic features are usual in urban areas. Solar radiation, air temperature, wind speed, wind direction and relative humidity vary remarkably due to the built environment in cities (Heidt et al., 2008). Urban heat island effect is caused by the extensive areas of heat absorbing surfaces, in combination of high energy use in cities. Urban heat island effect can increase urban temperatures by 2°C - 5°C (Bolund et al., 1999). This phenomenon can be seen in many metropolitan cities (Istanbul, Ankara, Bursa and Adana) in Turkey.

The most evident pressure of urbanization in Turkey on water sources is ever-increasing housing around catchment basins near the cities (Atabay, 2001). In this context, pollution caused by housing near catchment basins appears most widely around water dams and lakes which preserve the very scarce fresh water supply of Istanbul. Particularly, Omerli Catchment Basin located in Anatolian side is under urbanization pressure despite all protection measures. In addition, Elmalı, Kücükcekmece and Büyükcekmece Catchment Basins are alike under heavy pressure by planned and unplanned housing. As a result of fragmental plans that are produced by county municipalities in breach of upper scale plans, industry and human settlement cause pollution and pollution risks in these catchment basins. Other issues that impact pollution of water sources are industrial and agricultural activities. Aside from these, transportation activities increased by industrialization and urbanization play a non-negligible role in water pollution. On the other hand, toxic gases released to the atmosphere by industries and houses (like sulfur) penetrate into the sea and fresh waters through acid rains (Brooks et al., 1996). Exhaust gases from vehicles and nitrogen oxides from fixed burning plants are released to the atmosphere. These gases enter the natural gas cycle and complete chain reactions resulting in formation of nitric acid (HNO3), and fall onto earth as acid rains. Acid rain affects soil structure and washes off elements like calcium and magnesium and carries them to the ground water, and causes water to acidify and reduces agricultural efficiency (Kirby et al., 1994). All these processes naturally reach the water source and have an adverse effect on water quality. On the other hand, waste water problem is important as another dimension of the relationship between urbanization and environment. In this framework, according to 1997 official data of the Turkish Statistics Institute, "Only 43 out of more than 3000 municipalities where 76% of the population of Turkey live, in other words, only fifteen ten thousandths of the said municipalities have water treatment plants. Only 20% of the domestic waste water produced in the cities in a year can only be treated at treatment facilities" (State Planning Organization [SPO], 1999). Although the basic reason of pollution is lack of treatment, there are significant deficiencies in sewage and treatment facilities in our country. Unfortunately, the most common means of removal of waste waters in our country have been discharge of untreated or partially treated waste waters to the ground waters and disposal to waste lands far from areas of settlement (SPO, 1999). Aside from all these, other sources of pollution include domestic waste waters, water leakage from cesspools at places with insufficient sewage infrastructure, discharges from industrial activities to soil surface or illegal wells, underground water pollution due to chemical fertilizers and pesticides used in agricultural activities. However, Turkey lacks sufficient number of academic papers and researches on this issue.

The factors that contribute to soil pollution in Turkey include use of various fertilizers and pesticides to increase quantity and quality of agricultural production, discharge of solid and liquid waste, sludge applications, use of low-quality water in agricultural irrigation (such as Bafra and Carsamba Plain), atmospheric precipitation, erosion, thermal power plants (volatile ashes, stack emissions and storage

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sites), incidental release of industrial and urban treatment sludge to the soil or its use for fertilization purposes, irregular urbanization, establishment of industrial sites on inappropriate land (1st and 2nd class agricultural land, etc.), brick and roof tile industrial institutions, and use of polluted water in agricultural irrigation.

In the first years of the Republic, in regard to selection of industrial sites which is another area of interaction between urbanization and environment, a country-wide balanced distribution of industry was projected and important industrial areas were selected in a balanced fashion over the country subject to the transportation system of the country. However, in the subsequent years, industrial facilities were established on the most efficient agricultural areas such as Bursa and Konya Plain, and these agricultural areas faced the risk of extinction. However, investment decisions regarding as sector which is has an important place in the country's development have to be included in development plans that are placed at the highest rank in the planning level, and should be incorporated into regional plans, environmental plans and ultimately in local-scale plans, respectively.

The most important effects of urban development on environment are illegal housing and settlement. In addition to illegal housing areas that develop without a plan, settlement areas with high natural ecologic sensitivity and/or high income potential that are opened to settlement within the framework of a plan are seen as the biggest problems. Keleş defines this problem as "a plunder through a plan" (Keleş, 1997) and states that urban plans in Turkey pave the way to illegal housing and says "social values can be used as a vehicle to destroy environmental values" (Keleş, 1997). In this direction, the most important problem with urban planning has been the intention to derive benefits for some interest and pressure groups rather than to produce plans for public benefit. No doubt this is largely to the shift from a planning phenomenon which is driven by public power and public benefit to a planning approach rather driven by market power, overlapping with market purposes and reducing cities to a meta (Loomis, 2000). What is behind the ongoing illegal housing is the lack of a favor in the general community for public benefit, and that local governments that have a concern for individual unearned income as well as an obligation to apply the plan intend to share unearned income with voter segments for political reasons.

When another dimension which is to protect cultural environment is examined the historical and cultural heritage owned by cities are very important in the formation of a city identity. The planning of protected areas that have a historical, cultural and natural heritage is carried out through protection-oriented zoning plans caused to be prepared by the Ministry of Culture and Tourism and Provincial Private Administrations. Although there are many settlements in Turkey, for which protection-oriented zoning plans have been made, these plans have not been sufficient for a sustainable protection of the relevant areas. Aside from many problems experienced in practice, since protection-oriented zoning plans evaluate and decide upon protection areas in the lower scale, isolating protection areas from other parts of the city, they are not consistent with the general point of view of planning.

Another example in Turkey in the framework of urbanization - environment relationship is the use of efficient agricultural areas for other purposes. When the reasons for use for other purposes are investigated, they include the tendency of the cities to exceed the projected population and area occupation targets and spread beyond. In line with this, plains become the most preferred areas for such spread as they represent the most suitable geographical formation in terms of topography for the selection of settlement sites. Plains consisting of efficient agricultural areas qualified as class I and class II areas of land where this phenomenon is seen in Turkey's plains such as Gediz Plain, Kucuk Menderes Plain and Buyuk Menderes Plain are polluted and destroyed with their selection as areas of settlement and industry. In terms of urban planning, detailed researches should indeed be carried out as regards structure, capability and efficiency

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of the soil during the analysis stage. These analyses are used in the determination of areas suitable for settlement, however, when it comes decision-making, areas that have high efficiency and land quality become the most preferred areas for settlement since they represent the easiest threshold to overcome compared with other parameters (Jorgensen, 1991). Therefore, land requirements of the industry that develops very fast in Turkey and of the population that consequentially increases caused construction of illegal housing and industrial facilities around existing industrial facilities and connecting roads, and increased the pressure on efficient agricultural land. Thus, industrial zones formed along main transportation roads that connect cities to each other caused efficient agricultural land to disappear in a manner not to be regained again. Fast population growth and industrialization led to shift of agricultural land to urban and industrial settlement, damage to forests, and pollution of water sources.

The condition of forests, which is another issue, shows great similarities with agricultural land in terms of urban planning. Activities that lead to loss of forest area in Turkey are urbanization, tourism, and opening agricultural areas for other illegal purposes. Biological diversity is another important phenomenon that suffers damage due to urbanization and environmental interaction. The phenomenon of biological diversity, which is, maybe, the least considered factor in urban planning should be included in the analysis stage of the settlements to be planned, and should be correlated with urban planning.

SOLUTIONS AND RECOMMENDATIONS

As a result, when planning is considered in the context of general historical process, despite Turkey's nearly 60 years' planning experience, the planning system appears to be open to criticism in several aspects. In the light of these criticisms, all shareholders agree that the planning practice should change. When the main criticisms on Turkey's planning practice are evaluated, the top priority issue is that spatial planning systematic and strategy which are directly linked with national development planning have not yet been formed. Because this systematic and strategy have not matured, the principle of evaluating social, cultural and economic dimensions and providing input to planning cannot be realized in depth. In addition, there is a sustainable planning vision and strategy which is agreed upon by all stakeholders. For instance, researchers do not have a future vision and spatial strategy that takes into account physico-biological and ecological sensitivities and relationships of factors such as reduction of foreign dependency in transportation planning and energy requirement, diversity in energy, site selection for industrial zones and the environmental pollution and pollution risks caused by such selection (Power et al., 1997), elimination of socio-economic inequalities between regions, global climate change and Turkey's desertification risk, natural disasters and problems caused by misuse of land. It is seen that the selection of sites for mega projects such as the channel project, airport, nuclear power plants underway in Turkey has not been performed taking the above criteria into account. When unearned income promised by these mega projects and urban unearned income are not used for public benefit, but for the benefit of certain interest groups, spatial – social inequalities cannot be avoided. This attitude allows administrators who decide upon such policies to take autonomous decisions and maintain an unearned income-oriented development planning approach that reduces planning to housing.

In Turkey, many institutions in the existing planning system are producing physical plans at different levels and in very different processes. In the horizontal plane, there is no coordination and flow of information among the institutions that produce these plans, whereas on the vertical plane, there is no sufficient harmony and audit between physical plans produced at different levels. The Provincial Private

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Administration Law Nr. 5302 and the Municipalities Law Nr. 5393 delegate administrative power in many aspects to the local governments in accordance with the decentralization principle and localization policy, whereas in regard to upper scale planning, the law number 4856 and the Environmental Law Nr. 5491/2872 define the authorities related to upper scale plans. Furthermore, the Zoning Law delegates the duty related to Regional Plans to State Planning Organization. The fact that the current legal arrangements that guide Turkey's planning practice do not sufficiently include written rules and principles for the coordination that must be assured in the horizontal and vertical platforms, along with the uncertainty of strategies, prevent the establishment of integrity between levels. However, for the harmony of macro-spatial strategies established on a country level with the spatial strategies developed on a regional and local level, spatial strategies developed on every level should be developed with the participation and coordination of all investor institutions and should be applied in cooperation.

The exceptional articles of the Zoning Law amended several times on a project basis and the lobby created with the influence groups in Turkey, sectoral plans prepared by different institutions, arrangements that support local planning and the resulting fragmented plan making and approval authorities give rise to occurrence of fragmental practices and a confusion of authorities in the planning system. This situation prevents the establishment of audit mechanisms in planning. More than one institution possessing planning authority in the same area or part of an area being planned by a particular institution and other part being planned by another institution and the ambiguity with regards to holders of powers prevent production of planning decisions in coordination. All these processes lead to production of conflicting planning decisions on the same area and difficulties in the implementation stage of decisions made.

Areas of authority laid down by the Zoning Law and other relevant legal arrangements, and the mismatch between plan boundaries that need to assure a planning area integrity which is meaningful within itself and the catchment boundaries that specify an ecologic whole give rise to problems not only in planning processes, but also in practice. Because areas that have very intense physical, ecologic, economic, social and cultural relationships with each other and which in fact create an integrity of settlements are located inside different administrative boundaries, they are planned through different planning processes by different planners who are independent of each other and at different times. As such, lack of relationship causes sometimes production of conflicting plan decisions or make it difficult to put decisions into action.

Taking into account the living conditions in rural settlements, the population of the rural segment, the phenomenon of migration and urban-rural continuity, rural segment planning has been neglected in Turkey. In today's planning practice, rural areas exist only in the context of determination of development conditions and this existence falls within the scope of "rural settlement area boundaries" or "non-settlement areas". However, problems like loss of natural landscape of rural areas, loss of population in rural settlement areas, reduced agricultural production, rural poverty, loss of local architectural characteristics, etc., are problematic areas which must in fact be solved within the spatial planning system.

In Turkey's current planning system, systematic data may not be obtained, necessary analysis may not be performed for the reduction of natural disaster and settlement risks starting from country level down to the application plan scale, and strategies aimed at reducing risks cannot be developed. However, the basic purpose of planning is, in the first place, to assure sustainability of life. For this reason, the top priority in planning processes in all levels must be to reduce natural disaster and settlement risks.

For reasons such as the removal of obstacles before fragmental planning with the zoning law, lack of inspection mechanisms in planning and implementation, and failure to develop rules of professional ethics, etc., very wide areas have been planned particularly through additional and regional plans. This

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has been underpinned by sectoral planning and central housing investments as well as repentance laws. As such, areas planned regionally have been expanded further by integrating them with both upper scale plans and zoning plans. Drifting away from staging in lower scale planning and plan application has aggravated this problem. Today, areas which have been planned as urban development areas through zoning plans in several cities of Turkey have reached as big areas as to accommodate twice the population of what has been projected in the twenty-year projections of the city. In areas which have been planned as urban development areas, fast zoning applications have been carried out, and leapfrog and isolated settlement units outside of the urban settlement areas have been supported. Such big urban development areas have been planned, unfortunately, on qualified agricultural areas to a large extent. Such a practice gives great damage to the environment, and causes cities to grow beyond natural thresholds subject to these processes, and to exceed ecologic values, and to destroy non-renewable natural sources.

Also in this problematic area which is directly related to the above problem, leapfrog development and urban sprawl causes trade, housing and educational facilities, etc. which choose a site outside the city to give damage to environment, and increases their transportation costs and the cost to supply urban services (Burgess, 2000). Another very important negative consequence of urban sprawl is the vacation of urban centers, isolation of citizens from each other and loss of the color and wealth of urban life (Burton, 2002). For this reason, such a pattern of growth should be prevented.

Although it is a scientific imperative and also there is consensus in all platforms that planning should take place with the participation of specialists in an interdisciplinary environment, the practice of planning in Turkey has not, for long years, been carried out in that fashion. This imperative which has been partially met only in the planning stage of large cities or in special planning areas is carried out only by town planners in medium-size cities and small cities. However, aside from a city planner, specialists such as an eco-planner, architect, biologist, zoologist, geologist, agriculturalist, climatologist, hydro-geologist, sociologist, urban economy specialist, etc., should carry out an interdisciplinary spatial planning study.

For the success of planning and its recognition by the public, democratic participation and inspection mechanisms must be activated in the production and implementation of the plans. Although the necessity and benefits of participation in planning processes and urban management are recognized by the public in Turkey, concrete steps have not sufficiently been taken in practice. The taking of planning decisions without consulting different segments of the society gives rise to inconsistency of such decisions with the local reality and makes it difficult to put those plan decisions into action. Another important result of failure to assure participation is the lack of public inspection. Lack of inspection does not only lead to unhealthy living environments but also gives rise to irregular practices on the benefit of urban land and undermines the confidence of the society in the planning institution. For this reason also, effective audit mechanism should be developed.

In terms of planning levels in Turkey, development plans – regional plans – environmental plans and zoning plans are prepared, and development plans involve upper scale decisions which also include socio-economic decisions that need to be prepared with broad institutional participation. Although the State Planning Organization has been empowered in respect of regional planning, a planning that covers all catchment basins country-wide has not been made to date. At this point, regional plans to be prepared by the State Planning Organization should have strategies to guide lower scale plans, and on a regional level, environmental plans should be prepared with the participation of Provincial Private Administrations, Municipalities, non-governmental organizations, universities, and professional chambers.

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FUTURE RESEARCH DIRECTIONS

The chapter reports that the most important effects of urban development on environment are illegal housing and settlement. Accordingly, future researches in developing countries such as Turkey, it would be useful to focus on these issues. Besides, this kind of scientific studies carried out in developing countries needs to expand the literature with focus on relating planning function within the context of governance and the requirement for effective planning and development guidance to facilitate sustainable urban and national development. A clear framework from literature review would guide exploration of planning tradition in developing countries enabling the identification if issues and problems and explaining how and why they come to be. At the same time, in future researches there is a need to expand this to incorporate discussions relating to planning, urban management and governance, on one hand, and also issues of urban sustainability, including resources use, environmental impact and systemic effects resulting from current practices.

CONCLUSION

Planning studies at every level require a systematic database. In Turkey, there is a need for an institutional structure that decides in which detail, by which institution and through which means and by what kind of a system such data will be collected, archived, made available to users in regard to the industrial, housing, transportation, energy, tourism sectors, etc. in relation to spatially-oriented natural and cultural values, natural disaster and settlement risks. Establishment of a "national data center" that will assure coordination between institutions like Turkish Statistical Institute, The Scientific and Technological Research Council of Turkey, other non-governmental organizations that gather data on a country level today will enable to satisfy this very important requirement and to develop more consistent spatial strategies. In the scope of the National Program for the Adoption of the EU Acquis carried out by the Secretariat-General of European Union, the duty to collect spatial data and determine use of land as specified in the INSPIRE (Infrastructure for Spatial Information in Europe) has been assigned to the Ministry of Environment and Forestry in Turkey. The Environment Chapter (Chapter 27) published in the scope of this program details the activities to be carried out by the Ministry of Environment and Forestry for Turkey's integration with INSPIRE. In this framework, it is obvious that an infrastructure for spatial information systems must be established at the Ministry of Environment and Forestry, and in order to have a very strong database for the plans in near future, information technologies should be used, and plans and changes and audits thereof should be carried out and controlled by a single authority.

As a result of these observations, planning should not be simply a physical intervention tool in Turkey, and a planning paradigm should be created taking into account different variables that are able to descend from upper scales down to lower scales and define and establish spatial structure (environment, tourism, history, cultural assets, etc.). Interactions between urban patterns and ecosystem function are controlled by multiple stressors. Furthermore researchers will need to investigate relationships between urban patterns and human-induced stressors, interactions among multiple stressors associated with these patterns, and the existence of thresholds in these relationships.

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KEY TERMS AND DEFINITIONS

Ecological Planning: Ecological planning is the process of understanding, evaluating, and providing options for the use of landscape to ensure a better fit with human habitation.

Ecology: The study of the relationship of organisms with their environment.

Natural Resource: Natural resources are materials and components that can be found within the environment.

Sustainable Urban Development: Development that meets the needs of current generations without compromising the ability of future generations to meet their own needs.

Urban Development: Urban development is the social, cultural, economic and physical development of cities, as well as the underlying causes of these processes.

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Urban Planning: Urban planning is a technical and political process concerned with the use of land, protection and use of the environment, public welfare, and the design of the urban environment, including air, water, and the infrastructure passing into and out of urban areas such as transportation, communications, and distribution networks.

Urbanization: The process by which towns and cities are formed and become larger as more and more people begin living and working in central areas.

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Chapter 59
Rural Tourism in Transitional Russia's Economics:
Fake or Real Alternative to Traditional Agricultural Production?

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ABSTRACT

This chapter assesses the potential of rural tourism in Russia, addresses such threats to sustainable rural development as unemployment and depopulation, and substantiates the practicality of diversification of traditional rural sources of income by means of tourism and other alternative activities. The system approach is utilized, which envisages systematization and stocktaking of various aspects of sustainable development: available resources, economic conditions of agricultural production, market capacity and demand for agricultural commodities and food, employment and social issues, environmental conditions, and alternative sources of income for rural inhabitants.

INTRODUCTION

In the conditions of growing urbanization, more and more countries face challenges of ensurance of social and economic progress of their rural areas. Specific of agricultural production stipulates the main bottleneck: possibilities to replace labour and land with capital are very limited. That is why sustainability of rural areas in general terms means retention of rural inhabitants in their traditional environment by means of provision of sustainable employment and income.

Rural territories have great natural, demographic, economic and cultural potential. Rational utilization of that wealth is able to provide diversified development, full employment, high living standards and quality of life of rural population. However, real situation very much differs from that ideal picture, especially in developing countries, where agriculture usually takes significant part in the overall structure of GDP, and share of rural population pushes up to one third (and even higher) of the nation.

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Russia is considered as developed country; nevertheless, its rural territories have serious problems on their way to sustainable economic and social development: depopulation, unemployment, social tensions, low effectiveness of agricultural production, degradation of lands and rural infrastructure, etc. Such problems are the most severe in the southern under-industrialized parts of Russia, where agriculture dominates in regional products, and rural way of life is traditional for local people. During transformation of Russia's economy in 1990s agriculture became one of the most unattractive for investments because of its longer capital turnover, low return, outdated infrastructure and specific natural conditions of production. That, in turn, decreased level of income of rural people, created unemployment and forced migration to urban centers. Consequently, traditional rural regions in the South of Russia lacked not only capital, but also labour, that led to degradation of agricultural production and rural infrastructure, and arose social tensions.

Therefore, rural areas need additional sources of income to balance the economic development. For the southern parts of Russia, with their unique natural, climatic and resort potentials, rural tourism is one of the perspective ways to give new impulse to rural areas and ensure sustainable rural development. The objective of the chapter is to analyze the current state of rural development in Russia and to substantiate rural tourism as an alternative source of income for rural inhabitants.

The analysis is conducted on the case of Stavropol Region of Russia, which is located in the southern part of the country. The analyses involved 26 territorial districts of Stavropol Region, distributed by their levels of their social and economic development. The selection of the region is explained by its agricultural specialization, significant share of rural areas in region's acreage, prevailing rural population, and unique environmental and agricultural resources.

However, rural tourism itself is not enough to replace traditional agricultural activities in such "agriculturally-oriented" regions, as southern part of Russia, where agriculture dominates in domestic gross product. In order to achieve sustainability, rural tourism may act as only one of the tools. Potentially, it gives more employment opportunities (one of the key conditions of sustainable rural development), which provides rural inhabitants with sustainable income, competitive in comparison to urban territories.

Since recently, Russia's Government gives special weight to ensurance of sustainable rural development, including through rural tourism. General programs and concepts, accepted on the federal level, define the main state approaches to issues of rural tourism, but concrete rural areas need real and effective mechanisms. In order to manage rural tourism in an effective manner, it is necessary to assess the main agricultural, economic and social indicators of rural areas, to define the main threats and to discover potential points of growth of rural tourism. That is especially important taking into account high differentiation of rural territories (even within one region).

BACKGROUND

As to the definition of rural tourism itself, there are a lot of approaches. The official definition, accepted in Russia, is provided by the Federal Tourism Agency. It refers rural tourism as a kind of tourism, which facilitates permanent residence of tourists in rural areas for a purpose of rest and/or involvement into agricultural activities (Almukhamedova & Vilenskaya, 2013). The obligatory condition is the fact that accommodation facilities, both individual and specialized, have to be located in rural area or small towns without industrial or multi-storey constructions (Almukhamedova & Vilenskaya, 2013).

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However, we consider rural tourism as a much broader phenomenon, than set by its traditional definition. It is not only accommodation in rural areas in the conditions, as much close to rural ones as possible (house, furniture, clothes, etc.). Such a "territorial" approach to rural tourism limits its opportunities and retards development, as well as does not correspond to the real demands of broad segments of the population, looking for as much diversified forms of rest and relax, as possible.

Another approach to rural tourism is concluded in dedicated travels to rural areas with relatively undisturbed ecosystems and ethnocultural complexes, which have a direct impact into rural development and are subjects for control in the purposes of sustainable rural development. The given concept includes two major definitions. Firstly, rural tourism is referred to as an environmentally-oriented tourist product on the domestic and international tourist markets. Secondly, rural tourism is expected to act as one of the tools for sustainable rural development.

Referring to other approaches of rural tourism, provided by Russian researches (A. Kuskov, Y. Dzhaladyan, M. Birzhakov) (Kazmina, 2012), as well as World Tourism Organization (UNWTO) and Association for Development of Rural Tourism, we have accepted the following concept of rural tourism for the purposes of the current research: rural tourism is a kind of activity, related to organization of dedicated travels to rural areas, which provides tourists with a complex tourist product (accommodation, meals, excursion services, and entertainment), reflects and preserves natural and cultural identity of regions, and ensures economic benefits for hosting communities by development of employment opportunities and alternative sources of income for local population.

MAIN FOCUS OF THE CHAPTER

Approaches to Rural Tourism

The world experiences a change from mass tourism to more content-related travels. Concept of three "S" (Sun, Sea, and Sand) is becoming replaced by the concept of three "L" (Landscape, Lore, and Leisure). All those new tendencies are related to rural tourism to the fullest extent.

Rural tourism is a relatively new direction of tourism industry. It is also referred to as agricultural tourism or green tourism.

Traditional way of spending vacation at seashore is getting changed by preference to visit intact places, authentic in cultural and natural way. This segment in the tourism industry has been rapidly growing in the past decade, leading to rural tourism becoming not just a good business prospect, but a genuine vacation trend. The fundamental reasons for such kind of shift from traditional tourism to its variations are concluded in the growing technogenic burden on people, and in a far bigger amount of new emotional and educational impressions, obtained from natural and rural-oriented activities, in comparison with traditional set of tourist and recreational services in tourist centers.

Rural tourism focuses on actively participating in a rural lifestyle. It can be a variant of ecotourism. Many rural villages can facilitate tourism because many villagers are hospitable and eager to welcome visitors. Agriculture is becoming highly mechanized and therefore, requires less manual labor. This trend is causing economic pressure on some villages, which in turn causes young people to move to urban areas. There is however, a segment of the urban population that is interested in visiting the rural areas and understanding the lifestyle.

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What is the difference between rural tourism and the traditional one, so it requires separate theoretical and practical approaches? As we outlined above, rural tourists spend their time in rural areas, and not just outdoors (forest or mountains). Such kind of recreation attracts those urban inhabitants, who have never been to village before, or who miss rural way of life. Tourists are accommodated in rural settlements, with no industries and multi-storey buildings. There is a variety of accommodations: guest houses and rooms with necessary furniture, utensils, bed clothes, etc. It is possible to rent a room or a house for a weekend, or longer period, for example, through a whole summer time. Such a recreation is beneficial with its naturality, fresh air and healthy food, cooked with environmentally pure organic products.

Not every rural area or settlement is suitable for organization of rural tourism. Usually tourists seek for a quiet and regular life-style somewhere outside the accustomed urban civilization, with stillness, comfort living conditions, hospitality, moderate prices, natural food, pleasant impressions, and a rich variety of entertainments for children and adults. However, being isolated from urban noise, such rural areas have to have good transport network between settlements, entertainment infrastructure (cafes, restaurants, sport facilities, horse riding schools, hunter points, animal farms, zoos, etc.), as well as good and stable communications (Wi-Fi access, telephone). Entertainments may include beach-related rest on a river bank, fishing, hunting, mushroom and berries picking, sauna, cycling and horse riding, tours of local sightseeing and places of interest, excursions to animal and plant farms, animal feeding, and others (Sysoeva, 2014).

Concluding overview of theoretical and practical approaches to rural tourism, we have to emphasize its major social and economic impact to development of rural areas:

- Relaxation of urban inhabitants in rural areas;
- Awareness about rural way of life and various cultures and nationalities;
- Flow of funds from developed urban territories to underdeveloped rural areas;
- Establishment of new employment opportunities and alternative sources of income for rural people;
- Development of living standards and income levels of rural inhabitants;
- Retention of economically active population and young people in rural areas, lower migration outflows;
- Decrease of social tensions in rural areas;
- Establishment of market for local agricultural and organic products, local specialties and products of folk crafts;
- Development of infrastructure in rural territories, including road network, communications, distribution and entertainment facilities;
- Preservation of natural, environmental and cultural heritage of rural areas.

However, bearing a full set of benefits in theory, rural tourism is still not widely introduced into practice. There are certain difficulties and barriers on the way to its effective development, different depending on the country and separate regions, as well as success stories, which have to be studied in order to discover the best international practices and accommodate them for local conditions.

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RURAL TOURISM IN THE WORLD: HISTORY AND CONTEMPORARY PRACTICES

There are various opinions on origination of rural tourism as a separate segment of tourist market. In 1952 authorities of France supported the idea of accommodation of tourists on farms. It was expected that such an activity provided a secondary source of income for rural people, however by 1970s incomes from rural tourism of some farms even surpassed the ones from traditional farming activities (Ichetkina, 2012). Italy was also among the very first countries, who started rural tourism in 1960-1970s. Since that time, it flashed around the Europe and turned out to one of the most perspective kinds of tourism.

Analysis of international experience and historical issues of rural tourism in Europe let us to conclude five main preconditions for such a rapid growth of that kind of tourist activity in Europe:

1. Many of European people and, more important, governments of European countries started to consider growing environmental problems of big European cities and agglomerations in the early 1970s. The demand for naturality, fresh air, natural quietness and environmentally pure products arose at that time together with the strong awareness of environmental way of life and sustainable development.
2. On the very early stages of its development (1970-1980s) rural tourism was a part of state protectionism policy in Italy and France, which supported establishment of new job opportunities in rural areas.
3. Other countries were forced to look for alternatives to traditional agricultural activities in their rural areas as well, due to worsened economic and social situation in rural areas and shortage of resources to support domestic agricultural producers.
4. Agricultural production in most of the European countries demanded additional internal sources of income and support in order to ensure its development in the conditions of growing internationalization.
5. Demand for rural tourism services grew rapidly, since customers appreciated that new kind of recreation because of combination of environmental, recreational, cultural, and even historical approaches.

According to the UNWTO, annual increment of rural tourism as about 6%, while overall tourist industry grows on 2% (Almukhamedova & Vilenskaya, 2013). Such an outstripping growth rate of rural tourism confirms its perspective and importance for the tourist market in general.

Currently, there are over 700 mln tourists worldwide annually; 12% of them prefer rural-related recreation (Andreeva, 2011). Correspondingly, those figures characterize international flows only; however amounts of domestic rural tourists in some of the countries are quite substantial. Since rural tourism unites a wide range of various kinds of tourism, based on natural, historical, cultural, and other resources or particular rural areas, it grows rapidly. Over the past two decades, rural tourism in the USA and EU turned out to an independent high-profitable tourist industry. As of the UNWTO, rural tourism is now among five major strategic development directions of tourism until 2020 (Baranov & Bisko, 2012).

Rural tourism is popular in EU and USA for a number of reasons:

1. Growing mobility of people due to better availability and coverage of transport networks, including automobiles.

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2. Better organization of vacation time (weekends, holidays, shorter, but more frequents vacations, etc.).
3. Increasing dynamics of urban life and level of related stresses.
4. Variety and quality of tourist services, offered in rural areas, their specialization (educational, cultural, historic, ethnographic, gastronomy tourism, hunting, fishing, entertainments for children, etc.).
5. Popularity of outdoor social events (excursions, walks, cycling, horse riding, other specific kinds of sport).
6. Growing interest to cultural heritage of certain regions and territories, their traditions, local specialties and holidays (Kazmina, 2012).

Rural tourism is particularly relevant in developing nations where farmland has become fragmented due to population growth. The wealth that rural tourism can provide to poor households creates great prospects for development. However, world leading countries in the sphere of rural tourism are developed ones: USA, France, Spain, and Poland. Rural sector of tourist market is especially developed in Europe. There is the European Federation of Village and Farm Tourism, which unites 24 countries. Rural tourism encounters up to 20-25% of overall income of tourism industry in Europe, and that level increases year by year (Sysoeva, 2014).

Rural tourism exists in developed nations in the form of providing accommodation in a scenic location, ideal for rest and relaxation. We have studied contemporary practices of several countries, where rural tourism is the most developed, particularly USA, France, Spain, and Poland.

According the USDA, Cooperative State, Education and Extension Service, tourism is becoming increasingly important to the U.S. economy (USDA, 2008). Many niche tourism programs are located in rural areas. From wine tours and eco-tourism, to rural tourism and seasonal events, tourism can be a viable economic component in rural community development. The publication "Promoting Tourism in Rural America" (LaCaille, 2008) explains the need for planning and marketing rural communities, as well as weighing the pros and cons of the impacts of tourism. Local citizen participation is helpful and should be included in starting any kind of a tourism program. Being prepared when planning tourism can assist in a successful program that enhances the community. An estimate from the Federal Reserve Board in Kansas, based on 2000 data, shows that basic travel and tourism industries accounted for 3.6% of all U.S. employment (Wilkerson, 2003). Data from the Travel Industry Association of America indicate that one out of every 18 people in the U.S. has a job directly resulting from travel expenditures (Travel Industry Association of America, 2004).

Rural tourism is one of the major parts of tourist industry for some of the European countries as well. Thus, rural tourism in France is mediated by the National Organization of Recreation and Green Tourism. This organization provides recreational services, accredited according to the high national quality standards. France is visited by 7 mln tourists annually, who prefer rural recreations. There is a program of children's rural recreation during school holidays. Children aged 3-13 years are accommodated in families, get acquainted with rural household, play outside, and go hiking. They also learn folk dances, crafts, and foreign languages. The quality of such recreation is controlled and certified by the Ministry of Health Care and Social Support and the Ministry of Youth and Sport (Kundius & Chermyanina, 2011).

Rural tourism is also developed in Spain. This country attracts more foreign tourists into its rural areas (about 1.2 annually), in comparison with its domestic rural tourist flows. Spain offers over 5,000

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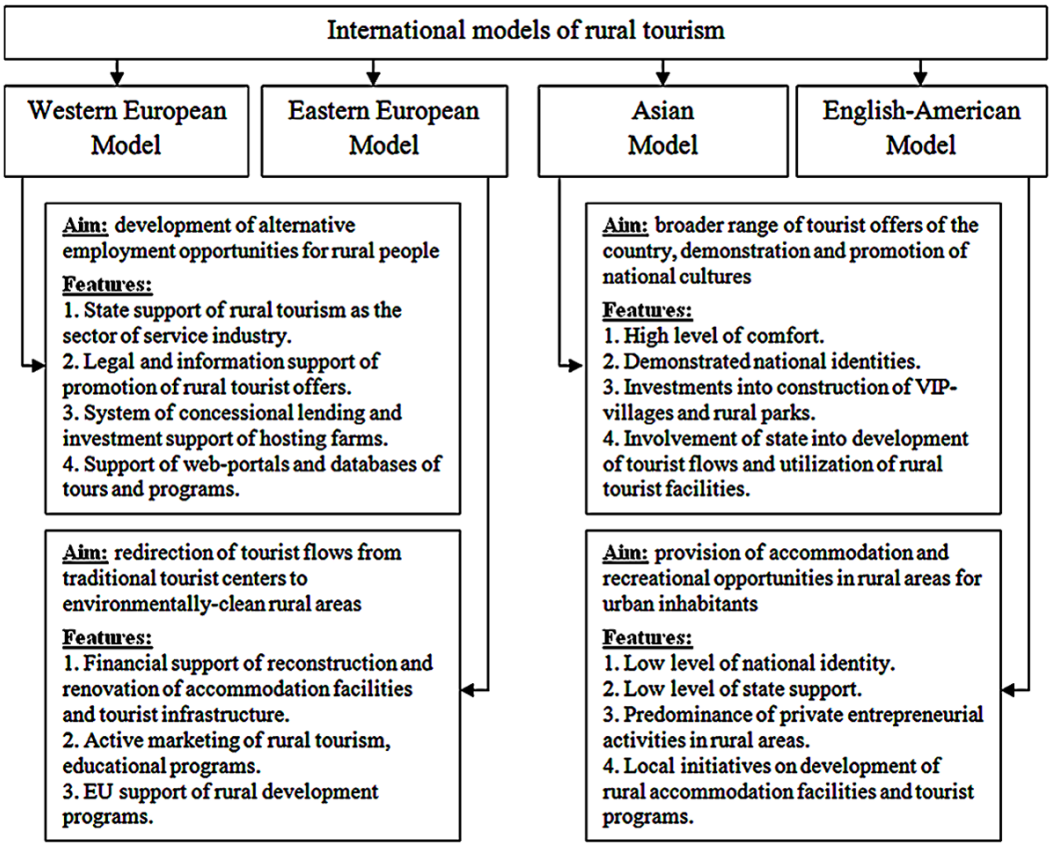
thousand various programs of rural recreation. Its rural sector is able to accommodate over 27,000 tourists at once. The prices are appropriate – $25-100 per night (Kundius & Chermyanina, 2011).

Another European country, where rural tourism is developed, is Poland. There is a target educational program "Green Schools", which includes obligatory two-week accommodation of children from urban areas in rural settlements, in specialized rural tourist households. Such recreation gives children opportunity not only to rest, but also to learn rural way of life. There are special education courses offered, for example "From Grain to Loaf", when children are involved in bread making (grain milling in a windmill, dough making and bread making) (Kundius & Chermyanina, 2011).

Studying the history and international experiences of rural tourism in various countries of the world, we have emphasized four models of rural tourism (Figure 1).

There are certain differences between four models, including two European ones. While the Western European Model aims at promotion of alternative sources of income for rural people through new employment opportunities, countries of Eastern European focus on redirection of their tourist flows from traditional tourist centers to rural areas. However, the final aim is to support those areas, since many of them are economically-depressed.

Figure 1. Major models of rural tourism and their features
Source: Author's development.



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Asian countries are very active in large-scale projects in rural areas. Governments support big constructions; the whole new complexes are established. It is very important for Asian countries to promote their national cultures and identities through historical, cultural and ethnographic programs in rural areas.

English-American Model of rural tourism is very conservative. It is oriented on provision of recreational opportunities for rural inhabitants in rural areas, and more focused on rural issues (rural way of life, contact zoos, etc.), than on national identities.

Anyway, regardless of the region and model, the portrait of an average rural tourist is as follows. That is likely a woman: women-men ratio is about 65% to 35%. Tourists are usually come with families with two kids in average. They are usually active sport people, would like to be closer to nature, and are open-minded to new impressions and opportunities. About 37% of rural tourists worldwide are aged 35-49; others are young people, attracted by rural romantics, and the older generation, who would like to rest from noisy cities. Tourists are more likely have medium or high level of income, and live in big cities (Sysoeva, 2014).

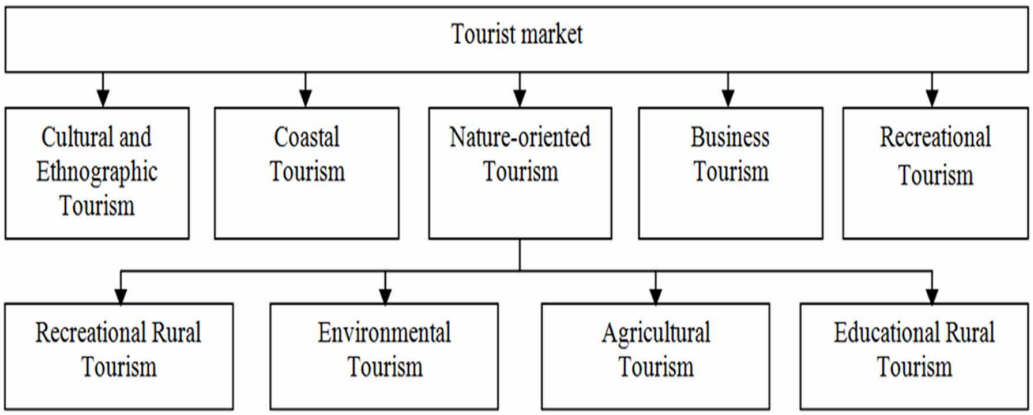
Rural Tourism in Russia: Weaknesses and Challenges

International tendencies are widespread, and new countries are getting involved into rural tourism activities. That is also the case of Russia, where rural tourism becomes more popular year by year.

Contemporary tourist market of Russia has several major segments (Figure 2).

The major preconditions of effective development of rural tourism are, on one hand, unique natural conditions, cultural potential of rural areas, national identity, and interesting traditions and customs, on other hand, demand for such type of recreation from urban inhabitants. As rural tourism is on the very early stage of development in Russia, there is no big competition in this market niche. The most developed regions in terms of rural tourism are Krasnodar Krai, Republics of Altay and Karelia, Leningradskaya, Pskovskaya, Yaroslavskaya, Ryazanskaya, and Kaliningradskaya Oblasts. Nevertheless, experts forecast a rapid growth of demand for rural recreation and related activities in most of the regions of Russia within the next few years (Sysoeva, 2014). Internet portal Hopes&Fears included development of local and, in particular, rural tourism, into the top-ten business trends in Russia (Kopylova, 2014).

Figure 2. Major segments of domestic tourist market of Russia with focus on rural and related tourism
Source: Author's development.



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As international experience shows, rural tourism not only creates new employment opportunities, but also supports preservation of small rural settlements and rural way of life, increases living standards of rural people and their incomes, and retains young people in rural areas. In turn, urban people have an opportunity to spend time outdoors, to test organic food, and to learn more about agriculture. The major directions of development of rural tourism in Russia are establishment of tourist villages on the basis of existing rural settlements with traditional architecture; rural tours with accommodation and meals for tourists; acquaintance with traditional rural way of life and crafts; rent of houses and rooms in environmentally clean districts (What is Rural Tourism, 2010).

Motivation of accelerated development of rural tourism in Russia includes the following reasons:

1. Deterioration of environmental conditions in big cities, growing level of technogenic burden and stress.
2. Temptation to spend holidays in environmentally clean areas.
3. Reappearance of interest to elements of traditional folk culture: architecture, cuisine, crafts, folklore art, and language.
4. Search of new sources of alternative (non-agricultural) income for rural people.
5. Desire to broaden communication network.
6. Growing competition in traditional spheres of investments in rural areas, search of new spheres and objects for investments.

According to the survey, held by Volkov (2012), the most popular kinds of nature-related recreation are hunting, fishing, and gastronomy tourism. The older generations are more interested in visiting historical and cultural places. The average period of tourist mobility is about 5-10 days. Shorter tours on holidays are demanded as well. The preferred time of recreation is summer. Winter recreations for hunting and fishing are also popular. Spring and autumn are low seasons in rural tourism (Sysoeva, 2014).

The resource potential of Russia is favorable for development of rural tourism. There are vast areas of agricultural land of appropriate quality and environmental conditions, high cultural and natural diversity of the country, well preserved local traditions and identities, and rich historical and cultural potential.

Unfortunately, having such huge potentials, most of the rural areas in Russia are far behind the ones in the above studied developed countries. Tourist companies, involved in rural tourism, seek for state support, since tourist flow is still low, and rural infrastructure is underdeveloped. However, in some of the regions of Russia local authorities started to pay their attention to infant industry of rural tourism.

Particularly, Rostov Oblast, one of the most industrially and agriculturally developed region in the southern part of Russia, develops two of its competitive advantages in the sphere of rural tourism: agricultural and ethnographic. Regional government together with local administrations organizes series of interesting events, which attract urban people to rural settlements. They are, for example, All-Russian festival of literature and folklore "Sholokhov Spring" in Veshenskaya settlement, regional ethnographic festival "Don Vine", and folklore theatrical performance "Festival of Don Fish Soup" (Almukhamedova & Vilenskaya, 2013).

Another region of Russia, which supports domestic rural tourism, is Kaliningrad Oblast. Kaliningrad's projects, related to rural tourism, were also supported by the European Union. The most western region of Russia is attractive for Europeans, since it shares boarders with Poland and some other EU countries. The region is popular among people from Moscow and Saint Petersburg as a holiday destination, attractive by unique environment, mild climate, Baltic seashore, and amber crafts (Kopylova, 2014).

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Moscow and Saint Petersburg, being the biggest cities in Russia, form a potential market for rural tourism. Located at a distance of 700 km from each other, they are the sources of effective demand for rural recreations for the regions between them. That is why development of rural tourist infrastructure in neighbor Tverskaya, Yaroslavskaya, Novgorodskaya, and Pskovskaya oblasts (apart from Moskovskaya and Leningradsksya themselves), is very perspective. There are many abandoned and destroyed villages between those agglomerations, since most of the population migrated to cities seeking better employment opportunities. However, those villages are attractive for investments, since constriction of ethnographic and rural tourist facilities is possible from scratch. There are whole villages in Yaroslavl Oblast, where tourists may follow master classes on various crafts. Such attraction points are becoming more and more popular among Russian and foreign tourists (Rural Tourism, 2012).

Small private museums and other attractions are also popular. There are over 30 such mini-museums of dolls, vodka, or teapots in Uglich. Every small town or rural settlement has the same opportunity. The main thing is how to position the tourist object and promote it, attracting potential partners and visitors. Effectiveness of rural tourism is very often in a direct correlation with efforts undertaken and ideas generated, since tourism is always about selling new impressions and positive emotions (Rural Tourism, 2012).

The analysis of contemporary market of rural tourism in various regions of Russia let us to discover the most common forms of rural tourism. They are target regional programs; rural tourism in national parks; tourist programs of individual entrepreneurs and rural households; rural tourism on farms; guest houses in rural areas; big tourist complexes and ethnographic villages.

Being the residents of the Stavropol State Agrarian University, located in Stavropol Krai, one of the regions of the southern Russia, we have also studied the contemporary state and potentials of rural tourism in that area. Doing that, we have compared the region with neighbor regions of Krasnodar and Rostov, and with Altay Krai, one of the leading regions of Russia in terms of development of rural tourism. The analysis of competitors included seven criteria:

1. Quality of services in the sphere of rural tourism and recreation.
2. Variety of rural tourist product, assortment of services and activities available.
3. Average price (holiday of a family of three people is accepted as a comparative base).
4. Promotion of tourist services and products, information network.
5. Image of the region, variety of its cultural, historical and ethnographical identities.
6. Development of marketing channels and ways of distribution of tourist products and services.
7. Domestic market share of rural tourism.

Each criterion is weighted: the lowest weight is 1 (poor), the highest is 5 (excellent). The assessment of four regions and seven criteria is concluded in the Table 1.

Analysis let us to discover strengths and weaknesses of each region, as well as their overall competitiveness in the sphere of rural tourism. It provides an overview of existing competitive advantages, targets, implemented strategies and tools. We may see, that Stavropol Krai, having a good variety of recreational and tourist opportunities (developed agricultural production, vast rural area, clean environment, mild climate, spa resorts, mountain tourism, rich ethnographical heritage, etc.), is still weak in promotion, marketing and distribution of those products and services to customers.

Based on the above presented assessment we have developed the "competitiveness polygon", which gives a picture of current levels of development of rural tourism in four regions (Figure 3).

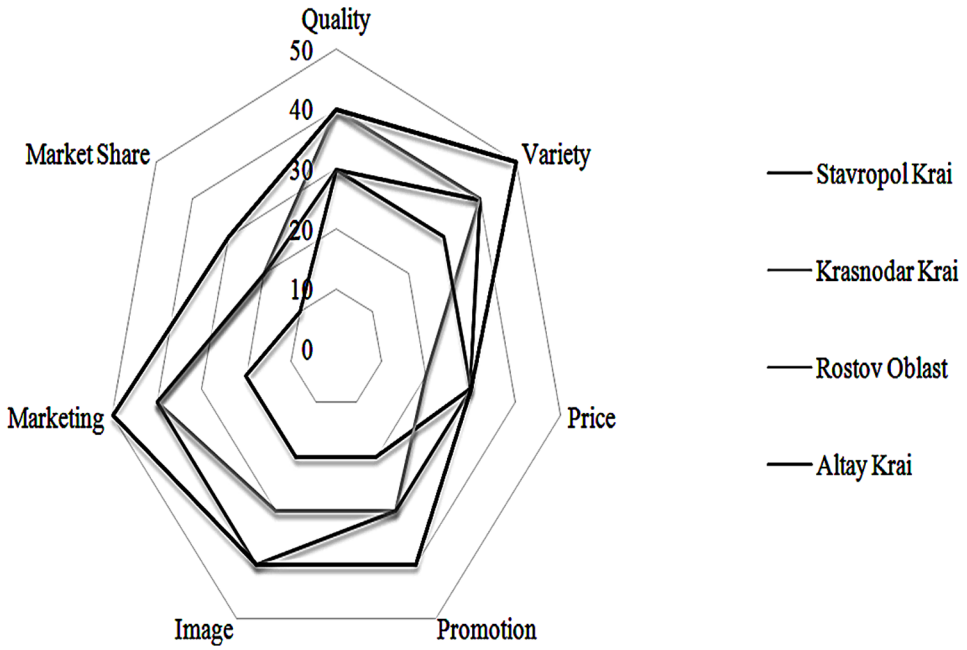
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Table 1. Assessment of comparative effectiveness and development level of rural tourism in selected regions of Russia

Criteria	Stavropol Krai	Krasnodar Krai	Rostov Oblast	Altay Krai
Quality of tourist product and services	3	4	3	4
Variety and assortment of tourist product	4	4	3	5
Average price	3	2	3	3
Promotion of tourist products and services	2	3	3	4
Image of the region, variety of identities	2	3	4	4
Marketing and distribution	2	4	4	5
Market share of rural tourist in the region	1	2	2	3

Source: Author's development.

Figure 3. Competitiveness polygon of rural tourism in selected regions of Russia
Source: Author's development.



Despite the essential differentiation of Russia's region in the context of development of rural tourism and various practices implemented, the overall tendencies are more or less the same. Obtaining a wide variety of competitive advantages and potentials for rapid development of rural tourism, Russia is still very far behind a number of developed (and even developing) countries. We have concluded the major competitive advantages and weaknesses of rural tourism in Russia, and combined discovered advantages (as strengths) and weaknesses (as threats) into the matrix of threats to sustainable development of rural tourism (Table 2).

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Table 2. Matrix of major threats to sustainable development of rural tourism in Russia

		Threats			
		1. Seasonal character (workers may lose income during low seasons)	2. Limited opportunities for high-qualified labour force	3. Destruction of local cultural and ethnographic environment	4. Shortage of resources available for traditional agricultural activities
Strengths	1. Natural and environmental resources, including vast rural areas 2. Differentiated historical, cultural and ethnographical identities of various regions 3. Alternative employment opportunities for rural people 4. Modernization and development of rural infrastructure 5. Retention of labour force in rural areas, its professional development 6. Development of organic production 7. Better environmental awareness of society	Diversification of tourist services and products. Stronger promotion of "low season" activities: ethnographic, gastronomy, and cultural events, not very much dependent of season	Programs for education and professional development of rural people. Special programs of career development for younger generations in order to retain them in traditional rural environment	Prioritization of "identity points" for each region, district and even settlement. Deeper specialization of tourist programs. Promotion of local cultural and ethnographic identities through special events, festivals, educational programs.	Diversification of income sources for rural people. Support of local agricultural production (including organic one), as a food base of a growing sector of rural tourism. Supply of incoming tourists with healthy local food and products.

Source: Author's development.

The major threats to sustainable development of rural tourism in Russia included its seasonal character (tourists prefer to come during summer or winter, but not in spring or autumn); limited opportunities for implementation of high-qualified labour force (until now most of the employees with high qualification leave rural areas and seek for better jobs and financial benefits in cities); "erosion" of local cultural and ethnographic environment (it is easier to offer tourists some popular product or service, than to develop a new one on the basis of local identity and to promote it); shortage of financial and labour resources for traditional agricultural production. Certainly, there are many more threats, which may be discovered and should be considered as essential ones for development of rural tourism. Some of them are hidden, nevertheless are even more substantial, than the tangible ones. Since Russia still has not adopted federal law in the sphere of rural tourism, there are uncertainties over administration, taxation, and other regulations. Because of that many rural household do not want publicity, and work in a "shadow". That is some kind of a vicious circle: one will never increase number of customers substantially without advertising, however the more you advertise yourself, the more you attract attention of controlling bodies (sanitarian and fire inspections, tax inspection, police, etc.). In case of undeveloped legislation, those inspections may easily change into either administrative pressure or even corruption cases. There are regularities for big hotels and restaurants, but they should not be implemented to small rural households, which decided to open a small guesthouse of café. There should be developed separate requirements (Kopylova, 2014).

Analysis of existing practices and positive experiences of various regions of Russia let us to elaborate a range of recommendations in the sphere of rural tourism, related to development of legislation and state support on federal and regional levels. The major are:

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1. Establishment of the unified register of subjects of potential entrepreneurship in the sphere of rural tourism and development of classification for products and services, produced within a rural settlement or district, which may be potentially utilized for the purposes of rural recreation. Such measure would let to discover competitive advantages of certain territory, and prioritize them.
2. Encouragement of businesses to promote rural products and services. In case of rural tourism, there should be organizational and information support of tourist agencies, which market rural recreation, in case of organic production – farms and distributors.
3. Correction of system of extension, consulting and educational services for rural tourism needs. There should be both federal corrections, and regional target programs and initiatives.

Rural tourism should become the economic growth point in rural areas, which drives entrepreneurship and supports solution of numerous social and economic problems of rural settlements. There should be also a system of state support developed for non-governmental and non-commercial organizations in rural areas, which would facilitate the overall process of sustainable rural development, including tourist, recreational, social, and cultural activities.

For its effective development, rural tourism has to be considered as a very perspective business and attractive field for investments. According to Ichetkina (2012), potential rural tourist market in Russia is about $2 bln annually; its profitability is expected to be 15-30%. As per one administrative district, potential annual income from rural tourism is assessed as $1 mln. There are over a thousand of administrative districts in Russia, which have appropriate and favorable conditions for development of rural tourism. That means a potential annual effect of rural tourism in Russia in the amount of $1bln. In case of complex approach (tourism plus development of related agricultural activities), an effect may grow up to $2 bln (Ichetkina, 2012). That confirms importance of rural tourism for rural areas as a source of income, alternative to traditional agricultural production, and a tool to diversify rural economy and to ensure sustainable rural development in the conditions of high vulnerability of international economics and growing international competition.

Tourism as a Factor of Sustainable Rural Development

As our analysis shows, rural tourism allows the creation of a replacement source of income in the non-agricultural sector for rural dwellers. The added income from rural tourism can contribute to the revival of lost folk art and handicrafts.

One of the most severe threats to sustainable rural development is unemployment in rural areas. Levels of unemployment and poverty are twofold higher in comparison to urban areas; while rural labour compensations are twofold lower than the ones in other industries. Small and medium farming is being developed slowly; rural economy stays sector-specific; recreational potential is underutilized. According to the All-Russian research institute of rural economy (VNIIESH), over one third of rural people consider an opportunity to leave rural areas in favour of cities. Among young people that share is even bigger – up to a half (Bondarenko, 2011). In 2000-2013 employment in rural areas was essentially lower in comparison to cities. There is an overall growth of employment rate, observed both in rural and urban areas in 2000-2013, however the growth rate for urban areas is threefold bigger, than in the rural ones. Employment rate for urban areas in 2013 gained 7.5 percentage points in comparison with 2000, while the one for rural areas – only 2.4 (Erokhin, 2014).

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However, high level of unemployment may be turned into an advantage. When employment opportunities are limited, people try to find alternative sources of income by themselves, establishing new businesses and implementing new ideas (Erokhin et al, 2014). For the purposes of rural tourism, unemployment means labour resources, not involved into other industries, which may be easily welcomed by newly established rural tourist facilities. Qualification of such free labour resources may be developed through special education programs and trainings.

Apart from unemployment, rural tourism is one of the ways to solve other problems of rural areas (primarily, deterioration of environment, soils and water resources, decreasing biodiversity) and ensure their sustainable development. Rural tourism is a tool to diversify rural economic, increase demand for local products and services. Such approach changes position of rural households and people: they become producers of agricultural products and providers of qualitative tourist services, demanded by local and external customers (Erokhin & Ivolga, 2013).

As international experience shows, rural tourism is also a way to elaborate strategies of rural development and enhancement of the role of local authorities. Local authorities and other structures across Europe consider development of rural areas as a priority direction of their activities in the context of integration with other aspects of rural life.

Sustainable rural tourism assumes solution of the whole range of problems: development of environmental tourist product; rational utilization of natural and cultural heritage of the region; consideration of interests of local economy on the basis of interaction and cross-fertilization; support of rural entrepreneurship and encouragement of enterprises, related to rural tourism; involvement of rural population and local communities into development of rural tourism and related industries; coordination of interests of businesses and local inhabitants on the basis of partnership and mutually advantageous collaboration (Kazmina, 2012).

In case of developing countries, where investments into agriculture and volume of state support are manifold lower in comparison to the developed ones, rural tourism has a serious potential to grow into a real alternative to traditional agricultural production, since it allows creating new sources of income for rural people without substantial investments (Erokhin & Ivolga, 2012). Certainly, more investments will be required as rural tourist market grows, but only accommodation facilities, people and some kind of entertainment program are needed to start up the business. As soon as new tourist offer becomes attractive, market mechanisms will automatically bring more investments into the business with high return rate.

Most of the businesses and authorities acknowledge prospective viability of rural tourism. However, are there real market preconditions for its development in Russia nowadays? Is it possible for rural tourism to turn into a real alternative to traditional agricultural production in the foreseeable future or that is just a fake? Interest to agricultural production in Russia is growing very slowly. As long as there are other industries with better return rate (oil and gas, metals, etc.), agriculture will lack investments (Erokhin et al, 2014). Misbalance may be corrected by state support and redistribution of financial resources, but such artificial mechanisms are always not very much effective and sufficient. There is a certain interest to organic production and consumption of environmentally clean products in Russia. The market is still very narrow, but year by year people more and more consider of what they eat. However, the demand is not always effective, since only consumers with a certain level of income in Moscow, Saint Petersburg or other big cities are ready to pay price premium for better qualities of organic products and food. They even ready to pay more, than in restaurants, if the organic approach is successfully marketed. People with lower incomes are not ready for higher prices, although they aware of organic food. Those categories

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are two major target groups for rural households. Farm food, offered in rural households during touring, is an excellent alternative to expensive organic products from supermarkets. People may see the whole production process, or even participate in it, and it provides farm food with an additional value.

In spite of interest to rural tourism and declaration of its importance for rural economic, there are no further actions from the government. There is no real support of rural tourism on the national level. However, as we have already discovered above, there are regions in Russia, which support rural tourism on their territories. Regional and local authorities see the potential of rural tourism, and do much for its support through target programs and other administrative, legislative and economic initiatives, where possible. Altay Krai is one of the most advanced in this way among other regions of Russia. Regional government supports rural tourism on the regional level; there is the regional target program implemented. Such regions as Kaluzhskaya, Belgorodskaya and Arkhangelskaya oblasts, and Republic of Karelia put over development of rural tourist households. Kaliningrad Oblasts starts to develop that direction as well (Kopylova, 2014).

SOLUTIONS AND RECOMMENDATIONS

Studying development programs in the sphere of rural tourism, implemented or currently existing in the regions of Russia, we have emphasized six major characteristics:

1. Involvement of administrative advantage.
2. Association of wade range of shareholders.
3. Assessment of resource potential of a territory.
4. Program staffing.
5. Investments into infrastructure of a territory.
6. Establishment of distribution channels for rural tourist offers and programs.

Governmental support is not able to do anything without development of entrepreneurial activities of rural people and businesspersons. Since rural tourism is a brand new kind of business in Russia, there are certain risks and uncertainties involved (long period of business start-up, difficulties in promotion and marketing of tourist products and services, high environmental standards to be met, and negative attitude of local people at least in the first instance).

Those difficulties may be loosening by joint involvement of local authorities, businesses, and rural people into development of rural tourism. It is possible to do through integration of all shareholders. There is the National Association of Country Tourism Organization, established in Russia in 2008, which is involved into consulting and education in the sphere of rural tourism, as well as brings together concerned parties. Regional associations and unions in the sphere of rural tourism should be established as well in order to accumulate Russian and international experience and best practices of rural tourism; establish extension, consulting and professional development centers for adults and educational centers for children; support regional government and related administrative bodies in development and implementation of target programs in the sphere of rural tourism; provide professional expertise of tourist programs and projects on the part of business, society and environment; develop tourist standards; provide certification opportunities for local farms and rural households; organize fairs and exhibitions.

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FUTURE RESEARCH DIRECTIONS

Alongside with the discovered problems and obstacles, the conducted research resulted with a range of perspectives of rural tourism in Russia. They are increasing employment opportunities for rural people, development of market for local agricultural (including organic) and souvenir products, alternative sources of income for rural people, prioritization of economic growth points for certain territories, cooperation of farms and rural households and development of regional infrastructure for rural tourism, promotion of new image of a territory as a provider of diversified and qualitative agricultural and tourist product, and growth of investment attractiveness of a region.

Contemporary state-of-the-art of rural tourism in Russia is still far behind the majority of the developed countries. Russia has essential resources for development of rural tourism, but real utilization of existing potentials is true for several regions of the country only. Further investigations in the sphere of effectiveness and sustainability of rural tourism are vitally important. Supported by adoption of the federal law, elaboration of the federal development program in the sphere of rural tourism, and targeted state policy, they may unlock the potential of rural tourism in Russia.

CONCLUSION

Rural tourism has to be considered as one of the directions of anti-crisis policy in rural areas. Development of tourism and recreation in rural areas leads to creation of new working places and alternative income opportunities in rural areas, attracts investments and promotes interest to rural way of life and traditions.

Rural tourism as an alternative source of income in addition to the traditional agricultural production is especially perspective in developing countries, where investments into agriculture and volume of state support are manifold lower in comparison to the developed ones. However, developing countries still face many problems when start developing their domestic rural tourist industries.

In order to ensure sustainable development or rural tourism, the management concept is required to be adopted. That should be the system of approaches to ensurance of favorable conditions for development of rural tourism as a high-effective, low-cost and competitive industry with positive social and cultural effects for local population and entire society. Such concept has to be based on the following principles:

1. Environmental friendliness, which is an aspiration to align mechanisms of preservation and reclamation of natural, social and cultural environment with business purposes.
2. Sustainable development, which is an optimization of development parameters with consideration of growth ceiling, determined by internal characteristics of production system and external environmental factors.
3. Effectiveness, which is the basis of production and market.
4. Social partnership between administration, business, local communities, and a wide range of other shareholders, including non-governmental and non-commercial organizations.
5. Relevance of adopted measures to specifics and peculiarities of rural tourism in certain territories.
6. Differentiation of approach to organization and implementation of various measures and events in the sphere of development of rural tourism.

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In case of Russia the above mentioned principles have to be introduced through the system state support of rural tourism as a socially and economically important industry, regulatory support of rural tourism development, elaboration and support of development programs in various regions of Russia, and establishment of federal and regional associations and unions of rural tourism shareholders. The latter measure is also related to development of extension services in the sphere or rural tourism. Extension and consulting networks should bring specialists together in order to support newly established and already existing businesses. Those centers may also accommodate professional development programs and trainings in the sphere of non-agricultural business and other alternative income opportunities in rural areas.

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KEY TERMS AND DEFINITIONS

Agricultural Production: Animal breeding and plant production by means of natural forces.

Alternative: One of the available variants of economic behavior compared to another variant in order to choose the best way of action.

Organic Production: System of farm management and agricultural production, which combines environmental methods of production, high level of variability, preservation of natural resources, and high environmental standards of agricultural production.

Rural Tourism: A kind of activity, related to organization of dedicated travels to rural areas, which provides tourists with a complex tourist product (accommodation, meals, excursion services, and entertainment), reflects and preserves natural and cultural identity of regions, and ensures economic benefits for hosting communities by development of employment opportunities and alternative sources of income for local population.

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Sustainable Development: A model of social development, which implementation satisfies all major vital requirements of current and every other generation under preservation of natural and environmental diversity.

Transition: A process of state transition, when radical transformation of entire social and economic systems occurs (transformation of property relations, social and economic institutes, management tools, and targets of economic development).

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Chapter 60
Challenges and Opportunities for the Development and Management of Urban Green Areas in Addis Ababa:
The Case of Cooperative Housing Green Areas and Street Trees in Nifas Silk Lafto Sub-City

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ABSTRACT

This chapter examines the challenges of, and opportunities for, the development and management of cooperative housing green areas and street trees. To deal with this issue effectively, the study employed mixed research methods and used questionnaires, in-depth interviews, focus group discussions, observations and desk reviews, for the purposes of data collection. The findings of this study identify a lack of awareness on the part of the public and of government employees, weak institutional capacities, a lack of coordination among stakeholders, and the absence of clear ownership and enforcement mechanisms, as representing the major challenges impacting the development and management of cooperative housing green areas and street trees. Therefore, in order to develop and manage these green areas properly, the study recommends that the good will, the coordination and the efforts of all stakeholders, including communities, government authority, and non-governmental bodies, be enhanced and duly coordinated.

INTRODUCTION

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The concept of the smart city is not a static one: there is no absolute definition of the smart city, no end point, but rather a process, or series of steps, by which cities become more "livable" and resilient, and thus able to respond more quickly to new challenges. The Office for the Revision of the Addis Ababa Master Plan has also explained that a smart city includes not only smart technologies, but also smart residents, smart mobility, a smart economy, smart housing, smart governance, and smart urban green area development and management. Thus, the development and management of urban green areas such as cooperative housing green areas and street trees, which are the focus of this chapter, are part of the definition of the Smart City in Addis Ababa. This is due to the fact that the development of multi-functional cooperative housing green areas and street trees contributes towards the aims of the smart city in terms of the improvement in the quality of life and environment for the city's population (Alamrew, 2002). The preservation of cooperative housing green areas and street trees in and around the city, also provides psychological satisfaction for the residents. An interesting insight into the purpose of urban green areas and their contribution to smart city development, is provided by Wondimu (2006). He argues that a city or town without sufficient green space can be qualified as an organism with no respiratory system.

As the city of Addis Ababa is now in the process of rapid economic transformation and urbanization, there is growing concern about the fate of green areas. The capital was once called the "forest city". In fact, at the beginning of the 20th century, some 10 million trees were imported from Australia and planted all over Addis Ababa (Berlan, 1963 cited in Wondimu, 2006). Since the nationalization of land in 1975, the green areas in the capital have been subjected to excessive exploitation and severe degradation due to the lack of careful management of green areas and inadequate greening activities (Horst, 2006). Recently, the city administration has been also unable to keep pace with the expectation emanating from the services and facilities of urban green areas and the city's international notion. Moreover, the smart development and management of urban green areas in Addis Ababa barely meets the standards set by other rival African cities, or even the standards set out in the master plan of the city itself (ORAAMP[1], 1996).

The smart development of cooperative housing green areas and street trees is usually planned and indicated in the settlement plan and road design of Addis Ababa. However, these green areas are not operating properly, or are not used appropriately by the residents of Addis Ababa. There are many problems related to these urban green areas, one of which is the level of cleanness. It is true that cleanness is one of the operational attributes for the good quality of urban green spaces, as this creates comfort and convenience for its users. Addis Ababa, however, is not lucky enough to have clean cooperative housing green areas and street trees. Indeed, in some cases these urban spaces are places where homeless people live, dump their garbage and use as toilets. Furthermore, the absence of the effective, timely cleaning and maintenance of these spaces further aggravates the problems.

Cooperative housing green areas also have problems concerning their current functionality and operation. In principle, they should serve all members of the housing cooperative; and they have to be accessible to such members. However, some of these areas are closed, or are simply vacant lots which do not offer any kind of public service. This situation also negatively impacts the environment, the appearance and the economic development of the city.

Generally, these green areas suffer in terms of their appearance, maintenance and cleaning. Moreover, there are also problems related to the extent of the availability and practicality of these urban spaces. However, Addis Ababa is going through a process of transition. Planning for future development and the implementation of management strategies are therefore essential for such urban spaces. However, very little systematic research has been carried out into cooperative housing green areas and street trees in Addis Ababa City.

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All the aforementioned problems are also true in the subject area of this study, Nifas Silk Lafto sub-city (NSLSC[2] BPCDM[3] office report, 2011). They are once again the result of the approach taken to the planning and development of these spaces, or of their management, or perhaps the combination of all such factors. Therefore, the challenges faced by cooperative housing green areas and street trees need to be analyzed in terms of planning for development and introducing better management mechanisms to expand the available services by taking advantage of existing opportunities in Nifas Silk Lafto sub-city.

This chapter aims to answer the following questions:

1. What problems are involved in the development and management of cooperative housing green areas and street trees?
2. What are the current local strategic practices for developing and managing cooperative housing green areas and street trees?
3. In what ways are the stakeholders involved in the planning, development and management of co-operative housing green areas and street trees?
4. What opportunities exist for the development and management of cooperative housing green areas and street trees?

THEORETICAL INSIGHTS

The Development and Management of Urban Green Areas as a Contribution towards the Development of Smart Cities

The concept of smart cities is difficult to define. The idea underlying the term "Smart City" is that by using innovation and technology, resources can be used much more efficiently. The term has a technological background and origins. Recently the concept of smart cities has gone beyond mere technological advancement, and many actors from different disciplines have tried to use various characteristics to define the concept of Smart City. For instance, Giffinger (2007) used six smart categories – People, Mobility, Living, Government, Economy and Environment – for an international ranking of Smart Cities. This typology has also been used by the European Commission (2014).

As we have inferred from the aforementioned concept of the Smart City, aspects of the urban environment such as green areas are considered to constitute smart city categories. The quality of life is also a major objective for most Smart City strategies. Well-functioning, attractive public spaces, together with an attractive environment, can act as symbols of a city and of living together, and may create a sense of ownership of the city among its population (European Commission, 2014). The same author also explained that public open spaces such as cooperative housing green areas and street trees are important factors when defining a city's "smartness".

Urban Green Area Development and Management

Recent studies have shown that planning the development and management of urban green areas requires the integration of the views of both planner and user. For instance, a study in Madina showed that the majority of users (80%) and (71%) want grass / turf and evergreen plants in their green spaces respectively (Irum et al., 2002). This indicates that during the planning, development and management

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process, users' views should be taken into account. If urban green space development strategies fail to include stakeholders' participation, this implies that social and environmental functions are being neglected (Balram & Dragicevic, 2005).

A study in Ankara, Turkey, shows that green space users' preferences include sitting on benches, walking and running facilities, a pleasant landscape, visual elements, nearness to water and a peaceful atmosphere (Oguz, 2000). In the pursuit of the development of quality green spaces, the standards should be set locally to accommodate requested activities and future changes. Public participation in the urban green area development and management process is very important if their values and ways of life are to be incorporated into the process[4].

Experiences involving the development of urban green areas also demonstrate that an effective way of managing urban green areas should be formulated according to an integrated approach and through subject-specific (thematic) strategies. An integrated approach entails the active involvement of the community, together with cooperative, enabling partnerships between local authorities, local businesses and voluntary groups (Bartone et al., 1994). The management of urban green areas within the overall functional area of a political authority and/or built-up city is also a thematic strategy (European Commission, 2007). Moreover, this approach is based on cross-departmental/sectoral cooperation, engagement with all relevant stakeholders, and the integration of local, regional and national policies[5].

Baycan-Levent and Nijkamp (2004) stated that urban green area development and management requires the active involvement of public, private and non-governmental actors at individual, community, city and national levels. Urban green area development and management should therefore involve those whose interests are affected both by green problems and by management strategies and action plans; that is, those who exercise control over the instruments used for implementing green management strategies, and those who possess the relevant information on a wide range of green issues.

Practical Experience of the Planning of Urban Green Areas in Ethiopia

The consideration of urban green areas in country's urban planning ventures and other social and economic development undertakings, has paramount importance for sustainable development. In this regard, the urban planning process in Ethiopia has been incorporating the issue of urban green areas in the overall planning exercise since 1886 (Fetsum, 2003). Fetsum (2003) also pointed out that this is reflected in the incorporation of green areas and parks in urban plans, the consideration of the compatibility of various land uses, the incorporation of generalized environmental objectives, and the identification of hazardous areas. In spite of such efforts, the facilities in urban green areas, even in the capital of Ethiopia, hardly meet the standards set by other rival African cities (ORAAMP, 1996). In order to address these problems, the government of Ethiopia has issued various supporting guidelines, policies and proclamation. These include the Ethiopian Constitution of 1995 (FDRE, 1995), the Ethiopian Environmental Policy of 1997 (FDRE, 1997), the Ethiopian Urban Development Policy of 2006 (Ministry of Federal Affairs, 2006), and its Urban Planning Proclamation no. 574/2008c (FDRE, 2008)

The Ethiopian Constitution establishes a series of general principles requiring that all people be given the opportunity to live in a clean, healthy environment. The concept of sustainable development and environmental rights are also enshrined in Article 43, 44 and 92 of the Constitution of the Federal Democratic Republic of Ethiopia (FDRE). While different action plans and proclamations are designed in line with the Constitution, federal, regional and local governments can design and implement sup-

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porting proclamations and various action plans designed to develop and manage cooperative housing green areas and street trees.

Moreover, the Environmental Policy of Ethiopia has recognized the importance of planning and creating green spaces within urban areas. This provision also creates opportunities for various stakeholders to develop and manage cooperative housing green areas and street trees as elements of urban green areas. Moreover, the Urban Development Policy of Ethiopia has recognized cities as entities that strive to work towards minimizing any serious risks to the urban environment. The policy document also pledged that the city government would work towards:

The development and protection of urban green areas, designing and developing environmental friendly development projects, planting and protecting institutional parks, residential green areas, street tree[s], and informal green areas, ensuring that an exemplary and leading role is played by the government and [ensuring] the participation of the private sector in environmental protection, selecting and adapting best practices, experiences and technologies suitable for urban environmental protection (Ministry of Federal Affairs, 2006).

Thus, urban development policy has rendered city governments responsible for the development and management of residential green areas such as cooperative housing green areas and street trees, with the joint involvement of other stakeholders. Furthermore, Urban Planning Proclamation no. 574/2008c has made chartered cities and urban administrations one of the institutional areas for environmental protection in Ethiopia. It has also prohibited any kind of urban development project that fails to take account of the detrimental impact on the urban environment in general, and on urban green areas in particular. All these are very important advances in the urban green area development and management in Ethiopia.

Experiences in Addis Ababa

The idea of a radial ring road surrounded by green belts was introduced by the second master plan for Addis Ababa. The plan was prepared by the planner of Greater London, Patrick Abercrombie (ORAAMP, 1996), upon request from Emperor Haile Selassie I. However, cooperative housing is a recent phenomena which only saw the light of day in the late 1970s as a result of the 1975 revolution.

The development and management of cooperative housing green areas and street trees are fundamentally inadequate. In order to rectify this situation, CGAA (2011) has introduced a number of undertakings, plans and actions comprising, among others, the City Development Plan of Addis Ababa, the Clean and Green Addis Ababa Development Plan, and the manual of the BPCDM Agency of the City Government of Addis Ababa. The Development Plan of Addis Ababa, which is currently under review, called for tree planting along the city's ring roads and existing streets, and imposed one-plot-one-tree requirements. The Clean and Green Addis Ababa Development Plan (CGAADP) was prepared in 2004 by the City Government of Addis Ababa in partnership with the Clean and Green Addis Ababa Society. The plan covered the period 2004-2025, and contained a number of interesting measures and ambitious programs regarding the greening of roadsides, median strips and open spaces. Moreover, the manual of the BPCDM Agency of Addis Ababa's city Government indicated a series of different institutions through which local residents could be involved in the development and management of cooperative housing green areas and street trees. The institutions and their corresponding responsibilities, are as follows:

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- Urban Plan Preparation and Information Office: responsible for preparing plans for cooperative housing green areas' development.
- Land Development and Ownership Administration Office: responsible for providing land records and other legal documents for cooperative housing green areas.
- Design and Construction Management Office: responsible for providing design standards for the development of cooperative housing green areas and street trees.
- Environmental Protection Authority Office: responsible for implementing Ethiopia's environmental policy with regard to the development and management of cooperative housing green areas and street trees; and for providing tree species planted on cooperative housing green areas and at road junctions.
- Addis Ababa Road Authority: responsible to provide evidences about the location of utilities which are found at the right-ways of the road.
- Water Development Office of the city: responsible for providing water services for the development of cooperative housing green areas and street trees.
- Justice Office: responsible for interpreting different environmental protection proclamations for the management of cooperative housing green areas and street trees.

RESULTS AND DISCUSSIONS

Challenges for the Development and Management of Cooperative Housing Green Areas and Street Trees

As the experience of Addis Ababa shows, the provision of land for citizens to construct houses through cooperatives also includes land designated as green space. In this regard, all 130 respondents (100%) replied that they had received land for the purpose of creating green areas, while the government provided them with land to construct houses through local cooperatives. In principle, these areas are allotted as breathing, recreational and social spaces for local neighborhoods. However, an examination of the archives in the study areas revealed that the development and management of cooperative housing green areas has deteriorated over the course of time.

Survey respondents were also asked to identify the challenges which hinder the development and management of cooperative housing green areas in their neighborhoods. 40% of respondents (52) said that the development and management of cooperative housing green areas is hindered due to public and government employees' lack of awareness of the causes and consequences of cooperative housing green areas' degradation, and of the benefits of the development and management of these areas. These may aggravate the loss, degradation and occupation of cooperative housing green areas by different sections of the community. The second largest group, 35% (45), said that the lack of active participation among stakeholders weakens the joint efforts of various actors to influence the process of development and management of cooperative housing green areas. A quarter of respondents (33) also mentioned that the hindered development and management of cooperative housing green areas was due to the lack of clear ownership and enforcement mechanisms. Such situations leave residents with limited opportunities to develop and maintain their cooperative housing green areas.

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Key informants from different government offices[6] directly or indirectly involved in the issue at hand, also confirmed the above-mentioned factors. Moreover, they described more specific challenges affecting the development and management of cooperative housing green areas. In their view, these challenges include:

- The lack of commitment, among different sections of the public, to complying with various drafted and enacted environmental proclamations, hinders the applicability of various proclamations to the management and maintenance of cooperative housing green areas; the lack of a clear, up-to-date database of cooperative housing green areas. For instance, the GIS map of the sub-city shows cooperative housing green areas as empty spaces, leading government to use the areas for other purposes. For this reason, cooperative housing green areas such as the green area of the Tewahido cooperative housing, are being used for waste dumping purposes; and
- The lack of cross-sectoral cooperation and the rival agendas of the offices in question, has contributed towards hindering the development and management of cooperative housing green areas. "Cooperative housing's green areas development and management have not been given sufficient attention even in the preparation of local development plans" due to the lack of coordination among the urban planners, the information office and the BPCDM office of the sub-city. However, Bartone et al. (1994) argue that the effective and sustainable development and management of urban green areas will only be achieved when the development and management of urban green areas are given sufficient weight when preparing local development plans. Thus, what is actually being done in the study area is different from this standpoint.

Politicians working on land-lease related issues sometimes allocate cooperative housing green areas for other uses in order to save land for different forms of development. Similarly, the focus group participants have pointed to various challenges that affect the development and management of cooperative housing green areas. In their view, these challenges include:

- The lack of proper plan implementation, which offers opportunities for the conversion of cooperative housing green areas for other purposes such as housing, waste dumping, stores for the residents' *Iddir*[7]*,* etc.;
- The lack of education and research regarding cooperative housing green areas, in order to plan appropriate action for the future greening of the areas;
- The disintegration of various cooperatives, thus limiting members' ability to develop and manage their common spaces in a coordinated, integrated manner;
- The lack of proper protection, follow-up, monitoring and evaluation of activities pertaining to the use and conservation of the areas by the government organs in question. This situation has created an environment conducive to incursion into cooperative housing green areas so as to use these areas for other purposes, such as official and unofficial housing construction, parking, for the residents' *Iddir*, and so on;
- Insufficient media coverage of cooperative housing green areas has contributed to the limited public awareness of the importance of the areas in question;
- The lack of any real links between government agencies and the members of the cooperatives, thus hindering the joint efforts needed for the development and management of cooperative housing green areas;

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- The various different government offices responsible for the development and management of cooperative housing green areas are not duly coordinated, and are accountable to other, different offices. This leads to competition between such offices, rather than cooperation, as a result of a conflict of interests; and
- The lack of accountability among the members of the cooperatives with regard to their green areas, which manifests itself in their lack of concern regarding the degradation of their cooperative housing green areas.

Local Strategies and Practices for the Development and Management of Cooperative Housing Green Areas

In the manual of the CGAA's BPCDM agency, the overall strategies for green area development and management are set out in a manner revealing a clear hierarchy of politicians, municipal administrations and other city stakeholders at all levels. The manual also mentions the fact that the strategies for the development and management of cooperative housing green areas are run by the sub-city and woredas' BPCDM offices, in conjunction with other government institutions[8] and with the members of the housing cooperatives. However, the various institutions responsible for designing local strategies do not work in conjunction with the BPCDM office. The reasons for this are as follows:

- Most of these institutions often focus on contingent, highly visible problems such as poverty, unemployment, the lack of housing, etc.;
- Some of these institutions have overlooked the environmental benefits and services associated with cooperative housing green areas, thus making them less inclined to design and implement specific strategies for the development and management of such spaces; and
- The above-mentioned institutions are more likely to compete with each other than to cooperate, which in turn reduces their commitment to designing and implementing the various strategies jointly.

Cooperative housing green areas are developed and managed by the members and committees of the housing cooperatives or *Iddirs* in the study area. However, this strategy is ineffective since most cooperative housing green areas are not clearly registered as the property of the cooperatives.

As far as concerns local strategic practices, a conference was held in 2010 in conjunction with the members of the Medirok and American housing cooperatives, on the topic of the importance of green areas to cooperative housing. The following forms of support were also provided to the members of Medirok and American housing cooperatives by the Woreda (District) 1 BPCDM office:

- Programs to raise awareness of the benefits of cooperative housing green areas;
- Networks were created with, and various supporting letters written to, other infrastructural sector offices such as the water and electricity boards, in order to readily obtain water and electricity services for their green areas;
- Legal letters were sent and land administration authority requested, in order to get cooperative housing green areas recognized as the property of the members of the cooperatives. Recognition was given as a result of such;

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- Guiding and monitoring the activities carried out within the green areas of the housing cooperatives, in order to facilitate the management of green areas for environmental and recreational purposes.

Following the conference and the abovementioned forms of support, the committees of the Medirok and American housing cooperatives acted as lobbies in an attempt to persuade government officials of the importance of cooperative housing green areas for urban life. Therefore, providing different awareness-raising programs to the members of the cooperative, with regard to cooperative housing green areas, and ensuring the tenure security of the green areas in question, are vitally important if appropriate strategies are to be designed and implemented. Current research supports this argument, since the members of the two housing cooperatives in question have started to maintain their green areas as shown below.

On the other hand, not all members of the various housing cooperatives were willing to contribute money; and could not take initiatives to design strategies for the development and management of their cooperatives housing green areas due to:

- The residents' limited awareness of the benefits of the development and management of cooperative green areas;
- The lack of confidence among the members of the cooperatives with regard to the tenure system of cooperative housing green areas. This situation lowered the willingness of cooperative members to participate in the design and implementation of various strategies for the development and management of their green areas.

Moreover, field observations show that most cooperative housing green areas have not been properly developed and managed; no greening or conservation has been undertaken, and they have become dumping areas rather than recreational spaces. This situation clearly indicates that local strategies for the development and management of cooperative housing green areas are incapable of addressing the problems relating to the development and management of the areas.

The Stakeholders' Involvement in Planning, Developing, and Managing Cooperative Housing Green Areas

Beer and Jorgensen (2003), in their study of Scandinavian cities, reported that residents' involvement in the development and management of cooperative housing green areas processes had increased the quality and the facilities of the green spaces in question. The current study, on the contrary, reveals that 69% (90) of survey respondents did not participate in the planning, development or management of cooperative housing green areas, with only 31% (40) of respondents replying that they were involved in those processes. Community involvement in planning green areas takes a variety of different forms, such as providing funding, attending awareness-raising programs, offering technical assistance, and also submitting ideas. However, survey results show that contributing money was preponderant, followed by attending the occasional awareness-raising program. Of this group of respondents, none of them had offered technical assistance, or submitted ideas for the planning and assessing of the community's needs. Of those respondents who did not participate in any way, almost 71% (64) said a lack of opportunities, unclear property rights regarding their green areas, and a lack of information, prevented them from

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participating in the planning process. Some 29% (26) also responded that their participation had been hindered due to the lack of motivation in the communities in question.

Of the 31% (40) of respondents who declared that they had participated in the development and management of cooperative housing green areas, 58.3% (23) replied that they had contributed money to, 18% (7) said that they had attended the occasional awareness-raising program organized by the government, 13.7% (6) responded they had participated in the planting of trees and the sowing of grass in their green areas, while 10% (4) replied that they had participated in community clean-up campaigns to rid the green areas of various types of litter and waste.

The survey results also indicate that the majority of the respondents had participated in the development and management of cooperative housing green areas through the contribution of money. Their participation in various awareness-raising programmes, and in planting trees, sowing grass and cleaning litter from their green areas, was relatively limited.

Key informants from different government offices (institutions) directly or indirectly involved in the issue, have confirmed the aforementioned nature of local residents' involvement in the planning, development, and management of cooperative housing green areas. As far as planning is concerned, the manual of the CGAA's BPCDM office reveals that there is no professional planner assigned to the planning of the green areas' development. Responsibility for such planning activity has been given to the sub-city's Urban Plan Preparation and Information Office. According to the aforesaid manual, the BPCDM office is responsible for conducting need assessments in relation to green areas, in line with the development of the settlements in question. However, this arrangement is "a fact on file", as no expert from the BPCDM office has ever been actually involved in the preparation of local development plans. This is also an indication that what is actually being done does not correspond to what is set out in the manual or the guidelines. This is due to a lack of interest among the various professionals concerned in working in a coordinated manner.

Notwithstanding the foregoing, the three Woredas' BPCDM core process officers stated that their offices had done their share in providing a number of development and management concessions, together with continuous follow-ups and support for the members of the cooperatives. The officers also mentioned that the members of the cooperatives are responsible for any capital investment costs for the development and management of their green areas. Furthermore, the performance standards to be met by the green areas are to be established by their offices, according to the Officers.

Observations regarding those green areas, the management of which has been taken over by the members of the cooperatives, reveals that there has been a certain improvement in the aforesaid green areas. The registered improvements in the green areas of the Abenezer housing cooperative can be attributed to the management system employed. This finding also tallies with Beer and Jorgensen's work which indicated that residents' involvement in the management of cooperative housing green areas improved the quality of the areas in Scandinavian cities. On the contrary, findings regarding green areas not run by the members of the cooperatives in question show that the areas are being used for waste dumping purposes.

Different stakeholder institutions explained that they did not actively participate in the planning, development or management of cooperative housing green areas. Moreover, officers from the NSLSC code enforcement office explained that the office was unable to resolve the problems of the illegal misuse of, and encroachment upon, cooperative housing green areas, due to a lack of clear laws and regulations governing cooperative housing green areas. In this regard, one code enforcement officer from Woreda 3 recounted his experience as follows:

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The invasion of the 'Dirbiabir' cooperative housing green area by the official construction boom was brought to the attention of my office. Subsequently another code enforcement officer and me, we went to the area and told the owner of the construction site that the area was a green area of the Dirbiabir housing cooperative. However, the owner of the construction site produced his legal construction permission and property deed that had been issued by the sub-city's land development and ownership administration office. We then went to our office and asked the Woreda's urban planning officer to check its legality. The Officer said that the area in question was the green area of the cooperative, according to the map of the cooperative. Therefore, due to the absence of any clear enforcement mechanism and of coordination among stakeholders, we cannot implement any preventive measures or redress the problem.

Opportunities for the Development and Management of Cooperative Housing Green Areas

Recently, the lack of green areas has become a concern of the entire community throughout Addis Ababa. This concern has generated some interesting opportunities (initiatives, plans, and actions) at different administrative levels. Such opportunities include the formulation of general policy frameworks such as the Environmental Policy, the Urban Development Policy, the Urban Planning Proclamation no. 574/2008c, and the Constitution of Ethiopia containing a general framework for the development and management of urban green areas. Moreover, the City Development Plan of Addis Ababa and the Clean and Green Addis Ababa Development Plan of 2004 contained a general framework for the development and management of urban green areas. Different areas covered by this study reveal the existence of certain opportunities to help develop and manage cooperative housing green areas. In fact, certain actions and the involvement of housing cooperative members in the development and preservation of their green areas are encouraging.

Survey respondents were asked to describe what opportunities there were to help develop and manage cooperative housing green areas in their neighborhoods. Of the 130 respondents, the majority 61% (79) replied that the existence of their green areas as vacant land represented an opportunity to develop such areas in the future. Some 30.7% (40) stated that the existence of a strong community based organization like *Iddir* was a good opportunity for joint undertakings aimed at the development and management of their cooperative housing green areas. Only 8.3% (11) thought that clean, green initiatives undertaken by the community and other stakeholders represented a good chance to develop and manage their cooperative housing green areas. On the other hand, the focus group participants pointed out that these opportunities can only be grasped if they are accompanied by awareness-raising programs, continuous follow-up and monitoring services.

Key informants from different government offices have also confirmed the benefits of the aforementioned opportunities for the development and management of cooperative housing green areas. They have also indicated the following opportunities:

- The establishment of BPCDM offices at different levels of the city;
- The manual of local development plan preparation explicitly cites urban green areas as essential elements of urban services;
- The existence of undeveloped and semi-developed green areas in the hands of cooperative members, the introduction of GIS and remote sensing to the office as another opportunity for managing land designed for different purposes, such as land reserved for green areas; and

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- The office's recently formulated enforcement manual which shows its intra- and inter-sectoral linkages with other offices.

Challenges for the Growth and Management of Street Trees

Street junctions and median strips comprise the most important opportunities for planting trees within the city. These trees also provide multiple benefits for business communities, residents and tourists. In order to obtain these advantages, different types of tree species have been planted both at the sides and in the medians strips of the roads comprised within the study areas, as shown in Table 1.

However, the aforementioned data revealed that 55% (1019) of the planted trees had died; only 45% (821) had survived. One can also see that the surviving street trees are not getting proper maintenance and protection in the study areas. Field observations of the surviving street trees have revealed that their growth and management are poor.

In an attempt to get residents' views regarding the growth and management of street trees, 130 respondents who were living adjacent to street trees were asked to express their opinions. 84.6% (110) of respondents said that the street trees were not growing properly or being duly maintained. Only 15.4% (20) of respondents reported that the street trees were being managed fairly well. From this, one can see that the street trees in question are not being properly cared for.

Survey respondents were also asked to identify the problems associated with the growth and management of street trees in their neighborhoods. 47% (61) of respondents stated that the community's wrong perception of the purpose of street trees hindered their development and management. Consequently, communities failed to act in order to care for and conserve these trees. The second largest group – 28% (36) – said that stakeholders' lack of participation had weakened the joint efforts of various actors needed for the growth and management of street trees. 25% (33) of them also mentioned that the growth and management of street trees had been hindered by street vending. This unofficial form of trading had a negative impact on the growth and management of street trees. Key informants have confirmed the above-mentioned factors. In addition, they have also mentioned specific problems affecting the growth and management of street trees. For example, insufficient institutional capacities characterized by the absence of continuous follow-up, the lack of trained staff capable of creating more effective, integrated partnerships with business communities, and the lack of financial resources, were perceived as critical factors for the BPCDM office's failure to fulfill their responsibilities effectively. Various different unofficial activities relating to the construction industry, such as the dumping of construction materials near to the street trees, also affected the latter's development and management. Furthermore, the poor selection

Table 1. Planted street trees and their status within the study areas

No.	Plant Types	Places Where Street Trees Are Planted	Number of Planted Trees	Surviving Trees (%)	Protected Trees (%)
1	Gravilia	Around Jemo	400	42	30
2	Jacaranda	Around Micheal Square	400	25	20
3	Zenbabaselen	Around Mekanisa and Jermen square	640	43	26
4	Zenbabapicok	Around Bisrate Gebreal and Sar Bet	400	47	35

(Source: NSLSC BPCDM office street trees inventory report, 2011)

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of tree species designed to combat carbon dioxide emissions, and the installation of urban infrastructural facilities such as fiber-optic lines, all negatively affect the growth of street trees.

The focus group discussants, key informants and survey respondents together identified the following problems affecting the growth and management of street trees:

- The lack of an integrated data base of street trees, which affects the efforts of various stakeholders to design and execute appropriate course of action for the growth and management of street trees;
- The communities do not feel that the trees belong to them. This feeling discourages the communities from participating in the development and management processes;
- The absence of integrated systems for the management of the street trees in different parts of the neighborhood;
- The lack of action plans for volunteers, resulting in lower volunteer participation in the growth and management of street trees;
- The absence of clear norms and standards governing the minimum distance to be observed between main roads and footpaths, and the places where the street trees are to be planted. Consequently, street trees are planted on footpaths and pedestrian ways, which leads to their deterioration as a result of the transit of pedestrians;
- Traffic accidents have also contributed towards the deterioration of street trees.

Local Strategic Practices Aimed at the Growth and Management of Street Trees

Local authorities are expected to take the lead in forming partnership with other local public sector agencies to develop wider community strategies for improving the economic, social and environmental well-being of their local areas. This would help them contribute towards the achievement of sustainable development (European Commission, 2007, p. 7). These strategies are often prepared and implemented by local authorities through local strategic partnerships bringing together different sections of the community, such as businesses and others. Therefore, it is a good idea to assess the types of local strategic practice being followed to develop and manage street trees in the study areas.

The Nifas Silk Lafto sub-city BPCDM officer mentioned various factors, such as the need for continuous maintenance of street trees under a sustainable system, the increasing damage to street trees, and the public's misperception of the value (benefits) of street trees within the sub-city, as having prompted the office to devise a long-term strategy for street tree development and management. According to her, the strategy has been adopted by the Woredas' BPCDM core process offices.

The three Woredas' street tree development and management policy document states that street trees are grown and managed by government officials, residents, business communities and voluntary groups. As for strategies, the development and management of street trees will be assigned to the abovementioned stakeholders in the form of adoption modalities by Woredas BPCDM core process officers. The strategies also set out a long-term vision for the development and management of street trees in an integrated framework, which is to be complied with and followed-up continuously. To demonstrate the values of street trees to partners, the strategy also provides evidence of the contribution made by street trees to the general appearance of the city and to urban life in particular.

Accordingly, the core processes resulted in a number of street tree development and management agreements between local government officials, residents, business communities and voluntary groups. However, an evaluation of the implemented strategies indicated in Woredas' street tree assessment report,

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shows that only 35% of the drafted strategies were actually implemented. According to the informants and focus group participants, the lack of implementation was attributed to insufficient awareness of the benefits of the strategies on the part of those officers concerned, together with the non-provision of incentives to volunteers. However, the study's findings also revealed that there are significant differences between those trees given to business communities, and those that are not.

Stakeholders' Involvement in Planning, Growing, and Managing Street Trees

According to the literature, stakeholders' participation involves the combined efforts of a great many institutions, organizations and individuals, aimed at the successful planning, development and management of urban green areas. It also indicates that cooperation among stakeholders is the way to achieve a greater synergy involving more than just the exchange of information or even collective decision making: partnerships, mutual trust and understanding are also required.

Contrary to the above arguments, the results of our questionnaires indicate that 65% (85) of respondents do not participate in the planning, growth or management of street trees. Almost 68% (58) of such respondents said that the lack of opportunities to do so prevented them from participating. Some 32% (27) responded that their participation was hindered by the lack of information. Moreover, almost 80% (68) of those respondents who do not participate in the street tree planning, development and management processes also said that government was doing this work. The remaining 12.5% (11) and 7.5% (6) of respondents, respectively, said that business communities or NGOs were participating in the planning, growth and management of street trees.

Stakeholders' involvement in growing and managing street trees takes different forms, such as the provision of suitable soil and water, planting trees, preparing holes for the planting of trees, and so on. Of the 35% (45) of survey respondents who participated in the growing of street trees in their neighborhoods, 33% (24) replied that they did so by providing suitable soil; 24.5% (11) responded that they contributed by planting trees along the ring roads; and 22.2% (10) answered that they dug holes to plant the trees. Others were involved by both planting trees along the ring roads and by digging holes for the trees. On the other hand, 78.3% (35) of said participants responded that their involvement consisted in watering the trees; 20% (9) said they were involved in the fencing off and protection of the street trees; and 1.7% (1) responded that they took part in raising the community's awareness of the fact that the trees belonged to them.

According to the BPCDM agency's manual, BPCDM offices at various different administrative levels are in charge of the planning, growth and management of street trees with the active involvement of different stakeholders such as local residents, business communities and NGOs. In order to know to what extent the government institutions in question fulfilled their responsibilities, officials from said government institutions were duly interviewed. The information obtained from the key informants is reviewed below.

According to the BPCDM agency manual, the street tree plan needs to be discussed in detail with experts from the Addis Ababa Road Authority. Recently, a number of discussions have been held with the Addis Ababa Road Authority regarding street trees planning. The road property protection and management team leader at AARA stated this point. A team leader also stated that "CGAA's BPCDM agency and its office at sub-city level, together with AARA, discuss and evaluate their plans and strategies twice a year".

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BPCDM offices at the sub-city and Woredas level have taken various forms of action for the purposes of the decoration, greening and protection of streets in the sub-city, by planting and maintaining street trees. The BPCDM agency's manual states that the Clean and Green Addis Ababa Development Plan (CGADP) is being implemented by BPCDM office at different levels of the sub-city with the involvement of other stakeholders such as business communities and NGOs. Similarly, the three Woredas' BPCDM core process officers said that various activities are being carried out by their offices and by different business communities, but the results have been insignificant. This is because various initiatives and actions are not implemented in a sustainable manner and with massive community involvement, due to:

- The lack of trained personnel capable of growing and managing street trees systematically;
- The fact that staff turnover has led to a lack of any integrated database and information about the status of the street trees;
- The unwillingness of professionals to provide home-to-home awareness raising programs concerning street trees for the communities; and
- The fact that large business communities are no longer interested in participating in planting trees along roads and at junctions owing to conflicts of interests.

As far as the development and management of street trees are concerned, field observations in different parts of the study areas revealed that the situation is very discouraging. However, those street trees that have been planted nearest to voluntary groups are receiving proper care.

Opportunities for the Growth and Management of Street Trees

All the different policies, plans and proclamations drawn up, such as the Constitution of Ethiopia, the Environmental Policy, the Urban Development Policy, and Urban Planning Proclamation no.574/2008c, contain general provisions for the development and management of urban green areas. More specifically, the City Development Plan of Addis Ababa, and the Clean and Green Addis Ababa Development Plan of 2004, see the greening of roadsides and median strips as one way of developing and nurturing green areas in the city of Addis Ababa. All these provisions should create conditions conducive to the specific implementation of courses of actions for the growth and management of street trees.

Moreover, survey respondents were asked to describe the opportunities for the creation of an environment conducive to the growth and management of street trees in their neighborhoods. Accordingly, about 52.3% (68) of respondents said that government involvement in street tree development and management represented a good opportunity. Some 30.8% (40) said that clean, green initiatives by the community and other stakeholders such as NGOs represented a good chance to develop and manage these trees. The remaining 16.9% (22) suggested that the business community's involvement in the growth and management of street trees should be perceived as a good opportunity for the creation of such an environment. Key informants from different government offices also identified similar opportunities. They also pointed to the establishment of BPCDM offices at different municipal levels; to the BPCDM agency's recently drafted enforcement manual that reveals its intra and inter-sector links with other offices; and to recent government partnerships with private concerns such as voluntary groups, business communities and social groups, involving their participation in such projects, all of which are perceived as good opportunities for the development and preservation of street trees.

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CONCLUSION

A lack of awareness on the part of the public and of government employees, together with limited institutional capacities, a lack of coordination among stakeholders, the absence of an up-to date data base, and the lack of clear ownership and enforcement mechanisms, have emerged as serious problems affecting the development and management of cooperative housing green areas. Similarly, the public's misperception of the benefits of street trees, the non-participation of stakeholders in the development and management of green areas and street trees, and the absence of an integrated data base containing precise details of the city's street trees, have together impeded the growth and management of street trees. Moreover, a weak institutional capacity characterized by staff shortages and the lack of trained staff, the absence of any regular follow-ups and protective measures, the poor selection of tree species, the lack of norms and standards regarding exactly where street trees should be planted, traffic accidents, and the installation of utilities, are all factors impeding proper street tree development and management.

As far as regards local strategic practices, while cooperative housing green areas are developed and managed by the members of cooperatives and *Iddirs*, the study reveals that this strategy is ineffective due to the lack of awareness and of property deeds relating to the green areas in question. On the other hand, street trees are grown and managed by the sub-city's BPCDM offices and Woredas, with the involvement of other stakeholders; however, this strategy has been poorly implemented and has been significantly constrained by a general lack of awareness, by insufficient follow up by the BPCDM experts in question, and by the absence of incentives to volunteers.

The study also found that there is a general lack of stakeholders' participation in the planning, development and management of these spaces. However, the Federal Democratic Republic of Ethiopia's Constitution, the Environmental Policy of Ethiopia, the Urban Development Policy, and Urban Planning Proclamation no. 574/2008c, all contain general provisions regarding the development and management of urban green areas by the stakeholders in question. The study also revealed that BPCDM's recently formulated enforcement manual, together with the office's intra and inter-sectoral links, represent good opportunities for the sector to implement green development and management projects in a coordinated manner. The involvement of housing cooperative members in the development and management of their own green areas, together with the recent establishment of private partnerships to develop and preserve street trees, are also deemed positive measures and practices.

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KEY TERMS AND DEFINITIONS

Challenges: Constraints that act as a bottleneck for the development and management of cooperative housing green areas and street trees in Nifas Silk Lafto Sub-city.

Community Based Organizations: This term denotes Iddirs and local business communities.

Cooperative Housing Green Areas: The green areas of cooperative houses that were built during the Dergue regime and by the current government through the adoption of a self-help approach in Nifas Silk Lafto Sub-city.

Local Strategic Practices: Refers to a set of actions designed to improve cooperative housing green areas and street trees in Nifas Silk Lafto Sub-city.

Opportunities: Refers to the initiatives and actions taken by the stakeholders to enhance the development and management of cooperative housing green areas and street trees in Nifas Silk Lafto Sub-city.

Stakeholders: Refers to those actors, including government institutions, communities or community-based organizations, and voluntary groups (NGOs), that are responsible for the development and management of cooperative housing green areas and street trees in Nifas Silk Lafto Sub-city.

Street Trees: Refers to trees planted both at the sides of roads and along median strips in Nifas Silk Lafto Sub-city.

Urban Green Area Development: Refers to improvement to cooperative housing green areas and street trees designed to maximize their benefits for urban life in Nifas Silk Lafto Sub-city.

Urban Green Area Management: Refers to the preservation and protection of cooperative housing green areas and street trees so as to meet the intended objectives in Nifas Silk Lafto Sub-city.

Woreda: District-level administrative unit.

ENDNOTES

1 Office for the Revision of the Addis Ababa Master Pan
2 Nifas Silk Lafto Sub-city
3 Nifas Silk Lafto Sub-city Beautification, Park and Cemetery Development and Management
4 Oguz (2000), Ibid., pp.165-171
5 E.C. (2007), Ibid., p. 7
6 Officers from the design and construction management office, the land development bank and urban renewal office, the urban plan preparation and information office, the land development and

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ownership administration office, the BPCDM office, the environmental protection authority office, and the code enforcement office of the Woredas in question and of Nifas Silk Lafto Sub-city, were interviewed.

[7] Social organizations established by the communities in order to resolve various social problems.

[8] The land development bank and urban renewal office, urban plan preparation and information office, land development and ownership administration office, design and construction management office, environmental protection office, water development office, and justice office, at different municipal administrative levels, are the institutions responsible.

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Chapter 61
The Drive Towards NEAR Zero Energy Buildings Through Professional Training in Southern Europe: The SouthZEB Project

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ABSTRACT

This chapter gives an overall summary of the challenges faced by European countries regarding the adoption of nZEBs, particularly focusing in the training needs in the Southern Mediterranean countries, and on the experience reached so far by the ongoing SouthZEB Project. Therefore, it first elaborates on the nZEB concept definition framework focusing on the relevance of the topic to local and regional development purposes. Secondly, the chapter gives an overview of the definitions that may be used to the adoption of nZEB across European countries. The perspective presented is first through a top-down approach, based on the policy implementation efforts developed by the European Commission and, after that, based on a bottom-up perspective, including an overview of existent voluntary standards that may be regarded as contributing to the adoption of near zero energy buildings. Thirdly, the chapter reflects on some of the barriers encountered that hamper nZEB adoption, specifically addressing the need for professional training in Southern European countries. Finally, the methodology used by the SouthZEB Project to define the training and certification needs, which is based on the participatory process, is presented along with an overview of the project major results achieved until now and the main difficulties identified so far.

INTRODUCTION

The implementation of European Energy/Climate policies fully comply with the goals of regional development and the buildings sector is one of the most relevant to tackle both dimensions. On the one hand, buildings are at the spotlight of the EU's energy efficiency policy, as nearly 40% of final energy consumption and 36% of greenhouse gas emissions is carried in the European building stock, such as residences, offices, shops and other types of buildings. On the other, it is a crucial sector to spatial development dynamics of a territory.

The 2030 European Commission Communications, published in July 2014, highlight the key role of the building sector, stating that "the majority of the energy saving potential is in the building sector". Therefore, improving the energy performance of Europe's building stock is crucial to achieve the EU Energy/Climate targets and, beyond these, to bring about drastic greenhouse gas emission reductions in the building sector of 88 to 91% compared to 1990 by 2050 (European Commission, 2011).

Over the past decade, energy efficiency has consistently reduced annual energy consumption and confirms its place as the first fuel option for the economy, according to the 2014 Energy Efficiency Market Report (International Energy Agency, 2014). In particular, the report evaluates 18 IEA[1] countries where energy efficiency has had the largest percentage improvements in the residential sector, driven by improvements in space heating, water heating, lighting and appliances, and where energy demand has been reduced by 5% in the period between 2001 and 2011. In this way, energy efficiency is strengthening its position as a fuel option for countries in their efforts to balance supply and demand in support of growth and competitiveness, energy security and environmental objectives. This strategy is far more pressing in Europe where final consumers' electricity bills are expected to continue on the rise, at least for the next following two decades (Rezessy, 2014) (Eurelectric, 2014).

It is in this given context of high potential for reducing the buildings' energy requirements, that the amendment act to the EU's Energy Performance of Buildings Directive introduced in 2002 (Official Jour-

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nal of the European Union, 2002) emerged in 2010 (Official Journal of the European Union, 2010) and became the main legislative instrument for improving the energy performance of the European building stock. In this amendment two key mechanisms are highlighted as guidelines for the energy performance improvement: the principle of *nearly zero energy buildings* (article 9 and article 2.2) and the principle of *cost-optimality* (article 5, article 2.14 and annex). In particular, the amendment establishes that by 2020, all new buildings constructed in Europe must be near zero energy buildings and, from 2018 onward, all new buildings occupied and owned by public authorities should be near zero energy buildings.

Parallel to the requirements of the recast of EPBD directive, the Energy Efficiency Directive (Official Journal of the European Union, 2012) establishes a common framework of measures for the promotion of energy efficiency within the European Union in order to ensure the achievement of the 2020 20% headline target. The measures focus on both the public transport and building sectors, which are the two largest sectors with energy savings potential. The public sector shall lead in the building sector by renovating 3% of buildings owned and occupied by the central governments starting from 01 January 2014 and by including energy efficiency considerations in public procurement, so as to purchase energy efficient buildings. Also, the Renewable Energy Directive (Official Journal of the European Union, 2009) sets requirements related to buildings. This directive stipulates that by 2014 all member states' building regulations and codes will require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation. This directive also states that from 2012 onwards, member states should ensure that new and existing public buildings that are subject to major renovation must fulfil an exemplary role, either at national, regional or local level.

Achieving Europe's 2020 and 2030 Energy/Climate targets is challenging and forces decision makers at multiple levels, urban planners, engineers and architects to re-design and adapt the built environment, mostly concentrating in cities, as the world continues to become more urbanized (United Nations, 2014). Local governments play a crucial role in mitigating the effects of climate change, contributing to energy savings and the rationale use of energy in their territories, particularly when one realizes that 80% of energy consumption and CO_2 emissions is associated with urban activity. However, often municipalities lack sufficiently high quality information to empower them to take ambitious decisions in this respect and even if decision makers at the local and regional levels want to start an energy relevant action, they often have no idea how to proceed.

With this in mind, the Covenant of Mayors was created by the European Commission in 2008, subsequent to the EU Climate Energy Package, to endorse and support the efforts deployed by local authorities in the implementation of sustainable energy policies. In order to translate their political commitment into concrete measures and projects, Covenant signatories undertake to prepare a Baseline Emission Inventory and submit, within the year following their signature, a Sustainable Energy Action Plan outlining the key actions they plan to undertake. Beyond energy savings, the results of signatories' actions are manifold: creation of skilled and stable jobs, not subject to delocalization; healthier environment and quality of life; enhanced economic competitiveness and greater energy independence. These actions serve as examples for others to follow, notably through referring to the "Benchmarks of Excellence", a database of best practices submitted by Covenant signatories. The Catalogue of "Sustainable Energy Action Plans" is another such unique source of inspiration, as it shows at a glance the ambitious objectives set by other signatories and the key measures they have identified to reach them (Covenant of Mayors, 2015).

Another example to keep in mind would be the project AIDA – Affirmative Integrated Design Action that took place from April 2012 to March 2015. The AIDA project aims at accelerating the market entry of nearly zero energy buildings (nZEB), the number of building professionals trained on integrated

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energy design and the number of municipalities starting to build/refurbish buildings to nZEB levels. This project works in close co-operation with leading experts from Italy, Spain, France, Austria, Germany, UK and Hungary and assists dedicated municipalities in these seven countries to develop tenders for new and renovated nearly zero energy buildings and increase the visibility of front runners by offering study visits for more than 3000 European building professionals and local decision makers. Moreover, it is expected to train at least 1500 building professionals on integrated energy design tools. In this way, it contributes to raise the awareness of decision makers and citizens under the belief that citizens will be better prepared and more willing to adopt nZEB, if their municipality sets an example thus giving them direct access to and experience of nZEB. Therefore, AIDA offers essential information to municipalities, supports them in setting up own ways and strategies to contribute to the 20-20-20 targets (AIDA Project, 2015).

As architects, engineers and builders start experimenting with more efficient integrated building design and as windows, appliances, lighting and buildings become more efficient and affordable, the adoption of nearly Zero Energy Buildings (nZEB) is expected to become mainstream. This will assure, in the long run, increased energy efficiency and enable coordinated exchange of energy between buildings and the electricity grids, while also providing comfortable healthy indoor environment to their users and moving towards a paradigm of decentralized energy generations and highly interconnected urban infrastructures, in the longer run. In fact, such buildings will become an interactive node of larger networks – the smart grids. Furthermore, not only will buildings meet most of their energy needs and operate independent of the grid, but in some cases, buildings may also provide more reliable energy services at lower cost to the grid, adding resiliency to it when it is stressed (Sioshansi, 2015).

In the meantime, a multitude of initiatives, actions and projects still need to be implemented throughout Europe to assist the achievement of widespread near Zero Energy buildings adoption. These range from those that provide financing schemes to energy efficiency and renewables in buildings, contribute to raising awareness and information of citizens, demonstration and pilot projects, supervision of energy performances (such as, energy audits), implementation of energy performance certification schemes, education and training to municipal workers, architects, builders and engineers.

One of the ongoing actions is the SouthZEB project which promotes the capacitation of engineers, architects, municipality technicians and decision makers, providing them training on nZEB concepts, specifically directed to Southern European countries, where nZEB adoption is shown to be lagging behind. The training to be provided to these professionals leverages on the know-how of front-runner countries participating in the project (Austria, UK, Northern Italy), but are also based on the participatory experience and counselling of representatives of the main entities working on the field in the Southern partner countries (Portugal, Southern Italy, Greece and Cyprus), that has been named the SouthZEB National Support Groups.

This chapter gives an overall summary of the challenges faced by European countries regarding the adoption of nZEBs, particularly focusing in the training needs in the Southern Mediterranean countries, and on the experience reached so far by the ongoing SouthZEB Project. Therefore, it first elaborates on the nZEB concept definition framework focusing on the relevance of the topic to local and regional development purposes. Secondly, the chapter gives an overview of the definitions that may be used to the adoption of nZEB across European countries. The perspective presented is first through a top-down approach, based on the policy implementation efforts developed by the European Commission and, after that, based on a bottom-up perspective, including an overview of existent voluntary standards that may be regarded as contributing to the adoption of near zero energy buildings. Thirdly, the chapter reflects

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on some of the barriers encountered that hamper nZEB adoption, specifically addressing the need for professional training in Southern European countries. Finally, the methodology used by the SouthZEB Project to define the training and certification needs, which is based on the participatory process, is presented along with an overview of the project major results achieved until now and the main difficulties identified so far. The chapter finishes with overall conclusions.

NEAR ZERO ENERGY BUILDING: FROM CONCEPT TO DEFINITION

The term near Zero Energy Building (nZEB) has been included in the recast of the EPBD directive as meaning a building that has very high energy performance, whose the near zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby (Official Journal of the European Union, 2010).

This definition is broad and conceptual, therefore, the term nZEB is seldom used "commercially", without a clear understanding of the dimensions behind it. Moreover, countries have been enacting policies and national targets based on a concept without a clear definition in place.

The term "near zero energy building" is very often used as a synonym of "Net zero energy building", despite that these two concepts are not exactly the same when looked at in a stricter sense. One first difference is that the "Net zero" focus is on the null energy balance requirement, possibly overweighting the importance of on-site renewable energy generation in disregard to the initial attempt to use passive energy efficiency measures that reduce energy demand needs, emphasising the local generation side of the energy balance. The "near zero" focus, on the other hand, is on the attempt to reduce the energy use of the building at an initial stage of the conception, as much as possible, and then, cover the remainder energy needs with on-site renewable energy generation. This difference will tend to dissipate while energy efficiency measures become more mainstream and cost-efficient.

Some other differences are much more relevant and based on scientific and technical differentiation of the underlying accounting terms and of the building system boundaries considered and have been studied by several authors, such as (Kurnitski, et al., 2012), (Marszal, et al., 2011), (Sartori, Napolitano, & Voss, 2012) in order to find a common and operational definition of the term near Zero Energy Building, not only in Europe, but more generally worldwide[2].

According to (Kurnitski, et al., 2012) a Net zero energy building (NZEB) is a building with an energy use of 0 kWh/(m^2 a) primary energy. For these authors, a Net ZEB is typically a grid connected building with very high energy performance and also it balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to ZEB from energy networks. Annual balance of 0 kWh/(m2 a) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid. Therefore, a Net ZEB produces energy when conditions are suitable and uses delivered energy during the rest of the time.

The definition proposed by the same authors (Kurnitski, et al., 2012) to refer to a "nearly Net zero energy building (nZEB) is a building with a technically reasonable achievable national energy use of > 0 kWh/(m2 a) primary energy achieved with best practice energy efficiency measures and renewable energy technologies which may or may not be cost optimal. To note that not all renewable energy technologies needed for nearly zero energy buildings have to be cost-effective, if appropriate financial incentives are not available.

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Another relevant term used in the amendment of the EPBD directive and also defined by the same authors (Kurnitski, et al., 2012) is the definition of the term *energy performance of the building* based on EN 15316-1:2007. According to these authors, it is the calculated or measured amount of energy delivered and exported actually used or estimated to meet the different needs associated with standardized use of the building, which may include, *inter alia*, energy used for heating, cooling, ventilation, domestic hot water, lighting and appliances. This energy performance of a building shall be expressed with a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value of on-site production. Appliances (households and outlets) have been later on added to the original definition of EN 15316-1:2007.

One of the main reasons for the term near Zero Energy Building to come up then would be that the Net zero target, at the time of the recast directive, in 2010, was so hard to achieve and so challenging to design that, when buildings created almost as much energy as they consumed they were called near zero energy buildings (Cole, 2015). More recently, with the will to push off limits towards sustainability goals, one can encounter examples of more ambitious design of "net positive energy buildings", those that so highly performant that achieve a positive energy balance and can actively contribute to its surroundings, such as, for instance, charging electric vehicles out of the building energy services (Kylili & Fokaides, 2015).

As it is referred by this author (Cole, 2015), over the past decade, numerous building projects have been presented as having "net zero energy performance". Such claims have been using a variety of different approaches: on- and off-site renewable technologies, the purchase of energy credits, among others. Efforts, subsequently, have been directed towards refining the formulation of a definition of "net zero" and these have provided some degree of clarity and theoretical framing. The spatial and temporal boundaries - identifying what is included and excluded from the analysis- and the definition of indicators and metrics are hugely important for writing the balance of net zero energy building. According to (Cole, 2015) one needs to clarify what energy use refers to, namely, whether it is calculated for energy demand or actual measured energy consumption. Also one needs to know what type of energy use is included in the balance, namely, if it is only building related or if it considers also the user related. Additionally, one needs to know how to include the building – grid interaction.

The (Marszal, et al., 2011) study indicates that the metric, the period and the types of energy included in the energy balance together with the renewable energy supply options, the connection to the energy infrastructure and energy efficiency, the indoor climate and the building–grid interaction requirements are the most important issues to be elaborated before defining a harmonized ZEB understanding.

Table 1 illustrates one possible framework definition proposed within an international joint projects effort undergone within the International Energy Agency (IEA) Task 40 on Solar Heating and Cooling (SHC) and Annex 52 Energy Conservation in Buildings and Community systems (ECBCS) titled "Towards Net Zero Energy Solar Buildings" (Sartori, Napolitano, & Voss, 2012). Table 1 results from that effort and frames the definitions of a Net ZEB and consequently differentiating it from a near Zero Energy Building. A Net Zero Energy Building is the "building system" delimited by a set physical boundaries, connected to any energy infrastructure, which the balance between its weighted energy loads and supplies is zero. The main difference between Net Zero Energy Building and near Zero Energy Building regards the balance metric, balance boundaries and generation systems localization.

According to (Aelenei & Gonçalves, 2014)) there is some consensus that zero energy buildings design should start from solar passive sustainable design. According to this, the Net zero energy performance may be achieved as a result of executing two fundamental steps: (a) reduce building energy demand -

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Table 1. Suggested definition of n(ear)ZEB coming from the N(et)ZEB

		Nearly Net ZEB	Net ZEB Primary	Net ZEB Strategic	Net ZEB Emission
Building system boundary	Balance boundary	Heating DHW cooling ventilation auxiliaries built-in lighting (only non-residential buildings)	Heating DHW cooling ventilation auxiliaries built-in lighting plug loads	Heating DHW cooling ventilation auxiliaries built-in lighting plug loads	Heating DHW cooling ventilation auxiliaries built-in lighting plug loads embodied energy
Weighting system	Metric	Primary energy	Primary energy	whichever metric	emission
	Symmetric	Symmetric	symmetric	Symmetric or asymmetric	Symmetric or asymmetric
	Times dependent accounting	Static	Static	Static	Static
Net ZEB balance	Energy efficiency	National/local energy efficiency requirements are fulfilled	National/local energy efficiency requirements are fulfilled	Any national/local energy efficiency requirements has to be fulfilled	Any national/local energy efficiency requirements has to be fulfilled
	Energy supply	On site generation driven by on/off site sources	On site generation driven by on/off site sources	On/off site generation driven by on/off site sources	On site generation driven by on/off site sources

energy efficiency and (b) generate electricity or other energy carriers, to get enough credits to achieve the desired energy balance - energy generating. Nonetheless there is no exact approach for designing and realizing a "Net zero energy building" as there are many different possible combinations of building envelope, utility equipment and on-site energy production equipment able to achieve Net zero energy performance. In fact, the definition of any ZEB building is very much dependent on the *local and regional context*, as well as on *the building type*.

A research group within the IEA's Task 40 "Towards Net Zero Energy Solar Buildings" project has analysed and evaluated the conceptual approaches and performance of almost 300 Net Zero-Energy and Energy-Plus buildings worldwide. This analysis shows a remarkable gap between the number of examples among the different European regions, while simultaneously there is an enormous need for the examples to have a geographical spread and be site specific since energy consumption in buildings varies greatly throughout Europe due to differences in climate, socio-economic factors, building techniques etc. The environmental impacts also vary due to different carbon intensities of energy systems.

The study developed by (Buildings Performance Institute Europe, 2011) highlight some of these existing differences, while it considers three European regions divided by climate, building typology and market similarities. The study estimates that there are 25 billion m^2 of useful floor space in the EU-27, Switzerland and Norway and it concludes that half of the total estimated floor space is located in the North & West region of Europe, while the remaining 36% and 14% are contained in the South and Central & East regions, respectively. Non-residential buildings account for 25% of the total stock in Europe and comprise a more complex and heterogeneous sector compared to the residential sector, which accounts for 75% of the building stock.

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Moreover, according to the same study (Buildings Performance Institute Europe, 2011), a substantial share of the stock in Europe is older than 50 years with many buildings in use today that are hundreds of years old. More than 40% of European residential buildings have been constructed before the 1960s, when energy building regulations were very limited. Table 2 highlights the construction period of EU building stock, depending on the European region.

Also, annual growth rates in the residential sector are around 1% average for whole Europe, while most countries encountered a decrease in the rate of new build in the recent years, reflecting the impact of the current financial crisis on the construction sector (Buildings Performance Institute Europe, 2011)

Despite the considerable differences between the various European countries climates, workforce capacitation and buildings regulations, on average, the residential building stock is responsible for 30% of total final energy consumption (Mlecnik, Visscher, & van Hal, 2010). Also, on average, domestic hot water and space heating are responsible for over 60% of the final energy consumption in both residential and non-residential stocks (Mlecnik, Visscher, & van Hal, 2010). This means that a direct and major impact could be achieved in residential primary energy consumption and space heating, in particular.

Over the last 20 years electricity consumption in European non-residential buildings has increased by a remarkable 74%, according to a recent report developed by (ECOFYs, 2014) which is caused by technological advances over the decades during and an increasing penetration of ICT equipment, air-conditioning systems etc. Also because of that, this study concludes that Building Automation has a key role to play in the implementation of nearly zero energy buildings. Building Automation is the connector of all the single requirements for nZEB, such as a well-insulated and airtight building shell, efficient HVAC system and a high share of renewable energy.

A TOP-DOWN APPROACH TO nZEB IMPLEMENTATION

As it was discussed in the previous section, the term near zero energy building means according to the recast of the EPBD, a building that has very high energy performance. The near zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby (Official Journal of the European Union, 2010). Since the Commission does not give minimum or maximum harmonized requirements, it has been up to the member states to define what for them exactly constitutes a "very high energy performance". This means also that a specific definition and implementation of near zero energy buildings is decided by each member state and there is currently a strong need for more guidance and common understanding for implementing sustainable but yet feasible near Zero Energy Building definitions (Buildings Performance Institute Europe, 2011).

Table 2. Age categorization of housing stock in Europe (Buildings Performance Institute Europe, 2011)

	South	North & West	Central & East
Pre 1960	37%	42%	35%
1961-1990	49%	39%	48%
1991-2010	14%	19%	17%

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It is recognised by (Sartori, Napolitano, & Voss, 2012) that different definitions are possible in order to be consistent with the purposes and political targets that may lay behind the promotion of Net ZEBs. Therefore, evaluating the criteria, and selecting the related options becomes a methodology for elaborating Net ZEBs definition in a systematic, comprehensive and consistent way. This can create the basis for legislation and action plans effectively achieve the political targets. The choice of a proper balance metrics and weighting system should depend on targets in the political agenda and not being driven solely by feasibility of Net ZEB projects or minimization of investment costs (Sartori, Napolitano, & Voss, 2012). It is important that authorities and competent national and regional bodies and legislators are fully aware of the effect of the weighting factors when deciding upon the metrics to adopt for the Net ZEB definition they want to set in place.

National roadmaps towards nearly zero energy buildings are needed for all member states and all countries shall draw up national plans for increasing the number of nearly zero-energy buildings. These national plans may include targets differentiated according to the category of building. Furthermore, each country, following the leading example of the public sector, should develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero energy buildings, and inform the Commission thereof in their national plans. The national plans shall include, inter alia, the following elements:

- The member state's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions and including a numerical indicator of primary energy use expressed in kWh/m2 per year. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards;
- Intermediate targets for improving the energy performance of new buildings, by 2015;
- Information on the policies and financial or other measures adopted in the context of for the promotion of nearly zero-energy buildings, including details of national requirements and measures concerning the use of energy from renewable sources in new buildings and existing buildings undergoing major renovation.

In March 2013, according to (Concerted Action, 2013) from a total of 19 European countries that provided detailed information six had their nZEB application fixed in a legal document and other six had the application ready but not yet legally fixed. The remaining seven countries were at various stages of developing the application of the nZEB definition, with national studies performed under evaluation or with studies underway.

Some months after, according to the progress report of the European Commission of June 2013, too little progress was recognized as having been made by the member states in their preparations towards nZEBs by 2020. Also, only limited information from the member states was made available at the time[3], preventing a proper evaluation of the national plans, and in particular of the adequacy of the measures envisaged by the member states in relation to the objectives of the EPBD (ECOFYs a, 2014).

In order to assist the comprehensive reporting and the possibility of comparison among the different European countries, the European Commission ordered a study near the end of 2013 that has been developed by ECOFYs. This progress report (ECOFYs a, 2014) is analysed herein so that it is possible to keep in mind the most recent available implementation data analysis on this issue.

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The (ECOFYs a, 2014) report concludes that despite nZEB reporting requirements intertwines with requirements from other current national reporting obligations, namely within NEEAPs (National Energy Efficiency Action Plan) and NREAP (National Renewable Energy Action Plan), one fundamental requirement is missing and needs to be addressed from scratch. This requirement consists of "requirement 1" establishing a national detailed application of the definition in practice for nearly zero energy buildings available, reflecting their national, regional or local conditions and including a numerical indicator of primary energy use. These have been the categories that seem to have been the most difficult to report among member states.

Until September 2014, with the exception of Greece and Spain, all member states submitted their national plans and almost all of them also submitted the consolidated information. Belgium and Austria submitted regional reports (ECOFYs b, 2014).

The analysis of the available information shows that more than half of the member states already implemented a nZEB definition in some form in September 2014. Among these countries are Belgium (Brussels and Flanders), Austria (all provinces), Czech Republic, Croatia, Denmark, Estonia, France, Ireland, Luxembourg, Latvia, Lithuania, Netherlands and Slovakia. Some other countries have had their nZEB definition still under approval, namely, Belgium, Hungary, Italy, Poland and Slovenia. Moreover, a few member states mentioned objectives that go beyond nZEB requirements, including zero energy buildings in the Netherlands, positive energy buildings in Denmark and France, climate neutral new buildings in Germany and the zero carbon standard in the UK (ECOFYs b, 2014). In particular, where a numerical indicator is set for the nZEB definition among countries, the requirements range rather widely from 0 kWh/m2/y to 270 kWh/m2/y and are mainly given as primary energy use in kWh/m2/y. The higher values are mainly from hospitals or other special non-residential buildings. For residential buildings the maximal primary energy consumptions ranges between 33 kWh/m2/y in Croatia (Littoral) and 95 kWh/m2/y in Latvia with a majority of the countries, like Belgium (Brussels), Estonia, France, Ireland, aiming at 45 or 50 kWh/m2/y. Other member states such as Belgium, Latvia and the Netherlands use a non-dimensional value (e.g. Belgium (Walloon) were an E-level of 60 is set at the moment) or an energy performance class (e.g. Latvia where nZEB have to comply with building class A++) as indicator. In some cases, member states (e.g. Czech Republic) did not define nZEBs for all building categories of the regulations, but in that specific example only for single family houses while definitions for other buildings are under development (ECOFYs b, 2014).

As regards the share of renewable energy the reporting is quite diverse, with only a few countries defining a specific minimum percentage and the majority making qualitative statements, such as Belgium (Brussels and Flanders), Bulgaria, Czech Republic, Germany, Denmark, France, Ireland, Italy, Latvia, Lithuania, Netherlands, Romania, Sweden, Slovakia and United Kingdom).

Intermediary Targets and Instruments in Use in Europe

Among the main results which are possible to identify so far from the implementation of the recast of the EPBD directive across all European countries are tighter energy performance regulations for construction and renovations, several building certification schemes and increased certification and inspections for heating and air-conditioning systems.

Different approaches have been used to setting intermediate targets (ECOFYs b, 2014). A majority of countries define intermediary targets as minimum energy performance requirements (e.g. 50 kWh/m2/y in 2015) or as required Energy Performance Certificate level by a certain year (e.g. level B by

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2015). Other member states define intermediate targets by stating that "all new buildings" or "all new public buildings" will be nZEB by 2015. Few member states (Belgium, Malta and the Netherlands) have set actual numbers for new buildings or new public buildings to be constructed by the year 2015. For instance, the Netherlands aims to build 60,000 new nZEB dwellings by 2015 and Malta set a minimum of 5% of the new buildings occupied and owned by the public authorities will be built according to nZEB (ECOFYs b, 2014).

The exemplary role of the public sector has been emphasised by several countries, such as Belgium (Brussels, Walloon), Bulgaria, Germany, Denmark, Estonia, Finland, France, Ireland, Italy, Latvia, Luxembourg, Malta and UK, through the establishment of specific intermediate targets for public buildings. Additionally, few countries set other targets, i.e. for the refurbishment of existing buildings into nZEBs, such as Belgium (Walloon), Denmark, Germany, Ireland, Slovakia and Slovenia. Other targets, such as a minimum share of nZEB are also set as an intermediate target for improving the performance of new buildings by 2015 (ECOFYs b, 2014).

MAIN POLICIES AND MEASURES IN SUPPORT FOR NEW nZEBs IN EUROPE

European countries reported a wide range of policies and measures in support of the nZEB objectives in their national plans and NEEAPs (National Energy Efficiency Action Plans), although it is often not clear to what extent these measures specifically target nZEBs (ECOFYs b, 2014). Compared to the 2013 Commission progress report, the number of policies and measures reported have increased.

According to this report, more than two third of the countries have polices and measures in the categories "awareness raising and education", "strengthening building regulation" and "energy performance certificates measures" in place.

Another focus of measures to promote nZEB are financial instruments and support measures - including, for instance, incentive policies, energy bonuses for private individuals, grant scheme for installation of renewable energy sources -, provide special guidance and financing for at-risk populations and subsidized mortgage interest rates for energy efficient homes. Exemplary countries using these policies are namely Austria, Belgium (Brussels, Walloon and Flanders), Czech Republic, Bulgaria, Hungary, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovenia and United Kingdom.

Various member states have policies and measures for "strengthening building regulations" which include tightening energy minimum standards for buildings or the minimum level of renewable energy in housing in place. Other measures which are often used by the member states are" energy performance certification" (e.g. certificate provides information about opportunities to improve building energy efficiency or scaled energy certificates), "demonstration and pilot projects" (e.g. project tenders with the topic "Sustainable home" or pilot projects "Existing nearly zero-energy buildings") and "supervision" (e.g. establish an efficient, high-quality system of energy audits or rollout of smart meters). Research and development policy measures are used less, only in Denmark, Finland, France, Germany, Italy, Netherlands and Slovenia.

Most of the policies and measures reported by the member states also apply for public buildings. The scope of measures for public buildings varies substantially between member states ranging from central government buildings only to all publicly-owned buildings or all buildings used for public purposes. Some member states have also specific measures for public buildings. Those are mainly monitoring

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campaigns (e.g. "NRClick" is an energy accounting system for the comparison of different municipalities in Belgium) and demonstration projects (e.g. in Germany the Zero-energy building for the Federal Environmental Agency (Umweltbundesamt)).

A BOTTOM-UP APPROACH TO IMPLEMENTATION

So far, near zero energy building (nZEB) is not a technical standard but a policy requirement leading to the tightening of future buildings' standards both for new buildings and renovations.

Some voluntary standards have emerged and have been widely adopted most of all in the so-called front runner countries. This voluntary wave is moved by the underlying fact that development of a regional energy economy should be optimized according to the available energy flows in the region using, for instance, a network system analysis method, which provides solutions for developing sustainable energy models, as exemplified in (Klevas, Biekša, & Murauskaité, 2014). In this sense, nZEB projects, which first aim to improve the energy efficiency in buildings and then integrate renewable energy sources in a way to cover the remaining energy needs, both in new and renovated buildings, fully comply with regional development strategic goals. Moreover, their implementation has a positive impact on security of energy supply, provides financial economies and improved comfort and health and has a multiplier effect for new jobs involving small and medium enterprises, as well as a reduction of environmental impacts.

In fact, production, distribution and use of energy resources in a region are key challenges for central and local governments, businesses and social service, customers and stakeholders. The most promising energy related factors contributing to regional development goals can be seen as the potential for energy savings and increased efficiency at the end-user side, such as renovation of old uneconomic buildings (Klevas, Biekša, & Murauskaité, 2014).

According to (Emtairah, Tojo, Thidell, Rozite, & Hayes, 2008), in most Nordic markets, building codes are claimed to be most influential instruments for creating the demand for energy efficiency in buildings. The effect however has been limited to certain areas of applications, mainly insulations and heat recovery. This and a historic emphasis on technical specifications (u-values of wall materials) rather than performance specifications (end energy demand per functional units) led to incremental improvements rather than radical changes.

Noteworthy on this respect is also the conclusion found by (Mlecnik, Visscher, & van Hal, 2010) that the diffusion of emerging and already existing voluntary European standards for highly energy-efficient houses is needed. Their complexity should be lowered and their relative advantage, trialability, observability, and compatibility should be increased.

Among some of the already existing building standards that contribute to near zero energy building the most well-known are the Passive House (Germany), Minergie House (Switzerland), Plus Energy House (Germany), Effinergie House (France), CasaClima (Italy) (Buildings Performance Institute Europe, 2011). Below an overview of these standards is presented.

Passive House

The term *Passive house* (*Passivhaus* in German) refers to a rigorous voluntary standard for energy efficiency in a building, reducing its ecological footprint. It has been originally developed by the German researcher, Wolfgang Feist, from the Passivhaus Institut (PHI), since the late 80s and results in ultra-low

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energy buildings that require little energy for space heating or cooling. This standard has progressively gained wide acceptance throughout Europe, with 32,000 buildings having this seal, in cities like Frankfurt (Germany), Brussels (Belgium) or in Lleida (Catalonia, Spain), among many others (Edifícios e Energia, 2014).

The Passive house design is not an add-in to architectural design, but a design process that is integrated. Although it is mostly applied to new buildings, it has also been used for refurbishments.

The Passive House standard was developed for heating load dominated climates of Central and Northern Europe and most of the existing Passive Houses are located in Austria, Germany, Northern France, Sweden and Switzerland. In Austria and Germany, for instance, the Passive house standard has been adopted as mandatory. Nonetheless, the design solutions of the Passive house standard can be successfully adopted to the requirements of warmer Southern Europe countries and some design guidelines have been already developed, namely, within the Passive-On Project (Passive-On Project, 2015). According to this project, homes built to the Passive house standard are buildings which assure a comfortable indoor climate in winter without the need for a conventional heating system. To allow for this, it is essential that the building's space heat load does not exceed 10 W/m^2 living area in order to be able to use a simple air preheater. Simulations and measurements have shown that for a typical German climate such a design leads to an annual demand for space heating of 15 kWh/(m^2a). Homes built to the standard, therefore, require roughly 85% less energy to heat that a house built to existing German building regulations.

The basics of the Passive house underlying principles and concepts are further explained as well as the certification standards.

Passive House Underlying Concepts

1. **Efficiency:** No matter the climate or region, Passive house can maintain a comfortable temperature throughout the year, with minimum energy consumption. These buildings are heated in a passive way: through the efficient use of solar energy, sources of internal heat and heat recovery, making unnecessary conventional heating systems, even in periods of colder winter. During the warmer months, the *Passive house* uses passive cooling techniques such as strategic shading to maintain indoor comfort temperatures. Anyway, the upper components, combined with a careful design can ensure the permanence comfortable temperatures all year round.
2. **Sustainability:** The *Passive house* uses up to 90% less energy than traditional buildings of Central Europe, requiring less than 1.5 liters of oil or 1.5 cubic meters of gas to heat a square meter for a year. In warm climates, also has been able to demonstrate a high energy savings, although these buildings typically require use of active cooling systems. Reducing energy consumption means reducing emissions of greenhouse gases, and the *Passive house* a truly sustainable alternative compared to conventional construction.
3. **Accessibility:** To determine the actual costs of a building, it must analyze the life cycle, and thus find that building a *Passive house* building involves an initial cost plus, but a high long-term economy. Currently, the construction of these buildings is now accessible. The initial investment in building components of superior quality demanded by the *Passive house* standard, is mitigated by the elimination of heating and cooling systems with high costs. Available for the construction of buildings liabilities, financial support makes this building even more viable.
4. **Comfort:** *Passive house* can achieve pleasant temperatures with reduced levels of energy use. Permanent ventilation systems provide fresh air needed, contributing to increased indoor air qual-

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ity. The mixture temperatures consistent and appropriate exchange of air prevents the appearance of damp and mold growth.

5. **Versatility:** The *Passive house* standard is purely based on performance and quality standards and therefore does not identify specific construction methods. Is a solid construction, wood or composites, architects are free to be creative in their designs Passive house. Manufacturers of prefabricated houses now offer models of Passive house buildings. The versatile the Passive house standard is also increasingly being applied in rehabilitation, through standard EnerPHit as well as in non-residential buildings, such as schools, office buildings, factories and hotels. Once the Passive house concepts are based on physical principles, each building can and should be adapted to your climate that surrounds it.

Passive House Underlying Principles

1. **Insulation and acclimatization:** Proper insulation of the building envelope prevents heat loss during the cold months and overheating during hot months.
2. **Passive house windows:** The strategic positioning and the high level of insulation provide the efficient use of solar energy.
3. **Ventilation with heat mechanical recovery:** The Passive house ventilation systems provide abundant fresh air, free of pollen and dust, with high energy efficiency by recovering heat.
4. **Airtightness:** Passive house buildings are designed to prevent leaks in surrounding thus increase energy efficiency, preventing heat loss and moisture damage.
5. **Free design of thermal bridges:** Prevention of thermal bridges, one of the main weaknesses of the building envelope, contributes to the achievement of pleasant temperatures, for the removal of moisture damage and improving energy efficiency.

Criteria for Certification

1. **Heating:**
   Heating Needs – $\leq$ 5kWh/m^{2}a
   Heating Loads – $\leq$ 10W/m^2
2. **Cooling (Including Dehumidification):**
   Cooling Needs – $\leq$ 15kWh/(m^{2}a) + 0,3 W(m^{2}aK)*G
   Cooling Loads – $\leq$ 10W/m^2
   Cooling Needs – $\leq$ 4kWh/(m^{2}aK)*Θe + 2*0,3 W(m^{2}aK)*G
   Inferior to – 45kWh/(m^{2}a) + 0,3 W(m^{2}aK)*G
3. **Primary Energy:**
   Primary energy needs for heating, cooling, water heating and power – $\leq$ 120 kWh/m^{2}a
4. **Airtightness:**
   Test for pressure difference η_{50} – $\leq$ 0,6 h^{-1}

Minergie House

Minergie is a registered quality standard for new and refurbished low-energy-consumption buildings mostly used in Switzerland, whose first idea was developed in 1994 by Heinz Uebersax and Ruedi Kriesi. This

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label is managed by the Minergie Association since 1997 and mutually supported by the Swiss Confederation, the Swiss Cantons and the Principality of Liechtenstein along with Trade and Industry. At the end of 2001, a further, more stringent standard for so-called passive housing was introduced, Minergie-P. Since then, further applications of the label have been defined, such as those for specific building components. The label is registered in Switzerland but also found around the world (MINERGIE, 2015).

The Minergie label may only be used for buildings, services and components that actually meet the Minergie standard. Today around 30,000 buildings have Minergie standard. Aslo, at present around 13% of new buildings and 2% of refurbishment projects are Minergie certified. These are mostly residential buildings. The goals of the Swiss national Swiss Energy Infrastructure and Environment Programme call for 20% of new construction and 5-10% of refurbishment projects to be Minergie certified. The Minergie standard is somewhat comparable to German KfW40 (new buildings) and KfW60 (refurbishment) standards.

Lessons learnt according to the MountEE project report (MountEE Project, 2015): Minergie is a powerful driving force in sustainable renovation and construction promoting regional markets for sustainable buildings and creating business opportunities for innovative builders, investors, enterprises and authorities. Minergie is meeting the objectives mentioned above to additional costs of only 10%. Moreover some strengths can also be criticized. Minergie took the monopole of quality labels in Switzerland. Anyhow, in other countries, it is difficult to use this label which is not always comparable to the national standards. Minergie does not take into account external site or mobility.

BBC Effinergie House (Bâtiment de Basse Consommation Énergétique)

A low-energy house BBC Effinergie house (BBC-Bâtiment de basse consommation énergétique) is a building that respects the French law set up by the order of May 8th, 2007 published in the Official Journal (Journal Officielle de la Republique Française) of May 15, 2007 which specifies that for the new residential constructions, the objective of maximal consumption in primary energy is fixed to 50 kWh/m^2 year, to modulate according to regions and altitude. Taken into account is the consumption of so-called conventional primary energy: heating, cooling, ventilation, auxiliaries, production of domestic hot water and lighting facilities. The BBC Effinergie label is assigned to houses that meet the requirements of the label Low Consumption Building (BBC 2005-Bâtiment de basse consommation énergétique) with the constraint of the airtightness of the building with the obligation to measure the impermeability in the air. As for appliances, there are seven classes ranging from economical housing (Class A) with an annual consumption of primary energy for heating, hot water and cooling below 51kWh/m2.year, up to a full energy housing (G). Effinergie can be compared to other standards used in Europe such as the above mentioned Minergie, in Switzerland, or the Passive house, in Germany.

Effinergie first label was launched in 2007and it has had a strong impact in stimulating the development of the French thermal regulation by establishing the objective of energy consumption average of 50 kWhep m^2/year. This value was taken as a basis of the RT2012. The association continues to work and offers several labels such as the "Effinergie +" in order to anticipate future RT2020 and encourage the enthronement of BEPOS constructive as standard.

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CasaClima

ClimateHouse is a reliable and proven methodology of Energy Audit and Certification (KLIMAHOUSE, 2015). Since 2002 this initiative aims to save energy and create a cultural change in the way people think – making ClimateHouse synonymous to health and well-being. Buildings designed according to the ClimateHouse standards can save up to 90% of the energy compared to traditionally built residences - thereby resulting in CO_2 reductions and financial savings.

The KlimaHaus-CasaClima promotes the adoption of building construction methods that meet energy saving and environment protection criteria. It offers easily understandable information as to the energy performance of a building, thus protecting consumer interests and helping to make better informed choice.

Plus Energy House

PlusEnergy is a term used in building design to describe a structure that produces more energy than it uses. The term was coined in 1994 by Rolf Dischwhen building his private residence, the Heliotrope, in Freiburg, Germany, as the first PlusEnergy house in the world. Disch then went on to refine the concepts involved with several more projects built by his company Rolf Disch Solar Architecture in order to promote PlusEnergy for wider adoption in residential, commercial and retail spaces. Disch maintains that PlusEnergy is more than just a method of producing environmentally-friendly housing, but also an integrated ecological and architectural concept. As such, PlusEnergy is intended to be superior to low-energy or zero-energy designs such as those of Passive house.

BARRIERS TO IMPLEMENTATION

There is a vast gap between the average energy use in current new buildings and what is required when the EPBD directive is implemented, in the near future. The implementation of the directive is, therefore, a tremendous challenge in all member states, both for society and the construction industry.

According to the (ECOFYs b, 2014) report, a real technology gap to be bridged until 2021 is not perceived, despite that nZEB are still positioned beyond "cost optimality". In fact, it is believed that current technologies related to energy savings, energy efficiency and renewable energies are sufficient to reach, in combination, a suitable target for near zero energy buildings. This cost optimality could be achieved by carrying out investment to allow for cost reductions, improved performance of components and systems or energy storage solutions which in turn can positively influence the viability and introduction of near zero energy buildings. Limitations, however, may arise particularly for renewable systems[4] due to disparities in time or place, especially if one technology would be significantly favoured by the market or by policies (ECOFYs b, 2014).

In this sense, investments need to increase to satisfy additional demand created by new nZEBs, despite that there are some differences regarding the different technologies at hand. The highest growth rates for achieving a well-developed nZEB market were identified by (Buildings Performance Institute Europe, 2011) for ventilation systems with heat recovery and for triple glazed windows. For these components the market is really small compared to what it should be to satisfy the necessary demand for full nZEB implementation. As for other nZEB technologies the gap is smaller. For instance, to satisfy the calculated

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demand, the current market for insulation materials should grow by about 2-3 times. The market for heat pumps, pellet boilers and solar thermal systems should grow at least in the same range.

Apart from these market deployment barriers, other barriers can be found regarding the transfer of knowledge and know-how among professionals. Authors in (Emtairah, Tojo, Thidell, Rozite, & Hayes, 2008) highlight the intrinsic characteristics of the construction industry to justify some specific difficulties in the innovation adoption process during the sector's operations. First of all, it is a project-based structured activity and, as such, creates several constraints for effective learning and transfer of knowledge between professionals and projects, necessary for innovation. Also, the process of buildings construction is tacit and codified to those actors involved, with a large amount of knowledge gained during the actual building process that rarely is documented or transformed into an organizational learning. Therefore, the cooperation based on temporary contracts between changing configurations of actors makes the learning process more difficult and slows down innovation (Goverse, Hekkert, & Worrell, 2001). Moreover, lessons learned in one system area often do not get passed on to another. For instance, building materials suppliers are often not involved in the design or building process and the design phase is often separated from the construction phase.

The same authors (Emtairah, Tojo, Thidell, Rozite, & Hayes, 2008) also recall that the weak relationships with formal knowledge institutions such as research centers and universities have been cited on several occasions as a reason for lower innovation adoption in the buildings and construction sector. Another fundamental weakness is the absence of energy efficiency learning from the traditional training of designers, engineers and consultants. Although one could find specialized courses on climatic design, passive buildings, alternative heating and cooling technologies as examples, these tend to remain outside the traditional specializations accessible to building sector (Emtairah, Tojo, Thidell, Rozite, & Hayes, 2008).

Therefore, when one looks at the current practices in the field of near Zero Energy Buildings, to date, only one percent of all new buildings in Germany are built according to the Passive house standard, therefore, it can be assumed that at EU level the percentage is smaller than one percent. The factor by which it should increase is, therefore, bigger than 100. A question that arises is whether the number of architects and engineers that are able to deal with new technologies and standards is adequate. There are about 3000 certified passive house planners around the world and 73 certified passive house certifiers (Passive House Planner, 2015). In the next few years, there will be about 2 million residential and non-residential buildings newly built per year in Europe. The gap is a considerable barrier to implementing the nZEB requirements for all new buildings in the near future. Technically every architect should be able to build an nZEB, however in practice that requires keeping up with standards and requirements that have to be fulfilled to build nZEB levels.

It should be stated that the design of nZEB requires an integrated design approach to minimize the building's energy consumption, while meeting all the occupants' needs. Thus architects, civil, mechanical and HVAC engineers, energy experts and installers should know the specificities related to the design of an nZEB (new technologies and standards) and work together in multidisciplinary teams from the beginning of the design phase, requiring know-how and skills (IEA Solar Heating & Cooling Program, 2003). However, the integrated approach and the knowledge of the exigencies of designing an nZEB is not common for architects and engineers among most European countries, leading in many cases to inefficient solutions, non-optimized buildings and higher costs due to extra measures for integration of energy efficiency measures and renewable energy systems. In this context, there is a substantial need for professionals such as architects and engineers specifically trained and educated in nZEB design ap-

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proach, addressing the integration of sustainable energy in buildings and built environment, not only to produce buildings meeting current EPBD standards, but especially for buildings within the near zero energy concept.

Training programs could overcome knowledge and know-how barriers. Some attempts have already been made within EU by developing training and certification schemes for nZEBs professionals, all of them carried by NGOs and none of them has become official. Some countries have shown significant commitment to the EU targets and have focused on nZEB prior to others (Austria, Czech Republic, Denmark, Finland, France, Germany, Switzerland, UK). In most of the countries in Southern Europe though, there is still a lot to be done. As seen in section 3, in Spain or Greece, for example, very few steps have been made even towards the definition of low energy buildings and their specifics.

The SouthZEB Project comes to fill-in this gap and to address the need of developing training and assessment schemes for intermediate and senior professionals involved in the nZEB building process (engineers, architects, municipality employees and decision makers) focusing especially on the transfer of successful practices and knowledge from front runner countries to the EU countries less advanced in this area. The training modules to be developed will be adapted to the participating countries' specific needs and regulations. A key novelty of this project is also special emphasis that will be given to the building tradition of the participating countries. The training modules will also present the integrated approach that is needed in the design of nZEB.

THE SOUTHZEB PROJECT

It has been identified that there is a substantial need for professionals such as architects and engineers specifically trained and educated in nZEB design approach. These professionals must be able to work in integrated multi-disciplinary teams, to improve energy performance of buildings and to address the integration of sustainable energy in buildings and built environment, to design buildings meeting EPBD standards and especially buildings within the nearly zero-energy concept.

It is generally also recognized that a number of Southern EU counties lag behind on certain issue on the implementation of the EPBD and RES Directives and some aspects can be improved in all target countries, namely the possibility to provide more specific training on the nZEB area since the existing training is more focused on the building energy certification process.

As the Central and Northern EU countries are more advanced in implementing a number of articles within the directives, an opportunity is recognized to exist to develop the training material necessary to assist the Southern EU countries to catch up in their progress toward nZEB.

It is in this particular context that the SouthZEB project emerged and began in March 2014 with an estimated duration of 30 months, until September 2016. The project is carried by nine European partners, including Universities, Energy Services Companies and Vocational Training Centers, namely, the Applied Mechanics Laboratory from the University of Patras in Greece (Coordinator), GARnet Energy Savings in Cyprus, Cyprus University of Technology, Distretto Technologico Trentino in Italy, Building Research Establishment in UK, University of Minho in Portugal, Instituto Superior Técnico R&D Association from the University of Lisbon in Portugal, BEST Gmbh in Austria and EUROTRAINING in Greece.

The SouthZEB Project aims to identify training needs required for the target Southern European countries (Greece, Cyprus, Italy (south) and Portugal) less advanced on the progress towards nearly Zero Energy Buildings (nZEB). Additionally the project intends to initiate a wide-scale roll out of accessible

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and recognized continuous professional development courses. In this sense, it addresses the Intelligent Energy Europe priority on Continuous Professional Development (SouthZEB Project, 2014).

In this context, the SouthZEB project aims to support the building sector intermediate and senior professionals in the Southern European countries (focusing on Greece, Cyprus, Italy and Portugal) to keep up to date with the market progression. To this end, the project is focused on the design and development of the training modules and on the assessment of the programs for these professionals. To support the large scale roll-out of the developed programs, the project is also engaged in training specialized trainers in order to enable multiplication effects in the direct transfer of knowledge to the stakeholders. Moreover, the Project will make the educational and certification programs available through a unique e-learning portal, available in five EU languages, and the course level of the modules are compatible with European Qualification Framework (EQF) at level 4.

The expected results from the SouthZEB Project have been set to train at least 1,500 professionals, including at least 400 professionals trained remotely through the e-learning platform and including 150 trainers, which have been divided among the four target countries according to key buildings sectors indicators. In Portugal, these goals are to train at least 26 trainers and 260 trainees; in Greece, to train at least 30 trainers and 300 trainees; in Cyprus, at least 12 trainers and 120 trainees; and in Italy, to train at least 82 trainers and 820 trainees. Also, the SouthZEB Project expects to achieve at least 3,000 users that will be the e-learning platform, thus broadening the impact of the project.

METHODOLOGY: AN INTEGRATIVE DESIGN OF nZEB TRAINING MODULES AND CERTIFICATION

In the framework of the project SouthZEB a Focus Group entitled National Support Group (NSG) has been created in each target country. It gathers key stakeholders on the buildings energy efficiency areas and also representatives from national architects and engineer associations, energy agencies, universities, research centres and private sector companies. Additionally, the consortium has also constituted one Advisory Board of Experts to assist the overall project formed by five renowned European professionals. This Board plays an important role in the implementation of the project and in the evaluation of its outcomes. As some of the modules specific areas are not within the exact fit of expertise of all target country partners, the feedback from the National Support Group (NSG) is of extreme importance.

A set of design meetings will be organized in each of these four Southern European target countries with each of the respective NSG to assess specific training and certification needs on each country considering regional and local context and the different several stages of implementation of the project. So far two rounds of design meetings have taken place, while two more are expected until the end of the project. The first round of meetings occurred between May 19th and July 3rd 2014 in each of the target countries, while the second round took place between February 9th and February 20th 2015. In all the Design Meetings held participants underlined the relevance and the opportunity of the SouthZEB project.

In the *first round of design meetings* the main issues under analysis have been to assess training and certification specific needs and the adequacy of the training modules proposed in the project Grant Agreement to the local context. In the *second round of design meetings* the main topics under discussion have been the minimum curricular or technical experience requirements to both trainers and trainees balanced with the proposed training objectives within the project duration; the certification structure within the project timeline and the role of the NSG members and project partners in the dissemination and training

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efforts. One particular topic addressed in Portugal and Italy has been the possible accreditation for the training modules by the existing professional associations and the future inclusion of SouthZEB outputs in their training offerings.

MAIN ACHIEVEMENTS UNTIL NOW

According to the Grant Agreement of the SouthZEB Project, the training modules will be based on recognized and successful professional development courses and will be adapted to the participating countries' specific needs and regulations. Special emphasis will be paid to the building traditions of participating countries. Training modules will also be developed for construction management and field supervision of nZEB as well as for training the decision makers in the preparation of appropriate funding schemes and other incentives for promoting nZEB. Best practice examples from successful programs in the most advanced (in this area) EU countries will be used in the training programs.

Based on the joint assessment of the *first round of design meetings*, a total of ten revised training modules have been defined relative to what was previewed in the Grant Agreement and which are summarized in Table 3. These represent some adjustments relative to the initial modules description in the Grant Agreement proposal. Among them, training modules 1 and 2 should be mandatory for all participants (trainees and trainers) and a minimum number of four training modules (out of the 10 available) need to have a positive evaluation on the exam in order to receive the "nZEB Designer" or "nZEB Trainer" certificate. Several new nZEB related topics have been incorporated into already existent training modules, such as (1) Adaptive Thermal Comfort, (2) User Acceptance of Technical Solutions to nZEB, (3) Cost Optimality of near Zero Energy Building technical solutions, among others described above. Also, new training modules have been created to address some of the suggestions made by participants in the first set of design meetings. One example is the renewed "Module 4 – Thermal Comfort" and "Module

Table 3. Near Zero Energy Buildings training modules (SouthZEB Project, 2014)

Module	Name	Hours	Target Audience
Module 1	nZEB Basic module	20h	Engineers, architects
Module 2	nZEB Advanced module	40h	Engineers, architects
Module 3	Thermal bridging	20h	Engineers, architects
Module 4	Thermal Comfort	20h	Engineers, architects
Module 5	SouthZEB framework module and local architectural regulations	30h	Engineers, architects, municipal employees
Module 6	nZEB simulation and design software module	30h	Engineers, architects, building technicians
Module 7	Low carbon technology and automation for nZEB	20h	Engineers, architects, building technicians
Module 8	Retrofitting towards nZEB	40h	Engineers, architects, municipal employees
Module 9	Construction management and field supervision of nZEB	40h	Professionals from construction sector
Module 10	Preparation of funding schemes and other incentives for nZEB	20h	Municipalities, local/ national authorities

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7 – "Low carbon technology and automation for near Zero Energy Buildings". More detailed information on the results from the first set of design meetings can be found in the SouthZEB Project webpage, on Deliverable 2.2 (SouthZEB Project, 2014). Table 3 presents the final set of training modules proposed.

The current detailed features of the training modules are documented in Deliverable 3.1, available in the SouthZEB website. Currently, the overall results from the set of second design meetings is under evaluation and the the project partners are in hands with the planning of the training modules sessions. These first will be directed towards training the trainers, during the second semester of 2015 and, after that, towards training the trainees.

DIFFICULTIES AND LESSONS LEARNED SO FAR

The project is currently progressing well, within the initial expectations of the consortium. Meanwhile, some difficulties have already been identified and overcome. Those difficulties considered most relevant presenting lessons to be learnt are summarized below.

National and Regional Issues

One of the concerns is relative to the coherence of the views on the nZEB underlying concept among the different modules and among the different target countries. It is recognized to be quite difficult to develop training in nZEB topic, as this training has to be in coherence with national building legislation and indications/methodology, which in this very moment are still missing. The challenge is to develop a common framework of these courses between the participant countries, even when it is verified that in some of these countries the definition of nZEB is not yet applied. The training and certification framework has been initiated at the European level, based on the introduction of the Energy Performance of Buildings Directive and other Directives and Regulations. The program of training modules and the certification framework is intended to be applicable across Cyprus, Greece, Italy and Portugal. Therefore, reference to national building regulations and standards is considered to be essential in the training modules.

In order to address this major concern, the technical and scientific principles behind each of the published training modules has remained consistent across all regions, while actual course content has been adapted in order to best address the regional narrative and requirements in each area. The approach taken in nine out of the ten courses has been to focus 80% on the technical and related background information, with around 20% being inclusion of regional, national and local issues. Module 5 is much more specific to local architecture and regulation (see Table 3) and is therefore 70% focused on local issues.

Number of Trainers and Trainees per Target Country

A core issue that came up in the early months of implementation of the project was the number of trainers and trainees each country should train and certify, as these have not been previewed in the Grant Agreement. Therefore, all responsible partners prepared a proposal, mainly based on the population of each country and the number of the professionals in the building industry which was discussed in one of the project meetings. The allocation of the trainers and trainees in the target countries was determined. Each target country has been tied to the goal to train a minimum of 12 trainers. Moreover, it is also a concern

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the engagement of both trainers and trainees in the courses to be developed in each target country. The theme is core and very much up to date, but there is a high risk that other issue such as available time and budget from trainees may overcome these positive expectations.

CONCLUSION

The definition of nZEB is still not consensual and conceptually can vary according to different perspectives and countries. Therefore, the term nZEB is seldom used "commercially", without a clear understanding of the dimensions behind it. Moreover, countries have been enacting policies and national targets based on a concept without a clear definition in place.

However, as it was presented in section 2, there is some consensus that near or Net zero energy buildings design should start from solar passive sustainable design and may be achieved as a result of executing two steps: (a) reduce building energy demand/energy efficiency and (b) generate electricity or other energy carriers, to get enough credits to achieve the desired energy balance /energy generating.

The exact approach for designing and realizing a near zero energy building has many different possible combinations of building envelope, utility equipment and on-site energy production equipment. Consequently, the definition of any ZEB building is very much dependent on the *local and regional context*, as well as on *the building type* and policy implementation has been progressing on a step-by-step basis, not as fast as it would be desirable as shown in section 3.

Meanwhile, some voluntary standards reviewed in section 4 have emerged and have been widely adopted most of all in the so-called front runner countries. This voluntary wave is moved by the underlying fact that development of a regional energy economy should be optimized according to the efficient use of the available resources and energy flows in that same region using, for instance, a network system analysis method, which provides solutions for developing sustainable energy models.

Section 5 highlights the fact that the definition of the near Zero Energy Building it is not the only problem to overtake, despite there is a vast gap between the average energy use in current new buildings and what is required when the EPBD directive is implemented in the near future. A significant and wide number of barriers have to be overcome. There are some limitations regarding market deployment of some technologies but also regarding the transfer of knowledge and know-how among professionals due to the intrinsic characteristics of the construction sector, such as being a project-based structured activity, in which a large amount of knowledge gained during the actual building process it is not documented or transformed into an organizational learning. Therefore, the number of architects and engineers that are able to deal with new technologies and standards are insufficient. To sum up, it is necessary to improve the skills and to expand the number of qualified buildings professionals, from architects, construction engineers to installers and workers. Moreover, municipalities occupy a key role when it comes to energy savings in existing housing. They are involved right from the beginning in renovation and restructuring plans and have a decisive contribution to make in energy saving and energy provision. Despite that, one of the main methodological problems to integrate energy efficiency and renewables projects into regional/local development procedures so that these energy elements may compile in integral uniformity in terms of regional/local goals identified by (Klevas, Streimikiene, & Klevas, 2009) is to have municipal officials that are willing and cooperative implementing these processes.

The nZEB training modules developed within the SouthZEB project aim at shortening the knowledge gap of professionals in the Southern European countries in nZEB concepts as this has been identified as

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a major barrier for the achievement at a national and regional level of the objectives established on the recast of the EPBD directive. As it was described in section 6, to this end, a series of relevant institutions and professionals in the buildings and energy efficiency fields have been involved in the educational contents definition process. This included the formal constitution of four Focus Groups to advice, one in each pilot country. The convergence of views related to the scope and contents of all training modules was found through discussions carried at each of the national design meetings held. One of the main challenges ahead is reaching the maximum number professionals to engage in the training sessions. The organisation and development of the 10 training modules on nZEB, the e-learning platform and the experience of the courses undertaken under the SouthZEB project are not expected to simply end with the completion of the project. In the future, training and certification will continue to officially exist on the basis of a future collaboration agreement and business model agreed upon by all the project partners.

With training and diffusion of knowledge to the building professionals within the SouthZEB project, such as building engineers and scientist, architects and architectural technologists, planners, civil and structural engineers, housing authority asset managers, facility and property managers, construction and accountancy professionals it is expected that changes will be facilitated and enabled. One is that nZEB design considerations are brought to the construction sector in Southern European countries right from the initial phase of the process of building new buildings or renovating existing ones. In this way, innovative technologies (for instance, application of PV panels to the building structures, geothermal heat pump systems) or design and construction methods (for instance, Building Information Modelling BIM which consist of intelligent 3D model-based process from planning, design, construction and management of the buildings) will become more easily used. Also it is expected that municipalities' executives in Southern Europe become more cooperative and willing to find the best way to integrate energy efficiency and renewables into the regional and local development goals, including developing specific local financial instruments to promote nZEB projects in each of the pilot country. Moreover, new energy services companies (ESCOs) will find a proper market to their offers of new energy solutions (for instance, the leasing of a PV rooftop system in a building whose ownership is from the company and not the building owner). Ultimately, all these innovative approaches and business models proportionated by the changes brought by nZEB buildings will enable higher overall efficiency, delay expensive investments in the grids and improve living standards and quality of life.

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KEY TERMS AND DEFINITIONS

Certified Training: Teaching of knowledge, skills and useful competencies developed within a certain recognized body of experts' framework.

Front Runners Countries: Countries that show more advancements in the achievement of stated goals.

Implementation of Directives: Actions with the aim to achieve the goals stated in the directive.

Nearly Zero Energy Buildings (nZEB): Buildings that have very high energy performance and who's nearly zero energy needs are covered as much as possible by renewable energy sources.

Net Zero Energy Buildings (NZEB): Identical to nearly Energy Buildings with an emphasis on the positive side of the energy balance and on this being delivered by renewable energy sources.

Regional Development: Stimulus to socio-economic activities based on endogenous resources.

SouthZEB Project: European project within the framework of Intelligent Energy Europe developing certified training for building professionals.

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ENDNOTES

1 The 18 IEA countries evaluated by the International Energy Agency Energy Efficiency Market 2014 Report are Australia, Austria, Canada, Czech Republic, Denmark, France, Finland, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States and represent more than 83% of total final energy consumption in OECD member countries and 33% of the total final energy consumption worldwide.

2 Around the world the terms used are not necessarily the same. For instance, in the United States the term used to refer to Zero Energy Buildings is Zero Net Energy.

3 According to this report 20 countries from EU-28 delivered the national report plan as required by article 9 of the EPBD are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Romania, Slovakia, Slovenia, Sweden and United Kingdom. Those that did not include are: Czech Republic, Estonia, Greece, Latvia, Malta, Poland, Portugal and Spain.

4 The renewables technologies refer to photovoltaic/building-integrated photovoltaic, wind turbines, solar thermal (solar water heaters), heat pumps, and district heating/cooling. In general, most of these are rather well established. However, the wide diffusion of PV and wind turbines generation may cause, among other things, power instability and compromise the quality of existing electricity grid structure. nZEBs should ideally be designed to function in synergy with the local utility grid and not putting extra stress on the existing electricity infrastructure (Li, Yang, & Lam, 2013).

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Chapter 62
Conditions for Development of Renewable Energy in Poland

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ABSTRACT

The Paper examines legal and financial tools which are used in Poland to succor the development of energy from renewable resources. In the first part a definition of sustainable development is given and the short history of this idea is shown. Then the concept of Sustainable energy is introduced. The second part describes main policies of European Union on sustainable policy and the Polish Legal System on Renewable Energy is described. The fifth part of the paper analyzes the sustainable development indicators provided by Eurostat for the energy produced from renewable resources. there are 6 indicators analyzed. In the end the forecasts for the development of RES in Poland is given. There are clues for development of different technologies in different provinces of Poland. There are also forecasts for the development of the renewable energy market in Poland.

INTRODUCTION

The environment has played a significant role in many theories of economics already in the nineteenth century, while its importance to the economy began to be noticed not until the second half of the twentieth century. Since then, environmental social, economic aspects connected altogether in one theory of sustainable development (SD) have become an important part of modern macroeconomic policy. In today's global economy, the European Union has adopted the role of a leader and promoter of sustainable development. Thanks to the efforts of the EU, a number of countries has managed to make significant commitments on the environment. At the same time, the European Union requires its members to fulfill the obligations to the protect the environment in the context of sustainable development. These requirements were a base to carry out studies showing changes in the field of sustainable development in Poland.

As energy is an integral part of SD, this paper will explain the meaning of energy in the theory of sustainability. It will also present the Polish renewable energy market and its changes during 2004 – 2013 period. In most cases the data is provided for 28 Member States of European Union (EU 28), but in some

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indicators the last available data was for 2011– before Croatia joined EU., so this data is for 27 Member States of European Union (EU 27). In the end the changes in sustainable energy indicators for Poland will be described and guideline to the further development of renewable energy installations will be given.

DEFINITION OF SUSTAINABLE ENERGY

Reflections on the human impact on the environment have their origins back in the mid of 20th century. The greatest importance for conceptualization of sustainable development had the first scientific publications on the impact of synthetic chemicals on the human health, reports on the environmental limits of economic growth, as well as the papers on relations of the human population size and the state of the environment. The main works which highlighted environmental problems were: Silent Spring by Rachel Carson published in 1962, Tragedy of the Commons by Garret Hardin published in 1968, Limits to Growth by Club of Rome published in 1972 and Deep Ecology by Arne Naess published in 1973 in *Inquiry Magazine* (Charkiewicz & van Benmekom, 2001).

Concerns that have arisen as a result of these publications convinced the United Nations (UN) to organize meetings, which aimed to recognize humanity's connection with environment. In 1972, UN held the Conference on the Human Environment, which focused on human – environmental interconnections. As a result of the Conference, the Declaration of the United Nations Conference on the Human Environment was created. It became the first document in international environmental law, which delineated the human right to a healthy environment (Kozłowski, 2000, pp. 105–106).

UN continued their work on effects of human actions on environment. In 1980, together with the International Union for the Conservation of Natural Resources (IUCN), UN published the World Conservation Strategy (WCS). This document, as a result of previously taken actions, proved that there is an interdependence between environmental conservation and economical development. WCS built the basis for the idea of sustainable development by highlighting that development depends on Earth protection.

In 1983 UN created the World Commission on Environment and Development (WCED), which main task was to prepare an agenda for global change into more environmental direction. As a result, in 1987 WCED released *Our Common Future* Report (called also Brundtland Report), in which it was stated that "the environment does not exist as a sphere separate from human actions, ambitions, and needs, and therefore it should not be considered in isolation from human concerns. The environment is where we all live; and development is what we all do in attempting to improve our lot within that abode. The two are inseparable." In these words WCED created the idea of development which joined economic, social and environmental issues accompanied by global solutions. This concept of development, for the first time called the sustainable development, addresses "the needs of the present without compromising the ability of future generations to meet their own needs". This broad definition orders present generation to act responsibly in three important dimensions, so that the future generations will be able to lead their lives at least at the same level as we do now. Those three dimensions submitted in Brundtland Report are: environmental sustainability, economic sustainability and social sustainability (Seema, 2010).

In Our Common Future it was proved that social and economic systems cannot run separately and without the influence on the environment. All, past, present and future generations, lead their lives by fulfilling different and often competing needs of society members. At the same time human beings live within limitations imposed by the environment, social rules and economic possibilities. This is why the idea of sustainable development needs to be treated as a system in which every all three spheres are

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connected and influence each other. The results of actions taken in any of those spheres are valid not only for today but also for the future. For example, leaking waste-water pipes can contaminate the soil, which may not harvest and cause hunger (The World Conservation Congress (WCC), 2004).

As apparent form the example, the pillars of sustainability should be considered as equal factors of development and equal attention should be put to them. In the theory, the three pillars play the same part, but the practice shows that development is often driven only by one need and only one sustainable pillar is taken under consideration. Present generation put the greatest attention to the economical problems forgetting that environment has an enormous influence on both social and economical sector. But sustainable development is not only about environmental condition and limits but also about ensuring healthy and just society operating in prosperous economy. To achieve this, the unsustainable development should be no longer pursued.

Energy is one of the most important issues to achieve sustainable development goals. Nowadays, energy is needed in every single aspect of everyday life. More and more of human actions depend on energy. Energy considered as electricity, fuels or heat and cold has an enormous impact on living conditions. When considering energy as one of issues of sustainability, it can be seen that energy has interconnections with all three pillars. In the field of environmental actions, sustainable energy is responsible for reduction of natural resources consumption, minimization of waste and pollution or reduction of primary energy consumption. Energy is also important for the society, because the prices of energy influence the living costs, the energy grids use public space and energy independence is strictly connected with national safety. Last but not least, energy is an important factor for the economy as it allows production to run, it is responsible for transportation, energy security etc.

Energy security is one of most important problems of modern energy policy. It concerns the ability of the free-market energy suppliers (producers, mines, refineries, power plants, transporters, suppliers, distributors), as well as regulatory, financial and R&D institutions, to deliver demanded amount of energy to the final consumer at a competitive price. Energy system has to consider a wide variety of potential disruptions. According to OECD (Organisation for Economic Co-operation and Development (OECD), 2007) The most worrisome and potential disruptions can be connected to:

- Extreme and unfriendly weather condition,
- Mismatch of an amount of energy supplied and demanded,
- Failures regulation process,
- Concentration of nonrenewable energy resources in certain regions of the world.

All those threats can have a negative influence on both social (higher energy prices, energy cuts) and environmental (air pollution, oil leakage) issues. The best impact of energy supply sector on the sustainable development is increasing the energy efficiency in everyday use and ensuring the delivery of secure and environmental-friendly energy. To achieve this a lot of work need to be done by international and national institutions, privet business sector and societies. One of pillars of building energy security is to extend the share of sustainable energy in the energy mix (OECD, 2007).

Sustainable energy is a form of energy acquired from renewable resources. This means that the production and consumption of sustainable energy serves the present generations without limiting future generations in terms of energy. Currently the sustainable energy consist of three main divisions: Energy Productions from Renewable Resources, Energy Conservation and Sustainable Transport (Shakeer Publishing BV, 2009).

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Energy Conservation and Efficiency policy is about reducing consumption of the energy by using less of energy service (conservation) or by using the lower amount of energy for certain actions (efficiency). To give an example – a lower amount of hot water used for heating is an example of energy conservation. The same amount of hot water used for heating a larger leaving space is an example of energy efficiency. Opponents of energy conservation complain that it limits energy services. Supporters prove that it reduces natural resources depletion and increases quality of the environment. It also has a positive influence on personal spending and national energy security (Zehner, 2015).

Sustainability in transportation is considered to be a very complex concept. It is composed of environmental factors such as fossil-based fuels consumption and emission controls (greenhouse gas emission, air pollution and smog). Transport is one of human activities that has an enormously negative impact on condition of the environment. The goal of a long term sustainable transport policy is a swift to renewable energy resources. Social aspect of sustainable transport is regarded in terms of roads' safety and number of crashes, time taken for commuting or fuel prices changes. Traffic congestion creates socio – economic costs by slowing goods and services flow. Last but not least, sustainable transport is based on third pillar – economical and technical efficiency. This is measured by the number of vehicles used for road, water and air transport, the source of energy as well as the infrastructure used. What is interesting, pipelines for transporting liquid or gas materials as also considered as components of sustainability in transportation, which is by transportation system efficiency and effectiveness as well as the environmental impacts of it (Leslie, Pearce & Harrap, 2012, pp. 295-311).

Production from renewable resources promotes energy technologies which use naturally replenished resources – such as wind energy, solar energy, bioenergy and hydroelectricity (including wave power, geothermal energy and tidal power). In 2014 energy from renewable resources took a share of 19% of global energy consumption and 22% of global electricity generation. The great advantage of renewable is that they exist all over the world, in the oppose to nonrenewable resources, which reserves can be found in limited number of countries. Many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas and developing countries. As in those areas energy is crucial for the development and proper functioning of societies, building renewable energy power plants results in increase of energy security, positive climate change mitigation, economic benefits and human development. This is why the deployment of renewable energy is growing worldwide. In 2014, at least 30 nations already had a share of renewable energy in energy mix higher than 20%. Renewable energy markets are expected to continue to grow in next decades. In 2013, global investments in renewable technologies amounted to more than US$ 214 billion. The country that invested the most in renewable energy in 2013 was China, which increased a number of wind, hydro, solar and biofuels installations (Renewable energy Policy network for the 21st Century (REN21), 2015).

SUSTAINABLE ENERGY POLICY IN USA AND CHINA

When comparing data on a total capacity or generation of renewable power, the first place in different categories is taken by USA, China or Member States of European Union. To give an example, Denmark is a world leader in Renewable power capacity *per capica* and wind power capacity *per capita*. In both cases Denmark is followed by other EU countries like Germany, Sweden and Spain). Spain is a leader of Concentrating solar thermal power (CSP) (followed by USA). Germany lead the solar PV capacity (followed by China) and solar PV capacity *per capita* (followed by Italy, Belgium and Spain) (REN21,

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2015). As the Renewable Energy Policy of European Union will be described below, now the policy of China and USA will be described.

According to REN21, in 2014 China was a world leader in many aspects of renewable energy. It had a greatest renewable power (including and not including hydropower) installed. It also had the greatest hydro and wind power capacity as well as hydropower generation in the world. This is mainly because in 2013 China installed more renewable energy plants than all EU Member States. To achieve this China has implemented four important actions: support of new and renewable energy investments, implementation of various energy-saving renovations, improvement of civil energy use conditions and increased environmental protection (China's Energy Policy, 2012).

Although China is a leader in so many sustainable aspects, the country does not stop where it is. In the 12th Five Year Plan China plans to develop new renewable energy sources, what should allow China to increase the consumption of renewable energy to the level of 15% of a total energy consumption by 2020. The development of renewable power plants, based mainly on hydropower, should also boost up the local employment, investments and living standards. (China's Energy Policy, 2012). To encourage the development of renewable power plants Chinese government uses such policies and financial tools as (REN21, 2014):

- Renewable energy targeting,
- Feed-in tariff and premium payment,
- Electric utility quota obligation
- Renewable Portfolio Standard (RPS),
- Tendering,
- Heat obligation or mandate,
- Biofuels obligation,
- Capital subsidy,
- Investment or production tax credit,
- Reductions in sales, energy, CO2, value-added Tax (VAT) and other taxes,
- Energy production payment,
- Public investment, loans and grants.

As biomass and solar power create a great potential for heating and power production, Chinese Government promotes and encourages the development of solar power plants, solar heating and cooling systems in big cities and industry and biomass systems in rural areas (China's Energy Policy, 2012).

China is a world leader of wind power production. This is why, the Government invests more in R&D studies in wind-power equipment production and development of offshore wind farms. At the same time standards and control in the wind power sector are improved and the wind power production is optimized (China's Energy Policy, 2012).

USA is the world's second energy consumer (19.2% of world's energy consumption) and this is the reason why the US Government decided to change the energy policy based on fossil fuels to a sustainable energy with a greater share of renewable. The first "pro – sustainability" Act was the American Recovery and Reinvestment Act. After its introduction in 2009 the Department of Energy was obliged to invest more than USD 31 billion in improvement of energy infrastructure as well as development of clean energy projects and energy efficiency (International Energy Agency (IEA), 2014).

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Second to come was the President's Blueprint for a Secure Energy Future (2011). It set an agenda for the federal energy policy, which main goal was to double the generation of wind, solar and geothermal electricity by 2020. It also aims to double the energy productivity by 2030. By those actions USA plans to become a world leader in clean energy production and consumption by 2030(IEA, 2014).

In 2012 US Government introduced the "All-of-the-above" strategy (2012) which main goal was to support the energy security and develop low-carbon energy technologies(IEA), 2014). To achieve this US Government has a different support polices, fiscal incentives and public financing tools. Among them may be mentioned (REN21, 2014):

- Renewable energy targeting (revised; sub-national level),
- Feed-in tariff and premium payment (revised, sub-national level),
- Electric utility quota obligation (revised, sub-national level),
- Renewable Portfolio Standard (RPS) (revised, sub-national level),
- Net metering (revised, sub-national level),
- Tradable Renewable Energy Certificate (REC) (existing, national level),
- Tendering (revised, national level),
- Heat obligation / mandate (existing, national level),
- Biofuels obligation / mandate (revised, national level),
- Capital subsidy or Rebeta (existing, sub-national level),
- Reductions in sales, energy, CO_2, value-added Tax (VAT), or other taxes (existing, sub-national level),
- Energy production payment (existing, sub-national level),
- Public investment, loans, or grants (revised, national level).

SUSTAINABLE ENERGY POLICY IN EU AND POLAND

In 1992 European Member States agreed that sustainable energy would play an important part in European Energy Policy. This is why the share of renewable energy in energy production and consumption keeps growing and the whole renewable energy sector is developing (see: Figure 1). In the Amsterdam Treaty, it was decided that sustainable development, with renewable energy as its part, would be treated as a principle objective for all EU countries.

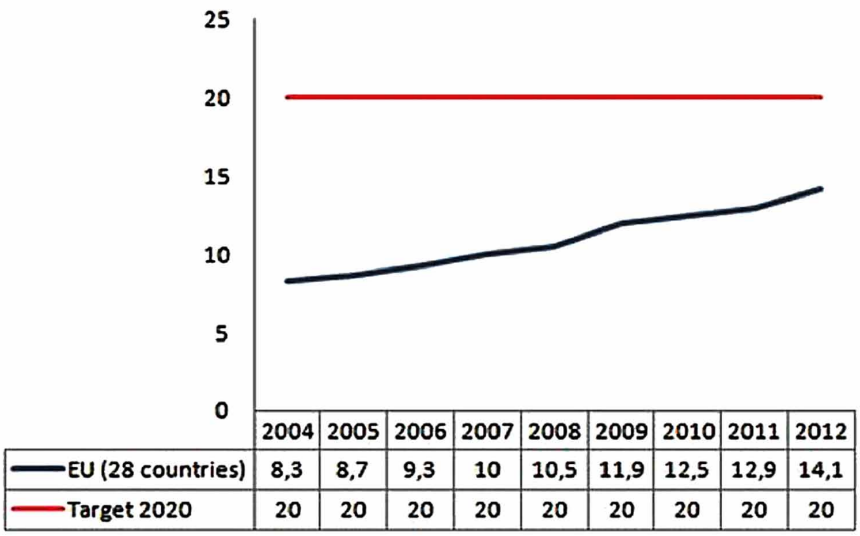
In 1992, at the UN Conference on Environment and Development held in Rio de Janeiro it was highlighted that the current levels of energy consumption and production are not sustainable. It was also stressed that the energy demand would continue to increase, what imposes the importance of development of renewable energy technologies. This should not only have a positive influence human health, the atmosphere and the natural environment, but also on energy independence and safety in all regions of the world.

In 2002, during Johannesburg Summit, UN set the actions for the development of sustainable energy. The main challenges of the Johannesburg Plan of Implementation ware (United Nations (UN), 2002):

- Improvement of the access to reliable and affordable energy services;
- Correlate the level of energy services with the improvement of living standards;
- Development of renewable energy technologies;

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Figure 1. Share of renewable energy in gross final energy consumption; data in %
Eurostat, 2015.



	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU (28 countries)	8,3	8,7	9,3	10	10,5	11,9	12,5	12,9	14,1
Target 2020	20	20	20	20	20	20	20	20	20

- Enlargement of renewable energy share in the global energy mix;
- Diversification of energy supply by development of more efficient and cost-effective energy technologies;
- Conjugation of a range of energy technologies to fulfill the growing demand for energy services;
- Dissemination and deployment of cleaner and more affordable technologies for both – energy conservation and efficiency.

Unfortunately, Rio and Johannesburg Summits failed to impose radical changes in the world's energy market, the European Union continued its sustainable policy rather strictly. Although during UN Summits no recommendations nor targets ware given, EU decided to introduce an annual increase of share of renewable energy in energy production and consumption at the level of 1,5% a year until 2010. As it would not be enough, EU created a group of "pioneer countries", which decided to set national and regional sustainable energy goals. Among 80 countries that joined the group, such countries as New Zealand, Brazil, South Africa and all EU members ware listed.

Yet, in 2004, during the European Conference for Renewable Energy in Berlin, EU set new ambitious goals for its member states. It was decided that 20% of European consumption should be produced from renewable resources by 2020. Those targets get binding for EU Member States in 2009, when Renewable Directive was set. This Directive set also a new goal for transportation – a 10% share of renewable energy sources used in all transport sectors. What is interesting, each Member State sets its own goals, which can be higher or lower than general EU targets.

In 2010, EU introduced a new development policy – Europe 2020. The main goal of this policy is to create a smart, sustainable and inclusive economy. It is believed that this will help European Union to reach high employment, competitive productivity and social cohesion with eco-friendly economy at the same time. In Europe 2020, the EU set five objectives for employment, innovation, education, social inclusion and last, but not least - climate and energy. Those targets need to be reached by 2020, but

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similarly as in previous case, each Member State could adopted its own national targets. Among climate and energy goals one can find highly ambitious targets which aim to reduce greenhouse gas emissions by 20% from the level measured in 1990. If the conditions are conducive, the reduction can reach even 30%. The other goals aim to increase the energy efficiency by 20% and reach a share of 20% of renewable energy in EU energy consumption (European Union (EU), 2010).

On October 23rd 2014, European Union supplemented goals from Europe 2020 with new targets for 2030 (European Council (EC), 2014). The new policy origins in all previous policies and is built on EU's experience and growing energy needs of EU inhabitants. The policy takes into account the earlier set targets and long term perspective. It is based on Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper. The main goals for 2030 are (Osiecka-Brzeska, 2013, p. 28):

1. Reduction of greenhouse gas emission by at least 40% in comparison to the 1990: sectors acting within EU emissions trading system (EU ETS) - such as power plants, industrial plants and others, will have to reduce its emissions by 43% by 2030. Sectors not covered by EU ETS are obliged to cut its emissions by 30%.
2. Increasing the share of renewable energy to at least 27%: this is supposed to changes EU energy system into more competitive, secure and sustainable system. This target was endorsed as binding at EU level.
3. Increasing energy efficiency by at least 27%: EU industry is about 19% less energy intensive than in 2001 and new buildings use 50% less energy than in 1980s and the trends are still improving. This is why EU set the target of 27%, but noted, that it will be reviewed in 2020 and may be changed into 30%.
4. Reform of the EU emissions trading system: in recent years the surplus of emission allowances has built up. The reform should ensure, that the EU ETS will be effecting and encouraging in promoting eco-friendly investments. It should also stabilize the market and become the main instrument to control and reduce greenhouse gas emission.
5. New governance system: each Member State is obliged to create a national plan for competitive, secure and sustainable energy. Transparent and reliable governance system should ensure the equal development of renewable energy and desirable reduction of greenhouse gasses. It should also help member states to introduce transparent national policies and effective support instruments for sustainable energy.

Five years earlier than 2030 goals, in 2009, European Union created Roadmap 2050. This document presents practical and objective analysis of ways to reach a low-carbon economy in Europe. The European Council set the goal to reduce greenhouse gas emissions by 80 - 95% below levels of 1990 by 2050. What is useful, this document not only sets the objectives but mainly addresses a high level greenhouse gasses emissions across all sectors of EU economy and analyses the power sector in depth, drawing conclusions based on facts from industry practice ad academic knowledge. Yet, the EU goals are thought to be inflated and some specialists are afraid that they can have an inhibitory influence on EU economy.

Among EU energy policies one of the most important is Directive 2009/28/EC, called also The Renewables Directive. It requires EU Member States to create National Renewable Energy Action Plans (NREAP), which will be a roadmap to reach targets set for 2020. This directive is binding for Poland and stipulates that the country will have a share of 15% of renewable energy resources (RES) in gross

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final consumption of energy. It is expected that in 2020 Polish economy will consume 69,200 ktoe and 10,380 ktoe will be come from renewable sources. What is more, the 15-percent-goal is a weighted average of three components, i.e. share of RES in electricity sector, in heating/cooling sector and in transport sector. As for polish targets the numbers are expected to reach the level of 19.13% (electricity), 17.05% (heating/ cooling) and 10.14% (transport) by 2020 (Eurostat, 2015). The goal adopted by Poland sets the country in the middle of requirements established by other EU Member States. In 2012, last data provided by Eurostat, Poland achieved 73% of its target for 2020, which means that the country reached a share of 11% of RES in gross final consumption of energy. (For more detail data please check Table 1).

Table 1. Sustainable energy share in energy mix in EU member states; data in %

	Geo\Time	2009	2012	Target 2020	% of 2020 Target Achieved in 2012	Status for 2012
1	Sweden	48.20	51.00	49.00	104%	Target achieved
2	Estonia	23.00	25.80	25.00	103%	Target achieved
3	Bulgaria	12.40	16.30	16.00	102%	Target achieved
4	Romania	22.60	22.90	24.00	95%	Target not yet achieved
5	Austria	30.40	32.10	34.00	94%	Target not yet achieved
6	Lithuania	20.00	21.70	23.00	94%	Target not yet achieved
7	Finland	31.20	34.30	38.00	90%	Target not yet achieved
8	Latvia	34.30	35.80	40.00	90%	Target not yet achieved
9	Denmark	20.40	26.00	30.00	87%	Target not yet achieved
10	Czech Republic	8.50	11.20	13.00	86%	Target not yet achieved
11	Croatia	13.10	16.80	20.00	84%	Target not yet achieved
12	Slovenia	18.90	20.20	25.00	81%	Target not yet achieved
13	Italy	9.30	13.50	17.00	79%	Target not yet achieved
14	Portugal	24.50	24.60	31.00	79%	Target not yet achieved
15	Greece	8.50	13.80	18.00	77%	Target not yet achieved
16	Slovakia	9.30	10.40	14.00	74%	Target not yet achieved
17	Poland	8.80	11.00	15.00	73%	Target not yet achieved
18	Spain	13.00	14.30	20.00	72%	Target not yet achieved
19	Germany	9.90	12.40	18.00	69%	Target not yet achieved
20	Hungary	8.00	9.60	14.65	66%	Target not yet achieved
21	France	12.20	13.40	23.00	58%	Target not yet achieved
22	Belgium	4.60	6.80	13.00	52%	Target not yet achieved
23	Cyprus	5.60	6.80	13.00	52%	Target not yet achieved
24	Ireland	5.20	7.20	16.00	45%	Target not yet achieved
25	Netherlands	4.10	4.50	14.00	32%	Target not yet achieved
26	Luxembourg	2.90	3.10	11.00	28%	Target not yet achieved
27	United Kingdom	3.00	4.20	15.00	28%	Target not yet achieved
28	Malta	0.40	2.70	10.00	27%	Target not yet achieved
	EU (28 countries)	11.90	14.10	20.00	71%	Target not yet achieved

Author's calculations based on: Eurostat, 2015.

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Poland is a EU Member since 2004. It's the ninth largest country in Europe (a total area of 312,679 square kilometers) the sixth most populous and the most populous post-communist member of the European Union (a population of over 38.5 million people). Polish GDP in 2014 reached 413,133.9 million euro, making Poland the eighth economy of the EU. Since the accession to the EU, Polish GDP has more than doubled - from 204,848 million euro in 2004 to 413,133.9 million euro in 2014. Although the GDP per capita is also growing (from 5,400 in 2004 to 10,700 in 2014), this indicator puts Poland on one of the last places in EU - the welfare of citizens is lower only in Bulgaria, Romania, Croatia and Hungary. Although Polish investments in R&D are higher every year (0.56% of GDP in 2004 to 0.87% in 2013), Poland took nineteenth place among EU Member States in 2013 with investments 2.4 times lower than EU average. The low investment has its output on eco-innovation of the country – Poland is the second last eco-innovative country of EU, with eco-innovation index at the level of 42% of EU average.

The Directive 2009/28/EC forced Member States to create NREAP until 2013. In 2013 Polish government passed an Act called "Small Energy Package". Among regulations about electricity end-users and gas distributors, the "Small Energy Package" defined the rules for the generation of electricity in micro-installations and electricity devices with a capacity of less than 40 kilowatts. Owners of micro-installations producing electricity are exempt from the obligation to run a business. What is more, the electricity generated in micro-installations should be bought at a price of 80% of average selling prices of electricity in the previous year. This was a great step for development of Polish renewable energy production, as it gave the chance to join the energy market by small producers. Yet, the Act put those producers in a less competitive position, as it obliged them to sell the electricity 20% below the market price. The "Small Energy Package" Act also amended Polish Energy Law, adding the obligation to develop the national action plan for renewable energy sources and create monitoring system for: renewable electricity market, heat and cooling from renewable sources market, agricultural biogas and bio market, liquid fuels and liquid biofuels used for transport (Ministry of Economy, Government of Poland (ME), 2013).

On 20th February 2015, Polish Government passed an Act on RES on renewable energy sources and handed it to sign by Polish President. The new RES Act is in line with EU policy for 2020 and 2030 and will allow Poland to reach the required share of renewable energy in gross energy production. What is more, the Act is beneficial for individuals who produce primarily electricity for their own use and sell any surplus to the grid. According to the Act, owners of domestic micro-installations up to 10 kW are guaranteed redemption surplus at a price higher than the market. Nowadays, the price of electricity in Poland is around 0,15 EUR per 1 kWh and micro-installations owners will be able to sell self-produced electricity at a price of 0,18 EUR per 1 kWh. This is a great change, which makes the sustainable energy from micro-installations more competitive than any other source of energy. This may be a unique chance for Polish renewable energy market to develop much faster than before (ME, 2014).

In addition to these recent legislative changes, Polish energy market offers a variety of tools to support the development of renewable energy. The most important Polish act on RES development is the Energy law from 1997. Renewable energy, as an integral part of energy market, is controlled by rules from the Energy law, although it regulates the entire energy sector. The main rules for power plants using RES in Energy law are (ME, 2014):

- Special rules for connection to the power grid and transmission of electricity generated,
- Ensured sale of the total amount of electricity generated,
- The right to issue and trade the Certificates of Origin (also called Green Certificates).

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One of the tools supporting investments in renewable energy is a reduction of fees for connection to the grid. Those fees are reduced by 50% for those of power plants which generate electricity from RES and their electric energy capacity does not exceed 5 MW. The other type energy company that can be exempt from fees are those which cogenerate electricity - this means they combine power and heat and their electric capacity is lower than 1 MW. Please keep in mind, that according to newly introduced RES Act, individual micro-installation owners do not have to pay this fee at all (ME, 2014).

Additionally, to a free grid connection, renewable energy power plants have a priority in transmission of electricity. This means that energy system operators have to collect all surplus of energy produced in renewable power plants and provide a transmission and distribution service. What is more the sustainable electricity has a priority to be collected before electricity produced in a non-sustainable way.

As a result of compulsion of renewable energy collection, energy-selling companies are obliged to purchase the surplus of electricity generated from RES which is interconnected to the grid located within the area in which the seller operates. There is also a purchase obligation for heat energy. According to the Energy law, heat-selling companies are obliged to purchase heat generated from renewable heat producer interconnected to the grid located in the area of a seller. There is a difference between heat and electricity selling obligation – whole surplus of electricity must be bought by operators, but at the same time operators may buy the sustainable heat surplus only to the extent of the demand of customers interconnected to that grid (ME, 2014).

What is also important the price of the energy generated from RES and sold to the energy system is predetermined in the Energy law. This price is equal to the average price of electricity or heat in the previous calendar year. The actual price for renewable electricity and grid is calculated and published by the Head of the Energy Regulatory Authority (ERA). For example, the average price of the electricity in 2012 was 48,4 EUR and this was the settlement value and a price of renewable electricity during all 2013 (ME, 2014).

Another type of tools implemented to support the development and promotion of renewable energy production are the Certificates of Origin. As it is regulated in Article 9th of the Energy law, the electricity generated in renewable power plant should receive a certified that proves that the energy is sustainable. Nowadays every electricity producer in Poland needs to have a share of sustainable energy in the energy mix. The companies have a choice between production of "green energy" which would ensure them the Certificates of Origin or a payment of substitution charge. The substitution charge is a way out, in which energy producer pays a legally established fee.

If the company produce sufficient amount of sustainable energy, it will receive a proper amount of Certificates and apply for their redemption at the ERA. If not, the company may buy the Certificates from other companies – the price of the certificate is determined on a Energy Stock Exchange. RES power plants, whose electricity capacity is not higher than 5 MW, are exempt from paying fees for registration in the Green Certificate Registration System and from stamp duty for the issue of Certificates of Origin.

In 2007 Polish government introduced a similar system of certificates for energy generated from combined heat and power production. However, there is no exemptions applied for certificates issued for energy generated from high performance co-generation to register in the Green Certificate Registration System and stamp duty.

Among the tools used for development of renewable energy, licensing is one of the most popular in the whole European Union. All the business activity connected with the production, distribution and trading of the energy, and renewable energy as well, requires a license issued by the Head of ERA. Licenses are issued for a definite time – usually between 10 and 50 years, but the applicant has a right to apply for

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a shorter license. The license to run a business in the field of energy is granted after application with a duty stamp (worth around 148 EUR). Each license holder has also to pay an annual fee to the ERA. The amount of the fee depends on the annual revenue received from the licensed activity of the company and a fixed coefficient – 0,0006.

The energy license can be granted to the individuals and companies who meet the following requirements (Polish Information and foreign investment Agency (PIFIA), 2015):

- Have residence or are incorporated in the EU Member State or EFTA Member State being a signatory of the agreement on the European Economic Area, or in Switzerland;
- Has sufficient financial funds or is able to document the capacity to obtain such funds;
- Has technical capabilities ensuring a regular business activity;
- Ensures employment of personnel having adequate qualifications, as provided in the Energy law;
- Has obtained a relevant zoning decision.

Although the license is quite easy to obtain, it can be also easily denied to individuals or companies who are in a state of bankruptcy or liquidation. Individuals or enterprises which lost their license during the last 3or were removed from the register of a regulated activity for reasons enumerated in the Freedom of Business Activity Act will also not receive a license. The third case in which a person or a company will be denied is the situation when this person on members of the board of the company have been sentenced for crimes related to the activities regulated by the Energy law (PIFIA, 2015).

Although all mentioned above instruments support the functioning and development of renewable energy in Poland, the sustainable energy still need to be subsidized. As energy projects in the area of sustainable energy are relatively expensive, investors in this energy sector may count on direct benefits, such as tax benefits and subsidies. Electricity generated from RES is exempt from excise tax. The exemption takes place when Certificates of Origin issued are redeemed (PIFIA, 2015).

Investments in renewable energy projects can receive subsidies from various EU funds, as well as Polish national funds. Most popular are the EU cohesion funds, which are available within the Infrastructure and Environment Operational Program. In Poland is is also possible to acquire a support from 16 Regional Operational Programs (RPO). Very important role in development of RES plays the National Fund for Environmental Protection and Water Management (NFOŚiGW). It offers additional funding in which renewable energy projects are eligible and favored. What is more, individuals pay an agriculture tax can reduce their payments by counting in the costs of investment in renewable energy infrastructure. The discount may reach 25% of the documented sustainable investment (Osiecka-Brzeska, 2013).

POLISH RENEWABLE ENERGY MARKET

Energy intensity of Polish economy is rather high (294.7 kg of oil equivalent per 1000 EUR), as the country is still developing, it is not expected that the energy intensity will fall. The problem is, that the Polish economy depends mostly on domestic coal mining. More than 60% of electricity produced in Poland comes from coal power stations. The country is trying to do the best they can to invest more in the development of renewable energy resource (Central Statistics Office of Poland (CSO), 2014)

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In period 2004 – 2012 the share of renewable energy in primary energy production was growing steadily. In 2012, when EU countries had a 22.3% share of renewable in the energy mix, in Poland renewable energy amounted to 11,7% of primary energy production. There was an 8% growth since 2011.

Since 2008 the share of renewable energy sources in total primary energy production grew in EU from 16.2 to 22.3% and in Poland from 7.6 to 11.9%. At the same time the amount of energy produced from renewable resources grew by 28% in EU and 57% in Poland. This means that the growth of sustainable energy is higher than the growth of total energy production. This situation is presented in Table 2.

During 2008 - 2013 period the greatest amount of energy was produced from solid bio- fuels. The share of other renewable energy resources changes – there is a clear upward trend of liquid bio- fuels, wind, biogas and solar power. Only water has noticed a cline in the power production. The share of different renewable energy technologies in the total energy production from renewable sources is shown in Table 3.

In 2013 energy produced from bio- fuels was more than 88% of all renewable energy produced I Poland. Solid bio- fuel produced 80% and liquid – 8,2% of renewable energy. The third place took wind energy with 6,05% share and water energy was nearly 2,5% of Polish renewable energy. Others energy sources produced less than 0,5% each. More accurate data is shown in Figure 3.

Figure 2. A share of renewable energy sources in a total energy production in UE and Poland; data in %
CSO, 2014, p. 21.

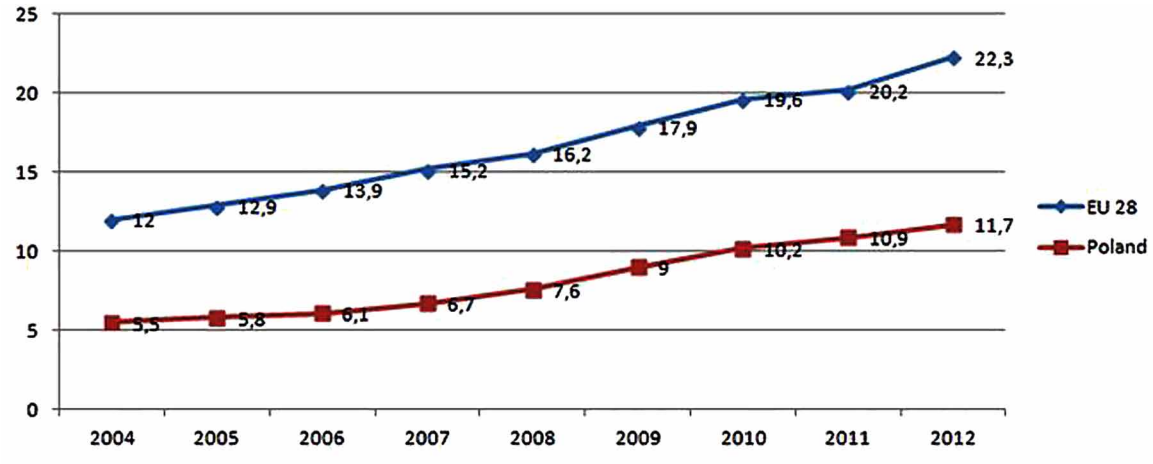


Table 2. The share of RES in energy production in years 2008-2013; data in TJ

	2008	2009	2010	2011	2012	2013
Total production of primary energy	29,985,356	2,816,880	284,028	2,882,363	3,038,291	2,005,544
Production of primary energy from RES	226,788	253,352	289,53	312,828	356,069	357,537
Share of renewable energy in total primary energy production	7.6%	9.0%	10.2%	10.9%	11.7%	11.9%

CSO, 2014, p. 24.

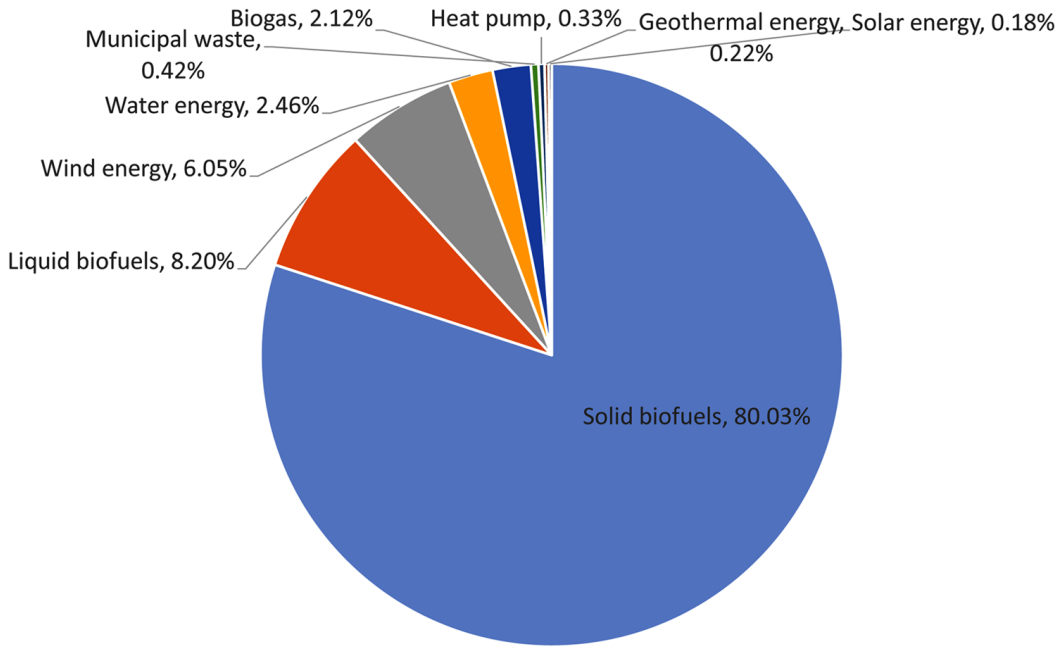
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Table 3. The share of technologies of renewable energy in the total production of energy from renewable sources in the years 2008 – 2013; data in %

Details	2008	2009	2010	2011	2012	2013
Solid biofuels	87.48	85.77	85.29	85	82.16	80.03
Solar energy	0.02	0.11	0.12	0.14	0.15	0.18
Water energy	3.42	3.37	3.65	2.68	2.06	2.46
Wind energy	1.33	1.53	2.08	3.69	4.8	6.05
Biogas	1.78	1.62	1.67	1.83	1.98	2.12
Liquid biofuels	5.47	7.04	6.64	5.76	7.97	8.2
Geotermal energy	0.23	0.24	0.2	0.17	0.19	0.22
Municipial waste	0	0.01	0.04	0.43	0.38	0.42
Heat pump	0.27	0.3	0.31	0.3	0.31	0.33

CSO, 2014, p. 29.

Figure 3. The share of renewable energy technologies in a total production of energy from renewable sources in 2013
CSO, 2014, p. 30.



In the period of 2004 – 2012 there was a stable growth of energy produced and consumed from solid bio – fuels. In 2013 there was a slight - 2,2% decrease in both of those sizes when compared to the year 2012. Still, if one compares 2013 to the same time in 2004 the growth would be higher than 68%. In the years 2004 – 2013, the structure of the consumption of solid biofuels changed.

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Since 2008, there has been a systematic increase of production of solar energy. Until 2008 Polish Main Statistics Office was analyzing only trade and service companies in terms of solar energy production. Since 2009 there has been a new study, which is carried out periodically with 3-year intervals. This study includes solar energy consumption in households, which is helpful to acquire additional data and show a full picture of Polish Solar energy market. Statistics results for 2013 showed that the total size of installed collector area was approximately 700 thousand m^2. Some sources differ on this data, e.g. The Renewable Energy Institute's research on sale of solar panels proved that the total size if installations was 1 480 thousand m^2.

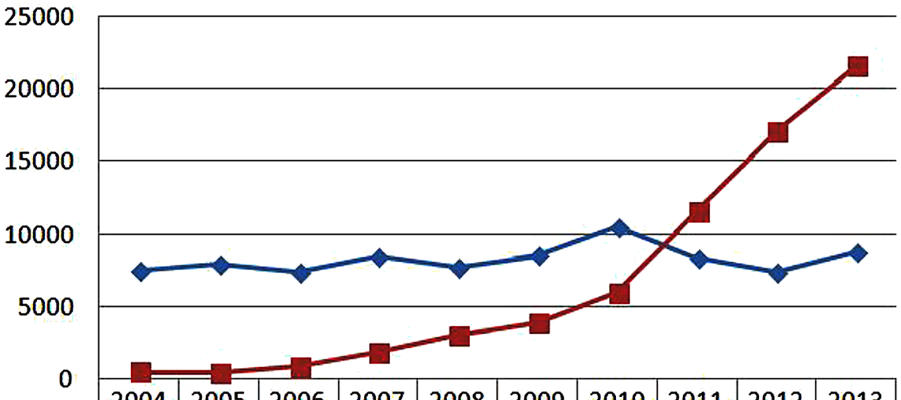
Between 2004 and 2013 there was a steady increase in the use of wind energy – from 512 TJ in 2004 to 21 614 TJ in 2013. This means that energy production from wind is 42 time higher than is was a decade ago. As it is shown in table, the energy production from water is kept at rather stable level. There have been some fluctuations, but the main trend is kept between 7 500 and 8 500 TJ. The highest production from water resources was in 2010, when it hit the level of 10 500 TJ.

During 2004 - 2013 period, the number of biogas increased steadily. Production of biogas in 2013 increased by 8.0% in comparison to a previous year. For the input of energy transformations 76.7% of biogas were used and the final consumption accounted for 23.3%. Most of the biogas 954.9%) was produced in for companies from the sector of trade and service.

From 2004 to 2011 there was a systematic increase in the extraction of landfill biogas. However, in 2012 and 2013 the amount of landfill biogas produced was lower by 3.2% and 4.1% compared to the previous year. The landfill biogas was mainly used in industrial power plants to generate electricity and heat. In the analyzed period of 2004 – 2013, there was an increase in the amount of biogas produced from sewage treatment plants. In 2012 there was an 19.7% increase in comparison to the previous year and in 2013 the increase was at the level of 1.0%.

When considering energy production from renewable energy resources in Poland, the production of electricity should be discussed separately. This is because the electricity determines a great share of energy produced from RES, especially the power from wind, water and sun. The general information

Figure 4. Changes of energy produced from wind and water in Poland in 2004 – 2013; data in TJ
Author's calculations on: CSO, 2014, p. 42.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Water energy	7494	7924	7352	8468	7748	8550	10512	8393	7333	8781
Wind energy	512	488	922	1878	3012	3878	5992	11536	17088	21614

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about electricity production from RES can be found in Table 3 in the time period of 2004 – 2013 the production of energy from RES grew systematically. At the same time there were changes in the size of shares different technologies in the production of renewable energy.

Figure 5 compares the changes in share of different technologies of renewable energy production in the year 2004 and 2013. It can be easily noticed that water technologies have lost the main position – from nearly 68% in 2004 to only 14% in 2013. The opposite trend was seen in wind energy – its share rose from 4,6% in 2004 to 35% in 2013. The share of solid bio- fuels also grew – it nearly doubled from 25% in 2004 to 46,5% in 2013. In 2004 no electricity was generated from solar of municipal waste. In 2013 it still had only a marginal significance. Picture 5 presents the changes in more details.

Electricity produced from renewable energy sources as a share of domestic gross electricity consumption accounted for 4.3% in 2008, 5.8% in 2009, 7.0% in 2010, 8.3% in 2011., 10.6% in 2012 and 10.7% in 2013. The share of electricity produced from renewable energy sources in the national gross electricity consumption is defined as the ratio of electricity acquired from renewable sources to gross electricity consumption, i.e. with losses and differences in the balance sheet.

In the years 2008 - 2013 the share of electricity generated from hydropower in total electricity production from renewable energy sources gradually decreased and reached 14.29% in 2013. At the same time, the share of electricity produced from solid biofuels remained at a high level - it reached Value of 46.43% in 2013. Another energy sources used to produce electricity (in terms of share in the total production of electricity from renewable sources) in 2013 were: wind energy - and biogas 35.18% - 4.04%. Municipal waste, solar and bioliquids were in 2013. Insignificant part in the production of electricity, which amounted to 0.049%, 0.009% and 0.003%.

THE CHANGE OF SUSTAINABLE DEVELOPMENT INDICATORS FOR POLAND

Eurostat has two head indicators, one operational and five performance indicators. Analysis of indicators for Polish is based on the data from 2004. and - depending on the data provided by Eurostat - will apply to 2010 or 2011. For a better picture of the situation, some indicators for Polish will be compared with the rates for other EU member states.

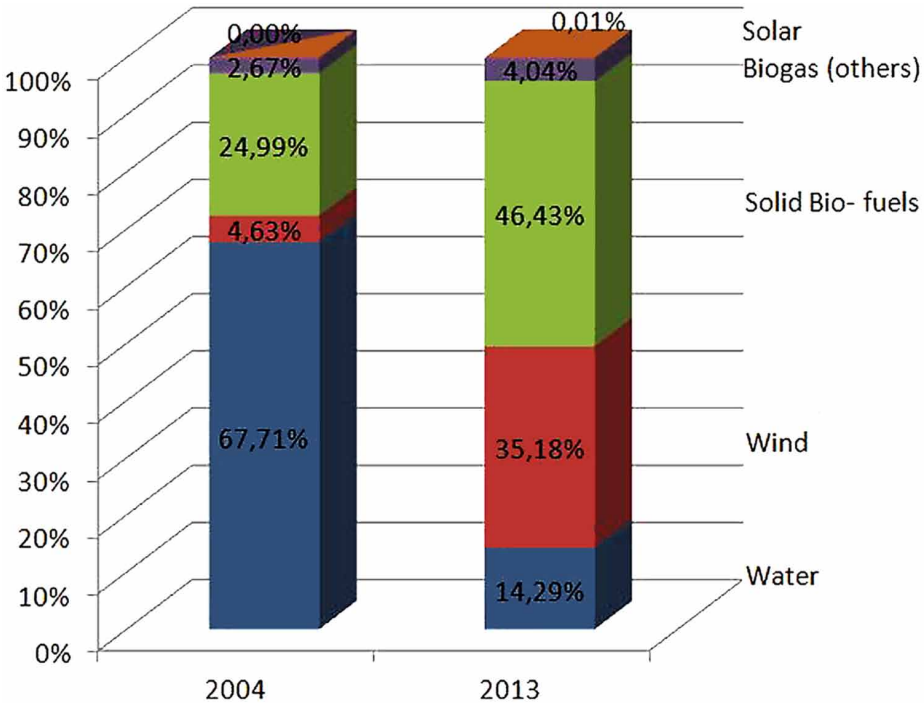
Table 3. Share of technologies in renewable energy production; time period: 2004 – 2013; data in TWh

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Total	3074.4	3847.7	4291.2	5429.3	6606.0	8678.7	10888.8	13137.0	16878.9	17.1
Water	2081.7	2201.1	2042.3	2352.1	2152.2	2375.1	2919.9	2331.4	2036.9	2439.1
Wind	142.3	135.5	256.1	521.6	836.8	1077.3	1664.3	3204.5	4746.6	6003.8
Biofuels	768.2	1399.9	1832.7	2360.4	3365.4	4904.1	5905.2	7148.4	9528.7	7923.5
Municipial waste	-	-	-	-	-	-	-	-	-	8.3
Biogas	82.2	111.3	160.1	195.2	251.6	319.2	398.4	451.1	565.4	689.7
Bioliquids	-	-	-	-	-	3.0	0.9	1.4	0.2	0.6
Solar energy	-	-	-	-	-	-	-	0.2	0.2	0.2

CSO, 2014, p. 29.

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Figure 5. Comparison of changes in share of renewable energy technologies in production of renewable energy in Poland between 2004 and 2013
Authors calculations on: CSO, 2014, p. 29.



The first head indicator of sustainable development in Poland in the field of energy is the primary energy consumption. As it is clear from the data presented in Table 4 in the period 2004-2013 the consumption of primary energy in the 28 EU Member States decreased gradually, reaching in 2010 level of 98,9% of consumption in 2004. The primary energy consumption in Poland in the same period was characterized by fluctuations, keeping the deviation of +/- 2%. This trend is also reflected in primary

Table 4. Primary energy consumption in Poland and the EU in the years 2004 – 2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU (mln TOE)	1706	1709	1718.2	1687.3	1686.6	1593.1	1652.4	1593	1583.9	1566.5
Poland (mln TOE)	86.9	87.7	91.7	91.6	92.8	89.9	95.8	96	92.9	93.2
Max EU - Germany (mln TOE)	320.1	317.2	327.6	310.4	315.2	296	310.4	294.4	296.8	302.5
Min EU - Malta (mln TOE)	0.9	1.0	0.9	1.0	0.9	0.9	0.9	0.9	1.0	0.8
Dynamics EU 2004=100	100.0	100.2	100.7	98.9	98.9	93.4	96.9	93.4	92.8	91.8
Dynamics Poland 2004=100	100.0	100.9	105.5	105.4	106.8	103.5	110.2	110.5	106.9	107.3
Poland/EU (%)	5.1%	5.1%	5.3%	5.4%	5.5%	5.6%	5.8%	6.0%	5.9%	5.9%

Author's calculations on: Eurostat, 2015.

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energy consumption in Poland as a share of primary energy consumption in the EU. In 2004 Poland consumption accounted for 5.09% of Union consumption, and in 2013 it had increased to 5.95%. The increase in primary energy consumption can be explained by the economic development of the country. Unfortunately, Eurostat does not publish data on savings and energy efficiency of individual Member States.

A positive trend for Poland is the decline in the share of solid fuels and gas in gross energy consumption (see Table 5). The share of petroleum products increased until 2009, but since then it has been steadily decreasing. The good trend for Polish sustainability is also an increase in the share of renewable energy in gross inland consumption.

Both in the European Union, as well as in Poland and other member states the share of renewable energy in energy mix has been increasing. Quantitative growth of renewable energy also affects the qualitative structure of energy consumed - renewables are an increasing share of gross energy consumption. Compared to the EU, Poland in the years 2004 - 2013 showed a slightly lower rate of growth of the share of renewable energy in gross consumption (see Table 6). However, Poland, with a 10.4 percent share of renewables in energy consumption, is closer to achieving the 15 percent target set for 2020 than the EU as a whole.

Table 5. The share of energy sources in gross inland consumption in the years 2004 - 2011, together with an indication of the direction of change year on year; data in%

The Type of Raw Material	2004	2005	2006	2007	2008	2009	2010	2011
Solid fuels	58.9	↓ 58.7	↓ 58.2	↓ 56.9	↓ 55.4	↓ 54.0	↓ 53.7	↓ 53.4
All oil products	23.9	↑ 23.9	↑ 24.5	↑ 25.2	↑ 25.8	↑ 26.2	↓ 26.0	↓ 25.9
Natural gas	12.9	↑ 13.2	↓ 12.9	↓ 12.8	↓ 12.7	↓ 12.7	↓ 12.6	↓ 12.6
Renewable energy sources	4.7	↑ 4.8	↑ 4.8	↑ 4.9	↑ 5.6	↑ 6.6	↑ 7.2	↑ 7.8

Author's calculations on: Eurostat, 2015.

Table 6. Share of renewable energy in gross final energy consumption in Poland and EU 2004 – 2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Target 2020
EU 28 (%)	8.3	8.7	9.2	10.0	10.5	11.9	12.5	12.9	14.3	15.0	20.0
Poland (%)	6.9	6.9	6.9	6.9	7.7	8.7	9.2	10.3	10.9	11.3	15.0
Dynamics EU28 2004=100	100.0	104.8	110.8	120.5	126.5	143.4	150.6	155.4	172.3	180.7	241.0
Dynamics Poland 2004=100	100.0	100.0	100.0	100.0	111.6	126.1	133.3	149.3	158.0	163.8	217.4

Author's calculations on: Eurostat, 2015.

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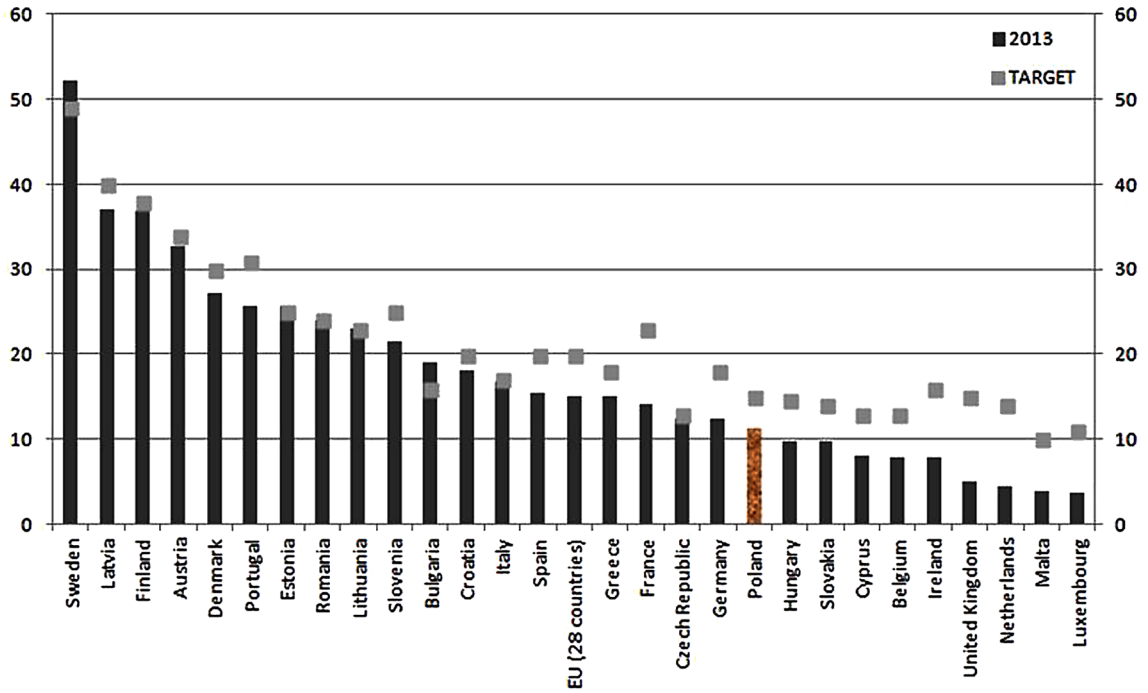
Compared to other Member States, Poland, consumes relatively little energy sources. In 17 EU countries the share of sustainable energy in gross energy consumption was higher than in Poland. Between 2004 and 2013, most of the renewable energy was produced in Sweden, Latvia, Finland and Austria (compare Figure 6). The smallest production took place in Malta - the share of renewable energy was 0.4 in gross energy consumption. In 2011, many Member states (e.g. Estonia, Lithuania or Romania) got close to the target set by the EU in this field. Sweden and Bulgaria ware the two countries to exceed the target. In 2013 Poland did not reach the 2020 target.

Operational indicator for sustainable energy is the energy dependence of the country and the Community. Energy dependence is understood as a percentage of net imports of energy in energy resources in the national gross energy demand. In other words, the energy dependence shows how a given economy is forced to rely on importing energy to meet its energy needs. Eurostat energy dependence distinguishes depending on the raw energy (coal, oil, gas) or total dependence, which includes all energy resources.

As illustrated in Figure 7, Polish energy dependence in the period 2004-2013 increased. It is not a good sign from the sustainable point of view. Although Poland reported a significant increase in energy dependence (from 14.5 in 2004 to 25.8 in 2013), the Polish energy dependence is lower than the energy dependency of the EU. The EU energy dependency was at the level of 53.24 in 2013.

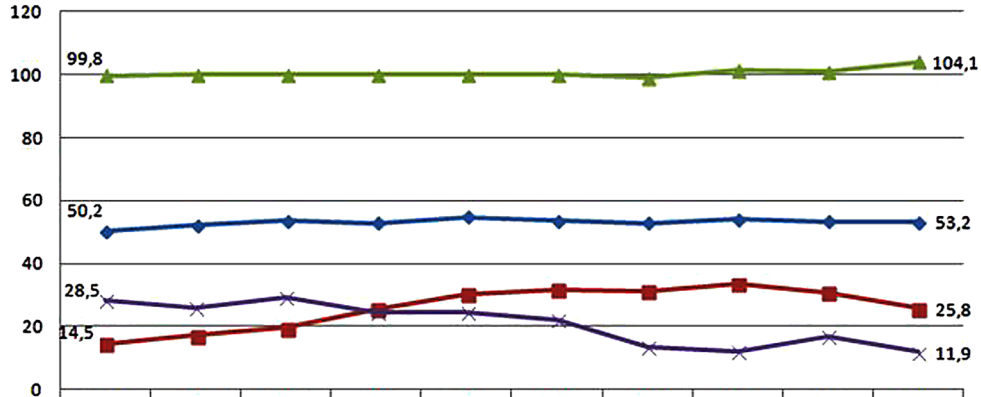
Figure 8 shows a comparison of the energy dependence of the member states and the EU-28 in 2013. The country with the highest energy dependence was Malta. Although the Polish energy dependence has increased since 2004, in 2011 Poland was still in the fourth place in terms of energy independence.

Figure 6. The share of renewable energy in gross energy consumption in the EU member states in 2013; data in %
Eurostat, 2015.



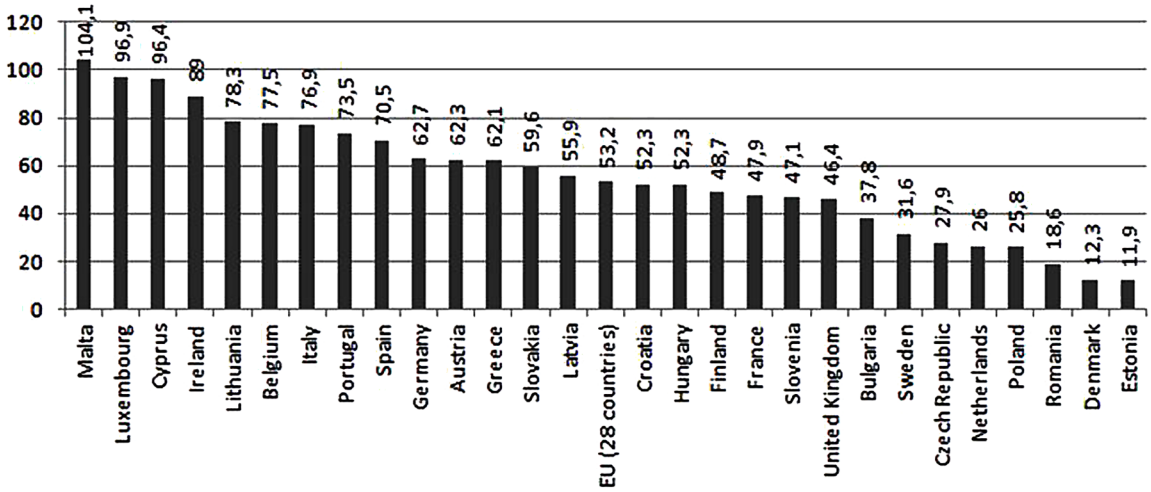
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Figure 7. Energy dependence in Poland and EU in the years 2004 – 2013
Author's calculations on: Eurostat, 2015.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU 28 (%)	50,2	52,2	53,6	52,9	54,7	53,7	52,8	54	53,3	53,2
Poland (%)	14,5	17,2	19,6	25,5	30,3	31,6	31,3	33,5	30,7	25,8
Max EU - Malta (%)	99,8	100	100	100	100	99,9	99	101,3	101	104,1
Min EU - Estonia (%)	28,5	26,1	29,2	24,7	24,7	22	13,6	12	17	11,9

Figure 8. Energy dependence of individual EU28 countries in 2013; data in %
Eurostat, 2015.



Lower dependence on imported energy factors than Poland was demonstrated by Estonia (11.9), Denmark (12.3), Romania (18.6). Polish energy independence is connected to the huge mining and export of coal.

Production of electricity from renewable energy sources in the years 2004 - 2013 grew steadily both in Poland and in the European Union. In EU the share of renewable energy in relation to gross energy consumption increased from 14.3% to 25.4%, which means an almost 78% increase. At the same time, the growth of renewable electricity produced in Poland was 509%. By 2013, the largest producer of renewable energy was Austria, which produced over 68% of electricity from renewables.

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Among the Member States of the EU, Poland is one of the six smallest producers of electricity from renewable energy sources - less renewable electricity produce only Malta, Luxembourg Hungary, Cyprus and Netherlands.

The share of renewable energy in transport fuel consumption in the years 2004 - 2008 in Poland grew three times faster than the EU28. Since then, the growth of renewable energy in transport in Poland has slowed down, but in EU kept the same trend (compare: Table 8).

It should be noted, that despite the rapid growth, the share of renewable energy in transport fuel consumption in Poland is still low. As it is presented in Figure 9, the share of biofuels in transport in Poland increased slowly from 0.7% in 2004 to 1.2% in 2007. Since 2007 a faster growth has been recorded. In 2011, it hit the level of 6.5%, but fell to 6.0% in 2013. The share of renewable energy in transport fuel consumption in the EU was 5.4%% in 2011 – it grew after a small collapse in 2011. Although in 2004 share of biofuels in transport in the EU was higher than in Poland, in 2008 Poland surpassed the EU average.

In 2011, Poland was one of the five leaders in the use of renewable energy in transport fuels, but lost this position due to rapid growth Austrian indicator. In 2013 Poland took the sixth place after Sweden, Finland, Austria, France and Germany. While the EU average was 5.4 in 2011, in Poland the use of renewable fuels amounted to 6.0%.

The data in Figure 10 shows that in 2011 in 11 EU Member States, the share of biofuels in transport fuel consumption was less than 1%, but in 2013 only Estonia (0.2%), Spain (0.4%) and Portugal (0.7%) had the share of biofuels lower than 1%. The greatest amount of fuels from renewable sources was used in Sweden (16.7%), Finland (9.9%) and Austria (7.5%). Poland took sixth place with 6.0% of biofuels.

Table 7. Production of electricity from renewable energy sources in the years 2004 – 2013. Data as % of gross electricity consumption

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EU 28 (%)	14.3	14.8	15.3	16.1	17.0	19.0	19.6	21.7	23.5	25.4
Poland (%)	2.1	2.7	3.0	3.5	4.4	5.8	6.6	8.2	10.7	10.7
Max EU - Austria (%)	61.9	62.4	62.4	64.6	65.2	67.8	65.7	66.0	66.5	68.1
Min EU - Malta (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	1.0	1.6
Dynamics EU 2004=100	100.0	103.5	107.0	112.6	118.9	132.9	137.1	151.7	164.3	177.6
Dynamics Poland 2004=100	100.0	128.6	142.9	166.7	209.5	276.2	314.3	390.5	509.5	509.5

Author's calculations on: Eurostat, 2015.

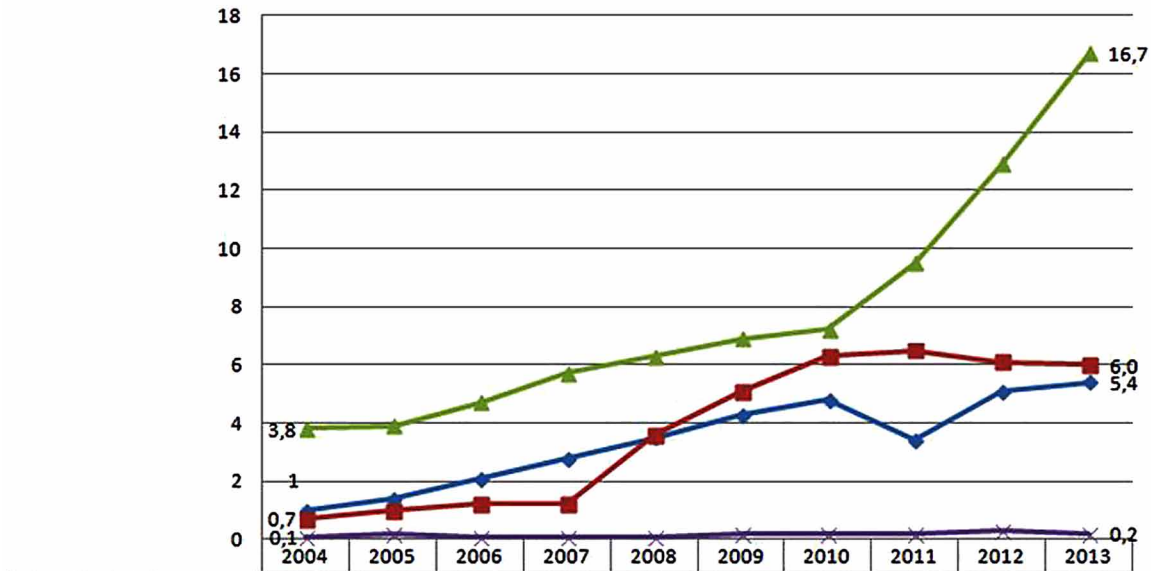
Table 8. The dynamics of the share of renewable energy in transport fuel consumption in Poland and in the EU28 in 2004 -2013

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Dynamics EU 28 2004=100	100	140.0	150.0	133.3	125.0	122.9	111.6	70.8	150.0	105.9
Dynamics Poland 2004=100	100	142.9	120.0	100.0	300.0	141.7	123.5	103.8	93.9	98.4

Author's calculations on: Eurostat, 2015.

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Figure 9. The share of renewable energy in transport fuel consumption in Poland and in the EU28 in 2004 -2013
Author's calculations on: Eurostat, 2015.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU 28 (%)	1	1,4	2,1	2,8	3,5	4,3	4,8	3,4	5,1	5,4
Poland (%)	0,7	1	1,2	1,2	3,6	5,1	6,3	6,5	6,1	6,0
Max EU - Sweden (%)	3,8	3,9	4,7	5,7	6,3	6,9	7,2	9,5	12,9	16,7
Min EU - Estonia (%)	0,1	0,2	0,1	0,1	0,1	0,2	0,2	0,2	0,3	0,2

Combined heat and power (CHP) in the years 2004 to 2013 grew much more slowly than the share of renewable energy in fuels. As seen in Table 9, the growth was stable in the EU28 as well as in Poland. The growth rate of the CHP system in Poland amounted to 3.5% and 11.4% in EU.

In Poland, the share of CHP in gross electricity production in 2004 was 17% and in 2011 it increased to 17.6%, but fell once again to 15.9% in 2013. In the EU, the share of combined heat was much lower during this period and reached 10.5% in 2004, 11.2% in 2011 and 11.7% in 2013. Interesting changes have occurred in Denmark, which was the leader of cogeneration until 2011. Now, despite the highest share of CHP in gross electricity production in the EU, Denmark recorded a decrease in the production of energy from cogeneration to 42.6% in 2006. In 2011, the share of cogeneration was 49.2%, but in both EU and Poland there was a decrease in use of combined heat. In 2012 Slovakia became the leader in this field with 78.6% and 77.0% of CHP as percentage of gross electricity generation. Specific changes in the reported period is shown in Figure 11.

The share of CHP in gross electricity production in 2013 was highest in Slovakia, which was followed by Denmark, Latvia, Lithuania, Netherlands and Finland (co-generation in these countries amounted to more than 30% of gross electricity production in 2013). Poland took 6th place, just after them with 5.9%. The data presented in Figure 12 proves that the smallest share of cogeneration is recorded by Malta (0%), Cyprus (1.4%) and France (2.4%).

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Figure 10. Use of renewable energy in transport fuels in the EU in 2013
Eurostat, 2015.

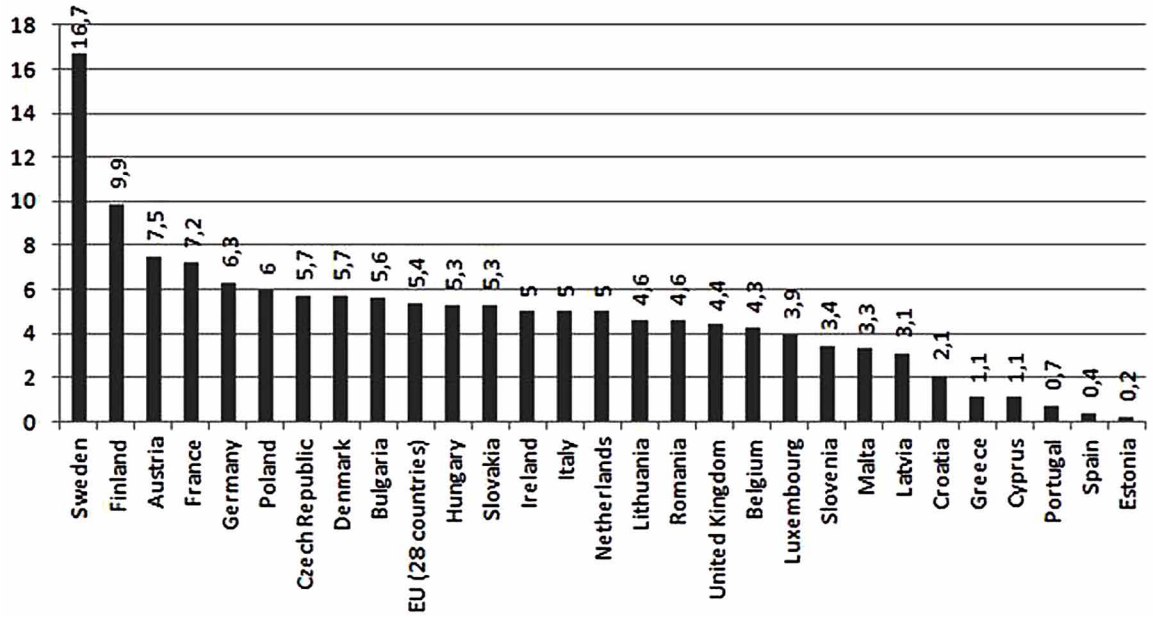


Table 9. The dynamics of combined heat and power (CHP) in Poland and the EU27 in the years 2004-2011

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Dynamics EU 2004=100	100	105.7	103.8	103.8	104.8	108.6	111.4	106.7	111.4	111.4
Dynamics Poland 2004=100	100	98.8	94.1	101.8	99.4	101.2	103.5	97.6	98.2	93.5

Author's calculations on: Eurostat, 2015.

An important aspect of renewable energy in the European Union was hidden energy taxation, which increased in the years 20046- 2013 decreased by more than 10% (see Table 10). In the same period in Poland, taxation was growing steadily and as of 2013 was 22.9% higher than in 2004.

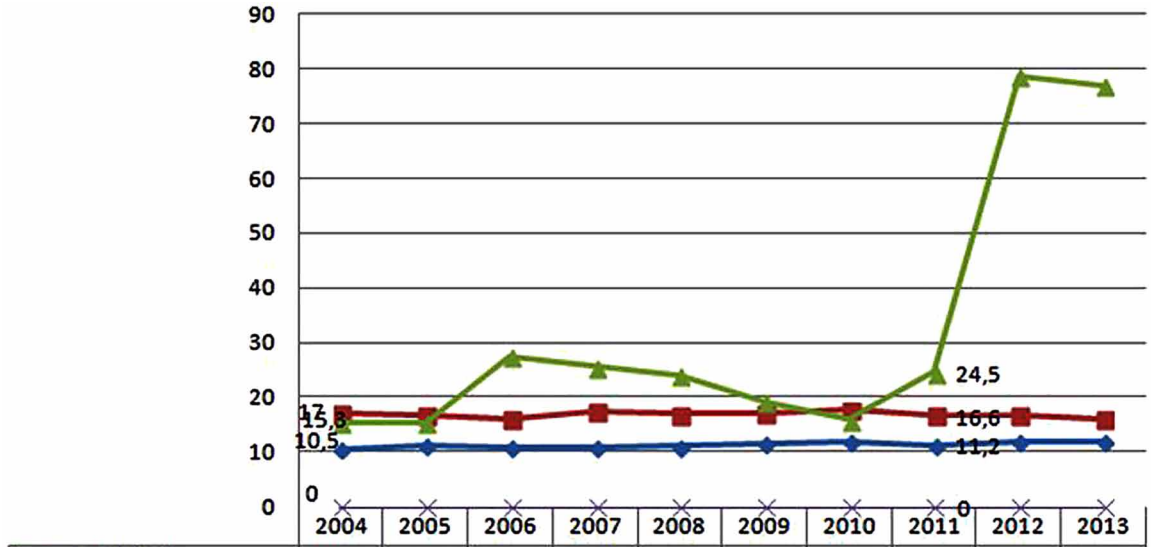
However, despite the increase in the use of hidden taxation of energy in Poland, these taxes are much lower than in the EU as a whole. As can be seen from Figure 13, the highest level of this tax in Poland occurred in 2013 and amounted to 125.82 EUR /TOE. At the same time, the EU average was 212.33 EUR/TOE. The lowest implicit tax among Member States amounted to 92.26 EUR/ OE and the highest 312.6 EUR/TOE.

In 2011, the highest energy taxation was in Denmark (EUR 417.68 / TOE), Italy (363.12 EUR / TOE) and Greece (257.19 (EUR / TOE). On the other hand, the lowest energy tax was in Slovakia 92.36 (EUR / TOE), Latvia (101.55 EUR / TOE) and Lithuania (104.76 EUR / TOE). Data for the EU Member States is shown the Figure 14.

Expenditure incurred on the development of renewable energy sources contribute to decreasing the cost of energy production, mainly through the reduction of environmental pollution and the depletion of natural resources dismissed. Financial expenditure incurred on fixed assets in the field of renewable

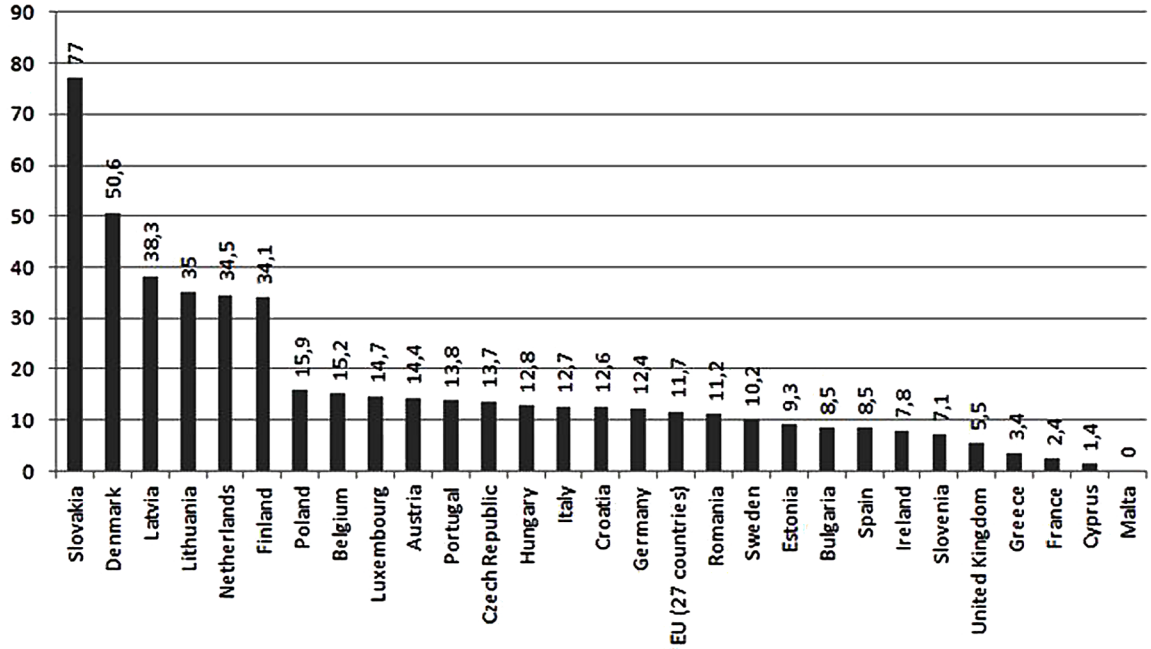
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Figure 11. Cogeneration in Poland and the EU27 in the years 2004-2011
Author's calculations on: Eurostat, 2015.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU 28 (%)	10,5	11,1	10,9	10,9	11	11,4	11,7	11,2	11,7	11,7
Poland (%)	17	16,8	16	17,3	16,9	17,2	17,6	16,6	16,7	15,9
Max EU - Slovakia (%)	15,3	15,3	27,6	25,6	24	19,2	15,9	24,5	78,6	77
Min EU - Malta (%)	0	0	0	0	0	0	0	0	0	0

Figure 12. Cogeneration in EU27 in 2012
Eurostat, 2015.



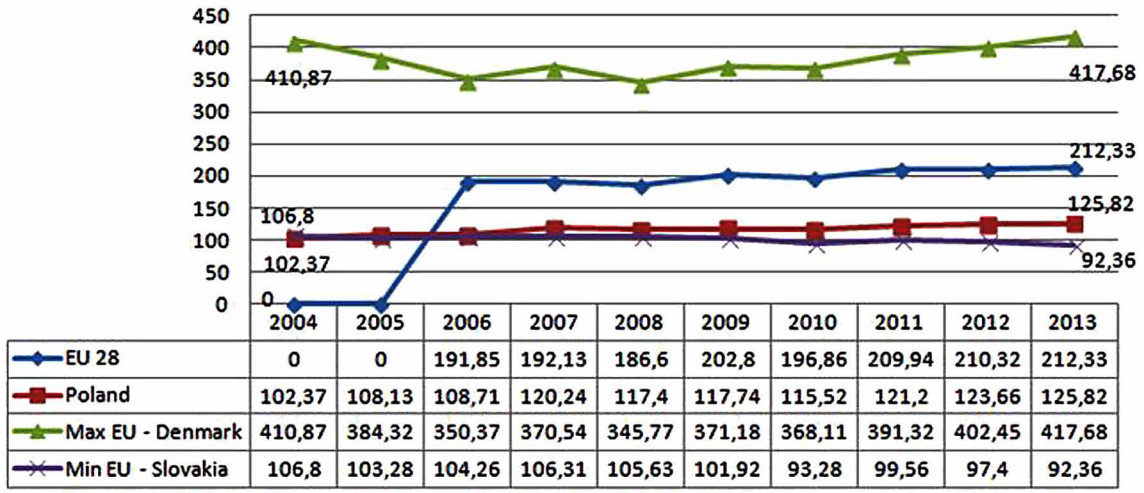
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Table 10. Dynamics of changes in hidden tax rates on energy in Poland and the EU in the years 2004 – 2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Dynamics EU 28 2006=100	nda	nda	100	100.1	97.3	105.7	102.6	109.4	109.6	110.7
Dynamics Poland 2004=100	100.0	105.6	106.2	117.5	114.7	115.0	112.8	118.4	120.8	122.9

Author's calculations on: Eurostat, 2015.
nda – no data available

Figure 13. Changes in hidden tax rates on energy in Poland and the EU in the years 2004 – 2013; data as EUR/TOE
Author's calculations on: Eurostat, 2015.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EU 28	0	0	191,85	192,13	186,6	202,8	196,86	209,94	210,32	212,33
Poland	102,37	108,13	108,71	120,24	117,4	117,74	115,52	121,2	123,66	125,82
Max EU - Denmark	410,87	384,32	350,37	370,54	345,77	371,18	368,11	391,32	402,45	417,68
Min EU - Slovakia	106,8	103,28	104,26	106,31	105,63	101,92	93,28	99,56	97,4	92,36

energy are part of fixed investment in environmental protection. In Poland in 2004 expenditure on fixed assets in the renewable energy sector valued totally to the sum of 18 million EUR. These expenditures increased in 2010 to the level of 105 million EUR. Despite almost fivefold increase, they accounted for only 3.9% of the total funds allocated to the fixed assets in the protection of the atmosphere and climate. Expenditure on fixed assets in the renewable energy sector was characterized by a lack of stability.

Fixed assets spending in renewable energy sources in rural areas recorded even greater fluctuations recorded (presented in Table 11). Expenditures for the development of renewable energy in rural areas amounted to 4.1million PLN in 2004 (0.8% of expenditures on environmental protection in this period). In 2010 expenditure on fixed assets were much higher and amounted to 88 million PLN. Their share in total expenditure on environmental protection in rural areas increased to 7.6%. Fluctuations in the level of expenditures for the years 2006, 2008 and 2010 were caused by the construction of new wind farms in rural areas in the regions of Middle and Western Pomerania.

General analysis of indicators of sustainable development give a relatively positive picture of Polish activities in this area. The increase in the production of energy (electricity and heat) from renewable energy sources, while reducing the share of solid fuels and natural gas is a positive trend in the structure

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Figure 14. Implicit tax rates for energy in the EU Member States in 2013; data in EUR/TOE
Eurostat, 2015.

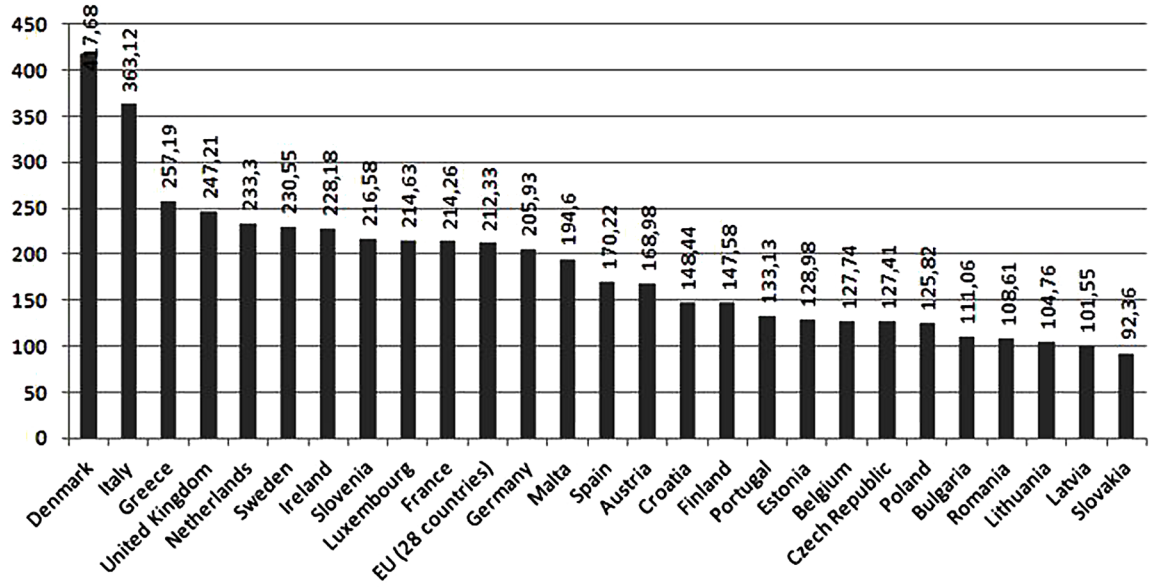


Table 11. Expenditure on fixed assets in the field of non-conventional energy sources; data in %

	2004	2005	2006	2007	2008	2009	2010
Total	1.36	0.89	2.97	2.12	2.11	2.02	3.91
Rural area	0.78	0.81	7.17	1.29	5.36	4.77	7.60

Czarski, 2011, p. 126.

of energy production in Poland. Also, the growing share of renewable energy in energy consumption is a sign of positive changes in the Polish energy sector. The share of renewable energy in Poland compared to other EU countries may seem alarmingly low. On the other hand, comparing to other EU countries, Poland has a large energy independence and this is one of the best indicators in Europe. A positive indicator for the sustainable development in Poland is the share of biofuels in transport fuel consumption. Poland is one of the leaders in the EU, and is supposed to keep its place as the indicator is changing positively. An indirect taxation of energy is also an important indicator, which in Poland is relatively low. It can be concluded that the increase in investment in fixed assets in the renewable energy sector stems from the low energy taxation, which translates the satisfaction of investors and increase funds for investments in RES.

FORECASTS FOR THE DEVELOPMENT OF RES INSTALLATIONS IN POLAND

In 2000 in the "Renewable Energy Development Strategy" it stressed that without government support the rapid development of renewable energy in Poland will be difficult, and technological potential of

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the country will not be used. It was also recommended to support the development of renewable energy sources as soon as possible, so that Polish companies can match to the level of the global renewable energy technologies. (ME, 2000). In the "Polish Sustainable Development Strategy 2025" support environmental activities of enterprises through appropriate financial and fiscal policies was guaranteed. Thanks to this support, any eco-friendly economic activities, including the activities in the field of renewable energy sources, has become more competitive, mainly through the internalization of external costs of environmental protection (Ministry of Environment, Government of Poland (MEn), 2003).

Directive 2009/28 / EC obliges Poland to hold a 15% share of renewables in the energy mix in 2020. Achieving this level of production requires at least a 25% share of RES installations in the energy system, taking into account the technical capabilities of the Polish energy sector. According to Stryjecki (Stryjecki, *2012,* p. 22.). it is possible to achieve, providing that the total installed capacity in the Polish energy system in 2020 reach the level of 41 - 42 GW, producing about 170 - 180 TWh. This means that the total renewable power capacity will amount to approx. 10 to 12 GW, which should result in the production of energy with a capacity of approx. 35 TWh. Stryjecki stresses that to achieve a 15 per cent share of renewable energy in final energy balance by 2020 it is necessary to take into account such factors as:

- The availability of resources for the different renewable energy technologies,
- The amount of planned investments of private investors,
- Financial, organizational, and technological conditions of the implementation of investment projects for different types of renewable energy sources,
- The availability of technology,
- Environmental conditions in individual regions and for different sectors of RES,
- Social determinants of use of renewable energy technologies in different regions.

By February 2015 the Act on Renewable Energy Sources has not been submitted to sign by President of Poland, so one cannot clearly define the government's plans for the development of renewable energy . The only official document providing plans for the development of RES is the National Action Plan for Renewable Energy Sources (NAP), which assumes an increase in the production of energy from renewable sources to 4151 ktoe.

The biggest role in the development of renewable energy sources for heating is granted to biomass- an increase of 790 ktoe to the level of 4636 ktoe in 2020. On the other hand, in the production of sustainable electricity the most important place was granted to wind turbines on land (1132 ktoe in 2020, an increase of 933 ktoe with comparison to 2010) and solar (506 ktoe, an increase of 485 ktoe with comparison 2010). In this area, the NAP also assigns an important role of energy from biomass and biogas, but it is stressed that Poland does not have sufficient resources of raw materials to produce the planned level of energy from these sources. In the long term, the NAP provides for the development of technologies such as offshore wind farms (production expected in 2020 -129 ktoe) and large aquatic plants (151 ktoe in 2020.).

The NAP forecasts an increase in renewable energy production capacity by 73% (3578 ktoe) in the years 2011 - 2020. The increase in heat produced from RES should reach 1824 ktoe (approx. 51% of the total capacity increase of RES), and another 1,753 ktoe should bring the growth of renewable electricity. According to government guidelines in 2020, the largest share in the production of renewable energy should have a solid biomass - 28%, followed by small wind turbines - 20% and solar power - 13%. The NAP marginally treated plate geothermal energy and hydropower, as there is no possibility of their use

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in the entire country. In addition, the production capacity of energy from these sources doed not significantly affect the balance of renewable energy production. Least attention is also put to forest biomass, which - in accordance with the principles of sustainable use of resources - from 2015 should not be a source of renewable energy (ME, 2010).

The prospect of the development of renewable energy sources in Poland by 2020 varies according to the type of RES and environmental conditions of the province. NAP puts greatest hopes on the development of wind energy in Western Pomerania, Pomerania, Podlasie, Kuyavian - Pomeranian and Wielkopolska. In addition, the rapid development of small wind energy should take place in eight other provinces. At the same time, despite the development of small wind power, NAP assumes that share of renewable energy in 2020 shall not exceed 1%. NAP predicts that solar energy will grow only in Wielkopolska, Mazovia, Silesia and Malopolska. In contrast, no significant development of photovoltaic is assumed, and this is because this source has a minimal impact on the balance of renewable energy.

The NAP predicts an increase in the production of energy from agricultural biogas to 384 ktoe, especially in the Warmia - Mazury, Podlasie, Kuyavian - Pomeranian, Wielkopolska and Lubuskie. Biomass from energy crops will grow best in Mazowieckie, Lublin and Subcarpathian and the straw will serve as a fuel in Pomorskie, Kujawsko - Pomeranian, Wielkopolska, Lublin and Opole (ME, 2010). When it comes to hydropower, the NAP assumes that the participation of all the technologies used in the production of hydropower will accumulate water energy to a maximum of 9% of the total production of energy from renewable sources. Geothermal energy may play a significant role in all provinces, but its development is dependent on the support provided to households and small businesses. The deep geothermal energy will be relevant only in Western Pomerania, Wielkopolska and Lodz. Hydropower based on river tides will develop slowly, and its share in the production of energy in all provinces would be negligible.

SUMMARY

Despite significant promotion and huge investment in renewable energy, its share in the Polish energy production is much lower than the EU average. In the EU in 2011 renewable energy accounted for 20.1% of total energy produced, which is twice the level of renewable energy produced in Poland. However, all indicators point to the fact that the Polish renewable energy is growing at a rapid pace, which is likely to lead to a significant increase in the number of power plants and micro-installations of RES. Thus, to increase the amount of renewable energy produced in the country. If the rate of development of the renewable energy sector is preserved, it is very likely that Poland will fulfill the objectives of the climate package - energy targets for 2020. However, to maintain such a high growth rate of renewable power capacity, tools should be maintained to support their development. Legal decisions ensure that funds supporting the development of renewable energy sources have already been allocated to be used for subsequent years. Although not all programs have a time frame up to 2020, it is known that at least until 2017, cash flows directed to investors in the modernization and construction of renewable energy sources will be not reduced. It is expected that they will lead to an equally rapid increase in production of renewable energy, as the one that had been in Poland by 2011. However, one should keep in mind, that not only financial aid is important, but also the legal conditions. In the uncertain legal situation, with changes often introduced and the lack of a final decision about the shape of the Law on renewable

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energy sources, private investors feel insecure and give up their investments. Therefore, it is important that the Polish government refined and implemented a law regulating the activities and forms of support for renewable energy power plants in a relatively short period of time. The combination of a stable legal environment and the availability of external forms of co-investments in RES should lead positive changes in the Polish renewable energy sector.

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Chapter 63
Supply Chain Social Sustainability and Manufacturing

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ABSTRACT

This chapter gives the overview of social sustainability in the supply chain of manufacturing industry. The author through literature survey identifies various definitions to social sustainability and suggest the approach to social sustainability problem in the supply chain. The readers are exposed with different social sustainability problems and what are the enablers and barriers to address such problem. In addition, the author identifies various social dimensions related to manufacturing supply chain and suggest as to how it can be addressed by various practices. Finally, the author identifies the research gaps in developing countries such as India, and suggests directions for future research. This is a vital contribution to the development of theory related to social sustainability in manufacturing Industries.

1. INTRODUCTION

The importance of sustainability in manufacturing has been talked over many decades. Formerly, the corporations were focusing predominately on fast paced production and innovative technologies. Now the focus has changed to sustainable manufacturing, because of increased awareness on limited resources, coupled with strict regulations, and corporate voluntary actions to meet the stakeholder's requirements.

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Sustainability is defined as "the development that meets the needs of today without compromising the ability to serve the future generations" WCED (1987) cited by Watkinson (2009). Due to climatic change and global warming, sustainability though it encompassed three dimensions such as environment, economic, and social, much emphasis was given on environmental dimension for over a decade. However, increasing stakeholder's awareness on safety, health, equity issues, and living conditions put back the focus on socially sustainable manufacturing and business practices. As more companies commit to sustainability and CSR policies, there is increasing pressure to consider social impacts throughout the supply chain. United Nations Human development Index (HDI) measures the countries based on income disparity, education and mortality, and the countries are ranked accordingly. This acts as a motivating factor for these countries to improve upon social sustainability activities. Majority of the developing countries were rated poorly because of social issues.

There were measures such as Sarbanes-Oxley act, Dow Jone's economic index (1896) and financial reporting making mandatory requirements for the corporations to be economically sustainable. Similary, there has been tremendous research done on environmental aspects of sustainability in the supply chain. However, very little has been done in terms of social sustainability in the supply chain because of very complex human issues involved in it. On the other hand, the research to study the inter relationship among the economic, environment, and society are integral to the concept of sustainability. It is very essential to characterize their interactions to understand overall impact on future generations. Although, social sustainability was included and considered as an integral part of sustainability, the role played by social is rarely equal to the economic and environmental concerns. The Global Reporting Initiative (GRI, established in 1997) has reported that social performance occurs infrequently and inconsistently across organizations. This was again described by the recent major study by Western Australian Council of Social Services (WACOSS), who noted that, "while there has been tremendous work done relate to environment and economic aspects, the social has tended to fall off the sustainability agenda.

Further, social sustainability studies were so far, discussed and emphasized on legislative, health and safety rather on comprehensive way of focusing all the relevant issues. Especially, in manufacturing supply chain, studies on social issues are bit scant. In manufacturing, the sustainability is measured based on the entire value chain of the corporate. When it comes to sustainability in the supply chain, the supply chain comprises of many individual companies. The sustainability of the chain is depending on many standalone companies who are part of the corporate value chain. The impact of sustainability is not only restricted to the manufacturing companies but also its suppliers (Ashby et al., 2012). More recently many manufacturing companies develop their supplier capabilities in developing countries for low cost advantage. Invariably, the actions and behavior of these suppliers to the societies where they operate from, impacts the global companies in their own locations. We can notice these incidents, for example the recent development of unethical standards followed by Chinese manufacturing companies, the usage of melamine tainted milk and lead-tainted toys and toxic tooth paste, defective tires and fake medicines led to 24 million customer settlements by menu foods and many companies in China (Tybout & Roehm, 2009). These acts not only tarnished the image of the buyer, it also impacted on their financial performance. Yet another example of unethical actions such as "expired meat" supplied by one of the Mc Donald's largest meat supplier damaged the image of the company. This was resulted in suspension of burger products in China and US (CBS News, 2014). There were several other incidents of social issues related to supply chain. More recently, Wal-Mart's most preferred "shrimp" was procured from Thailand based supplier, whose facilities lack the basic living conditions, health and hygiene, and poor wages, etc. This was highlighted by many social organizations.

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Especially, in developing countries, the issues related to social sustainability, still needs to be addressed. The recent noble price winner Khailash Satyarthi and his social efforts recovered and rehabilitated many child and bonded labourers from manufacturing set up in India. Further, TATA, a leading corporate brand was questioned by the World Bank, for the employee living conditions in their plantations. These are many social sustainability issues faced by the employees in the supply chain of manufacturing industries (World Bank report, 2014). Most of the developing countries are still plagued with child labor, gender inequality, and poverty, health problems because of lack of awareness on social sustainability measures.

To understand the importance of social issues better, a practitioner from leading corporate house says […] "In operations, people factor involve 85% of work and decisions, and the involvement of machines and automation is only 15%" […] It means, the people play a vital role in the operations. This reinforces the need for the study, which would focus on social aspects in the supply chain which can lead to sustainability of the manufacturing.

In this chapter therefore, we attempt to bring together the available literature on social sustainability, emphasizing more on manufacturing. What enables the social sustainability? And the various impediments to social sustainability adoption were explored. In addition, the relevant social issues and how these issues should be approached and addressed were examined. So that social sustainability becomes reality in manufacturing.

2. SOCIAL SUSTAINABILITY

Many of the scholars referring to 'social sustainability' draw mainly upon the definition of sustainable development provided by the Brundtland Commision Report, *Our Common Future*: "Development that meets the needs of the present without compromising the ability of meeting future generation needs" (Bruntland, 1987). This definition appeals enormously because it holds the possibility of reconciling people needs with bio-physical environmental management goals through economic development. It captures the essence of a much larger construct that attempts to address both tangible and less tangible necessities for life which, in turn, was seen to depend on reviving growth; meeting essential needs for jobs, changing the quality of growth, food, energy, water and sanitation; conserving and enhancing the resource base; ensuring a sustainable level of population; reorienting technology and managing risk; merging the environment and economics in decision-making.

The Bruntland Commission report on sustainability much emphasized in terms of management of natural resources, but not in terms of society, people and culture (Chatterjee & Finger, 1994). Later research, advocated three important aspects of sustainability: environment, long-time focus on environment and equity (Pearce et al., 1989). Similar study conducted by a few researchers argued that sustainable development also 'embraces the need for equity' (Elkin et al., 1991). In urban planning circles sometimes sustainability means three E's: Environment, economy, and equity without much thought of whether equity alone can lead to social sustainability or not.

Many authors have also concurred with the view that for the enterprise to be sustainable, it needs to internalize social costs, grow and maintain capital stocks, foster democracy and enlarge peoples' choices and distribute property rights fairly (Gladwin et al., 1995). The United Nations Conference on Sustainable Development (UNCSD, 1998) has specified in Section 1 of Agenda 21(Economic Dimensions), promotion of economic growth; in Section 2(Social Dimensions),creation of productive employment and achieving equality; in Section3(Environmental Dimensions), reduction in use of natural resources

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and protection of the natural environment. United Nations conference on sustainable development set an agenda for social development. It also discussed about the inter relationship between environment and social requirements. Many researchers have even proved that if the basic human needs are not addressed, it will be very difficult to address the environment sustainability goals because, in developing economies people tend to spoil the natural resources for their own personal benefits. Later, many scholars did extensive research on social sustainability; notably, Sachs (1999) and Godschalk (2004), through their research titled "Social Sustainability and Whole Development" identified a number of essential elements including equitable income and access to goods, social homogeneity and services and employment. Sachs (1999) also pointed out the importance of 'cultural sustainability' which required balancing externally imposed change with continuity and development from within, and of 'political sustainability' based on human rights, democracy and effective institutional control.

Magis and Shinn (Cited in Dillard, 2008) review the literature and found the four emergent principles of social sustainability: human well-being, equality, democratic government, democratic society. Further they argue that these four principles create self-reinforcing virtuous cycle that facilitates progress towards even environmental sustainability.

Bansal (2005) described social equity as an important component of social sustainability and asserted that all members of society had equal access to resources and opportunities. In organisations, social equity term was extended to give the meaning of "fair and equitable treatment of employees" (Krause et al., 2009).

Later, Bramley and Power (2009) asserted that social sustainability was often equated with social cohesion, social capital and social inclusion. This also underlines the importance of focusing on higher needs such as access to necessary goods and services, and basic societal development. Further, research on social sustainability have emphasised providing intra and inter-generational equity and distribution of power, employment, resources, education, freedom, provision of basic infrastructure and services, justice, and access to influential decision-making fora (Bramley & Power, 2009; Mitlin & Satterthwaite, 1996; Källström & Ljung, 2005; Redclift, 2005).

More recently, Vallance (2011) in his research titled "What is Social Sustainability" described a three-fold literature schema comprising: (1) development sustainability addressing basic needs and creation of social capital, (2) bridge sustainability concerning behavioural changes to achieve bio and physical environmental goals, and (3) maintenance sustainability, which refers to social and cultural characteristics such as ways in which people actively resist or embrace change. On the basis of the studies mentioned above and their outcomes, it is clear that social sustainability is all about social issues and the ways in which they can be addressed which may lead to long term well being of the people in the societies. In the next section, an attempt is made to identify various definitions of social sustainability.

2.1 Defining Social Sustainability

In this section, we examine the issues involved in defining social sustainability for the purpose of creating common research agenda for society and organization usage. A working definition of social sustainability is provided below. However, it was much problematic in this task of arriving at single useful definition and instead, this section suggests various useful approaches that could be adopted. As we aware that social sustainability is related much with the people and human of the particular society. Though, the social sustainability can be an universal bigger agenda, it may bound to differ in terms of "where" and "what" because of different social issues that evolve over a period in societies. These issues are highly

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contextual. For examples, the social issues between western countries and other developing nations vary. Further to elaborate, the issues such as juvenile arrests, living wages, and recreations are not relevant in developing nations. In developing countries issues like poverty, health, safety and sanitation, hygiene and bonded and child labour becomes highly relevant. Though, all the issues irrespective of the society looks relevant under bigger umbrella, the time and priority of the issues makes it more contextual in nature.

Generally, there has been a strong focus on defining sustainability as a condition, and measuring it with a series of indicators. Social sustainability is known to be life enhancement feature within communities, and has the process that can achieve life enhancement feature. The following features are possible indicators to social sustainability:- equity in accessing the key services including health, education, transport, housing and recreation, and equity between generations: meaning that future generations should not be disadvantaged by the activities of current generations. Further, we will elaborate in detail about social dimensions and indicators under "social dimensions section". Many scholars through various researches have defined social sustainability.

To name a few, Lafferty and Langhelle (1999), Sharma and Ruud (2003) defined "social sustainability as a human code of conduct which needs to be achieved in an equitable, inclusive and prudent manner".

"Development that improves the quality of human life while living within the carrying capacity of supporting ecosystems" (WWF, UNEP, IUCN, 1991).

"The preservation of the planet and its ecosystems, society and its communities, for finest, equitable environmental and human health and wellbeing" (Hill, 1998).

Social Responsibility is defined as ''the continuing obligation by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families, local community and society at large (WBCSD, 2000).

Polése and Stren (1999) define the social sustainability of a city as: 'Development and/or growth that is compatible with the harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population."

Western Australian Council of Social Services (WACOSS, 2000)

Social sustainability occurs when the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy and liveable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life.

Robert Putnam (2001) describes "social capital" is an important aspect of social sustainability, just as environmentalists describe "natural capital" to environmental sustainability, and amenities.

According to Dillard et al. (2008) a working definition of social sustainability developed through seminars and workshops over a period: that social sustainability should be understood as

1. The process that generates social health and well being now and in the future and
2. Those social institutions that facilitate economic and environmental sustainability now and for future

A most appropriate definition is provided by Harris and Goodman (2001): A socially sustainable system must achieve fairness in distribution and opportunity and adequate provision of social services including health, education and gender equity and political accountability and participation

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Wackernagel (2001) pointed out the importance of social sustainability by saying: "human health aspects are essential for the well-being of a society, but they should not be confused with environmental sustainability"

Sustainability is essentially an anthropocentric concept of inter- and intra-generational justice (Grunwald 2001),

Littig and Griessler (2005) defined as "claiming the right to a dignified life to humans" The Organization for Economic Cooperation and Development (OECD) views social sustainability in two diverse dimensions: human and social. The human dimension refers to man's skills, abilities knowledge and talents, which determines an individual's performance in the labor market and is also relevant to the process of economic growth (OECD Insights, 2008) cited in Tracey & Anne (2008). Social capital facilitates collective actions that are beneficial to the society (Hobbs, 2000; Milward, 2003).

With the extensive review of literature and understanding, social sustainability was defined and touched upon various social issues that falls under the ambit of "humanness". Hence, for the purpose of understanding, a working definition can be written:

"Social sustainability is all about addressing social issues of the people of today in the societies that can create a sustainable future for future generations"

Since this study focuses on supply chain related social issues, we further limit ourselves to various social aspects that are specifically related to supply chain that are discussed in the next section.

3. SOCIAL SUSTAINABILITY IN THE SUPPLY CHAIN

Social sustainability in the supply chain of manufacturing industry is of paramount importance because of increased stake holders awareness on not only "where" the product is made but also "how" and "at what" conditions the products are produced. Though, this creates somewhat undesirable situations for the corporate, due to involvement of cost, the benefits of human capital and its importance for strategic advantage of the corporations was well researched and explored. Hence, the corporate in the modern times, understand social issues and attempt to find the different ways of integrating the human and social aspects into the supply chain. Therefore, social sustainability in the supply chain talks about how people can be protected from the products and processes that affects the human being safety, health and well being. Before we define social sustainability in the supply chain, we need to understand "Who", "What" and "How", it means who are the people being targeted? What issues should be addressed? And how should we address these issues? (Wood, 1991).

The answer to the first question: stakeholder theory that addresses all the stakeholders in the supply chain including suppliers, employees, society, NGO's, and customers (Freeman, 1984, 2004; Stieb, 2009; Campbell, 2007). Yet another research described the similar view: social responsibility was seen as an organization's ability to manage stakeholders (Waddock & Bodwell, 2004; Clarkson, 1995). Further, resource based view supports that human resources, which can't be easily imitated or copied by the competitors, gives the company a strategic advantage in the market (Barney, 1981). Second, many scholars have identified various issues related to people in the manufacturing supply chain. For instance, human rights and labour working conditions were identified by Emmelhainz and Adams (1999). The study in US emphasised on health and safety, diversity, philanthropy, human rights and ethics in the supply chain (Carter & Jennings (2002a, 2002b, 2004). This research also proved that ethics can't be used as social sustainability dimension in the supply chain.

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Dyllick and Hockerts (2002) provided one representative definition of corporate sustainability: "meeting the needs of a firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities, etc.), without compromising its ability to meet the needs of future stakeholders as well". Further, they emphasised the importance of human capital and societal capital in social sustainability of the corporations. Similar research by many scholars insisted on various human issues such as safety, health, diversity, working conditions, child and bonded labor, and poverty in the supply chain (Whooley, 2004; Carter, 2005; Maloni & Brown, 2006; Kortelainen, 2008; Vachon & Mao, 2008; Andersen & Skjoett-Larsen, 2009). Further, some scholars have identified criteria of fair and equitable treatment, human rights, child and forced labour, training, employment and wages as issues in the supply chain (Pagell & Wu, 2009). There was another research that linked social issues of supply chain and country's economic performance through life cycle analysis (Hutchins & Sutherland, 2008).

Labuschagne et al. (2005) revealed practices related to poverty alleviation, administering justice, human rights, and welfare of all employees in the supply chain. Leire and Mont (2010) explained social issues such as reduction of unemployment, protecting employee health and safety, ensuring equal treatment and preventing social exclusion and how these dimensions were linked and incorporated in the supply chain

Finally, many authors described through various studies, in which how social issues can be addressed in the supply chain. One way to address is, incorporating these parameters in corporate's buying process known as socially responsible buying (SRB). Socially responsible buying (SRB) refers to the incorporation of social issues in purchase decisions advocated by organizational stakeholders (McWilliams & Siegel, 2001).

Further, Carter and Jennings(2002a, 2002b, 2004), Ciliberti et al. (2008) described the role of purchasing managers in the area of social responsibility within the supply chain and how the enactment of these roles could lead to improved trust and supplier commitment through purchasing social responsibility (PSR) and logistics social responsibility (LSR). Later research by Leire and Mont (2010) indicated how social criteria could be used to monitor suppliers and ensure their compliance. Bai and Sarkis (2010), Mani et al. (2014) have demonstrated usage of social parameters, in supplier selection. It means, incorporating social parameters in evaluation and selection of suppliers. Goworek (2011) in his research emphasized on socially responsible and environmentally sustainable sourcing practices and how it could be applied to clothing industries. Socially responsible supplier development (SRSD) and its importance in measuring the buyer's sustainability, and the relationship between social sustainability and supplier development efforts were established in China (see figure 1) (Lu et al., 2012).

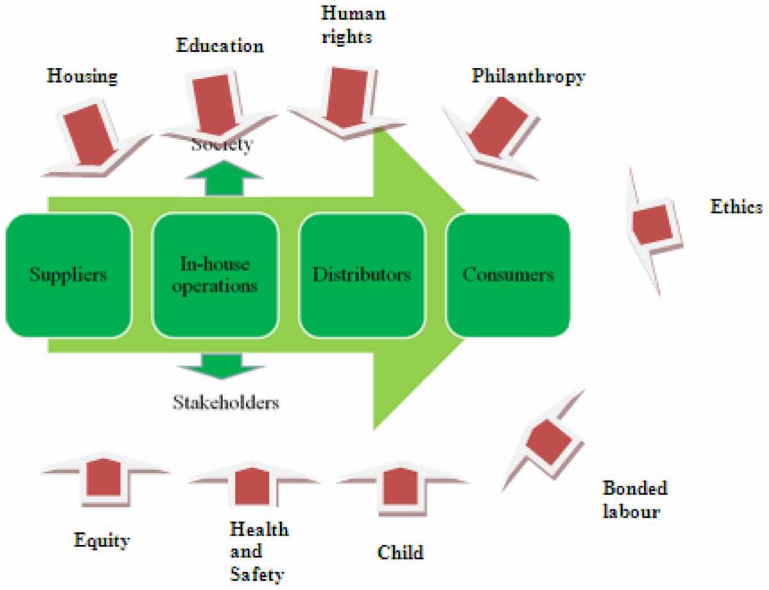
With above analysis, we possibly can form the working definition of social sustainability in the supply chain as "how the corporate manage and addresses the various social issues such as equity, health, safety, wages, working conditions, philanthropy and labour rights across the supply chain that will help the corporate to maintain, and sustain the human resources that in turn leads to long time survival of the corporation"

4. ANTECEDENTS AND IMPEDIMENTS TO SOCIAL SUSTAINABILITY

Another aspect of social sustainability in the supply chain deals with what enables social sustainability adoption. Many renowned scholars have identified ways and means of integrating social parameters into the supply chain. For example, one researcher asserted that socially responsible organizational buying fully depended on two factors: first, the skillful policy entrepreneurs who institute new policies

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Figure 1. Supply chain stages in manufacturing and relevant social issues
Source: Mani et al. (2015a)



with zeal for social wellness in their policy decisions, and second, the organizational context in which decisions are made (Drumwright, 1994). There have been many other studies focusing on how social sustainability can be achieved if corporates enact their roles responsibly. Drumwright (1994), Clarkson (1995), Strong (1997), McWilliams (2001), Campbell (2007) along with Ehrgott et al. (2011) argue that various parameters such as customer requirements, stakeholder requirements, employee requirements, skilled policy entrepreneurs, economic status of corporates, and public and private regulation influence social sustainability adoption (Table 1). Mani et al (2015b) have established many new enablers for social sustainability adoption in emerging economies, which include awareness on social sustainability, social organisations pressure, pressure from employee union, investor's pressure, and financial status of the company.

There are many enablers and barriers which can lead to social sustainability adoption in the manufacturing supply chain and these are explained in the preceding section with the help of table 1.

4.1 Antecedents to Social Sustainability

a) Awareness of Social Sustainability

Awareness of social activities can act as a key parameter to accelerate social sustainability (Haugh & Talwar, 2010; Maloutas, 2003). If the manufacturing companies are aware of the social sustainability parameters and their relevance to social capital development, this may help in adoption of social sustainability in the supply chain.

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Table 1. Antecedents to social sustainability adoption in the supply chain

S. NO	Antecedents	References
1	People oriented organisation culture	Carter and Jennings(2000, 2002)
2	Top Management leadership or skillful policy entrepreneur	Drumwright (1994),Carter and Jennings(2000, 2002), Ehrgott(2011), Mani et al. (2015b)
3	Government regulation	Carter and Jennings(2000, 2002), Aguilera et al. (2007), Campbell (2007), Ehrgott(2011)Mani et al. (2015b)
4	Customer pressures	Carter and Jennings(2000, 2002), Ehrgott(2011), Mani et al. (2015b)
5	Individual values	Carter and Jennings(2000, 2002)
6	Pressure from employee union	Aguilera et al. (2007), Campbell (2007), Mani et al. (2015b)
7	Direct incentives	Mani et al. (2015b)
8	Awareness on social sustainability	Mani et al. (2015b)
9	Stakeholders pressure	Aguilera et al. (2007), Campbell (2007), Mani et al. (2015b)
10	Competitive pressures	Campbell (2007), Mani et al. (2015b)
11	Social concerns	Mani et al. (2015b)
12	International certifications	Mani et al. (2015b)
13	Shareholders pressure	Mani et al. (2015b)
14	Ability to spend(Financial status)	Campbell (2007), Mani et al. (2015b)
15	Social organisations pressure	Campbell (2007),Mani et al. (2015b)

b) Competitive Pressure

In modern economy, the companies are always very much conscious about the competitor's actions that may potentially strengthens the corporate capabilities. The social measures adopted by competitors may force the other corporations to adopt similar measures for sustainability (Lamming & Hampson, 1996; Sarkis, 2003; Zhu & Sarkis, 2006; Carter *et al*., 2000; Rao & Holt, 2005). For example, corporations with inimitable resources and capabilities by the competitors, are necessary for gaining sustainable advantage. Further, Rao and Holt (2005) have established relationship between sustainable measures and competitive advantages.

c) People Oriented Organizational Culture

Organization culture can be defined as set of values, believes, assumptions, and ways of thinking and shared by organizations members, and taught to the new members of the organization (Barney, 1986; Chapman & Jehn, 1994; Weiner, 1988). This means that organizational culture influence the work behavior. Similar research has established, relationship between culture and organizations success. Further it was used by Carter and Jennings and proved that it helps in social sustainability adoption (Carter & Jennings, 2000).

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d) Customer Requirements

In manufacturing, many of the companies are expected to comply with customer requirements because of dependence and the economic relationship between these organizations. Many studies have proved that these requirements and their necessity in developing socially sustainable suppliers and their impact on buyers image and financial performance (Christmann, 2004; Drumwright, 1994; Sen & Bhattacharya, 2001; Wilkes, 2008; Lu & Lee, 2012; Carter & Dresner, 2001; Klassen & Vachon, 2003; Sarkis, 2003; Zhu & Sarkis, 2006).

e) Direct Incentives

Government direct and indirect initiatives in the form of tax benefits and other subsidies may drive the social sustainability (Cerin & Karlson, 2002; Hilson & Nayee, 2002; Ostrom & Wynne, 1993). For examples extending property rights acted as incentives for corporations to practice sustainable measures (Cerin & Karlson, 2002). Governments other incentives such as permitting individual harvest, territorial rights, and price ecosystem services, coupled with public research and monitoring promote sustainability in fishing industry (Campbell, 2007).

f) Corporations Financial Ability

The company's economic health and the level of competition determine the probability of adopting socially responsive behaviors. Further, small companies first tend to focus on economic sustainability and as they move on in the ladder, they extend their focus on social sustainable measures (Campbell, 2007; AlKhidir & Zailani, 2009; Luthra *et al*., 2011).

g) International Certifications

Many international certifications that include 26000, ILO, OHSAS 18001, AA 1000, ISEA 1999 for social standards exerts pressure on the corporations for social compliance. This will in turn impact on corporate image and operational performance (Viscusi, 1979; Handfield et al., 2002; Gonzalez & Sarkis, 2008; Zuckerman, 2000). Some voluntary certifications and labeling have helped in achieving social sustainability in coffee industry (Reynolds *et al*., 2007).

h) Investors Pressure

Shareholders and investor's actions influence the adoption of social sustainability measures in the organization (Tagesson *et al*., 2009; Buchholz & Rosenthal, 2005; Laplume *et al*., 2008). The investors positive role in bringing sustainability reporting was identified by many case studies (Tagesson *et al*., 2009).

i) Easy to Implement Without Resistance

Top executives 'resistance to change' attitude acts as barriers to social sustainability adoption. On the contrary, attitude to accept the change may speed up social responsiveness in the organizations (Shrivastava, 1995).

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j) Pressure From Employee Unions

Employee unions, in the bigger organizations act as catalyst in negotiation and demanding for social sustainability measures. With bargaining power, these unions exerts pressures on the top management to address social issues and adopt corrective measures on top priority. (Sen & bhattacharya, 2001; Hansson et al., 2003; Nortan, 2014).

k) Regulatory Compliance (Government Regulation)

Regulatory authorities or Government regulations as part of external stakeholder group certify the corporations to streamline and regulate for social measures. Government –protector of the society bring in many policies to regulate and orient the companies in their socially responsive activities(Green et al., 1996; Gonzalez & Sarkis (2008); Beamon, 1999; Raynolds et al., 2007) .Further, There is a positive relationship between government regulation and social sustainability adoption in corporations(Carter & Jennings, 2000; Ehrgott et al., 2011) .

l) Skillful Policy Entrepreneur

The top executive's role in adopting social sustainability was established by many researchers. Drumwright (1994) in his research advocated the policy entrepreneur who invests to institute his policies can drive the social sustainability (Banerjee *et al*., 2003; Buckholz, 1991). Yet In another research, Carter *et al*. (2007) mapped the social network within an organization to demonstrate how a low level manager effectively championed and drove a safety related supplier management project.

m) Social Concern

The organization's social concern can have a positive role in social sustainability adoption. Many organizations, through several reporting standards display their social concern (Laufer, 2003; Walker & Preuss, 2008).

n) Social Organizations Pressure

Social groups encourage corporations to implement social sustainability practices. Walker and Preuss (2008) identified the importance of social groups for corporate performance. For example, non-governmental organizations (NGO's) that works on child and bonded labor, living conditions, gender equity, health and hygiene. In India, a few of these popular social organizations are Samhita, Ruchika, Sulabh International, Sambhav, and the Parikrma foundation.

o) Stakeholder's Pressure (Others)

Other than internal stakeholders, the external stakeholders, i.e., Media influence the organizations in social sustainability adoption (Jones, 1995; Post et al., 2002; Maignan, 2002; Sharma & Vredenburg, 1998; Sarkis et al., 2010). A research conducted by Jones (2005) on the 18 top corporations showed how

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companies practiced social sustainability measures due to stakeholders pressure to feature their ratings in Dow Jones Sustainability Index(DJSI)

4.2 Impediments to Social Sustainability

Many scholars while discussing the barriers in the supply chain of manufacturing Industries identified various aspects leads non-adoption and act as bottle neck for the social sustainability. For instance, Bebbington and Dillard (2008) described that there are four factors contribute relative neglect of social sustainability by the organizations. First, the corporate's economic aims, commonly known as increasing the wealth of the shareholders. Second, the issues related to social sustainability has its modern origin in environmental sustainability issues. Thus social sustainability sometimes seen as related to developing world issues, such as access to water, education and health care etc. The third aspect of social sustainability is the social issues are often seen to be the responsibility of the state or society. Four, social sustainability appears to bring in severe challenges in understanding and communication than the other forms of sustainability. Further, research on social sustainability established many other barriers as described in Table 2.

a) Lack of Awareness

Lack of awareness of social sustainability measures may hinder sustainable development in the supply chain. On the other hand, awareness of relevant social activities can accelerate social sustainability (Haugh & Talwar, 2010). Maloutas (2003) emphasises the need for creating awareness of social sustainability as the lack of cognizance in adopting social measures is impeding the movement in the direction of social sustainability.

Table 2.

S. No	Impediments	References
1	Lack of awareness	Haugh & Talwar (2010), Maloutas (2003)
2	Lack of competitive pressure	Lamming and Hampson, (1996), Carter *et al.,* (2000), Rao and Holt, (2005), Campbell(2007), Rao and Holt (2005)
3	Lack of customers' requirements	Ehrgott *et al.* (2010), Christmann (2004), Drumwright (1994), Sen and Bhattacharya (2001), Wilkes(2008), Carter and Dresner (2001), Klassen and Vachon, (2003), Sarkis(2003), Zhu and Sarkis (2006).
4	Lack of investor pressure	Tagesson *et al.(*2009)
5	Lack of pressure from employee unions	Bhattacharya et al.(2012), Hansson *et al.(*2003), Haugh and Talwar (2010) Campbell (2007), Aguilera et al. (2007)
6	Lack of pressure from regulatory authorities (Government regulation	Campbell (2007), Green *et al.* (1996), Gonzalez *et al.* (2008), Beamon(1999), Raynolds *et al (*2007).
7	Lack of interest from skillful policy entrepreneur	Banerjee, 2003; Buckholz, 1991). Ehrgott *et al.* (2010)
8	Lack of social concern	Laufer (2003) Walker and Preuss *(*2008)
9	Lack of pressure from social organizations	Walker and Preuss (2008) Campbell (2007), Bartley (2003)
10	Lack of stakeholder's pressure	Jones (1995), Post *et al.,(*2002), Maignan and Ralston (2002), Sharma and Vredenburg (1998), Laplume *et al.(*2008)

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b) Lack of Competitive Pressure

A moderate level of competition among the corporations tends to encourage them to behave in socially responsible ways. On the other hand, high or low competitions tend to make them socially less responsible (Campbell, 2007). As some organisations utilize their socially sustainable image for overall strategic advantage, other organisations are compelled to adopt socially sustainable practices. In a global environment, competitive pressure plays a vital role in the supply chain. In social sustainability, the companies will have the resources and capabilities which cannot be easily imitated by their competitors who, therefore, will be forced to own and maintain such resources of their own, helping the cause of long-term sustainability (Lamming & Hampson, 1996; Carter *et al.,* 2000; Rao & Holt, 2005). Rao and Holt (2005) identify the linkages between sustainability measures and competitive advantage and also establish the relationship between sustainability and financial performance of a firm.

c) Lack of Customer Requirements

The customers or consumers can exert a strong pressure on the firms to adopt social sustainability measures through CSR if their requirements necessitate such measures (Aguilera *et al.,* 2007). In fact, the customers' requirements with regard to social dimensions may go a long way in achieving social sustainability. These demands not only mandate the suppliers to adopt sustainable practices in the short-term but also guarantee long-term sustainability in the supply chain. The growing requirement of the development of a socially responsible supplier base and its impact on the company image and financial operations has been affirmed by several researchers (Ehrgott *et al.,* 2010; Christmann, 2004; Drumwright, 1994; Sen & Bhattacharya, 2001; Wilkes, 2008; Carter & Dresner, 2001; Klassen & Vachon, 2003; Sarkis, 2003; Zhu & Sarkis, 2006).

d) Lack of Investor Pressure

The role of investor pressure in social sustainability reporting has been brought out by many case studies. As shown by these studies, privately owned companies do not disclose as much social information as the state owned organisations (Tagesson *et al.,* 2009).

e) Lack of Pressure From Employee Unions

Employee unions are the members of the internal stakeholder group, involved in pursuing the corporates to behave in a socially responsible way through negotiations and dialogue (Campbell, 2007). Aguilera *et al.* (2007) affirm that employee unions have an important role in compelling the corporates to be more socially sustainable. They play a role of catalyst in successfully bargaining for social measures (Bhattacharya et al., 2012; Hansson *et al,* 2003; Haugh & Talwar, 2010).

f) Lack of Pressure From Regulatory Authorities (Government Regulation)

Government regulations through law enactment and law enforcement can bring in social change in the corporations (Aguilera *et al.,* 2007). The government, as part of the external stakeholder group in the developing countries, monitors the corporations in their social sustainability measures (Campbell, 2007;

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Green *et al.,* 1996; Gonzalez *et al.,* 2008; Beamon, 1999; Raynolds *et al.,* 2007). There is a positive relationship between government pressure and implementation of social sustainability measures (Ehrgott *et al.,* 2010).

g) Lack of Interest of Skillful Policy Entrepreneurs

As Drumwright (1994) affirms, socially responsible buying happens because of two key understandings: skillful policy entrepreneur who uses his resources to institute policies; and the organisational setting in which these policies operate (Banerjee, 2003; Buckholz, 1991). Ehrgott *et al.* (2010), in their research, mapped the social network within an organisation to show how a handler at the lower ranks effectively championed and drove to a safety related supplier management project.

h) Lack of Social Concern

Organisations' social concern can have a positive impact on the social sustainability measures (Laufer, 2003; Walker & Preuss, 2008). Organisations increasingly display their social measures through many reporting standards carried out to show the corporate's social concern to the stakeholders and shareholders of the organisation. Lack of social concern may hinder social sustainability in the corporations.

i) Lack of Pressure From Social Organisations

The NGOs and other social organisations that monitor the corporations for socially responsible behaviour may tend to increase social sustainability (Campbell, 2007; Bartley, 2003). Moreover, socially responsible corporate behaviour tends to overlap with the extent to which the firms belonging to the industrial and corporate systems are amenable to dialogue. The NGOs, through boycotts, campaigns and multi-party dialogues, can influence the corporates to adopt socially responsible practices (Aguilera *et al.,* 2007). Walker and Preuss (2008), in their research on sustainability, emphasise the importance of the social groups' pressure on corporate performance. In fact, the presence of active social groups warrants the adoption of social sustainability practices by the corporates.

j) Lack of Stakeholder Pressure

Internal stakeholders through their direct strategic decisions, and external stakeholders exercising their collective voice, can influence the acceptance of socially sustainable practices in the corporations (Aguilera *et al.,* 2007). On the other hand, the media stakeholders can also influence the organisations in their adoption of social sustainability criteria (Jones, 1995; Post *et al.,* 2002; Maignan & Ralston, 2002; Sharma & Vredenburg, 1998; Laplume *et al.,* 2008). An inquiry conducted by Jones (2005) in 18 top corporations revealed how companies were adopting social sustainability measures pushed primarily by the stakeholder pressure, in addition to their ratings in DJSI to be specifically recognised for their name and report.

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5. SOCIAL SUSTAINABILITY DIMENSIONS

One of the fundamental questions that must be answered if we are to move forward with social sustainability in manufacturing: What are social sustainability dimensions? How do we measure these aspects in the supply chain? A consensus has not been reached on the measurements of social sustainability because it is highly contextual in nature. Further, sustainability indicators were largely developed by consultancy firms (such as Elkington's own company) who extend services to large companies by helping them to arrive at indicator system for their corporate sustainable reporting. Social sustainability is very difficult to quantify than economic and environmental impact and it is the most neglected part of triple bottom line reporting. All the social sustainability indicators are too general to be useful and specific indicators needs to be developed for particular state and industry, further down to company level. This means that the usefulness of these indicators to academic discourse in particular context of social sustainability is questionable (table 3) (Mckenzie, 2004).

Social sustainability dimensions were first proposed by United Nations Division for Sustainable Development (UNDSD, 2001) and widely accepted by the researchers, academicians and practitioners. This framework describes themes and sub themes and under sub themes-indicators etc. The first of these framework proposed by United Nations Division for Sustainable Development measures progress of social sustainability indicators that are tied to Millennium Development Goals. According to this framework, indicators first classified by the primary dimensions (Social, environmental, and economic) then by

Table 3. Comprehensive list of various social sustainability indicators adopted by many scholars across the globe.

Social Sustainability Indicators	
Human Rights	Philanthropy
Income disparity	Population
Justice to all	Poverty
Juvenile arrests	Quality Education
Life companion	Recreation
Living Wage	Reliable and sufficient social system
Objective basic Needs	Safety
Objective equal opportunities	Fair distribution of burden between generations
Objective social resources	Financial position
Abuse and disciplinary practices	Freedom of association
Cultural Sustainability	Gender Discrimination
Employment	Wages
Employment gender ratio	Working Hours
Environmental reports	Access to goods and services
Equity	Affordable housing
Ethics	Bonded labour
Gender Ratio (Employment)	Child abuse or Neglect
Harassment	Child labour
Housing Security	Creation of social capital
Social homogeneity	Cultural diversity
Subjective basic needs	Health
Subjective equal opportunities	Health Insurance
Subjective social resources	

Source: Mani et al. (2014a)

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their theme (for example: education), and finally by sub theme(for example., literacy). The broad themes under social dimensions are: equity, health, education, housing, security, and population. Under each sub theme, at least one or as many as three quantifiable indicators associated with it. These indicators very useful and are shared to many countries by Human Development Report Office of UNEP.

Further, there is another frame work called "The sustainability Reporting Guidelines" developed in conjunction with many stakeholders, including business houses, non-profit organizations, investor organization, and trade unions. This was primarily the effort of United Nations Environment Programme (UNEP) in association with Coalition for Environmentally Responsible Economics (CERES). Though this framework is very similar to that of UNDSD, it is different in many areas. These framework differentiates "core" and "additional indicators –core indicators are more relevant to reporting organizations and stakeholders, others are named as additional indicators. However, majority of these indicators are subjective and qualitative. Within 'sustainable reporting guidelines' many of these indicators are informative however, it is very difficult to incorporate such qualitative guidelines in decision making tools required by business. Carter and Jennings (2000, 2002, 2004) through his research in US has proposed many social dimensions, including diversity, human rights, philanthropy, safety, in manufacturing Industries.

Labuschangne et al. (2005) has contributed to the improvement of sustainability framework by proposing additional indicators that incorporates criteria from number of key frameworks, namely: United Nations Commission on sustainable development, Global Reporting Initiative, Sustainability metrics of institution of chemical engineers, and Wuppertal sustainability indicators. They have concluded that the indicators within these frameworks are not "adequate" as a result eight supplement guidelines were reviewed to identify additional indicators. Similarly, Supply chain counsel has proposed, "SCOR people" framework through Supply Chain Operation Reference (SCOR) model for manufacturing supply chain. However, sustainability reporting framework, proposed by Global Reporting Initiative (GRI), A non-governmental organization is widely accepted among corporate circles (Table 4).

Though, there were many adequate dimensions and measures for social sustainability in manufacturing industries as we discussed earlier. The dimensions and indicators cannot be generalized because "socialness" evolves over a period of time in the society and social issues are highly contextual. For example the social issues in developing countries are different from that of developed economies.

Various researches conducted by many renowned scholars have identified specific social sustainability dimensions that can be used as a tool for measuring social sustainability in manufacturing industries.

For examples Sachs (1999) identified dimensions such as access to goods, employment, cultural sustainability, human rights in New York City. Further, The research done in US manufacturing companies brought many social dimensions such as, diversity philanthropy, safety, and human rights (Carter & Jennings, 2000, 2002, 2005). In this research, however the authors could not establish direct relationship between social sustainability and financial performance. Instead, they could find trust and learning played a vital role between suppliers and buyers, invariably that led to cost reduction for the buying organization. Similar study, by Gupta (2007) uncovered human rights and labour standards in Indian manufacturing companies. Yet another research in German, the social dimensions such as objective basic needs, subjective basic needs, objective social resources, subjective social resources, cultural diversity, and social security system were established and ranked based on priority (Omann & Spangenberg, 2002).

There were other social indicators including financial position, life companion, and recreation have been used by Kallstorm and Ljung (2005). In Canada, another empirical study done by Vachon and Mao

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Table 4. List of criteria and sub criteria and Indicators proposed by UNDSD and adopted by Mani et al. (2014) in India.

Criteria	Sub Criteria	Indicators
Equity	• Poverty • Gender equality • Gender discrimination	• Percentage of population living below poverty level • Unemployment rate • Gini index of income inequality • Percentage ratio of average female wage vs male wage • The practice of granting or denying rights of privileges based on gender
Health & Safety	• Nutritional Status • Mortality • Sanitation • Drinking Water • Healthcare Delivery • Safety measures provided by corporates	• Children nutritional status • Mortality rate under 5 years old • Population who have adequate sewage facilities (%) • Access to safe drinking water • Access to primary health care facilities • Safety measures undertaken by the company to protect the employees
Wages	Wage standard	Standard of wages against man hours spent
Education	• Literacy Level • Education Level	• Adult literacy ratio • Access to primary education up to 5th STD
Philanthropy	• Donation to Temples & MUTT • Donations to NGO's • Donations to Schools & Colleges	• Money donated to religious organizations • Money given to Non Governmental Organization (NGO's) • Money given to schools and colleges
Human Rights	Human Rights- Environment	How human rights are protected (right to associate, speak)
Child and Bonded Labour	• Child labour • Bonded labour	• The percentage of child labour employed • Percentage of bonded labour employed
Housing	Living Conditions	• Human and floor ratio • Hygienic conditions
Ethics	• Supplier Ethics • Ethical Environment	• Ethical values adopted by the supplier • Ethical environment

Source: Mani et al. (2014a)

(2008) suggested the dimensions such as labour, employment, and gender. Hutchins and Sutherland (2008) in their research in US established relationship between social sustainability indicators such as wages, health, safety, equity, quality education, and philanthropy and the financial position of the country and through life cycle analysis. In various other studies conducted by many researchers in countries such as UK, Sweden, and London, China established many social performance indicators including ethics, environment, employee compensation, philanthropy, health and safety, child labour, bonded labour, education and housing facilities, etc. as listed in Table 1 (Yakovleva et al., 2012; Kogg & Mont, 2012; Schlossberg & Zimmerman, 2010; Andersen et al., 2009; Lu & Lee, 2012; Husgafvel et al., 2014).

However, caution needs to be applied while selecting the social indicators in a particular country. This might look different view than that of conventional way of thinking that all the societies are getting merged because of globalization and liberalized economy. And we get an illusion that all the social issues may be same. However, it is not true; this can be well noticed by the research done by Mani et al. (2015c) in two different global supply chains and their social sustainability practices in India and other continents. In which, the author emphasized that the social issues and indicators to measure such issues are different from one continent to other (Table 5).

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Table 5. List of various social sustainability dimensions used by the researchers in different countries.

S.No	Authors(References)	Social Dimensions used in Various Researches
1	Poist(1989)	Housing, diversity, Philanthropy, safety, health and hygiene, hunger, education
2	Carter et al. (1999)	Procurement from minority supplier
3	Emmelhainz and Adams(1999)	Human rights, labour practices.
4	Carter & Jennings (2000)	Diversity, philanthropy, safety, human rights, ethics
5	UNDSD(2001)	Equity, health and hygiene
6	Carter & Jennings (2002)	Diversity, philanthropy, safety, human rights
7	Whooley(2004)	Diversity, safety, equity, health and hygiene.
8	Carter (2005)	Diversity, philanthropy, safety, equity.
9	Hens (2005)	Equity, poverty, health and hygiene
10	Maloni and Brown (2006)	Safety, human rights, labour practices, health and hygiene
11	Kortelainen(2008)	Human rights, child and bonded labour, poverty.
12	Hutchins and Sutherland (2008)	Philanthropy, health, safety, equity.
13	Vachon and Mao (2008)	Equity, labour, poverty
14	Andersen (2009)	Safety, human rights, labour practices, child and bonded labour, procurement from minority suppliers, education.
15	Pagell and Wu(2009)	Safety, child and bonded labour.
16	Wong et al. (2010)	Safety, human rights, labour practices, child and bonded labour.
17	Leire and Mont (2010)	Safety, equity, employment, health and hygiene
18	Yakovleva et al. (2012)	Equity, employment, wages.
19	Gopalakrishnan (2012)	Diversity, safety, human rights, health, hygiene, ethics
20	Lu et al. (2012)	Ethics.
21	Husgafvel et al. (2014)	Health and safety, lobour practices, human rights, wages, education and training.

Source: Mani et al. (2015b)

CONCLUSION

A sincere attempt was made to expose the concepts and literature pertaining to social sustainability and how it was practiced in manufacturing supply chain under various domains. Based on the above literature and analysis, there were many dimensions and indicators, related to social sustainability in the supply chain, emerged. Social sustainability as a subject, it was very difficult to define due to the fact that it is highly contextual in nature further, it is a growing phenomenon, as the researcher keeps dwelling around "socialness" under various domains in different geographies. When people apply social sustainability in any domain, bit caution, and care need to be maintained as the indicators tend to vary from one domain to another. We conclude that social sustainability parameters can't be generalized and still there is research-able gaps exist in different geographies. For example, research on social sustainability in developing countries can bring in some visible and actionable results that could help in decision making and policies.

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Section 6
Critical Issues and Challenges

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Chapter 64
Energy and Carbon Footprint-Aware Management of Geo-Distributed Cloud Data Centers: A Taxonomy, State of the Art, and Future Directions

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ABSTRACT

Cloud computing provides on-demand access to computing resources for users across the world. It offers services on a pay-as-you-go model through data center sites that are scattered across diverse geographies. However, cloud data centers consume huge amount of electricity and leave high amount of carbon footprint in the ecosystem. This makes data centers responsible for 2% of the global CO2 emission. Therefore, having energy and carbon-efficient techniques for resource management in distributed cloud data centers is inevitable. This chapter presents a taxonomy and classifies the existing research works based on their target system, objective, and the technique they use for resource management in achieving a green cloud computing environment. Finally, it discusses how each work addresses the issue of energy and carbon-efficiency and also provides an insight into future directions.

INTRODUCTION

In recent years the use of services that utilize cloud computing systems has increased greatly. The technology used in cloud is not new and its main goal is to deliver computing as a utility to users. Cloud computing consists of virtualized computing resources inter-connected through a network, including private networks and the Internet. Over the years since its formation, different definitions for cloud

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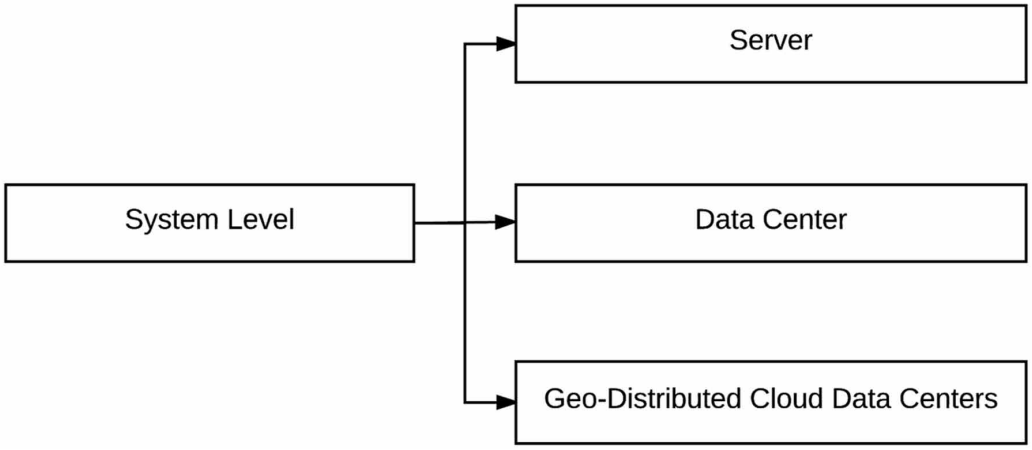
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computing have been proposed. According to the definition by the National Institute of Standards and Technology (NIST) (Mell and Grance, 2011): "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models". The three service models provided by the cloud providers are Infrastructure, Platform, and Software as a Service.

Cloud computing delivers service, platform, and infrastructure services to users through virtual machines deployed on the physical servers. Virtualization technology maximizes the use of hardware infrastructure and physical resources. Hardware resources are the servers located within the data centers. Data centers are distributed across the world to provide on-demand access for different businesses. Due to the distributed nature of cloud data centers, many enterprises are able to deploy their applications, such as different services, storage, and database, in cloud environments. By the increase of demand for different services, the number of data centers increases as well; which results in significant increase in energy consumption. According to Koomey (2008) energy usage by data centers increased by 16% from the year 2000 to year 2005. Energy consumption of data centers almost doubled during these five years, 0.5% and 1% of total world energy consumption in 2000 and 2005, respectively. Hence, during the recent years there has been a great work on reducing power and energy consumption of data centers and cloud computing systems. Recently, considering data centers carbon-efficiency and techniques that investigate cloud data centers energy sources, carbon footprint rate, and energy ratings have attracted lots of attention as well. The main reasons for considering carbon-efficient techniques are increase in global CO_2 and keeping the global temperature rise below 2°C before the year 2020 (Baer, 2008).

In the rest of the chapter, the authors provide an in-depth analysis of the works on energy and carbon-efficient resource management approaches in cloud data centers, based on the taxonomy showed in Figure 1. The authors explore each category and survey the works that have been done in these areas. A summary of all the works is given in Table 1.

Figure 1. Taxonomy of energy and carbon-efficient cloud computing data centers



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Table 1. Summary of various techniques for energy and carbon-efficient resource management in cloud data centers

Project Name	Goal	Architecture	Technique	Carbon-Aware
Dynamic right-sizing on-line algorithm, Lin. et al. (2011)	Minimize energy consumption and total cost	Single data center	Online prediction algorithms for the number of required servers for the incoming workload	No
Green open cloud framework, Lefevre et al. (2010)	Minimize energy consumption	Single data center	Predict the number of switched-on servers through providing in-advance reservation for users	No
Prediction-based Algorithms, Aksanli et al. (2011)	Maximize renewable energy usage and minimize number of job cancellation	Single data center	Use prediction-based algorithms to run the tasks (mainly batch jobs) in the presence of renewable energies	Yes
GreenSlot scheduler, Goiri et al. (2011)	Maximize renewable energy usage and minimize cost of using brown energies	Single data center	Prediction-based algorithms for the availability of solar energy and suspending the batch jobs in the absence of green energy	Yes
Multi-dimensional energy-efficient resource allocation (MERA) algorithm, Goudarzi et al. (2012)	Minimize energy consumption and maximize servers' utilization	Single data center	VM placement heuristic to split the VMs and place them on a server with the least energy consumption	No
Multi-objective VM placement, Xu et al. (2010)	Minimize power consumption, resource wastage, and the maximum temperature on the servers	Single data center	Data center global controller places the VMs based on a multi-objective algorithm to provide balance between power consumption and temperature	No
Green SLA service class, Haque et al. (2013)	Explicit SLA to guarantee a minimum renewable energy usage to run the workload	Single data center	Power distribution infrastructure to support the service and optimization based policies to maximize cloud provider's profit while meeting user's green SLA requirements	Yes
Cost-aware VM placement problem (CAVP), Chen et al. (2013)	Minimize the operating cost	Distributed data centers	VM Placement using meta-heuristic algorithms, considering different electricity prices and WAN communication cost	No
Energy model for request mapping, Qureshi et al. (2009)	Minimize electricity cost	Distributed data centers	Request routing to data centers with lower energy price using geographical and temporal variations	No
Free Lunch architecture, Akoush et al. (2011)	Maximize renewable energy consumption	Distributed data centers	VM migration and execution between data center sites considering renewable energy availability	Yes
Energy and carbon-efficient cloud architecture, Khosravi et al. (2013)	Minimize carbon footprint and energy consumption	Distributed data centers	VM placement heuristics to place the VM on the data center/cluster with the least carbon footprint and energy consumption and on the server with the least increase in power consumption	Yes
Framework for load distribution across data centers, Le et al. (2009)	Minimize brown energy consumption and cost	Distributed data centers	User request is submitted to the data center with access to the green energy source and least electricity price	Yes
Geographical load balancing (GLB) algorithm, Liu et al. (2011)	Minimize brown energy consumption	Distributed data centers	Use the optimal mix of renewable energies (solar/wind) and energy storage in data centers to eliminate brown energy consumption	Yes

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Table 1. Continued

Project Name	Goal	Architecture	Technique	Carbon-Aware
Online global load balancing algorithms, Lin et al. (2012)	Minimize brown energy consumption and cost	Distributed data centers	Route requests to the data centers with available renewable energy using online algorithms	Yes
GreenWare middleware, Zhang et al. (2011)	Maximize renewable energy usage	Distributed data centers	Submit the requests to the data center site with available renewable energy, while meeting provider's budget cost constraint	Yes
Environment-conscious meta-scheduler, Garg et al. (2011)	Minimize carbon emission and maximize cloud provider profit	Distributed data centers	Near-optimal scheduling policies to send HPC applications to the data center with the least carbon emission and maximum profit, considering application deadline	Yes
Carbon-aware green cloud architecture, Garg et al. (2011)	Minimize energy consumption and carbon footprint	Distributed data centers	Submit the user requests to the data center with the least carbon footprint, considering user deadline	Yes
MinBrown workload scheduling algorithm, Chen et al. (2012)	Minimize brown energy consumption	Distributed data centers	Copy the data in all the data centers, then based on the request deadline and the data center with least brown energy consumption executes the request	Yes
Federated CLEVER-based cloud environment, Celesti et al. (2013)	Minimize brown energy consumption and cost	Distributed data centers	Allocate the VM request to the cloud data center with the highest amount of photovoltaic energy and lowest cost	Yes
Temperature-aware workload management, Xu et al. (2013)	Minimize cooling energy and energy cost	Distributed data centers	Joint optimization of reducing cooling energy by routing requests to the site with lower ambient temperature and dynamic resource allocation of batch workloads due to their elastic nature	No
Provably-efficient on-line algorithm (GreFar), Ren et al. (2012)	Minimize energy cost	Distributed data centers	Use servers' energy efficiency information and places with low electricity prices to schedule batch jobs and if necessary suspending the jobs	No
Optimization-based framework, Le et al. (2010)	Minimize cost and brown energy consumption	Distributed data centers	Distribute the Internet services to the data centers considering different electricity prices, data center location with different time zones, and access to green energy sources	No
Dynamic load distribution policies and cooling strategies, Le et al. (2011)	Minimize cost	Distributed data centers	Intelligent placement of the VM requests to the data centers considering data centers geographical location, time zone, energy price, peak power charges, and cooling system energy consumption	No
Online job-migration, Buchbinder et al. (2011)	Minimize cost	Distributed data centers	On-line migration of running jobs to the data center with lowest energy price, while considering transport network costs	No
Spatio-temporal load balancing, Luo et al. (2015)	Minimize cost	Distributed data centers	Route the incoming requests to the data centers considering spatial and temporal variation of electricity price	No
Data centers' intelligent placement, Goiri et al. (2011)	Minimize cost, energy consumption, and carbon footprint	Distributed data centers	Find the best location for data center, considering location dependent and data center characteristics data	Yes
GreenNebula, a prototype for VM placement that follows-the-renewables, Berral et al. (2014)	Minimizing data center and renewable power plant building costs	Distributed data centers	Find the best geographical location to build data centers and renewable power plants and migrate the VMs, whenever necessary, to use a certain amount of renewables (solar or wind)	Yes

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ENERGY EFFICIENCY IN SERVERS

Servers are the physical machines that run the services requested by users on a network. Servers are placed in a rack and any number of racks can be used to build a data center. Servers along with cooling systems and other electrical devices in the data centers consume 1.1-1.5% of the global electricity usage (Koomey, 2007). Hence, power and energy management of servers by the increase in users' demand for computing resources is irrefutable. Figure 2 shows a classification of techniques that are used in data center servers to reduce energy consumption. Virtualization and consolidation are two well-known strategies that make the data center servers energy-aware. These are two powerful tools that are applied in cloud data center servers in order to reduce energy consumption and accordingly carbon footprint.

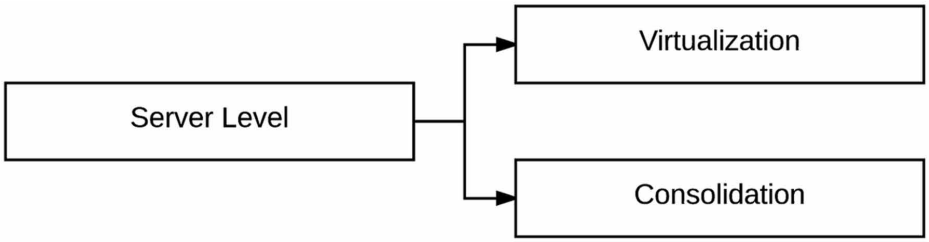
Virtualization

Virtualization technology is the main feature of data center servers that leads to less energy consumption (Brey & Lamers, 2009). By having virtualized servers and resources, and using virtualization technology several virtual machines (VMs) can be built on one physical resource. Three types of virtualization that are widely used in data centers are hardware, software, and operating system virtual machines. The VMs run on the servers share the hardware components, that helps the operators to maximize server's utilization and benefit from the unused capacity. By maximizing server's utilization, huge savings in cost and energy consumption of data centers will be made. Decrease in data centers costs and energy consumption is not the only advantage of using virtualization technology. As the average life expectancy of a server is between three to five years, data and applications need to be consolidated and migrated to another server. Virtualization helps these two techniques to be done faster and with less cost and energy.

Consolidation

Server consolidation technique benefits from emerging of multi-core CPUs and virtualization technology. It's aim is to make efficient usage of computing resources to reduce data centers cost and energy consumption (Srikantaiah, Kansal, & Zhao, 2008). Consolidation is used when the utilization of servers is less than the cost associated to run the workloads (energy cost to run servers and cooling cost for data center servers). By using consolidation, servers can combine several number of running VMs and workloads from different servers and allocate them on a certain number of physical servers. Therefore, they can power-off or change the performance-level of the rest of physical servers and reduce the energy consumption, cost, and carbon footprint.

Figure 2. Server level energy and carbon-efficient techniques



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ENERGY EFFICIENCY IN DATA CENTERS

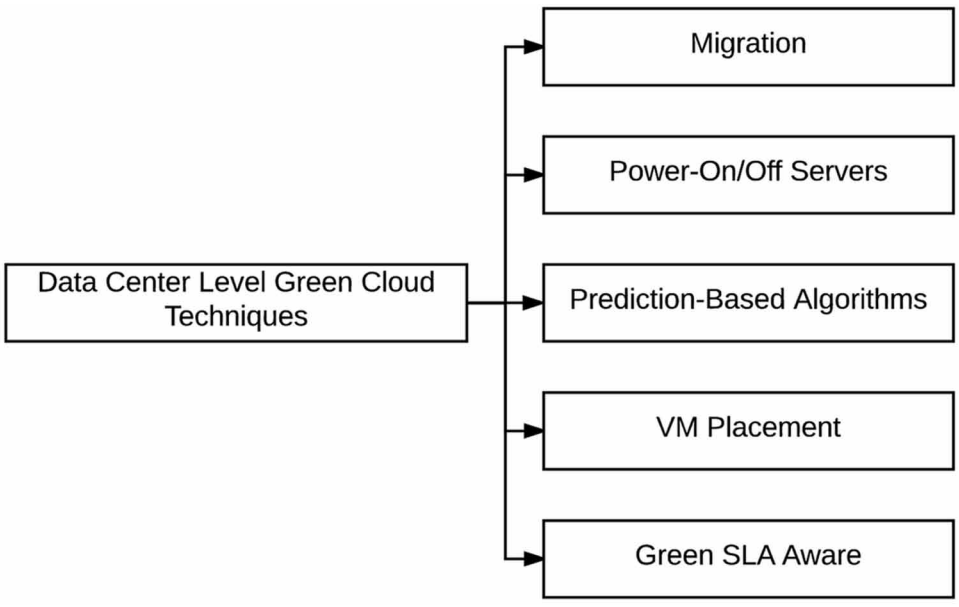
This section gives an overview of the researches that have been done at data center level to improve carbon and energy-efficiency of cloud data centers. An extensive taxonomy and survey of these techniques is done by Beloglazov, Buyya, Lee, and Zomaya (2011). Most of the works within a data center focuses on reducing energy consumption, which can indirectly result in carbon footprint reduction as well. Figure 3 classifies different approaches that have been taken for single data center. Some approaches use server level techniques (virtualization and consolidation) to migrate the current workload (user applications or virtual machines) and turn-off unused servers. Moreover, a provider could use the incoming workload pattern to place user request in the best suited cluster and server (and virtual machine for user applications) with less increase in energy consumption and carbon footprint.

Migration

Using virtualization, data center workloads migrate between servers. VM migration is the process of moving a running virtual machine from its current physical machine to another physical machine. Migration should be done in a way that all the changes be transparent to the user and the only change that user may encounter is a small increase in latency for the running VM or application.

Migration allows a virtual machine to be moved to another physical server so that the source physical server could be switched off or be moved to a power saving mode in order to reduce the energy consumption. VM migration in cloud data centers could be done off-line or live (Harney, Goasguen, Martin, Murphy, & Westall, 2007). There has been a great amount of work done in this area try to identify the VMs on the servers with low utilization that could be migrated, so that the provider can put the unused servers in idle or power-off state.

Figure 3. Data center level energy and carbon-efficient techniques



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Power-On and Off Servers

When in an idle state data centers consume around half the power of their peak utilization and power state (Barroso & Holzle, 2007). There are technologies that try to design data center servers so that they just consume power in the presence of load, otherwise they go to a power saving mode. Work that is done by Lin, Wierman, Andrew, and Thereska (2011) uses a dynamic right-sizing on-line algorithm to predict the number of active servers that is needed by the arriving workload to the data center. Based on the experiments that are done in Lin et al. (2011) dynamic right-sizing algorithm can achieve significant energy savings in the data center. We should consider that this requires servers to have different power modes and be able to transit to different states while still keeping the previous state. Moving the system to different power consumption modes is a challenging problem and requires dynamic on-line policies for resource management.

Green Open Cloud (GOC) is an architecture which is proposed by Lefèvre and Orgerie (2010) on top of the current resource management strategies. The aim of this architecture is to switch-off unused servers, predict the incoming requests, and then switch-on required servers on the arrival of new requests. GOC proposes green policies to customers in the way that they can have advance resource reservation and based on this knowledge cloud provider could estimate how many servers, and when they should be switched-on. Using this framework and strategy, they were able to save a considerable amount of energy on cloud severs.

Prediction-Based Algorithms

Aksanli, Venkatesh, Zhang, and Rosing (2012) used the data from solar and wind power installations in San Diego (MYPVDATA) and National Renewable Energy Laboratory (NREL), respectively to develop a prediction-based scheduling algorithm to serve two different types of workloads, web-services and batch-jobs. The main goal of this model was to increase the efficiency of the green energy usage in data centers. Based on the experiments of the proposed model, the number of tasks that were done by the green energy resources increased and the number of works that were terminated because of the lack of enough green energy resources decreased. This model uses a single queue per server for web services which are time sensitive applications, and for the batch-jobs it uses the Hadoop which is the general form of Map-Reduce framework.

GreenSlot scheduler (Goiri t al., 2011) also proposes a scheduling and prediction mechanism to efficiently use the green energy sources. Goiri et al. (2011) consider solar as the main source of energy and smart grid, known as brown energy, as the backup power source for the data center. The main objective of GreenSlot is to predict the availability of solar energy two days in advance so that it can maximize the use of green energy and reduce the costs associated with using brown energy. GreenSlot uses the suspension mechanism when there is not enough green energy available and based on the availability of enough solar energy it resumes the jobs. According to the experimental results that are presented in comparison with other conventional scheduling mechanisms, like backfilling scheduler (Mu'alem & Feitelson, 2001), GreenSlot scheduler can significantly increase the use of green energy for running batch-jobs and decrease the brown energy costs, which leads to less carbon footprint and moving towards a sustainable environment. Unlike web-service jobs which are time-sensitive batch-jobs are compute intensive and the deadline is not critical as web-service jobs, so the suspension will not affect the user quality of service (QoS) parameters.

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VM Placement

Users send their requests to the cloud Infrastructure as a Service (IaaS) providers in the form of VMs. Goudarzi and Pedram (2012) presented a VM placement heuristic algorithm to place the VMs in physical servers in a way to reduce data centers energy consumption. The algorithm receives the VM requests and splits each VM into several copies and places them on servers. Each copy of VM gets the same amount of physical memory but with different CPUs. The total summation of assigned CPUs for copies of a VM request will be equal to the required CPU by the VM at the time of arrival to the data center. The proposed algorithm, which is known as MERA (Multi-dimensional Energy-efficient Resource Allocation), receives the VM requests and after a certain time epoch places the VMs on the servers and calculates the consumed energy. Then, it splits the VMs and places the copies on servers and recalculates the energy consumption. Based on the calculated energies the algorithm makes decision whether to split and replicate VMs or not. This algorithm tries to increase the servers' utilization while decreasing the energy consumption without considering the physical characteristics and energy related parameters of servers and data centers. Moreover, it does not perform the VM placement dynamically. The algorithm receives a group of VMs and after a certain time epoch performs VM placement. In addition, intercommunication between replicated VMs could lead to bottleneck and high energy consumption. Finally, in the placement all VMs are treated the same. As all the replicated VMs get the same amount of physical memory, whilst for memory-intensive VMs this could result to shortage in resources and it is better to make balance between CPU intensive and memory intensive VM requests.

The work done by Xu and Fortes (2010) addresses the problem of data centers VM placement with the objective to simultaneously minimize resource wastage, power consumption, and maximum temperature of the servers. They used a genetic algorithm on the global controller of the data center to perform the VM placement. The global controller receives the VM requests and then based on a multi-objective VM placement algorithm assigns each VM to a server. This algorithm, same as the previously discussed work, performs VM placement after receiving all the VM requests, which is not in a dynamic manner. Moreover, the algorithm makes balance between power consumption and temperature. Therefore, it uses more servers to distribute the load and avoid hotspots in the data center. This might cause more carbon footprint as more servers will be used and more electricity will be consumed.

Green SLA Aware

Due to the high energy consumption by cloud data centers and climate concerns, cloud providers do not just rely on the electricity coming from brown energy sources. They have their own on-site green energy sources or draw it from a nearby power plant. Moreover, enterprises and individuals demand for quantifiable green cloud services. Haque, Le, Goiri, Bianchini, and Nguyen (2013) propose a new class of cloud services that provides a specific service level agreement for users to meet the required percentage of green energy used to run their workloads. They undertake a new power infrastructure in which each rack can be powered from brown or green energy sources. The optimization policies have the objective of increasing the provider's profit by admitting the incoming jobs, with Green SLA requirements. If cloud provider cannot meet the requested percentage of green energy to run the job should pay penalty to the user, which means decrease in the total gained profit of running jobs. The type of green energy used by Haque et al. (2013) in the data center is solar energy and they predict the availability and amount of solar energy based on the method proposed in Goiri et al. (2012). The experiments carried in their

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work are based on comparison with greedy heuristics, and they show that optimization based policies outperform the greedy ones. Furthermore, among optimization based policies cloud provider can decide whether wants to increase the number of admitted jobs or violate less Green SLAs.

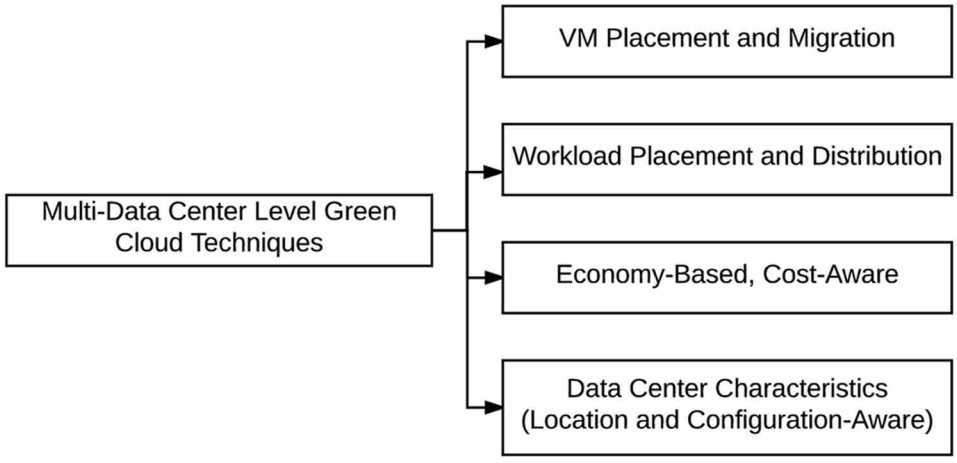
In the calculated total cost to run the admitted jobs in the work by Haque et al. (2013), it is not clear that whether it is the cost to run the servers or the total cost in the data center, including overhead energy cost as well. This is important because overhead energy is dependent on the data center power usage effectiveness (PUE) and this varies by the change in the data center total utilization and ambient temperature (Rasmussen, 2007; Goiri, Le, Guitart, Torres, & Bianchini, 2011). Therefore, the calculated value for profit in the optimization based policies would vary based on the two aforementioned parameters for different jobs with different configuration requirements and also time of the day.

ENERGY EFFICIENCY IN GEOGRAPHICALLY DISTRIBUTED DATA CENTERS

Applying different policies to switch-off and on servers and placing user requests within a data center could lead to reduce in energy consumption. But still these are not enough to solve the problem of high energy consumption and carbon footprint by cloud data centers.

By increasing the use of cloud computing services that leads to increase in energy consumption and carbon footprint in the environment, some cloud providers decided to use green energy as a secondary power plant. Therefore, the need to have a scheduling policy to select the data center site to run the user request based on the energy source is necessary. Moreover, data center selection based on considering different data centers energy efficiency, as it has a direct effect on total carbon footprint, reduces energy consumption and carbon dioxide in the ecosystem. This section explores different energy and carbon-efficient approaches have been taken across distributed cloud data centers. Some of the applied techniques are the same as single data center level, but with considering factors to select the data center site before cluster and server selection. Figure 4 shows the taxonomy of different approaches taken at multi data center level with different optimization objectives, such as minimizing cost, energy consumption, carbon emission, and maximizing renewable energy consumption.

Figure 4. Multi data center level energy and carbon-efficient techniques



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VM Placement and Migration

Research works in this area consider initial placement of a VM and further monitoring of the running VM to meet the optimization objective. Virtual machine (VM) placement in a geographically distributed data center environment requires selection of a data center and a server within the data center based on the optimization objective and data centers characteristics. Moreover, after the VM placement considering the future state of the host data center and other data centers, cloud provider can perform VM live migration to move the VM to another data center with preferable parameters. There are a few research works that consider these two techniques.

Chen, Xu, Xi, and Chao (2013) developed a model for optimal VM placement considering a cloud provider with distributed data center sites connected through leased/dedicated lines. They introduce a cost-aware VM placement problem with the objective of reducing operational cost as a function of electricity costs to run the VMs and inter-data center communication costs. For this purpose, they take advantage of variable electricity costs at multiple locations and wide-area network (WAN) communication cost to place the VMs using a meta-heuristic algorithm. Similarly, Qureshi, Weber, Balakrishnan, Guttag, and Maggs (2009) try to minimize electricity cost of running the VMs by initially placing the VMs into data centers with low spot market prices. They take advantage of spatial and temporal variations of electricity price at different locations.

Akoush, Sohan, Rice, Moore, and Hopper (2011) propose an architecture known as Free Lunch to maximize renewable energy consumption. They consider having data center sites in different geographical locations in such a way to complement each other in terms of access to renewable energy (solar and wind) by being located in different hemisphere and time zone. The architecture considers pausing VMs execution in the absence of renewable energy or migrating the VMs to another data center site with excess renewable energy. The proposed architecture provides a good insight to harness renewable energy by having geo-distributed data center sites with dedicated network. However, this model has technical challenges and limitations dealing with VM availability, storage synchronization, VM placement and migration that have been pointed out in their work.

Work done by Khosravi, Garg, and Buyya (2013) addresses the problem of energy consumption and carbon footprint of distributed cloud data centers by proposing a novel framework and algorithm for VM placement. This system model uses a component known as Cloud Information Service (CIS) in order to get the data centers' information and updates to perform the scheduling algorithm. The information a data center sends to the CIS consists of data center's available resources, energy and carbon related parameters, such as power usage effectiveness, carbon footprint rate/s (a data center might use more than one energy source), and servers' proportional power as a metric related to the CPU frequency and utilization. The cloud broker, as the interface between users and cloud provider, uses this information to perform a dynamic two-level scheduling algorithm. The algorithm places the VM in the data center/cluster with the least carbon footprint and energy consumption (first level), and in the server with the least increase in the power consumption (second-level), while meeting the users' quality of service in terms of number of rejected VMs. The proposed algorithm reduces the carbon footprint and energy consumption considerable in comparison to other competing algorithms.

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Workload Placement and Distribution

A large body of literature recently focused on reducing energy consumption and energy costs by load placement and distribution across geographically distributed data centers.

Le, Bianchini, Martonosi, and Nguyen (2009) proposed a framework to reduce cost and brown energy consumption of cloud computing systems by distributing user requests across data center sites. This is the first research that considers load distribution across data center sites with respect to their energy source and cost. The framework is composed of a front-end that receives user requests and based on a distribution policy forwards the requests to the data center site with less cost and more available green energy sources. The request distribution policy sorts the data center sites based on the percent of the load that could be completed within a time period and minimum cost to run the requests. The evaluation results show that by knowing data centers' electricity price (constant price, dynamic, or on/off-peak prices) and base/idle energy consumption of the servers', significant improvements in cost reduction will be made. Moreover, being aware of the energy sources (green or brown) in the data centers could lead to less brown energy usage with a slight increase in the total cost.

Zhang, Wang, and Wang (2011) use the idea of distributing the load among a network of geographically distributed data centers to maximize renewable energy usage. They proposed a novel middleware, known as GreenWare, that dynamically conducts user requests to a network of data centers with the objective of maximizing the percentage of renewable energy usage, subject to the cloud service provider cost budget. Experiment results show GreenWare could significantly increase the usage of renewable energies, solar and wind with intermittent nature, whilst still meeting the cost budget limitation of the cloud provider.

Following the idea of reducing brown energy consumption in data center sites, Liu, Lin, Wierman, Low, and Andrew (2011) proposed the geographical load balancing (GLB) algorithm. The algorithm takes advantage of diversity of data center sites to route requests to the places with access to renewable, solar and wind, energy sources. Considering the unpredictable nature of renewable energy, specially wind, GLB algorithm finds the optimal percentage of wind/solar energies to reduce the brown energy consumption and carbon footprint. Moreover, the authors consider the role of storage of renewable energies, when they are not available in data centers in reducing brown energy usage. Based on the experiments, by using even small-scale storage in the data centers, the need for brown energy will decrease and in some cases even will be eliminated. A question that might rise with Liu et al. (2011) work is the carbon footprint caused by the batteries in a long-term period, since renewable energy storage in the data center sites is done through reserving them in the form of batteries. Lin, Liu, Wierman, and Andrew (2012) extended the GLB algorithm to reduce the total cost along with reducing the total brown energy consumption for geographically distributed data centers. They compared their proposed algorithm with two prediction-based algorithms with a look-ahead window, known as receding horizon control (RHC) a classical control policy and an extension of RHC known as averaging fixed horizon control (AFHC) (Kwon & Pearson, 1977). The analytical modelling and the simulations carried, based on real workload traces, show that GLB algorithm can reduce the energy cost by slightly increase in network delay. Moreover, it can eliminate the use of brown energy sources by routing user requests to the sites where wind/solar energy is available.

Garg, Yeo, Anandasivam, and Buyya (2011) proposed an environment-conscious meta-scheduler for high performance computing (HPC) applications in a distributed cloud data center system. The meta-scheduler consists of two phases, mapping the applications to the data center and scheduling within

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a data center. They treat the mapping and scheduling of applications as an NP-hard problem with the objective to reduce carbon emission and increase the cloud provider profit at the same time. They run different experiments in order to find the near optimal solution for this dual objective problem. The parameters taken into account in the simulations and scheduling algorithms are data centers' carbon footprint rate, electricity price, and data center's efficiency. The simulations carried for high urgent applications (with short deadlines) and different job arrival rates help the cloud providers to decide for each application which scheduling algorithms should be used in order to meet the objective of reducing the carbon emission or maximizing the profit. Moreover, they proposed a lower bound and an upper bound for the carbon emission and profit, respectively. Another work done by Garg, Yeo, and Buyya (2011) addresses the issue of energy efficiency of ICT industry, specially data centers. The main focus of this work is to reduce the carbon footprint of running workloads on data centers by proposing a novel carbon-aware green cloud architecture. This architecture consists of two directories, which imposes the use of green energy by data centers while meeting users and providers' requirements. In this framework, cloud providers should register their offered services in the aforementioned directories, and the users should submit their requests to the data centers through the Green Broker. The scheduling mechanism used in the broker, Carbon Efficient Green Policy (CEGP), chooses the cloud provider based on the least carbon footprint while considering users QoS parameters. The performance evaluation results of the proposed framework and policy in comparison with a traditional scheduling approach shows that CEGP can achieve a considerable reduction in energy consumption and carbon footprint in the ecosystem. However, this algorithm does not work dynamically. It receives all the job requests and based on the jobs deadline assigns them to the data center with the least carbon footprint. Moreover, it only considers high performance computing applications (non-interactive workloads) with predefined deadlines at the time of submission.

Chen, He, and Tang (2012) use the idea of geographically distributed data centers to increase usage of green energy and reduce brown energy consumption in data centers. They proposed a workload scheduling algorithm, called MinBrown, that considers green energy availability in different data centers with different time zones, cooling energy consumption for data centers based on outside temperature and data center utilization, incoming workload changes during time, and deadline of the jobs. The workload used to run the simulation is HPC jobs with sufficient slack time to allow advanced scheduling. The algorithm copies all the data in all the data centers and based on the least consumed brown energy executes the task. Based on the simulation results, the MinBrown algorithm reduces brown energy consumption in comparison to other competitive algorithms. The idea of replicated data in distributed data center sites itself results to high energy consumption that is not considered in Chen et al. (2012) work. Moreover, assignment of the jobs and tasks are based on the availability of green energy, that does not consider communication between tasks of the same job and jobs of the same workload. Finally, the scheduler does not consider an efficient resource assignment within a data center in a way to reduce the need for future consolidation of the running jobs.

The idea of federation of cloud providers can be useful for relocation of computational workload among different providers in a way to increase the use of sustainable energy. Celesti, Puliafito, Tusa, and Villari (2013) take advantage of a federated cloud scenario to reduce energy costs and CO_2 emissions. They consider cloud providers' data centers are partially powered by renewable energies along with getting the required electrical energy from electrical grids. The main contribution of their work is based on the approach of moving the workload towards the cloud data center with most available sustainable energy. This is inspired by the fact that if a provider generates more green energy than its

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need, it would be difficult to store the exceeded amount in batteries or put it in public grids; therefore, the easiest way is to relocate the workload to the site with the excess renewable energy. The architecture is based on an Energy Manager, that is known as CLoud-Enabled Virtual Environment (CLEVER). By applying CLEVER-based scenario, the VM allocation would be based on the energy and temperature driven policies. The energy manager in the architecture receives different data centers' information, such as temperature, sun radiation, energy grid fare, photovoltaic energy, cost, and data centers' PUE and number of available slots or physical resources, and based on this data assigns VMs to the site with the most sustainable energy and least cost.

Celesti et al. (2013) work increases the use of sustainable energies and it is based on the availability of the photovoltaic (PV) energy. When a site has a high value for the PV energy, the outside temperature would be higher and this will increase the need for more energy for the cooling, and as a result higher PUE value. Relying only on the amount of used PV in the system is not enough for a green and sustainable system. Cloud providers should consider the whole picture and take into account all the parameters that affect the total CO_2 emission. Moreover, Celesti et al. (2013) assume that each new VM request would be replicated in all the federated providers. Considering the consumed energy for this replication and the effect of network distance are also important that should be considered by the time of system design.

Xu, Feng, and Li (2013) take advantage of diversity in data centers location to route the incoming workload with the objective of reducing the energy consumption and cost. They studied the effect of ambient temperature on the total energy consumed by cooling system, which is 30% to 50% of the total energy consumption of data centers (Pelley, Meisner, Wenisch, & VanGilder, 2009; Zhou et al., 2012). Energy consumption often is modelled as a constant factor, which is an over-simplification of what is happening in reality. Xu et al. (2013) considered partial PUE (power usage effectiveness) to participate cooling systems' energy along with the servers' total energy consumption. Through using partial PUE data centers can route the workload to the sites that use outside air cooling and reduce considerable amount of energy consumption. Moreover, they took advantage of having two types of incoming requests to manage the resources and reduce the energy consumption. The proposed model does not only depend on the energy consumed by interactive workload form users, instead it reduces energy costs by allocating capacity to the batch workloads, which are delay tolerant and can be run at the back-end of the data centers. The proposed joint optimization approach could reduce cooling energy and overall energy cost of data centers.

However, the proposed partial PUE only considers the energy consumed by cooling system as the total overhead energy in the data center. Based on the introduced definition by Xu et al. (2013), PUE is mainly dependent on the ambient temperature, while IT load of the data center is the second important factor affecting the PUE (Rasmussen, 2007). Finally, source of the energy used to generate the electricity and its carbon footprint is not considered. This is important because as mentioned earlier reducing energy cost does not necessarily lead to reduce in the carbon footprint in the environment.

Economy-Based, Cost-Aware

Cost associated with energy usage in large data centers is a major concern for the cloud providers. Large data centers consume megawatts of electricity, which leads to huge operational costs. Work done by Ren, He, and Xu (2012) takes advantage of different electricity prices in different geographical locations and over time to schedule batch jobs on the servers in scattered data centers. Their proposed online optimal algorithm, known as GreFar, uses servers' energy efficiency information and locations with low elec-

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tricity prices to schedule the arrived batch jobs from different organizations. GreFar's key objective is to reduce energy cost, while assuring fairness considerations and delay constraints. The scheduling is based on a provably-efficient online algorithm, that schedules the jobs according to the current job queue lengths. Based on the simulation results, GreFar online algorithm can reduce system cost, in terms of a combination of energy cost and fairness, in comparison to the offline algorithm that has knowledge of system's future state. The algorithm's main contribution is to serve the jobs when the electricity price is low or there are energy-efficient servers in the system. To accomplish this objective, it queues jobs and suspends low priority jobs whenever the electricity price goes up or there are not enough efficient servers in the system. This approach is not applicable for interactive jobs and web requests that are time sensitive and need to be served immediately from the queue and also cannot be suspended. Moreover, the cloud provider does not consider the cost of the transmission network and its energy consumption at the time of data center selection to submit the job request.

Le, Bianchini, Nguyen, Bilgir, and Martonosi (2010) take advantage of capping the brown energy consumption to reduce the cost of serving Internet services in data centers. They proposed an optimization-based framework to distribute requests among distributed data centers, with the objective to reduce costs, while meeting users' service level agreement (SLA). The main parameters that affect the site selection by the framework are different electricity prices (on-peak and off-peak loads), different data centers location with different time zones, data centers with access to green energy sources, which enables the data center to have a mixture of brown and green energy. The front-end of the framework performs the site selection and optimization problem for the arrived requests periodically, in contrast to heuristic algorithms, which are greedy and select the best destination for each request that arrives (Qureshi et al., 2009). The optimization framework uses load prediction by Auto-Regressive Integrated Moving Average (ARIMA) modeling (Box, Jenkins, Reinsel, & Ljung, 2015) and simulated annealing (SA) (Brooks & Morgan, 1995) to predict the load for the next epoch (one week) and schedule the requests. This approach helps the front-end to decide about the power mixes at each data center for the next week, unless a significant change occurs in the system and predictions. Le et al. (2010) use simulation and real system experiments with real traces to evaluate their proposed framework and optimization policy. The evaluation results show that by taking optimization policy and using workload prediction, diversity in electricity price, taking benefit of brown energy caps, and use of green energy sources significant savings in cost related to the execution of Internet services in distributed data centers would be made. The framework assumes that all the received requests from the users are homogeneous. While in the real systems this is not the case and having heterogeneous requests and distributing them in a way to reduce resource wastage is very difficult and itself results to huge energy consumption and accordingly high costs. Moreover, it focuses on the electricity prices in different locations without considering the carbon footprint rate of the sources. Since some brown energy sources, which are cheap and lead to reducing the system overall cost, may lead to huge amount of carbon dioxide in the ecosystem.

The other work by Le et al. (2011) investigates different parameters that affect the electricity costs for geographically distributed data centers with the focus on IaaS services that run HPC workloads. According to their proposed cost computation framework for the data centers, there are two important parameters that affect the total cost, energy consumed to run the service and the cost for the peak power demand. The provider can reduce the consumed energy by selecting the sites with off-peak period electricity prices, lower outside temperature, and lower data center load, so that the energy used for cooling would be low. Because as the data center temperature rises, the provider needs to use chillers to reduce temperature, which increases the energy consumption dramatically. In order to show this relation, they

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used a simulation model for the data center cooling system. Based on the simulation model, increase in the outside temperature and data center load forces the providers to use the chillers in order to keep the data center cool. This simulation has been carried with real workload traces from the Feitelson (2007), Parallel Workloads Archive. Le et al. (2011) compared their two proposed algorithms, cost-aware and cost-aware with migration, with baseline policies. Based on the results, considering above mentioned factors can reduce the energy cost of data centers. Moreover, predicting the need to use the chillers for system cooling and considering the transient cooling prevents the data center from overheating and would not let spikes in the temperature.

Le et al. (2011) conducted sensitivity analysis to investigate the effect of parameters, such as predicting the run-time of the jobs, the time to migrate the jobs, outside temperature, price of the energy in a region, and size of the data center on the total cost of the data center. According to the simulation results, in order to maximize the cost-saving all the electricity-related parameters should be considered in job placement in the system. One of the shortcomings of this work, similar to the previously discussed work, is not considering the source of electricity. As some brown energy sources with high carbon footprint might be cheaper and more desirable to run the services. Moreover, as the temperature changes during the day and the consumed energy for cooling changes consequently; PUE should be modelled as a dynamic parameter instead of having a constant value per data center. Considering network distance and the energy consumption of intra and inter-data centers will also affect the total cost.

Work by Buchbinder, Jain, and Menache (2011) has also the objective of reducing energy cost for a cloud provider with multi data center sites but with a different approach. They perform on-line migration of running batch jobs among data center sites, taking advantage of dynamic energy pricing and power availability at different locations, while considering the network bandwidth costs among data centers and future changes in electricity price. The total cost in their model, is the cost of energy to run the jobs at the destined data center plus the bandwidth cost to migrate the data. To attain an optimal algorithm with lower complexity comparing the optimal off-line solution, Buchbinder et al. (2011) proposed an efficient on-line algorithm (EOA) with higher performance comparing to the greedy heuristics that ignore the future outcomes. The calculated cost in their work is based on the data centers' operational cost, which focuses on the energy consumption by servers and transport network. However, a considerable part of the energy consumed by a data center is related to the overhead energy, such as cooling systems. Moreover, the objective of reducing the energy cost and routing the jobs to the data center with lowest cost without considering the energy source might lead to increase in the carbon footprint in the environment. The migration of running jobs in this work is in the context of batch jobs, which are delay tolerant in comparison to user interactive requests such as web requests that are delay sensitive. Therefore, the applicability of this algorithm should be investigated for other workloads and user requests in a cloud computing environment. Similarly, work by Luo, Rao, and Liu (2015) leverages both the spatial and temporal variation of electricity price to route the incoming requests between geographically distributed data centers targeting energy cost minimization.

Data Center Characteristics (Location and Configuration-Aware)

There are several works try to make data centers energy and carbon-efficient by reducing the number of active servers or run the virtual machines and applications on the physical machines with the least energy consumption and carbon footprint rate. However, geographical location of the data center has a direct impact on the amount of consumed energy that leads to CO_2 emission in the ecosystem. Work done by

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Goiri et al. (2011) considers intelligent placement of data centers for Internet services. Their goal is to find the best location for data center site to minimize the overall cost and respect users' response time, consistency, and availability. They classified the parameters that affect data centers overall cost into location dependent and data center characteristics data.

The location dependent data specifies the data center's distance to the network backbones, power plants, and the CO_2 emission of the power plant. Moreover, it includes the electricity, land, and water price. The last and one of the most important factors related to the location is the outside temperature. Since, when the temperature goes high the need for cooling increases as well. Cooling system is an important parameter in the data centers, which its energy consumption increases as outside temperature increases. Indeed, high temperature leads to need for more chillers and more chillers increases data center's total energy consumption. This situation eventually leads to higher PUE and energy consumption, which indirectly increases carbon footprint. Goiri et al. (2011) propose a framework to find the most optimum location for the data center to minimize the total costs. Explicit decrease in data center's cost, leads to indirect decrease in energy consumption and carbon footprint.

In order to increase the use of renewable energies, Berral et al. (2014) propose a framework to find the best location to site the data centers and renewable power plants, solar and wind in their work. In the meantime, their objective is reducing total cost for building these infrastructures to support cloud HPC services with different amounts of renewable usage. Berral et al. (2014) divided the costs of building green cloud services into capital (CAPEX) and operational (OPEX) costs and CAPEX itself is divided to costs dependent and the costs that are independent to the number of servers to be hosted. Independent CAPEX costs are cost of bringing brown energy to the data center and connecting to the backbone network. Land cost, building green power plants, cooling infrastructure, batteries, networking equipment, and servers are part of the dependent CAPEX costs. Costs incurred during the life cycle of the data center, such as network bandwidth and amount of brown energy usage are part of the OPEX. Brown energy consumption is the total energy needed by the servers and overhead parts, such as cooling and networking, minus energy derived from renewables. To calculate the overhead energy, Berral et al. (2014) use PUE as a parameter related to the location temperature. It should be noted that temperature is not the only parameter that affects PUE, data center load is also an important parameter that changes PUE value (Rasmussen, 2007).

In order to take the most of the generated renewable energy in different data centers, Berral et al. (2014) compare different approaches such as net metering, which is directing the excess renewable energy into the grid and mix it with brown energy, using batteries and having storage for renewables or not having any storage and migrating the load to the sites with available solar or wind. One of the shortcomings of their work is neglecting the network delay and amount of energy consumed due to VM migration, as the

data centers are scattered at different geographical locations. Moreover, all the data in this system are replicated at all the sites, which itself imposes overhead and increases energy consumption.

CONCLUSION AND FUTURE DIRECTIONS

In this chapter, the authors studied the research works in the area of energy and carbon footprint-aware resource management in cloud data centers. They first had an overview on the existing techniques in green cloud resource management with the focus on a single server and a single data center and the limitations facing these techniques, specially not being able to harvest renewable energy sources at different locations.

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The authors then focused more specifically on the works considering geo-distributed cloud data centers, as nowadays most of the big cloud providers have data centers in different geographical locations for disaster recovery management, higher availability, and providing better quality of experience to users.

A large body of literature in the context of distributed data centers considers assigning resources to the arrived requests in such a way to minimize brown energy consumption. They use different techniques such as applying VM placement heuristics, workload scheduling, and targeting data centers with the most available renewable energy. These works explicitly consider access to renewable energy sources to minimize brown energy consumption and carbon footprint. However, some of the research works achieve energy efficient resource management through minimizing cost and the cost of brown energy usage, which indirectly could lead to less carbon footprint in the ecosystem.

Research in the area of energy and carbon-efficient resource management in data centers is still an important field of work. Apart from the surveyed techniques in this chapter, there are still areas that can be pursued by researchers. VM migration across data center sites to harvest the renewable energy sources is still at its early stages. First of all, it is important to study the effect of minimizing brown energy usage and carbon cost versus network cost and delay imposed due the data transfer over the network. Selecting the VMs to migrate depending on the application running on top of the VM with respect to users' service level agreement is also another area of future study.

There are studies that consider storing excess renewable energy in batteries to use at times of the day that renewable sources are not available. Since main cloud providers started to build their own on-site renewable energy sources and having large scale renewable energy power plants, studying the cost-effectiveness of storing the renewable energy for future usage and contributing to the electrical grid is an important area for future study.

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Chapter 65
Factors Influencing Foreign Land Acquisition and Sustainable Development in Nigeria

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ABSTRACT

Of the major factors of production, land is considered the most important. Land is such a valuable resources that the desire to acquire it has been a cause of struggle among the people virtually in all hitherto existing human societies. Land acquisition is influenced by numerous factors in which all play relevant roles in understanding the dynamics of land and its utilization among the people in the society. In Africa, foreign land acquisition has become a topical issue because of the richness of the African land resources, and the scamper for these resources has been a source of concern for many observers. This chapter analyzes the factors inhibiting foreign land acquisition in a developing country like Nigeria and examines the challenges posed by such practices to the attainment of sustainable development.

INTRODUCTION

Land is fundamental to human life in many ways. Apart from the fact that it is the place of dwelling, there is virtually no human activity that could be achieved without considering the land factor. All human endeavours from religious to economic and even political activities take place on the land (Adedipe, Olawoye, Olarinde, Okediran, 1998). The Creationist theory of human evolution conceived that man is

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created from land and he would eventually return into it after his demise (Quran 20:55 and Genesis 2:7). Land is a free gift of nature and a fundamental necessity of life because it remains the platform on which the social, political and economic activities of a society dwell upon (Enikuomehin, 2005).

The importance of land in human general life could also be inferred from the fact that food, clothing and shelter which are the basic essentials of human living have substantial linkages to land. "Foods grow out of land while shelter is affixed to it, and man's clothing is made largely from what grows out of land" (Babalakin, 2004:1) cited in Famuyiwa & Omirin (2011). In other words, whether in ancient times or modern society, land constitutes a significant index and an unavoidable necessity for socio-political and economic development. There is hardly any social, political or economic venture that does not require land. No wonder the classical economists such as Adams Smith and Alfred Marshal classified land as one of the fundamental factors of production (Alade, 2005). Land is an essential economic commodity. It is limited in supply and as such; the demand for it often outweighs its supply.

Land has an enormous importance to people's life generally. However, despite its huge importance, it is limited in supply. According to Alade (2005), land accounts for approximately 20% of the whole earth surface and it is not everybody or all nations that has it in abundance because of its finite quantity and essential quality. There has always been a high quest to acquire it by all and sundry. A search into the economic history of many human societies revealed several social conflicts among tribes and within nations all as a result of struggle for land acquisition. This is because of the significant relationship that exists between land acquisition and the general development of the nation. Land is a fundamental factor of production in the agricultural sector; it has an essential role to play in increasing as well as sustaining agricultural production. The extent to which this role is performed is determined in part by methods of land acquisition and arrangements for the ownership and use of land. Aside agriculture, land is also useful and needed for various other human activities which would make life easier and better for the human folk.

Land acquisition pattern do enhance the general developmental status of a nation and it has been empirically examined through the history of all hitherto existing societies that land play enormous roles in the political economy of the people in a given society. However, despite the prominent relevance of land in man's life, it is also generally influenced by several factors. Therefore, it is important to consider these factors because of the important roles that land acquisition system plays in attaining sustainable socio-economic development of any nation. Such an effort will go a long way in enhancing the optimal utilization of land resources in our nation and it would also go a long way in bringing about the socio-economic sustainable development that is generally lacking in a country such as Nigeria. It is against this background that this chapter wants to examine the linkages among the varying factors determining land acquisition, land acquisition patterns and sustainable socio-economic development in Nigeria.

CONCEPTUAL DISCUSSION

In order to make the work more comprehensive, there is the need for conceptual clarification of terms relevant to the chapter.

Foreign Land Acquisition

The history of foreign land acquisition in Africa could be traced to the coming of major European powers, such as Portugal, Spain, France and Great Britain, to Africa in search for Africa's rich mineral and

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agricultural resources. The struggle for African lands and natural resources culminated into the popular Berlin Conference of 1884/85 in Germany which eventually led to the scrambling and partitioning of African lands. It could even be right to argue that the whole essence of imperialism and colonialism is about struggle for land acquisition. This brief insight is a pointer to the fact that, the issue of foreign land acquisition in Africa is a discourse that has a long time outstanding history. Conceptually, land acquisition could be described as the act of acquiring piece of land or large pieces of land for private or public use. Land acquisition takes the form of legal or illegal, willing or forceful acquisition of land belonging to other person or groups for private or public use. Inferring from the above, foreign land acquisition could be described as the act of acquiring (usually a large portion) a piece or pieces of land by individual or individuals who are not citizens of the community in which the land is acquired. More often than not, economic factors have always been the fundamental determinants of foreign land acquisition in many developing countries like Nigeria. In addition to economic variables, political factors could be another reason for land acquisition. In other words, because land is such a valuable political-economic resources, there has always been a high quest to acquire it by people virtually everywhere around the globe.

The political and economic history of the world clearly shows that foreign land acquisition has been a common practice in many human societies. Foreign land acquisition is so common even in traditional societies that this has always be the source of misunderstanding, conflict and sometimes outright war among many rulers in the world from time immemorial. For instance, many notable personalities in the history of mankind became very popular due to their ability to conquer foreign lands. Warriors such as Alexander the Great, Julius Cessare, Ibn Batuta, among others, are relevant examples to be cited in this direction. Indigenously, some personalities such as Uthman Dan Fodio and some rulers in the old Oyo Empire are practical examples of individuals who made history by conquering foreign lands in order to acquire landed properties. Similarly, historical names such as Adolf Hitler of Germany become a name to reckon with in human history due to his ability to conquer foreign lands, though, his thirst to capture more foreign territories led to his eventual demise. Furthermore, empirical examples could be cited of Western nations that gained enormous political and economic advantages due to their ability to conquer foreign lands. These nations were able to solve their huge and pervasive political and economic problems when they conquer foreign lands and incorporated them (the acquired lands) into their political and economic domains (Frank, 1967; Galtung, 1971). In other words, the acquisition of foreign lands by these nations eventually contributed to their remarkable economic success (Walter, 1973).

Specifically, the persistent and recent rush by the countries in the Gulf Region and Far East Asia for land acquisition in Africa was triggered by global financial crisis of 2008 which created a vacuum for international capital investment. Consequently, there has been rapid interest in establishing large farmlands in Africa regions in order to make up for the deficiency in food supply faced by those regions (Deininger, 2003a). The International Land Coalition describes this development as global commercial pressures on land and technically refers to the phenomenon as land acquisition (Matondi, Havnevik & Beyene 2011). What could be inferred from the above discussion is that foreign land acquisition is a common phenomenon in human societies since the traditional period to modern times. Although, the reason for foreign land acquisition in the past was majorly through force and mainly done for political-economic reasons, but lately, there has been some changes in the trends of foreign land acquisitions as one of the major reason why the practice is still been held is due to the problems of food shortage and the global economic meltdown. In other words, foreign land acquisition has been one of the means of showing political strength of a nation, a way of making up for food shortages and a necessary condition for economic development of many human societies.

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Observing from a political-economy perspective, Friis & Reenberg, (2010) cited in Usman (2013) described land acquisition essentially as grabbing for control. That is grabbing the land and other associated resources in order to derive benefits from such resources. Fundamentally, land could be acquired for various reasons but most recent literatures such as Von-Braun & Meinzen-Dick (2009), Odhiambo (2011), and Daniel & Birhanu (2012) often see agricultural factor as the only reason why lands are acquired in recent times, ignoring the fact that land could be acquired for other various developmental activities. The latter argument could be supported by recent happenings which have shown that the acquired communal lands in some communities were used for the creation of roads, railways, harbours, and airport; construction of hospitals, schools; rural and urban electrification; provision of water and sewage facilities; urban expansion; establishment of national parks; mineral exploration; and logging of forests.

Sustainable Development Conceptualized

Although sustainable development is the term to be conceptualized, such conceptualization would be more meaningful if one examines the concept of development first. According to Olatunji (2011); every nation strives for development; this is because development is one of the basic necessities of modern life. Development is a holistic concept; it is multi-dimensional and generally inter-related. It is related to all spheres of life vis-à-vis political, economic and cultural development. Development is a difficult concept to define because it is a relative, ambiguous and complex. According to Walter (1973); development can be examined from two major perspectives: the individual and societal perspectives. At the level of individual, development is the ability of an individual to develop its innate capacities to the extent that he/she would be useful for him/herself and the society. From societal or macro perspective, development could be defined as the ability of a group or a given set of people to harness their physical environment in such a way that life will be easier and better for them. In this respect, a development cannot be worthwhile until it is sustainable.

Sustainable development is a term widely used by political and economic stakeholders all over the world, even though the notion lacks a uniform interpretation (Robert, *et.al.* Thomas & Anthony, 2005). It can be argued that the term is quite relative because the notion of sustainability varies among scholars from various disciplines and the actualization of sustainable development in any nation will cut across various sectors of the society. As early as the 1970s, the word sustainability was employed to describe an economy in equilibrium with basic ecological support systems. The term become popular after it was used by the Brundland Commission in its 1987 Report famously tagged "Our Common Future". In the Report, the Commission coined what has become the most often-quoted definition of sustainable development. The term was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition contains some important elements. A sustainable developed system is that which:

1. Can meet the need of the present generation.
2. Would cater for the rich and the poor.
3. Would not have a devastating effect on present and future human ecology.
4. Would not affect the upcoming generations negatively.

The above definition is similar to the view of the World Conservation Union (1991) cited in Centre for Environmental Education (2007) which sees sustainable development as the general improvement

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in the quality of life while living within the carrying capacity of the ecosystems. In the words of Solow (1999) cited in Collier & Hoeffler (2004), if sustainability is anything more than a slogan or expression of emotion, it must amount to an injunction to preserve productive capacity for the indefinite future. What could be inferred from the foregoing is that most of the definitions of sustainable development are influenced by either the economists or the ecologists conception with each defining the concept from his/her own basis of understanding. Toman (1999) captures the concept from both economist and ecologist perspectives as: system of positive change in the society which take cognizance of the whole sector of the society and which will not be causing damage to the eco-system for the present and future generations.

Furthermore, the 2002 World Summit on Sustainable Development presented three angles of sustainable development which are: economic development, social development and environmental maintenance. In this perspective, three variants of social development can be inferred. These are: (1) 'social' which includes social development, social progress, and positive social change in terms of general conditions of life. (2) 'human' which has to do with general human development in terms of morals, character and feelings, i.e. development which takes the well-being of the entire human community as important; and (3) "justice and equity" which has to do with social justice, equity and poverty alleviation. This perspective of sustainable development held that development cannot said to be sustainable unless it takes the importance of rule of law, equality before the law and upholding fundamental human rights into cognizance.

In the same vein, attempts have been made by some other scholars such as Toman (1999), Tatyana (2004), and Adebayo (2010) to conceptually classify the important elements of sustainable development into three. These are environmental, economic and social sustainability. With such conception, a social system can be said to be sustainably developed only if such a system can maintain an equilibrium level of development taking those three elements into cognizance. Furthermore, others such as Usman (2013) have suggested possible ways to delineate the concept. For example, the Circle of Sustainability Approach identified four important elements as constituting sustainable development. These are economic, ecological, political and cultural sustainability. Some scholars have gone ahead to include another important element of sustainability known as 'institutional' or 'good governance'.

According to Kundan cited in Ugoh (2008), the concept of sustainable development is the efforts at improving the environment or natural resources for the purpose of improving the quality of human life in such a way that the needs of the future generation are not jeopardized. In this regard, sustainable development is an organizing principle for human life on the planet earth. This author posits a desirable future state for human societies in which living conditions and resources meet human needs without undermining the sustainability of natural systems and the environment, so that future generations may also have their needs met. Sustainable development ties together concern for the carrying capacity of natural systems with the social and economic challenges faced by humanity.

Technically, sustainable development must be able to provide answers to the following questions: What are the needs to be sustained? What needs to be developed? What needs to be sustained is the nature which comprises of the earth, (land) biodiversity, the ecosystems, community (cultures, groups, and places). What need to be developed are the people (child survival, life expectancy, education, equal opportunity; economy, wealth, productive sectors, consumption, society institutions, social capital, states, and regions) are the social facts that needs to be developed. In other words, development can only be said to be sustainable if it take these factors into consideration. It could be deduced from the discussion on sustainable development thus far that the land factor plays an immense role to achieve sustainable development in any human society. This is so because land form an important part of human ecology

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and as such it is important to note that, a system can only said to be developed if land and its constituted resources are optimally utilized and not negatively affected for the present and the future generations. In essence, land and its constituted resources must be utilized optimally before sustainable development could be achieved in any given society. To further elaborate the importance of land factors in sustainable development process of any nation, some theoretical models are used to explain this further.

THEORETICAL MODELS

In order to make this discussion more scholarly robust, attempt has been made to use some relevant theoretical models to explain the importance of land in the general developmental process of the society. Two theoretical models were adopted in this chapter. These are the Three Pillars Model (TPM) and the Egg of Sustainability Model (ESM).

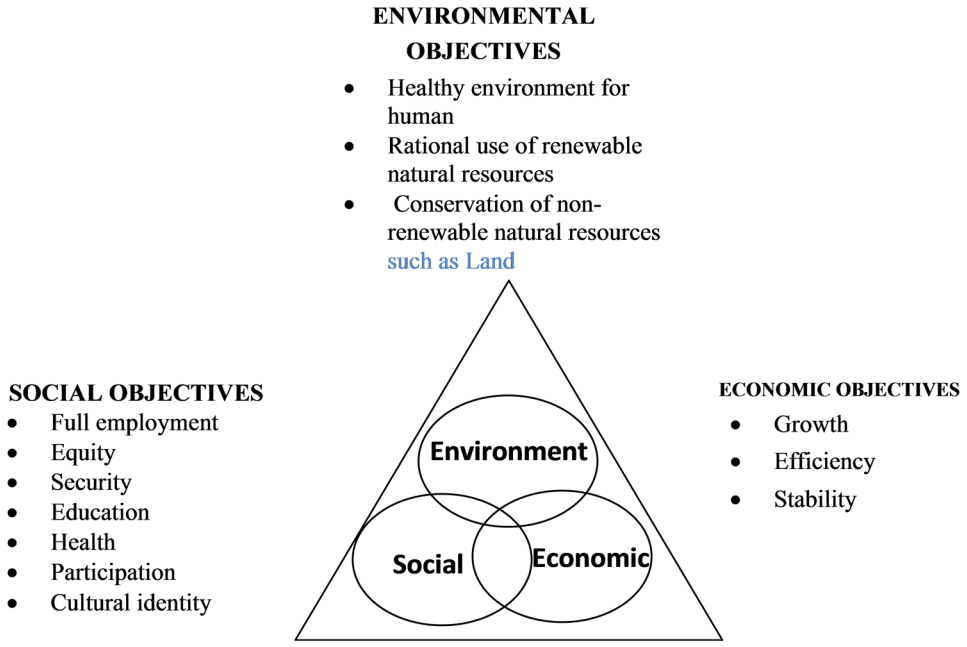
Three Pillars Model (TPM)

Three pillars model of sustainable development was popularized through the work of Tatyana (2004). According to this model, sustainability is like a structure which needs three important pillars to stand on, this means that some important pillars are necessary as a frame to make sustainable development possible, these three pillars according to this school are: economic pillar, social pillar and environmental pillar. The economic pillar encompasses developmental factors that have to do with economic viability of the people which on the longrun will lead to macro economic development in the society. Other indicators of the economic pillar are economic growth, productivity, efficiency, economic stability and so on. On the other hand, the social pillar includes those areas of living that has to do with socio-cultural dynamics of people's life. This pillar embraces factors such as full employment, equity, security, peace, education, health, popular participation, cultural identity, harmonious relationship among the people of the world, cultural preservation, etc. The environmental pillar includes issues such as healthy environment for human living, rational use of renewable natural resources such as land, and conservation of non-renewable resources.

Adapting this model to our present situation, the model could be used to justify the fact that development is a multi-dimensional phenomenon because it cuts across various aspects of human living vis-à-vis economic, social and environmental spheres. And that it is until the developmental process of a society is able to maintain an equilibrium in all these sectors before it can be regarded as being sustainable. Moreover, it could be deduced from the three pillar model that the land which is an important component of the physical environment is an important factor that determines the sustainable status of development process. In other words, the relevance of this model to this chapter is quite visible in the sense that land is an important pillar or foundation on which sustainable development could be achieved. Narrowing the application of this model to the Nigerian situation, it could be said that Nigeria as a country has not been able to witness sustainable development because it has not fully utilized its land resources. And because lands are not properly utilized, the country is unable to witness rapid and meaningful socio-economic development. The basic conception of the three pillars model is presented in the diagram below.

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Figure 1. Diagram showing the conceptual schema of the Three Pillars Model
Source: Tatyana (2004)



In the triangular relationships among the three pillars, it could be deduced from the figure that environment which land constitutes its major component is placed above the other two pillars. This is an indication to the fact that land constitutes the basis for any meaningful development in any human society. More so, this is a pointer to the fact that land is an important component not only to sustainable development but even to the other two fundamental pillars of sustainable development.

As could be seen from Figure 1 above, The Three Pillar Model presents a perfect theoretical frame for the understanding of the obvious links between societal pillars and the achievement of sustainable development in the society. The model has also been able to bring out the importance of land factor in the attainment of sustainable development of a nation but it fails to emphasize the impossibility of achieving an equilibrium level of sustainability through the three pillars. Despite the above palpable shortcomings, the Three Pillar Model has been able to bring out the substantial importance and relevance of land in achieving sustainable development in any human society.

The Egg of Sustainability Model (ESM)

The second theoretical model adopted in this paper is the Egg of Sustainability Model. This model was built in 1994 by the International Union for the Conservation of Nature (IUCN). The model illustrates the relationship between people and ecosystem as one circle inside another, like the yolk of an egg (Figure 2). This implies that the people are within the ecosystem, and that ultimately one is entirely dependent upon the other. In this sense, social, economic or any form of development can only take place if the environ-

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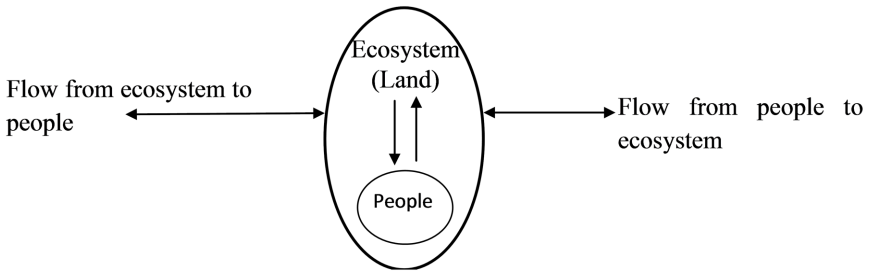
ment offers the necessary resources: land, raw materials, production sites and so on. Making inference from the conception of this model, it could be said that human development is entirely depending on the eco-system in which land is part and parcel of it. In this manner, land is highly crucial in achieving meaningful and sustainable national development in any human society generally and Nigeria specifically. It is the belief of this model that the eco-system and human development are super-coordinated system.

Furthermore, the Egg of Sustainability model is one model which stresses the importance of natural resources (especially land) in the general development of any nation. Another important inference that could be drawn from this model is that the extent at which a state or a country would witness sustainable and meaningful socio-economic development is highly dependent on the level on which such state or society is able to utilize its land and other natural resources. This is because, it seems development is lying fallow in nature (the eco-system) and it is through our ability to explore and utilize these resources that will determine the level of sustainable development witnessed in the country. Adapting this particular idea to the Nigerian society, it could be said that Nigeria is a country that has very great potentials to be a great nation, considering the available natural resources lying fallow within its eco-system. But, because of its inability to utilize these land resources effectively, the country is facing serious socio-economic problems, as millions of its population is living in abject poverty, and the youth unemployment is persistently increasing. In other words, the conception of this model is that if a country such as Nigeria wants to experience rapid and sustainable development, it should be able to put enormous interest on how to develop its land resources effectively.

Generally, the level of relationship between the eco-system and the attainment of sustainable development in a country could be further understood through the diagram presented in Figure 2.

As could be seen from the preceding discussion, the Egg of Sustainability model is used to explain the level of inter-dependent relationships between people and the level of land utilization and also that the achievement of sustainable development in a society is dependent on the extent at which the people could utilize their land resources. However, this model could be faulted on the premise that it has narrowed down the utilization of land to the quality of people's management of it. The model, in this sense, has neglected certain instances where the land resources are not viable to be explored. Besides, some natural occurrences such as drought, desertification, landslides and many other natural occurrences could cause a situation where proper utilization of land would be impossible even if the people are willing to do so. In spite of this limitation, the model is justifiable or useful for the analysis of high level of interconnection between the quality of people as a determinant for proper land utilization and the appropriate utilization of land resources would eventually lead to sustainable development.

Figure 2. The egg of sustainability model
Source: (IDRC, 1997) cited in Centre for Environmental Education (2007)



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FOREIGN LAND ACQUISITION AND SUSTAINABLE DEVELOPMENT: THE NEXUS

The recent intensification of foreign land acquisition in developing countries is triggered by two major socio-economic factors. These are: global food crises of 2007/2008 and global financial crisis of 2008. The global financial crisis of 2008 greatly affected most food-importing countries such as Saudi Arabia, Qatar and United Arab Emirates which hitherto referred to as the Gulf States. One of the reasons these countries are massively affected is because they were tremendously constrained by insufficient land and shortage of water, but rich in capital and seriously in need for agro product. Also, countries with extremely large populations such as China, South Korea and India faced the problem of food insecurity arising from rising rate of population growth. Thus, considering the changing global atmosphere and economic terrain, the agricultural sector clearly requires more investment (Deninger, 2003b).

As a result, there is the need for the Gulf States and countries in the far-East Asia to spread their investment tentacle outward in order to be able to tackle the problem of food scarcity they are being confronted with (Lambin, Geist & Lepers, 2003). And because Africa is a continent with rich arable lands and other physical and natural resources, Africa becomes one of the best regions to explore in this regard. Mbow (2010) argued that African continent became attractive destination for foreign land investors due to its potential and actual richness in agricultural and other natural resources. According to a joint study conducted by the Food and Agricultural Organization (FAO) and the International Institute for Environment and Development (IIED) in 2008, the study found out that since 2004, there has been nearly 2.5 million hectares worth of approved land allocations in just five African countries. These countries are: Ethiopia; Ghana; Madagascar; Mali; and Sudan (See table 1).

Table 1. Land deals in Africa

Recipient Country	Number of Deals	Magnitude (1,000ha)	
		Minimum	Maximum
Ethiopia	26	2.892	3.524
Madagascar	24	2.745	
Sudan	20	3.171	4.8999
Tanzania	15	1.717	11.000
Mali	13	2.417	2.419
Mozambique	10	10.305	
Uganda	7	1.874	1.904
DR Congo	6	11.048	
Nigeria	6	821	
Zambia	6	2.245	
Ghana	5	89	
Malawi	5	307	
Senegal	5	510	
Total (all 27 countries)	**177**	**51.415**	**63.111**

Sources: GRAIN (2008), Von-Braun and Meinzen-Dick (2009) and Gorgen, Rudloff, Ullengerg, & Nath (2009)

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It could be deduced from Table 1, that African lands have been greatly acquired by foreign investors and many African countries welcome the development probably due to its potential effect on their Foreign Direct Investment. Consequently, some observers such as Lambin *et.al* (2012), Odhiambo (2011) and Daniel and Birhanu (2012) are of the view that such a rush if properly utilized by the host African countries would go a long way in making the African countries to experience massive transformation in its agricultural and other land related sectors of their economy. Some economists such as Sheikh (1978); Smith (2003) and Sheila (2006) regarded this as the engine room or the major drivers of sustainable national development.

In support of the above assertion, Von-Braun & Meinzen-Dick (2009) argued that because of the urgent need for greater development in rural areas and the fiscal inability of the developing country governments to provide the necessary infusion of capital, large-scale land acquisition of land can be seen as an opportunity for increased investment which would result in the creation of a potentially significant number of industries, farms, off-farm jobs, development of rural infrastructure, poverty alleviation programmes, construction of schools, health posts and so on. In other words, foreign land acquisitions have the potential of bringing rapid development to the host communities and appropriate profit to the land grabbers (Cotula, Vermulen, Leonard, & Keeley, 2009).

According to Cotula *et. al.* (2009), agricultural sector has recently drawn renewed attention as the potential source of rapid or massive economic development in the African continent. This explains why most African leaders invite foreign land investors from the Gulf States such as Saudi-Arabia, Qatar, and the United Arab Emirate (UAE) and other areas. For example the South African farmers Organization (Agri SA) recounts that the organization is invited by recipient country governments such as Ethiopia, Madagascar, Sudan, Tanzania, and Mozambique to take over abandoned state farms in an attempt to strengthen the agricultural sector (Goodspeed, 2009; Reuters Africa, 2009). Zaugg (2009) reported that government has offered as much as three hectares of the country's (Ethiopia) most fertile land to foreign investors on concessional leases of 50-99 years. This is in recognition of the fact that attracting foreign land investors to the country would enhance investment; increase the efficiency and land distribution while boosting agrarian productively and capital accumulation (De Soto, 2000; World Bank, 1989).

In Nigeria, communal land acquisitions have a long history. The acquisition of communal lands in Nigeria could be traced back to the conquering period of Usman Dan Fodio. Fodio was said to have been able to extend his Caliphate from the core north across the River Niger (Abubakar, 1980). Many historians such as Milsome (1979) and Usman (1979) are of the view that it was the coming of the colonial masters that thwarted Fodio territorial extension further south (Hunwick, 1966) and Adeleye (1971a). Another major trend in the history of land acquisition in Nigeria is experienced with the coming of colonial masters to the country. One of the major features of colonialism is the forceful acquisition of land by forcefully withholding the right of the traditional authority to land ownership (Walter, 1973). The conception of the colonial masters is that land should be forcefully taken from the native authority because the continued holding of right to land by the native authority would cause a blockade to the general developmental projects which the colonial government would want to embark on. Acquired land during the colonial period were used for several developmental projects such as the construction of roads, housing estates, industrial estates, recreational facilities, hospitals, ports, schools etc.

After independence, acquisition of land is still a common practice. In major cities in Nigeria such as Lagos and Abuja, land acquisition by government has always been a common experience. In Niger Delta Region of the country, many lands were acquired to establish oil companies and many others needed for industrial outfits. For instance, in 1966, Merdermott oil company acquired 50 acres of land

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near Igbudu in the then Mid-Western State of Nigeria for the company's operation. Other multi-national oil companies such as Mobil, Shell BP, Texaco, among others occupied many communal lands in the region. Although these hectares of land were forcefully acquired from the host communities but it should be noted that such acquisition, according to some observers such as Chan (2003) and Ghatak, Mitra & Mookherjee (2012), led to industrial development of the region. This is so because such acquisition has not only led to increase in the level of oil production in the country but has also led to improvement in the country's Gross Domestic Product. Equally, it has generated millions of jobs for unemployed youths in the region and the country generally.

In 2004, a five-man delegate from the White Commercial Farmers Unions of South Africa and Zimbabwe was invited by the Kwara State government for fact-finding in Kwara State, Nigeria. The visit was expected to last for a week following the completion of their fact-finding; agreements were reached between the two parties for the establishment of commercial farms in the state (Ariyo & Mortimore, 2011). With this agreement, large hectares of land were acquired from the indigenous people in order to develop large scale agricultural set-up in the area.

Also in 2010, a consultant to the Federal Government of Nigeria, Mr. Idiong, stated that the Nigerian government had invited Gulf countries seeking food security to come to Nigeria and invest on farmland (Noah, 2013). According to him, Nigeria has about 71.2million hectares of farmland of which less than 50% is under use. Similarly, a Mexican Agricultural firm (Union De Iniciativa S.A. De C.V) established Banana plantation at Uekan community in Tai kingdom of Ogoni, in the Niger Delta region of Nigeria. Ollan International, an Asian agribusiness firm has also acquired 6,000 hectares of farmland in Nasarawa, Nasarawa State to establish farm plantation. Examples of such invitation are numerous in many states across the federation.

Aruwa (2011) reported that 31,000 hectares of land was acquired in Odogwu, Ibaji of Kogi State of Nigeria for the construction of an ultra modern sugar factory, worth US$510 million, jointly by the Nigeria National Petroleum Corporation, Kogi State Government and international Trans-oil Corporation of USA. This deal is expected to produce about 87 million litres of ethanol for agro-fuels annually, which is highly critical for industrial development (Oyalowo & Kadiri, 2011). Generally, land acquisition has helped the Nigerian government in changing the fortunes of her rural and urban lands at least in the host communities. In other words, it could be inferred from the foregoing that the acquisition of lands for agricultural plantations, construction of factories/industries and the building of basic social infrastructures can bring sustainable national development to Nigeria and Africa in general. This is because of their potential in bringing about an enabling investment which is the fundamental ingredients and critical drivers of socio-economic development which are highly needed in Nigeria.

FOREIGN LAND ACQUISITION IN AFRICA: A CRITIQUE

The above analysis generally highlights the potential developmental prospects of foreign land acquisition in Africa; however, it would be erroneous to conclude on the premise that the above analysis has exposed all sides of the coin regarding foreign land acquisition and sustainable development in many African countries. Although, the above presentation represents the protagonist arguments on the issue of land acquisition, it is however important to present the antagonist view of the analysis. The antagonistic view regarding foreign land acquisition sees the whole practice of land acquisition as basically a capitalist endeavour, a practice which is generally guided by capitalist principles and selfish orientation.

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The investors according to this perception invest in the host communities only to explore the natural resources, exploit the people and cause damage to the eco-system. Land acquisition practices according to this point of view do not on the long run add value to the lives of the host communities, rather it eventually make them worse off.

According to a World Bank report in (2010), the investments been made by the foreign land acquirers are giving almost zero-return back to the host communities in terms of job creation or other socio-economic compensation. World Bank studies (2010) reported that many foreign land investors failed in bringing or generating sustainable benefits to the affected communities; instead, they contributed to asset loss and usually leave the local people worse off. For instance, in Mozambique, foreign land investors established sugarcane plantation, with the promise of generating 2,650 jobs (World Bank, 2010), however, only 35-40 people were employed full time plus some 30 other persons on a seasonal employment basis despite investor's promise of 2,650 jobs. Further, these investors use local water supply and roads without compensation, thus negatively affecting the community main source of water supply (World Bank, 2010). In this regard, there is no gain-saying the fact that foreign land investment deals in most cases failed substantially in providing safety nets for people in many host communities (Behnke, 1994; Lastarria – Cornhiel, 1997; Niamr – Fuller, 1998; Gray & Kwane, 1999).

A similar example could be cited in Kenya where, a plantation farm established by the Dominion Farm disrupted the socio-economic and cultural lives of the people of the host community. The inhabitants of the community claimed that their livestock die from polluted water; women complained of increasing pregnancy miscarriages most likely due to the aftermath effects of pollution, resulting from usage of chemicals such as the aerial spraying of pesticides and herbicides. They equally complained that the farm management has blocked water or diverted some canals causing water to flood their farms and destroy crops (Peter, 2014). In addition, large-scale land acquisition can result in local people losing access to the resources on which they depend for their security and livelihoods. Increased usage of communal land for plantation, construction of factories/industries, schools, hospitals and other basic infrastructures could make the local people to be directly displaced and dispossessed of the land they live on.

Scholars like Arstan, Khalilian & Lange (2011); Von-Braun, & Meinzen-Dick (2009); Oakland Institute (2013); Thaler (2013) have argued that acquisitions of communal lands are likely to cause non-violent or violent social conflict in response to the accumulation and enclosure of their traditional land by the foreigners. Emphatically, the emerging social conflicts may be antithetical to sustainable development. In other words, there can be no meaningful and sustainable development in the atmosphere of social chaos and upheavals, which communal land acquisition could generate.

Sometimes, many inhabitants are displaced during the acquisition and accumulation of communal lands. For instance, in Democratic Republic of Congo, the acquisition of land for maize project by Zhongxing Telecommunication Equipment Corporation ZTE in 2007 led to the displacement of many local farmers. In Liberia, the acquisition of land for rice project by the foundation for African Development Aid and the Libya-Africa Investment Portfolio (ADA/LAP) in 2011 led to the displacement of 30% of the local population without compensation (World Bank, 2010). In Nigeria, rice project in North-Eastern Nigeria State of Taraba has culminated into loss of sources of livelihoods for about 45,000 inhabitants who had to vacate their lands; and the depletion of an important grazing area, Mutum Biyu Gassol Local Government Area of Taraba State, Nigeria (Noah, 2013). In Kwara State, the acquisition of lands by the Kwara State government for South African and Zimbabwean farmers resulted in the eviction of over 400 families and 1289 local farmers in 28 communities from their ancestral lands (Hofstter, 2004; Mustapha, 2010). The import of the above analysis is that victims of land acquisition do suffer some

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devastating experiences which to a very extent could have a negative feedback on the well being of the affected people. Of which if one reflect back on the essential element of the meaning of sustainability, one would realize that land acquisition experience which follows such sequence have not followed the route of sustainable development. In other words, the critique of foreign land acquisition is of the conception that foreign land acquisition, instead of improving the social situations of the people of Africa is actually contributing to their woes. Such scenario, according to Du Toit & Neves (2007a) has a high tendency of engendering chronic poverty and massive underdevelopment in the Africa region.

By and large, the acquisition of communal lands for developmental purposes has not fully yielded the expected results partly because the land grabbers have not clearly understood the general background characteristics of the affected communities. Thus, it can be logically said that acquisition of communal land for developmental purpose may not bring about the much more needed meaningful and sustainable development in Nigeria if the socio-cultural factors as well as other important background factors of the recipient community or communities are not adequately considered.

FACTORS INFLUENCING LAND ACQUISITION IN NIGERIA

Economic Factors

The economic importance of land is one of its most vital values. The fact that land is an important factor of production has made it to attract remarkable value in human societies. This important factor has influenced land grabbing system in many African societies such as Nigeria. Traditionally, land is utilized for various economic activities such as farming, hunting, grazing etc. The fear of losing such economic activities which are the mainstay of the livelihood of the rural people usually made it difficult for them to release their lands for the government or other interested users. Land acquisition from indigenous people has become a contentious issue in Nigeria because most often, the government would acquire land without compensating the indigenous owners (Famoriyo, 1973). The general economic policies of the government also affect the general structure of the economy. According to Famariyo (1973), structural changes in the economy are likely to have some impacts on land acquisition systems in the society; he particularly observed that the advent of a monetized economy and increased aspirations for material well-being among the people are important economic factors that affect land acquisition system in many communities in Nigeria. More so, a particular community is likely to forfeit its rights over indigenous landed property if the people observe that the proposed project on the land would benefit them economically, or probably that such acquisition has benefited some communities before.

Cultural Factors

So many livelihoods and cultural practices are directly tied to land. Lands are the basis of the economy, and are often the foundation of spiritual and cultural identity (Lambin, *et.al.* 2003). The acquisition of lands for roads, railways, harbours and airports development; construction of hospitals and schools; urban and rural electrification; provision of water and sewage facilities; urban expansion; establishment of national parks; mineral exploration; logging of forests and growth of large agribusiness have the potential of affecting people's important religious or cultural sites and destroying networks of social relations, thereby weakening traditional communal bonds and support. The Habitat Agenda (2012) recognized that

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indigenous people are socio-culturally attached to their ancestral lands. Consequently, the organization reiterated the rights of the indigenous peoples to their lands.

Specifically, cultural factors influencing land acquisition pattern of a collectivity include traditional norms, beliefs and values, cultural practices, etc. There are numerous cultural practices and sites such as shrines, grazing lands, burial grounds and other places where traditional cultural practices take place. Since these sites have important cultural/spiritual value, it is usually difficult for indigenous people to release such lands for other people who might need it for developmental purposes. Religious beliefs and practices are other cultural elements that influence land acquisition pattern on many African Societies. According to Adedipe *et.al.* (2008), the flexibility of the land tenure system in the Southern part of Nigeria is affected by the religious beliefs of the local people. For example, when communal tenure is associated with religious rites and traditions, it displays a considerable lack of adaptability to rapid change (FAO, 1953). According to Orua & Okoh, (1998), the advent of Christian missionaries during colonial period and the outbreak of the Nigerian civil war (1967-1970) hastened the productive use of hitherto sacred lands and unpermitted foods, and also relaxed gender restrictions on agricultural activities.

Cultural factors are important considerations when land is to be acquired because what might appear as an empty land to a foreigner might, in the real sense, be an ancestral burial ground or religious shrine of the indigenes (Thaler, 2013). Another cultural factor which often influence land acquisition process in Nigeria is inheritance. Many communal lands are usually inherited and because of the high numbers of individuals attached to it, it is often difficult to acquire such land massively because individual needs might differs, and as such while someone might be willing to keep the land for his upcoming upspring, another sibling might be willing to release his/her own portion for commercial leasing and another person might be willing to utilize his or her own portion for any other purpose. Such condition will consequently lead to land fragmentation which often demean the value of the land especially if such pieces of land is needed for large scale commercial activities.

Political Factor

Man has been described as a political animal. Historically, the volume of land owned by a political empire often justify the political-economic strength of such empire, as such most empires often struggle for more lands and that has been the main reason for most of the notable bloody conflicts ever recorded in human history. In Nigeria, this factor has been one of the socio-cultural factors that often influence the decision of the indigenous people to release their land for large scale agriculture and several developmental purpose, some of such people are of the view that the government acquiring their land is indirectly relegating their territorial relevance. More so, the indigenous people are also of the orientation that government often acquires their lands for political reason and that such acquisition will not benefit the people on the long-run. More so, because land arrangement pattern in many communities in Nigeria is generally overlapping and the boundary system is generally porous, such a situation often brings about conflict of interest among the political and power elites of communities when a large portion of land which cut across the boundaries of several communities are to be acquired.

Institutional Factor

Corruption has been an institutional problem in Nigeria. Consequently, several government initiated policies regarding land use and land ownership have been abused while the ordinary citizens have often

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been misled to develop negative attitude against the government or foreigners who might have genuine intention of using the land for better developmental purpose. In other instances, previous experiences of the local people regarding some foreign land acquirers have made them to be reluctant in releasing their land to foreigners (Kadiri & Oyalowo, 2010; World Bank, 2010). Ojikutu, & Bennett (2012) observed that the practices of large-scale and general land acquisitions require improvement especially on issues that has to do with poverty, social class and many other institutional factors.

Poverty is another institutional social factor influencing people's orientation towards the release of their land for foreigner's acquisition. It was said in an interview conducted by GRAIN, an international Non-Governmental Organization of the United Small and Medium-scale Farmers' Associations of Nigeria (USMEFAN) that "the material poverty of Nigerian small holder farmers is usually exploited by governments and their local and foreign land grabbers." He described the term Responsible Agricultural Investment (RAI) as a subterfuge designed to "hoodwink Africa and make crime wear the garments of salvation" (Obasi, 2012:19 cited in Ojikutu *et.al,* 2012).

Land Tenure System

Land tenure system is a common land ownership system common throughout Africa and this system has been traditionally adopted by many communities in order to control the occurrence of disputes and social conflicts that usually occur as a result of land ownership and control. Land tenure system occurs at varying levels, from individual to group, family to community tenure ownership. However, with the advent of modernization, land tenure system became a problem issue in the general socio-economic structure on many countries in Africa. This is so because the land tenure system often encourages land compartmentalization and fragmentation which often makes the land to become un-wholesome and could not be useful for large commercial uses.

In order to overcome such shortcomings caused by the land tenure system, government often result in forcefully acquiring such volumes of land from the tenure owners so that the land can be used for large scale farming, housing schemes, industrialization or other developmental purposes. Despite the effort towards the eradication of land tenure system, the system still persist in many communities in Nigeria and this has been a cog in the wheel of development of the people in many areas of their life. Commenting on the tenure system in Eastern Nigeria, Aruah & Okoh (1998:19) assert that:

Individual tenure has not been able to meet the rising demand for land, owing mainly to the small size of individual holdings. Except for the provision of land for residential purposes, land requirements for agriculture and related industries cannot be adequately provided for by individually held land. Hence neither productivity gains nor increases in employment opportunities have been achieved through individually held land.

Another dimension from which tenure system could influence the use of land for developmental purpose is when land tenure systems prevent or limit the use of land for credit facilities, in such a situation, even if a farmer has portion of land which he could use as collateral to obtain credit facilities, the rule of the game would deter him/her, thereby limiting the developmental potential of the individual. Migot-Adholla, Benneh, & Atsu (1991) report that for sub-Saharan Africa, one of the negative features of tenure regimes concern restricting the individual holder's ability to transfer land, and even in case of transfer, there is restriction on the categories of persons to whom land may be transferred to.

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Land Disputes

Land possesses economic value by virtue of competition for its use between different individuals and groups. Aruah & Okoh (1998) opine that as the area of land per caput declines, the relative value of land rises and land potentially becomes a source of conflict among individuals and communities. Going by the above observation, often times, rivalries and conflict often occur between neighboring communities due to land disputes and when such problem occur, it is often difficult for the government or any land grabber to utilize such acres of land due to the fact that the acclaimed land owners could go any length to make sure that the disputed land eventually become theirs, as a result, tussles in form of metaphysical and physical attack arise. Even though, if such disputed lands are forcefully acquired, there is high tendency that the people of the community will not give adequate security to the project the land is been used for or might be destroying it in order to show their grievances on the project. To Fabiyi & Adegboye, (1977), since title to land in many African communities is often undefined and cadastral surveys are not available, boundary disputes are indispensable. Menkiti (1972) notes that, owing to such disputes, vast tracts of prime agricultural land may be under-utilized while farmers complain of insufficient land. Even if such lands are to be utilized for other developmental purpose, such disputes will make such action impossible.

Opportunities and Risk

This factor is more or less a psychological factor; it is the situation whereby the land owners consider the risk and opportunities available for them when they release their land for commercial acquisition. The idea of opportunity and risk is similar to the utilitarian theory of human behaviour which stress that before human being engage in a particular act, he usually weigh the pros and cons and only take to those acts which he realized that the gains are more than the pains. The pain and gain factor could be used to explain the level of rational thinking of the indigenous people and how such orientation could influence their actions to release or not to release their landed properties for foreign acquisition.

CONCLUSION

This chapter has concerned itself with the issue of examining the nexus among the varying background factors, foreign land acquisition and sustainable development with particular reference to the situation in Nigeria. While land acquisition was considered a critical phenomenon in the quest towards development or to ameliorate the problems of financial crunch or for the purpose of food security, the intervening background factors were seen to be a mediating factor in the attainment of such lofty goals both for the host communities and the land grabbers. In the preceding discussion, critical attempt has been made to bring to the fore the importance of land in general human living. Historically, it has been established that land factor has been an important background factor that has a remarkable impact on the history of humanity. Further, attempt has been made to give conceptual definition of important terms relevant to the study. In order to give a sound backing for the chapter, two theoretical models were presented to explain the importance of land factor in the general process of development and it has been observed through the theoretical explanations that land is indeed an important component to be considered in the discussion on sustainable development.

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Furthermore, it was observed in the chapter that land acquisition pattern is not an independent variable as the process and the overall dynamics of land acquisition pattern is influenced by numerous factors ranging from social, economic, political, and institutional and many other relevant factors. The discussion on factors influencing foreign land acquisition is based on the conception that before land acquisitions could be useful for its intended purpose of bringing about sustainable development, there is the need to take the background factors very important. By and large, in order to make land acquisition pattern useful to achieve sustainable development in the country; some recommendations were seen as very important in order to facilitate foreign land acquisition for the attainment of sustainable development in the country.

First and foremost, human being is essentially a cultural being and as such cultural factors are important factors that should be considered when acquiring land from the natives. This is necessary because there is the need to have popular consent before land are acquired, this is further necessary because any land acquired from the people without respecting the socio-cultural features of the people will be tantamount to failure. In essence, it is important that the government and the foreign or local land grabbers consider the socio-economic characteristics of the local people before assuming the ownership of the land. For instance, if a land that is hitherto utilized for religious or spiritual activities is allocated against the wish of the people, such as land might be a source of conflict and rancour between the people and the land grabbers.

Also, there is the need for the government to monitor the activities of the land tenants so that their existence in the area will not be threatening the socio-cultural existence of the people and their activities should not be that which will be causing damages to the eco-system, this is necessary because any developmental activities that is not friendly to the environment would be considered as not being a sustainable development. More importantly, there is the need for the people of the community to be creating a leveling ground for the foreign land grabbers so that the people of the community don't become a threat for their operation. In this regard, there is the need for government to find a way of making the host communities benefit immensely from the acquisition exercise so that such can serve as motivating factor for them and such would also make acquisition easier in other communities in the future. Bye and large, land is an important natural resources which must be given utmost priority by all and sundry due to its importance as the place where human being and other creations as well as non-living things dwell upon; also because it is an important factor which have an enormous influence as a determinant of sustainable development of any nation.

In furtherance of the above recommendations, this chapter also considered the recommendations given by Von-Braun & Meinzen-Dick (2009) on land issue deals is also relevant for this study. These authors recommended that: there should be transparency in the negotiation of land deals, this is very important as one of the major problems of land deals in many African countries is that the transfer arrangement are not only dubious but many at times tricky. Such a situation has led to gross disappointing experience by the host communities which on the long run make the host communities develop a harsh and unfriendly relationship with the land grabbers. In addition to the above, they also suggest sharing of benefits as an important factor to be considered in order to make land grabbing deal work for the betterment of all the parties involved. Going by the model of risk and opportunities or the gain and pain factor, the hosts are very likely to relinquish their rights to land ownership if they observe that the releasing of such land will accrue lots of benefits to the community. However, if they perceive such acquisition as been risky for the community, they are likely to reject the acquisition deal. In other words, land acquisition deals should be structured in such a way that the host community will benefit a lot from the deals.

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However, it is important to note that land is an important aspect of man's life and as such a concept or a fact that needs to serious scholarly attention. Although, this chapter has provided insight into factors influencing foreign land acquisition and sustainable development in Nigeria, it has only examined the factors as practically observed in the Nigeria setting. As such, there is the need to look into many other factors which the author has not mentioned. Similarly, such an effort could also be replicated in many other African countries because; it is observed from reviewed literatures that many African countries are having problems with land acquisition and utilization. More so, this work is a theoretical attempt, some other empirical works needs to be carried out in this direction in the future, such an effort would make one see the issue of land acquisition and utilization from more practical angle.

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KEY TERMS AND DEFINITIONS

Acquisition: It literally means to gain possession of something or to establish control over it.

Culture: It means the total ways of life of the people in a particular society. It is the sum total of man's possession comprising language, arts, religion, technology and other attributes which are acquired by man in the society and are transmitted from one generation to another.

Development: Holistic concept used to describe the socio-economic and political transformation in the society.

Foreign: Something from outside a specific jurisdiction; ideas, customs and practices that are alien to a particular territory or society.

Land: It is the earth surface including the sea excluding the sky; it is one of the major factors of production.

Sustainable: Enduring socio-economic and political transformation without destroying the ecological system.

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Chapter 66
Corporate Social Responsibility (CSR): Theory, Regulations, and New Paradigms in the Framework of Sustainable Development Strategy

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ABSTRACT

CSR is a driver unanimously recognized by companies. This is more important looking to the Horizon 2020 objectives, in which CSR will play an important role. However, at present, there are a lot of theories and regulations about CSR, which are controversial, complex, and unclear. In this confusing landscape, a critical element emerged: the importance of social enterprise as key. The authors, after a brief summary about the main CSR theories and the principal normative aspects to frame the issue, focus their attention on new sustainable models, with particular referring to the social enterprise. The authors base their starting idea on national CSR approach and support their hypothesis of CSR by bringing examples from various countries (United States, Switzerland, Germany) and from important companies. In their conclusion, the authors clarify their idea about the correct CSR approach, introducing the concept of the Gross National Happiness (GNH).

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INTRODUCTION

Since the second half of the last century, the debates concerning the CSR theory were numerous (Bowen, 1953; Levitt, 1958; Friedman, 1962; Ackerman, 1973; Evan and Freeman, 1988; Freeman, 1994; Lee, 2008). Initially, this "tool" has been adopted by businesses only as "interface" towards external stakeholders needed of some social input. Today, the CSR represents a key driver for a sustainable innovation: in fact all the modern companies focus their attention not only towards economic objectives, but also towards other kind of these (environmental impact, social address, sustainable and rural development linked to the management of territories and productive contexts, etc). In this sense, the CSR could be considered as a "new behavior" that transform the company's approach regarding the modern market and the stakeholder.

The CSR is based on the valuations, resources and needs of social significance; it is directed to the creation of economic, human, social, and environmental integrated value in long term. This has been confirmed by the crisis period that has underlined the flaws of the modern economic model and society. Nowadays, in fact, the European Union (EU) is faced with an unprecedented crisis. Originated in the Unites States of America (USA), the financial crisis soon became global through complex and subtle contagion mechanisms.

Much has been written about how the financial sector has indulged in mindless risks and how this and the resulting fiscal deficits have seriously afflicted the economy (Allen et al., 2010; Stiglitz, 2010; Battiston et al., 2012). The financial crisis has brought dramatic consequences for economies and societies. Various questions emerge about responsibility for the crisis and, implicitly or explicitly irresponsibility; the obligations to take responsibility for the costs and other adverse effects of the recession; and the nature of responsibility for social welfare and business probity in future national and global governance (Herzig & Moon, 2013). EU's economic and monetary union, understood as a hybrid governance model seeking the reconciliation between centralized monetary policy and national fiscal policy, is subject to many controversies and debates.

In this context, the concept of the CSR and, in particular, the social enterprise as an alternative business model has arisen as a response to the relentless and never-changing economic and political swings. In the last 30 years or more, numerous studies have been dedicated to the relationship between CSR and financial performance (Cochran & Wood, 1984; McGuire et al., 1988; McWilliams et al., 2000; Barnett & Salomon, 2006; Ducassy, 2012). This relationship still gives rise to debate and the results remain controversial, although recent surveys of the available literature give the upper hand to a generally positive relationship between these two variables (Orlitzky et al., 2003; Margolis et al., 2007). Through the CSR application, the enterprises aim to become more competitive, producing wealth and operating in compliance with the environment and the interests of consumers (Margolis et al., 2007). In other words, an enterprise that has a series of objectives, outside the income production, will be more stimulated to reach them implementing and creating new methods and tools helping this purpose. In fact, using the old approach of the company (that linked only to the economic objectives) there is not great space to creativity and inventive because the instruments to reach economic scopes are more or less the same. Instead, through the CSR approach, it is possible to stimulate proper mind to create particular and innovative ideas to reach all the objectives. Inevitably this behaviour will bring a competitive advantage in the market. Moreover, we have to consider that many people give to charities, invest in socially responsible funds, consume "green products" (products that protect the environment and replaces artificial ingredients with natural ones), supply their blood, or give their time and sometimes even their lives for

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good causes (Benabou & Tirole, 2010). Such social behaviours obey a complex mix of interdependent motivations. An enterprise that invest and aims to these issue, in compliance with the CSR approach, will be more interest for the consumer and it will manage to loyalty them in the long period. In general terms the CSR has been always considered a potential tool for the enterprises to fight the economic critic moments (Morsing & Schultz, 2006) but many authors believe that the CSR has been applied without the right approach (often the CSR is idea has remained closely linked to the theory and have not developed tools to implement it in certain contexts and this has determined the failure of enterprises (Hollingsworth & Boyer, 1988).

The first definition about CSR was in the Green Paper (European Union, 2001, p.6) "Promoting a European Framework for CSR: a business contribution to sustainable development", in which CSR is described as the concept whereby "companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis". Nowadays, the national and international governments have understood the importance of the CSR as tool to going towards the common sustainable objectives in line with Horizon 2020 principles. For instance, In Denmark, the first law on green accounts was passed in July 1995 In 2002 the government strengthened the law (Holgaard & Jorgensen, 2005). Or In 2002, Austrian business organizations and the Austrian Federal Ministry of Economics and Labour decided to raise the awareness of CSR in Austria by formulating a CSR guiding vision for Austrian businesses after consulting a broad variety of stakeholders. (Konrad et al., 2008). Again, Even non-governmental organizations, such as the International Organization for Standardization (ISO), OCED or UN Global Compact where play an important role. These organizations contribute through the production of voluntary standards, to orient the conduct of undertakings towards new models of development. In other words, act voluntarily acting in line with the applicable standards, contributing towards the enhancement of enterprisers' social behaviour.

Summarizing, presently, the CSR is unanimity accepted as important and strategical driver to fight the problems of the modern word: In other words, through the CSR approach is possible to create a sustainable mentality that permit to the companies and the stakeholders to have many tools (not only economic) and objectives. Nowadays, many persons are convinced that the "modern problems", as obesity, extreme globalization, industrial pollution, etc. are the main issues to be addressed. The CSR, changing the behavior of the companies and other economic actors, can contribute to become more aware of these issues in order to deal with emergency In this sense, the development of the social enterprise concept can became the new tool in opposition to the present crisis. There is the necessity to correctly conceptualize this assumption in order to put the right substrate to develop all the CSR framework in a common vision.

On the basis of the illustrated theoretical approaches (Hollingsworth & Boyer, 1988; Margolis et al., 2007; Bernabou &Tirole, 2010) this chapter has been divided in different paragraphs: in the first part we present a short view of two mean CSR theories: Friedman and Freeman. Secondly, we tell the evolution of CSR, analyzing the mean documents written towards Horizon 2020. A single paragraph is dedicated to the normative aspects at international level, determines the different CSR approaches. Finally, in the conclusions, we provide to explain our idea of social enterprise and the possible implications toward a global sustainable perspective.

In particular, the author believes in the Gross National Happiness (GNH) approach. Gross National Happiness is a term coined by His Majesty the Fourth King of Bhutan, Jigme Singye Wangchuck in the 1970s. The concept implies that sustainable development should take a holistic approach towards notions of progress and give equal importance to non-economic aspects of wellbeing: for instance the economic aspects (as GDP) are the same importance of mental health or the time that one person uses to work or

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sleep In the Bhutan country a GNH index has implemented. This index is a single number index developed from thirty-three indicators categorized under nine domains. Omitting the methodology behind the GNH index (Ura et al., 2012), we want emphasize the theoretical innovative approach that can take his bases from the more big concept linked to the economy of Happiness The economics of happiness is an approach to assessing welfare which combines the techniques typically used by economists with those more commonly used by psychologists. The economics of happiness does not purport to replace income-based measures of welfare, but instead to complement them with broader measures of well-being (Graham, 2005). In this perspective, it is possible measure the Happiness degree inside a country or in a specific context. Through this, it is possible to correct and determine political and economic actions to improve the happiness and consequently develop also economic indicators: a happy population is a productive population (Di Tella et al., 2003). The GNH index uses two kinds of thresholds: sufficiency thresholds, and one happiness threshold. In order to measure the 9 domains of GNH, 33 indicators were developed. Figure 1 briefly shows the domains and the indicators of the GNH index.

In these general terms, the companies, trough the CSR approach and all instruments linked, can contribute to develop the contest in which the population lives and works. The final scope is enhancing all the system in a sustainable vision (in this sense see Marquis et al., 2009).

THEORETICAL ASSUMPTIONS: A SHORT COMPARATIVE ANALYSIS OF TWO MEAN CSR THEORIES OF FRIEDMAN AND FREEMAN

In the theoretical approach of CSR, the opinion that the modern enterprise has not only an economic and juridical dimension but also an ethic dimension is today worldwide accepted. However, the researchers who are not agreed about the nature of this dimension. In general term, the debate evolves the proponents of "stockholder view", the fans of "stakeholder view" and, finally, the overlaps of both theories (Charreaux & Desbrieres, 2001, p. 109).

We can summarize the first vision with the following sentence: the manager has the moral duty to increase the income of the investors. In the second vision, instead, the manager has to respect all company's stakeholders. Both the theories are agreed that the manager has moral duties but they not converge about what are these.

There have been a lot of discussions about which is the right direction (Moore, 1999; Moir, 2001; Smith, 2003). At the present, all the research is agree only that there isn't a unique solution shared. Furthermore, some theories combine different approaches and use the same terminology with different meanings (Smith, 2013; Angelopoulos et al., 2013).

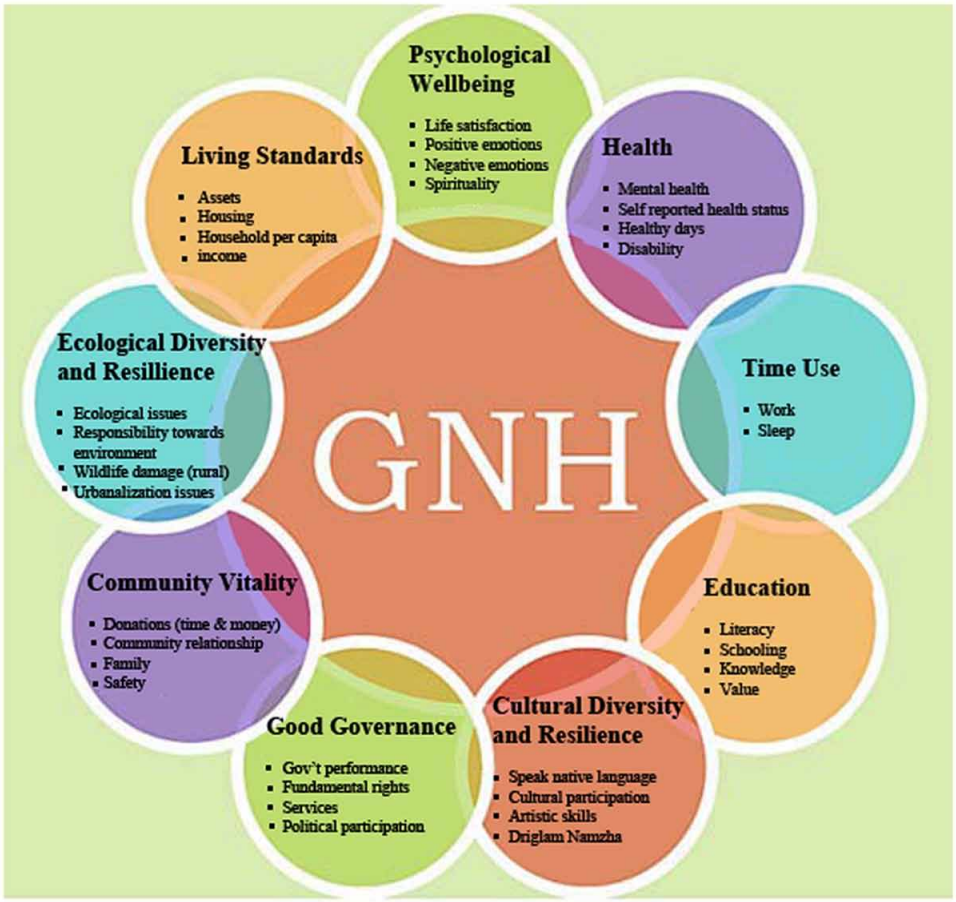
In this confusion, two theories constitute the base of the theoretical approach: the Milton Friedman's (stockholder view) and the theory of Ronald Edward Freeman (stakeholders view).

Friedman's Theory

The economist Friedman (1957, 1962, 1970) affirms that there is only a CSR, using the resources for activities to increase proper profits, staying inside the "play's rules", in a correct competition mechanism. The managerial decision to sacrifice corporate profits to the attainment of social objectives, such as, for example, to promote employment, eliminating discrimination nations and prevent pollution would then

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Figure 1. Domain and indicators of GNH index
Source: Ura et Alli, 2012.



pave the way to socialism. For Friedman, in fact, only the capitalist system can effectively guarantee the political rights. In this sense, CSR is seen only as a strategic tool to achieve economic objectives and, ultimately, wealth creation.

This thesis assumes that the company is owned by a group of investors who join between them voluntarily pooling their resources in order to reach an increase in their wealth. Given this premise, we can imagine that company does not have ethical obligations beyond those to its investors (Friedman, 1957). Friedman (1970), however, does not deny that management can engage in "Social" consistent, but he believes that it should do so only in strategic perspective, through activities that contribute to increase the profits of the company (by reducing the legal costs incurred in litigation, improving the good reputation of the organization, increasing sales, etc.). Therefore, if such activities (others might call "socially responsible") are not justifiable in terms of a gain for investors, then they should not be undertaken. A well-known approach is that which takes the straightforward contribution to maximizing the shareholder value as the supreme criterion to evaluate specific corporate social activity. Any investment in social demands that would produce an increase of the shareholder value should be made, acting without deception and fraud. In contrast, if the social demands only impose a cost of the company they should be rejected.

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Freeman Theory

Instead of focusing on generic responsiveness, specific issues or on the public responsibility principle, the approach called "stakeholder management" is oriented towards people who affect or are affected by corporate policies and practices.

William, M. Evan (1988) and Ronald, Edward Freeman (1990) were responsible for the development of a theory of the firm based on the model of the stakeholders able to offer an account the nature and purpose of the enterprise and the moral claims that this must satisfy.

Advance the proposition that the managers have a "trust - relationship" to a wide range of stakeholders of the company, meaning that suppliers, customers, employees, shareholders and the local community, as well as the management in its role as agent of these groups; those individuals or groups have a legitimate interest or a legitimate claim on the company (Freeman, 1988), since they have invested time and resources in relation to it (Mitchell et al., 1997; Moir, 2001; Crane and Ruebottom, 2011).

This version of the theory finds its basis in the Kant's (2002) moral principle of respect for persons. For the German philosopher "humanity is itself dignity"; man can never be reduced to being treated by the man himself as a mere "means" but must always be treated as an end. The man regarded as a person-Kant argues—is above all price, which can never be regarded as a "half" (or for the purposes of others or for their own purposes). The dignity of man, then, consists of an "absolute intrinsic value" which requires all other rational beings (humans) the respect of both his own person that the person others (with which we are faced at par). From these thoughts you can find the basis for the approach of Freeman.

Therefore, the management treats all stakeholders as equally important and has an obligation against them (Freeman, 1994). Since it is not always possible to meet all the demands of all stakeholders, as some of they may conflict with others - sometimes it can happen that one of the groups' stakeholders can derive, from a particular managerial decisions, economic advantage statement at the expense of other groups.

For Freeman and Evan (1990), if the purpose of corporation and so its organizational structure should reflect the idea of "stakeholder management", the main "structural mechanism" is a Board of Directors composed of representatives of different groups of stakeholders elected by a special shareholders. In particular, the authors affirm that this is possible "with the responsibility to manage the affairs of the corporation in respect of the interests of its stakeholders, thus ensuring the positive resolution of any conflicts" (Freeman & Evan, 1990, p. 339).

Critics to the Theories

Both the theories of Freeman and Friedman had several critics regarding specific terms of the theoretical approaches.

Milton Friedman has often been criticized by liberal economists, especially from the Austrian school. Murray N. Rothbard (2009), anarchy, capitalist thinker, called the theories of Friedman as totalitarian and statist. In particular, he sharply criticized the contradictions in economic thinking of Friedman from many points of view, such as from a monetary point of view, and in general on the central role given to the State.

Friedman is also heavily criticized by journalist Naomi Klein (2007), area progressive Canadian, who in his book "The Shock Doctrine" argues that liberal reforms desired by Friedman and his disciples are applicable only through violent shock that capture public attention.

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The jurist Christopher Stone (2004) was responsible for the critical examination of some of the topics of Freeman's theory that could be adduced in support of the Friedman's position. According to the argument of the "promise", at the base of the obligation of the corporation to shareholders, there would be a moral duty to keep promises and management, at the same time, when he promised to shareholders of maximize their profits. In the opinion of Stone is not possible because few people invest their money in a corporation according to the express promise of the management that it will be managed in such a way to maximize their profit. In truth, few shareholders in America invest their money directly into a corporation.

The philosopher Goodpaster in many works (1991, 1994, 2004) has pointed about the CSR theories and different approaches. In particular, he has criticized the argument put forward by proponents trustee of the multi - stakeholders, according to which managers have a obligation type trustee to stakeholders (other than shareholders), as no proper basis. The unique nature of the relationship between shareholders and management is due to the fact that among them there is a relationship of agency or contract under which "agent" must act in the interests of the "main". It follows that managers have fiduciary duties of a legal nature to the shareholders who have not to the other stakeholders.

Ultimately, both theories have had many critics but also positive judgments, the foundations of which were then developed further theories (Garriga & Mele, 2004). So the CSR study field has grown significantly and today contains a great proliferation of theories, approaches and terminologies (May & Cheney, 2007; Gupta, 2014).

EVOLUTION OF CSR, FOCUSING ON NEW SUSTAINABLE MODELS: STUDY AND ANALYSIS OF MEAN DOCUMENTS WRITTEN TOWARDS HORIZON 2020

Today businesses are increasingly judged by the extent to which they consider the main interests of society. Thus, the concept of CSR has been transformed dramatically: from a pure philanthropic perspective, instead of being merely a legal compliance approach, it has developed into an explicit responsible management issue. Now a third stage of CSR, discussed as Sustainable Entrepreneurship (Intending to a new attitude of entrepreneurs who not only aims at a profit related to the present but to a club, not only economic but also linked to the long-term for their own future and that of future generations), has arrived: in this sense, the main question is the link between the modern companies and their contribute to the present challenges (Schmidpeter, 2014). There are a lot of conceptualization linked to the theory of CSR and the issues connected. In this paragraph we provide to give a synthesis of those that are considered strategic and critical towards the sustainable development (Van Marrewij, 2003; Steurer et al., 2005; Moon, 2007).

Moral Capitalism

The theory of "moral capitalism" starts from the assumption that the crisis has brought to light not only the flaws of the ruling economic model, but also the flaws of our society. Largely, we could describe what happened using the words "lack of morality". When society's laws change in such a way that so many people lose their moral compass, this tells something significant about society.

Zohar (2004), in her book "Spiritual Capital: Wealth We Can Live", said that the Capitalist, the culture and the business practices operating within it are in crisis. The capitalism, as we know it today

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is unsustainable. So, the Capitalism seems to have changed those who allowed themselves to be enchanted by it. It is also worth remarking that the present crisis represents the most recent and serious consequence of the way in which the importance of ethics and responsibility have been neglected in the decision making process of the business environment

Moral capitalism implies that business people use their decision making power to analyze and balance their own urges, like greed and other temptations. We have in the modern age several examples: The New York Stock Exchange and NASDAQ adopted comprehensive new corporate governance regulations which substantially change the way corporations disclose information to stockholders and the public. The SEC has instituted a requirement obligating CEO's and CFO's of public companies to certify legally that their financial statements and reports are accurate and not misleading-exposing these executives to possible criminal charges if their numbers turn out to be bogus. Many large and small corporations have likewise acted quickly to adopt new practices by approving and implementing revisions to their governance structures, policies, and programs. Moral Capitalism implies an area as large as possible in which the virtue overlaps the self interest (Young, 2009). Moral Capitalism stakes a lot on our human side. It requires us to activate the divine side of this changing world, to use our virtues in order to reorient our passions.

Zohar (2009) underlines that moral capitalism cannot emerge from nothing. It is not possible create a moral and good situation without personal and constant efforts. It is our full responsibility to make good things happen: all the economic actors evolved in a complex context must give proper contribute to develop and enhance the moral issues. Family and society influence the way in which moral norms are acquired and put into practice. People have to learn how to be good.

Adam Smith and Moral Capitalism

Moral Capitalism is nothing new. Adam Smith, the icon of the free market supporters, wrote "The Theory of Moral Sentiments" (1759), a book which was published 17 years before his more famous "The Wealth of Nations". In that book he argues that, when people try to acquire the best for themselves, the individuals also create welfare for others. However, Smith believed that, in business, the individuals are capable of acting in their own interest from the perspective of the whole.

Smith underlined that the essential condition of a fair society is given by the moral character of its individuals. Smith believed that the selfish inclination towards power can be restrained, and he talks about the innate ability of perceiving what the other people feel and wish for. Smith posited, in fact, the creation of a moral capitalism instead of a greedy one.

The markets, states Smith, are the result of negotiations and commercial transactions. He affirmed that by generating jobs and revenue, the markets determine the social welfare, a goal that is not undermined by the self interest.

In his concern for the poor, for the maintenance of the institutions dealing with health, education and infrastructure, Smith believed that there must be a healthy and balanced public sector. He also underlined the importance of prosperous communities, of regulating authorities and of the role that values must play in our lives.

Another important think derived from Carleen Hawn, an economic journalist: he stated that "the spiritual father of spiritual capitalism is not Mahatma Gandhi, or Dalai Lama. It is Adam Smith" (Hawn, 2008, p. 1). After all, there must be a reason why his most famous book is called "The Wealth of Na-

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tions", not "The Wealth of Individuals". Always in his book "The theory of moral sentiments" (1759), Smith argued that the free market, in which every person is perfectly free to follow own interests in own way, and to use both proper knowledge and capital in competition with every other person, is the best way to create wealth. He also claimed that the benefits of the free market should increase not only the welfare of individuals, but that of society as a whole.

Our Common Future and the Future We Want

The report "Our Common Future" by the World Commission on Environment and Development (WCED) in 1987 seems highly suggest a sustainable development paths ought to provide the impetus—indeed the imperative—for a renewed search for multilateral solutions and a restructured international economic system of co-operation. In other words, in this paper we take conscience that there is no need that the world economy is compared with other topics that relate to social and people first rather than business. There are described a lot of guidelines as examples to going on the development challenge: reviving Growth and Changing the quality of Growth, Meeting Essential Human Needs, Ensuring a Sustainable Level of Population, Conserving and Enhancing the Resource Base, Reorienting Technology and Managing Risk, Merging Environment and Economics in Decision Making, etc. Surly, this is not a simple challenge because cut across the divides of national sovereignty, of limited strategies for economic gain, and of separated disciplines of science. It is clear, in fact, that all nations start from different contextual framework and consequently from different economic path (D'Aveni, 2012); so, it is necessary matching up across these different to the common wealth.

The report called Our Common Future placed environmental issues firmly on the political agenda; it aimed to discuss the environment and development as one single issue. An oft-quoted definition of sustainable development is defined in the report as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 41). In addition, key contributions of "Our Common Future" to the concept of sustainable development include the recognition that the many crises facing the planet are interlocking crises that are elements of a single crisis of the whole and of the vital need for the active participation of all sectors of society in consultation and decisions relating to sustainable development.

More recently, the world's leaders of united Nation who met in Rio de Janeiro (2012), in a paper entitled "The Future We Want" agreed to pursue the necessary steps to advance the world towards a more sustainable future. "The Future We Want", was still significant in preserving key principles of sustainable development. In particular in that document nine principles are explained: Political commitment to sustainable development, Reaffirming the 1992 Rio Principles, Reaffirming rights, Implementing existing commitments, Green economy, Sustainable development goals, Reform of the institutional framework for sustainable development, Effects on trade, Regulation of corporations

The Rio+20 conference was a milestone on the long road to sustainable development: At that time it showed up in such priority objectives to renew our commitment to sustainable development, assess the gaps until now, to recognize and address the new challenges. In particular, the topics of discussion are strong sati the Green economy and the institutional framework for sustainable development (Romero & Broder, 2012). Substantially, despite the multiple critics, It cemented support for the agreements reached at the 1992 Earth Summit and renewed the commitment of leaders to put their countries on a path towards improving people's lives today while preserving the planet for future generations. It was a

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bright moment of international cooperation at a time of profound national and global challenges. Leaders agreed to develop a new set of sustainable development goals, building upon the achievements of the Millennium Development Goals (MDGs) that the UN launched 13 years ago and that have been so instrumental in the fight against poverty.

Sustainable development is not only about promoting economic and social well-being while protecting the environment; it is about working together, across the globe, to responsibly manage the earth's life support systems and ecosystems (Hongbo, 2013). In its broadest sense, the concept of sustainability implies the ability of a process of development to sustain over time the reproduction of global capital consists of the economic capital, human / social and natural environment.

The most widely used definition is the one provided in 1987 by the Independent Commission on Environment and Development (World Commission on Environment and Development), chaired by Gro Harlem Brundtland, according to which: "Humanity has the ability to make development sustainable, that is, to ensure that it meets the needs of the present without compromising the ability of future generations to respond to them."

The central element of this definition is the need to seek an inter-generation equity-type: future generations have the same rights as those of today. It can be seen also, though less explicitly expressed, a reference to equity between generations, i.e. within the same generation of people belonging to different political, economic, social and geographic have the same rights. The success of this utterance, primarily from the ecological, animated international debate, resulting in numerous insights and further development of the concept of sustainability, which over time has been extended to all the dimensions that contribute to development.

The "green economy" a theoretical model of economic development that stems from an econometric analysis of the economic system where in addition to the benefits (increase in Gross Domestic Product) of a production system takes into account the environmental impact that the potential environmental damage caused by full cycle of processing of raw materials from their extraction, through their transport and transformation into energy and finished products to the possible environmental damage that produces their final elimination or disposal is considered one of the important tools available for achieving sustainable development and it could provide good options for policymaker: it should contribute to eradicating poverty as well as promote sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems.

The Role of CSR in New Sustainable Models

In a world already ravaged by the old policies and methods of exploitation, are more and more new road models related to social sustainability. Social innovation consists of new products, services, and models that simultaneously meet social needs and challenges and create new relationships and collaborations.

An application of particular interest in social innovation is constituted by social enterprises - often as an opportunity for convergence and collaboration between the public, private and third sector.

The added value is compared to a traditional business services in an effort to produce high-relational, in trying to "network" with the experiences of the third sector, to produce positive externalities for the community. The theoretical concept of social responsibility has become known since 1970, although various related concepts were integrated into the scope of organizations and governments since the nineteenth century: in fact, in that period a lot of great companies (IBM, McDonalds, Microsoft, Wall

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Mart, Auchan) started to think about a new approach in their missions. Not more only economic but also social and environmental scopes. As previously mentioned, in the past, social responsibility was mainly focused on the business sector: the companies used it just as a tool to pursue economic objectives (Schmidpeter, 2014).

Economic activities increasingly require more ethical foundations, environment, and social considerations, which are in constant development. The CSR governs the relationships among organizations and stakeholders (Carroll & Buchholt, 2011).

In recent years, many cases showed the importance of CSR/SR, have been demonstrated; a lot of companies start to develop social activities to clients and countries: for instance Pax Cult has donated 10% of profits to a social organization. Cole and Parker helped the developing countries, or again, Hero farm has organized social meetings. At the same time, the negative impacts on individuals, society and the environment have been generated when organizations do not conduct their business in a socially responsible manner think of the companies that exploit children for work or Asian countries where there are exhausting work conditions; or the oil companies that do not respect the environment.

The famous examples of Enron, WorldCom, Adelphia or Savings and Loan demonstrate that CSR is more than an exercise of public relations or a simple marketing strategy (Mills, 2003).

Above all, people constantly look for a sense and a purpose in life. And they want to find them in the very place where they spend the greatest part of their time, at work. They want to work for a good organization, one that treats both them and anybody else with respect (Mitroff, 2008).

The role of leadership is crucial due ethical CSR should not be perceived only from a rational perspective, as a transactional process. It has to reach the emotions of the people. Employees have to regard this kind of action as their natural way of living. Therefore, the organization has to be able to assure a strong congruence between its image and its personality. CSR proves to be an important vehicle (Schiopu et al., 2012).

Leaders and managers must see above their own interests, and should see their role as the one to determine the company to have goals and spiritual values, not just profit. They should also take responsibility for the world in which they operate and where they create wealth. In other words, they have to remember their self that they are, first of all, person that have the primary mission to create common welfare in every form (there are at the present companies that are coming in this direction: think to Google, Danone and Nestlè).

Leaders may give up almost anything—except responsibility—towards their employees and towards the organisation. John Rockefeller Jr. used to say, "I believe any right brings a responsibility; any opportunity, an obligation; any property, a duty" (Maxwell, 1999, p. 50).

There is a pretty prevalent prejudice in the people' mind according to which ethics and CSRcsr translate only into costs for the business community; for this reason, only those companies with a significant cash flow can afford to develop an ethical and responsible behaviour (Solomon, 2001). This prejudice reflects a misunderstanding of the notion of ethics in business. Ethics is nothing else than a kind of charity, dependent on the existence of enough sums of money to be divided among those fighting for a good cause. Ethics, in business, concerns the way in which companies are run and the way in which the reports between the companies and stakeholders are being managed (Ridderstrale, 2007).

Zohar (2009) posits that the CSR is the term that people use when they mean compassion. This think is supported from other authors (Ruiz & Vallejios, 1999; Babiak & Wolfe, 2013). Every corporation is for CSR but they don't usually practice it. But "if somebody really is compassionate, he is going to be much better at relating to your employees and the wider community" (p. 2).

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The true measure of a firm's performance go beyond the profit growth and market share, is connected to the moral values and the ethics values. The business domain has to acquire a moral dimension, becoming more oriented towards services and towards getting value.

The New Paradigm of Social Enterprise

There is no commonly agreed definition of social enterprise, although some author tried to analyze (Dahlsrud, 2008). We want try to give our definition of CSR as a practice which is motivated by the objective of solving social and/or environmental problems, but which uses the tools of capitalism, especially trade, to do so.

The New Approaches of Social Enterprise

Recent work by Sarasvathy and Venkataraman (2011) suggest that entrepreneurship may offer an alternative to the scientific method in solving some of the increasingly complex problems facing modern society. For several authors (Verreynne et al., 2013) Social Enterprise seems to have the potential to improve efficiency and effectiveness by innovating new products, processes, strategies, and/or business models to better meet their beneficiaries' needs. In other words, the Social enterprise represents a new shape of company's behaviour that permit to organize and manage the corporate system in a more efficient way, aims different and precise objectives, not only economics but also environmental and social.

The idea of social enterprise as an alternative business model has arisen as a response to the relentless and never-changing economic and political swings the world has endured over the past two centuries. Since the beginning of the Industrial Revolution, two broad ideological models have been continuously batting against each other for supremacy: capitalism and socialism (Serafinn, 2013). At the present, there are numerous recent applications about this theoretical assumption (for example see Brown, 2014).

"Social Enterprise Alliance" states that the institution of the social enterprise provides us with a viable opportunity to break from this dizzying swing of extremes, and balance the best of all ideologies. It addresses social concerns, more efficiently than government (because this is its principal mission), which no longer has the mandate or resources to solve every social problem; more sustainably and creatively than the non-profit sector, which faces declining funding streams and increased demands for innovation; and more generously than business, which is mandated to place pre-eminence on shareholder returns, but is also realizing it can't succeed in a decaying world (Kai, 2006). A social enterprise has two goals: to achieve social, cultural, community economic or environmental outcomes; and to earn revenue (Galle, 2013). On the surface, many social enterprises look, feel, and even operate like traditional businesses. But looking more deeply, we can discover the defining characteristics of the social enterprise: mission is at the centre of business, with income generation playing an important supporting role. Finally one of the future channels could be the networking (Fulk & Connie Yuan, 2013); in this vision, the new paradigm of the social enterprise will have good develops. Definitively, the social enterprise constitutes a complex and multi-sided phenomenon, which remains difficult to interpret. However we have some empirical examples that permit us to explain why specific enterprises have developed so quickly and will continue to spread.

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NORMATIVE ASPECTS: WHAT, AT INTERNATIONAL LEVEL, DETERMINES THE DIFFERENT CSR APPROACHES

The CSR has become over the years an increasingly important role in the global economy and sustainable development. In Europe, the first definition of CSRcsr is contained in the Green Paper (2001) "Promoting a European framework for CSRCSR" (p. 7) in which the Commission shall specify what is meant by CSR. In particular, the focus is on the Companies that "endeavour" to raise the standards of social development, environmental protection and respect of fundamental rights and embrace open governance, reconciling interests of various stakeholders in an overall approach of quality and sustainability.

The common characteristic of social enterprises is that they have a transactional relationship with their beneficiaries, who are either purchasers of the firms' goods or services or suppliers of input (including labor) to the firm. The essence of the theory is that through these transactions, social enterprises gather information on their patron-beneficiaries' ability to transact with commercial firms (e.g., workers' skills, borrowers' creditworthiness and consumers' ability to pay). That information permits social enterprises to tailor the form and amount of subsidies to the specific needs of individual beneficiaries. This "measurement" function makes social enterprises relatively efficient vehicles for allocating subsidies as compared with more traditional donative organizations and with other forms of hybrid organization, in particular firms that pursue CSR policies (Johannisson, 1987)

Nowadays companies come out of its traditional boundaries to establish itself as a social actor and not only as an economic actor, giving a contribution to the welfare of society (Magatti & Monaci, 1999; Mariano, 2005). In other words, we can affirm that all major companies have understood the importance to pursue social and environmental objectives, not only economics. This due the changing of the consumer's behaviour that is more evolved and he looks with positive "eyes" the companies that contribute to the development of these issues. This translates in a major propensity to buy from specific "social" companies rather that other.

In this sense, there are a lot of modern examples of global companies: McDonald's Awards Suppliers for Advancing Global Sustainability Initiatives for instance is a competition in which social and environmental McDonalds suppliers behaviour are evaluated; every year McDonald publish a winner report highlighting how suppliers achieved significant results by identifying opportunities and applying sustainable solutions in diverse places around the world. McDonald's leadership and industry experts recognized sustainable accomplishments across eight platforms: Climate Change and Energy; Water; Waste; Land and Biodiversity; Human Health and Welfare; Animal Health and Welfare; Community Impact and Economics. This initiative had a great success and many McDonald's supplier have enhanced their processes in social and environmental vision (http://news.mcdonalds.com/Corporate/manual-releases/2014/McDonald-s-Award-Suppliers-for-Advancing-Global-Su).

The new Nestlé in Society 2013 report transparently shares the Company's progress and challenges in meeting its 35 forward-looking commitments that cover nutrition, water, rural development, sustainability and compliance (http://www.nestle.com/media/newsandfeatures/2013-csv-report). The report underlines Nestlé's fundamental belief that, for a company to be successful over the long term and create value for shareholders, it must also create value for society. Novartis is implementing continuous programs aiming to fight malaria and other disease in the central Africa (But there are many other examples worldwide).

The culture of enterprise changes towards the affirmation of the culture of CSR. Companies cannot restrict their business in the production of goods and services but must satisfy the needs of all its stakeholders because they are part of the social, economic and political environment in which they live.

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The European Commission in his Communication (2006) "wishes to give greater political visibility to CSR, to acknowledge what European enterprises already do in this field and to encourage them to do more" (p. 2). Commission has announced its support for the launch of an alliance aimed at European companies who are already engaged in CSR or intending to engage in this sense.

Europe has to become a pole of excellence on CSR forasmuch as the "subscription" to such a system can be a valuable contribution to sustainable development and employment.

The European strategy in the field of CSR for the period 2011-2014 was update with the Communication COM (2011) 681. One of the most important changes is the new definition of CSR: "the responsibility of enterprises for their impacts on society" (p. 6). The new definition is definitely wider and more consistent with other international instruments because not only considers the issues of environmental and social as before, but also takes account of the initiatives linked to the respect of human rights, as well as the consumer protection.

There can be two different meanings of corporate responsibility: the first one is the development of products, services and innovative business models that contribute to social well-being and leading to improved quality and productivity of jobs (Porter & Kramer, 2011). The second one is based on risk analysis in order to identify, prevent and mitigate the possible negative effects that the company may have on the surrounding environment (Cruz, 2013).

In the Communication 681 is given a real action plan that the Commission intends to carry out in order to spread the "culture" of CSR (e.g. supporting the transnational company agreements (TCAs) between enterprises and European or global workers organizations). In particular, inside the agenda chapter there are the mean activities that EU intends to bring on to promote the CSR development: give public recognition to what enterprises do in field of CSR. Moreover, the Commission has launched a wide range of programs to work with enterprises and other stakeholders on critical social and environmental issues: the Retail Forum for Sustainability; the EU Platform for Diet, Physical Activity and Health; the Business and Biodiversity Campaign; the process on corporate responsibility in the pharmaceutical industry; the European Food and Sustainable Production Round Table; the University- Business Forum; the Advertising Round Table; and the European Pact for Mental Health and Wellbeing (http://ec.europa.eu/enterprise/policies/sustainable-business/files/csr/new-csr/act_en.pdf)

The norm SA 8000 (Social Accountability, 2001) is the first standard in the international sphere, it is one of the world's first auditable social certification standards for decent workplaces, across all industrial sectors. It is based on conventions of the International Labour Organization (ILO), United Nations (UN) and national law, and spans corporate and industry codes to create a common language to measure social compliance. It takes a management systems approach by setting out the structures and procedures that companies must adopt in order to ensure that compliance with the standard is continuously reviewed. The SA8000 (2001) is designed to certify certain aspects of business management relating to CSR, such as respect for human rights, respect for the rights of workers, the protection against the exploitation of minors, and guarantees a safe and healthy workplace job. Compared with the codes developed by companies (http://www.sa8000.info/) the SA 8000 offers a greater guarantee given by an external audit, carried out by third parties, to verify compliance with the standards. SA8000 is characterized by its flexibility as it can be applied both in developing countries and in industrialized countries, from small and large organizations and the private sector and the public sector.

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The standard was developed in 1977 in New York by Social Accountability International, an organization that brings together international representatives from governments, universities, trade unions, certification and consulting company (http://www.sa-intl.org/). The main motivations, by all the involved organizations, that drive an organization to adhere to the SA 8000 standard could be summarized (Social Accountability International, 2001, p. 4):

- **To Preserve the Credibility and Reputation:** The attention to the surrounding reality, through a system of management of social responsibility, generates a positive image of company, which is reflected in a greater respectability of the mark;
- **Increased Confidence by Consumers and Social Organizations:** The confidence of the stakeholders is enhanced by the demonstration of compliance with the ethical and social principles;
- **The Improvement of Relations with the Institutions:** Compliance with the requirements of social responsibility facilitates relations with the institutions;
- **Control of Ethical and Social Correctness in the Supply Chain:** The company, through the eye of an independent third party accredited, shows that social responsibility principles are respected in the whole chain of suppliers and sub-suppliers;
- **Improvement of the Business Climate:** Workers feel protected by the company in which they operate. Companies assume commitments to the continuous improvement of working conditions and feel more involved in the achievement of corporate objectives.

The SA8000 includes eight requirements that must be met by the company seeking certification and which are related to the fundamental human rights of workers. In other word, through the regulation of this document it is possible to follow the correct guidelines in the relationship with the workers. Through the respect of these requirements the company can obtain certification with which it is shown that the organization meets the requirements social responsibility of the norm (Casotti, 2005).

The certification SA 8000 (Social Accountability International, 2001, pp. 5 - 8) social thus provides for the satisfaction of eight social requirements relating to:

1. **Child Labor:** It is forbidden the exploitation of child labor.
2. **Forced Labor:** It is forbidden to get a service through the use of threats or demand for money.
3. **Health and Wealth at Work:** The firm must comply with the minimum standards for a safe and healthy working environment, must try to prevent accidents and diseases minimizing the causes of hazards inherent in the work place.
4. Freedom of association and right to collective bargaining should be allowed the right to join or create a union and to require a collective agreement without generating retaliation or intimidation towards workers.
5. **Discrimination:** There should be no discrimination of race, caste, national origin, religion, disability, age, gender, sexual orientation, union membership, or political.
6. **Disciplinary Procedures:** Corporal punishment, coercion, physical and mental, the injury to workers are punished.

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7. **Working Time:** It must be that one established by the legislation in force.
8. **Remuneration:** The remuneration shall comply with the minimum legal requirements (Social Accountability 8000, 2008, p. 5).

The ISO 26000 (Social Responsibility. International Standard Organizations, 2010) represents a new standard for CSR and constitutes a "guide on CSR" (http://www.iso.org/iso/home/standards/iso26000.htm) which aims to empower all types of organizations about the impact of their activities on society and the environment. This is not a standard certification but a guide to harmonized principles and translate ideas into effective action, improving already developed best practices and helping to disseminate it for the benefit of the international community.

Accountability, transparency, ethics, respect for stakeholders, law enforcement, international standards of behavior, and human rights are the main elements proposed by this new guide, with these great thematic it is possible to develop in concrete the approach of Social Enterprise (Social Responsibility. International Standard Organizations, 2010). After a long bureaucratic process which lasted five years and involved representatives of one hundred forty countries and international organizations, the ISO 26000 was approved with 94% of the vote. ISO 26000 does not replace the existing social responsibility activities, but will help to further enhance them. A company that voluntarily adheres to the ISO 26000 guidelines get several benefits, including: competitive advantages, reputation, ability to attract and retain workers and customers, maintaining motivation, commitment and productivity of employees, obtaining a complete overview of investors, shareholders, donors, sponsors and the financial community, better relationships with corporations, governments, media, suppliers, peers and communities in which the company operates.

The ISO 26000 is useful for any kind of organization; it provides guidelines to explain the main characteristics of CSR: concepts, terms and definitions, orientation and characteristics, principles and practices related, subjects, issues and key topics, integration, implementation and promotion of socially responsible behavior within the enterprise and its sphere of influence, identification and involvement of stakeholders, commitment in the Communication of CSR (ISO 26000, 2010).

The main intent of the standard is to assist the organization in contributing to sustainable development. The ISO 26000 also encourages companies to find new instruments and initiatives to develop social responsibility. The guide proposes seven main themes to which every organization should pay attention. These themes presented in the text of the guide through specific sections are: the organization; human rights (with all the issues of discrimination, civil rights, political, economic, social and cultural principles and rights of workers); work practices (including the relationships among the employees, working conditions, social dialogue, health and safety in the workplace, the update for employees); the environment (pollution prevention, use of renewable resources, commitment to the issue of climate change, protection of the environment, biodiversity and restoration of natural habitats); good practices (anti-corruption, fair competition, promotion of social responsibility in the value chain, respect for the right of ownership); consumers (the promotion of marketing strategies loyal, real information and objective, fair contracts, pay attention to the health and safety of consumers, sustainable consumption, attention to service, complaints and problem solving, data protection and compliance consumer privacy, easy access to key services, attention to education and consumer awareness); the involvement and enhancement of the community (employment creation and development of the main resources of the area, development of technology, creation of wealth and income, halth and social investment

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CONCLUSION: FROM GROSS DOMESTIC PRODUCT TO GROSS INTERNAL HAPPINESS

About CSR

The CSR (CSR) has increasingly attracted the interest of researchers from various disciplines from the start 1960. The statistics of journals and authors show that CSR issues have become a hot topic since 2000. Moreover, since 2005, many authors worldwide have published hundreds of CSR papers every year (Kotler & Lee, 2005; Maignan et al., 2006; Windsor, 2006; Maak, 2007; Porter & Kramer, 2006; Wanderley et al., 2008; Lindgren & Swaen, 2010).

Social responsibility is defined by the European Commission as "a concept through which companies integrate social and environmental concerns in their business operations and in their interaction with stakeholders on a voluntary basis" (European Commission, 2011). Now the CSR represents perhaps the most important social and human objective for the European Union in the next future. In this sense, the EU's communications are very numerous (COM (2001)366; COM (2006)136). Looking at the Horizon 2020 explain, European Union has declared (2011) that CSR could become the key driver for a real sustainable future (European Commission, 2006).

Starting from this definition we can say that CSR is a whole business culture including business ethics, consumer rights, economic and social equity, technology which do not affect the environment, fair treatment of workers, transparent relations with public authorities, moral integrity and community investment.

CSR is a critical theoretical framework considered in the academic, scientific and especially in the business world. There are a lot of interesting aspects and topics around the CSR issue. In this chapter we have tried to focus the attention in several of them: firstly, we have wanted underline how the different CSR theories have generated a long debate that is still open today. Starting from the two main theories (Friedman, 1957; Freeman, 1990) we can conclude that today the world if dived in two big groups regarding CSR: a first group is composed from so-called "extremists" persons. These would like to institute a compulsory CSR not only among the world companies but also in all contexts. On the other hand there are "skeptics" who do not believe absolutely in this instrument except as a "mask " to produce a "corporate conscience" which can then be resold. Finally, we can individuate a third group, external from the debate: those persons who advocate that the CSR is really taken by all companies, and all entities in general, as the foundation for any governance aimed at the development of the first human capital.

A particular aspect in which we strongly believe, as authors as well as persons, is the institution of the social enterprise (Centre for Community Enterprise, 2013). This aspect is very interesting because provides, with a viable opportunity, to break from this dizzying swing of extremes, and balance the best of all ideologies. It addresses social concerns, more efficiently, more sustainably and creatively, which faces declining funding streams and increased demands for innovation, proof of what works and collaboration can be make together (Social Enterprise Alliance, 2013).

In general terms, the CSR should be an expression of the small and medium-sized enterprises' idea of a concept whereby companies decide voluntarily to contribute to a better society and a cleaner. This means not only fulfilling legal expectations, but also going beyond compliance and investing more into human capital, the environment and the relations with stakeholders.

Our desire is that all the companies, facing to the challenges of a changing environment in the context of globalization and in particular the Internal Market, believe that CSR could be a strategical driver to

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generate economic added value. Although the prime goal of a company is to generate profits, at the same time, they can contribute to social and environmental objectives, through integrating CSR as a strategic investment into their core business strategy.

A company, to be competitive on the market and to overcome moments of crisis, cannot act just in the interest of the shareholders, but must take into account the needs of all those who work, buy, contract, choose and decide in the market.

The use of CSR is not only a cost, but also an effective competitive tool which the companies can use to distinguish themselves and, if possible, stand out on the market. The company which demonstrates to be in compliance with certain environmental and social standards, in fact, has several advantages with regard to access to credit, participation in tenders, purchase of its products by consumers, which are reassured by trademarks and other signs testifying the virtuous conduct of the enterprise.

The same system of free competition requires to the company to establish and maintain the confidence gained in the market, taking a more responsible behavior in economic, environmental and social terms.

The elaboration of standards poses the problem of building a shared platform that can be applied and controlled in a uniform manner. In this direction, at the international level, the creation of a global standard commonly accepted is being proposed.

The CSR is a notion that includes a lot of activities that take place inside and outside of the organization. Beyond the speeches launched by different organization representatives, what really counts is the practice (Carroll & Buchholt, 2010). The CSR is not achieved only with the participation of one person or a small group of people. We need a whole community to act in this direction, starting with the CEO and going down to the shop worker.

There is now recognition that Maximizing GDP is not the same as maximizing wellbeing (Stiglitz, 2010), in fact, through the GDP is possible just to delineate an economic profile of a particular context or situation, while, if we want considering the welfare level or profile, we have to use other indicators. The level of Gross Domestic Product (GDP), a frequently used indicator of economic development, naturally suffers at the expense of increased leisure.

Sustainable technologies (that tools and electronic operations that have a good impact regarding social, environmental and sustainable issues) are yet to be widely implemented, and the global community trumpets the need to achieve higher levels of human development—defined as expanding people's choices—countries tend to be short sighted in helping their economies to provide now, rather than in the long-term. The CSR (CSR) is a great tool that can permit to create a revolution, now possible, to try to attack this problem.

About Our Idea

Concluding, is our opinion that, in face to this great world crisis, CSR could represent a key element for a sustainable future in which the main importance is given to the so-called Gross National Happiness (GNH) rather that to the Gross Domestic Product (GDP). First of all, in fact, The modern society is asking for new values, especially linked to the well-being status and not just linked to the economic indicators (Diener & Seligman, 2004). While there is no single official definition of GNH, the following description is widely used:

"Gross National Happiness" (GNH) (Ura et al., 2012) measures the quality of a country in more holistic way [than GNP] and believes that the beneficial development of human society takes place when material and spiritual development occurs side by side to complement and reinforce each other.

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The GNH is based in a moral principle that there are important issues beyond economic and productive ones. The general aims of the GNH approach are:

1. Setting an alternative framework of development;
2. Providing indicators to sectors to guide development;
3. Allocating resources in accordance with targets and GNH screening tools;
4. Measuring people's happiness and well being;
5. Measuring progress over time; and
6. Comparing progress across the country (Ura et al., 2012).

The GNH Index is based on a survey of 7142 people which was completed in all 20 districts of Bhutan in the year 2010 and is representative by rural and urban area and by districts or Dzongkhags.

The GNH can be considered as the next stage in the evolution of economic indicators for sustainable development, going beyond merely measuring values that can be expressed in money. GNH is an attempt to develop an indicator that accounts for all relevant values on this planet, including happiness. Moreover, by taking happiness as the objective, GNH serves as an important yardstick for a framework of Buddhist economics. Breakthrough research in quantum physics, medicine, biology, behavioral science, psychology and cognitive science, the science of the mind is more making relevant to economics. Conversely, within the profession of economics, many attempts are being made to broaden the scope of economics into the domain of psychology, which led to the emergence of economics and neuron-economics behavioral (Overbeeck et al., 2013). Summarizing, in this chapter the authors wanted to give a brief description of the CSR's theory and the normative aspects. In particular, we emphasized the new paradigms linked to the sustainable models the modern world requires. In this context, we used the GNH as examples of success to fix the mind of the companies and the other economic actors towards new approaches that have to be created to growth towards different objectives not more exclusively linked to economy issue but also to other aspect, as social and environmental ones (Brooks, 2013). In this sense the tool of CSR and its different approaches could represents a right path to a sustainable future (Christensen et al., 2007). The different examples reported from examined countries and companies confirm there is possible to create a new strong consciousness that, together a volition, could bring to a sustainable future.

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KEY TERMS AND DEFINITIONS

Corporate Social Responsibility (CSR): Form of corporate self-regulation integrated into a business model; ensures its active compliance with the spirit of the law, ethical standards and international norms.

Environmental Development: Another kind of sustainable development focused on environmental, climate, and biodiversity objectives.

Gross National Happiness: Concept implies that sustainable development should take a holistic approach towards notions of progress and give equal importance to non-economic aspects of well-being.

Horizon 2020: Horizon 2020 is the biggest EU Research and Innovation programme. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.

Life Models: Models and styles to improve proper life and draw a specific purpose and activities.

New Sustainable Development Models: New models that, in a global common vision, ensure a sustainable development for the next young generations.

Social Enterprise: Organization that applies commercial strategies to maximize improvements in human and environmental well-being, rather than maximizing profits for external shareholders.

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Chapter 67
Sustainability Criteria for Tourism Attractions:
A Case Study of Germany

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ABSTRACT

With the start of mass tourism in the 1980s, comprehensive concepts were developed not only to optimize these positive effects but also to minimize the negative impacts of tourism on the environment (Garrod & Fyall, 1998). Problematic with the development of these concepts is the variety of approaches, each with different emphases, as well as the diverse interpretations of the term 'sustainability' (Losang, 2000). However, the topic of sustainability will be one of the drivers of future tourism development and will further increase in significance (Lohmann & Aderhold, 2009). In response to the growing importance of sustainability, the government of the federal state of Baden-Württemberg, Germany, intends to implement and facilitate a sustainability check for tourism attractions. The aim of this study is to provide insight into the perception of sustainable tourism, to examine the ways how to implement it in tourism attractions in Baden-Württemberg and to determine specific sustainability criteria. Semi-structured interviews were conducted with 18 experts of the tourism industry in Germany to better understand the requirements and expectations of such a sustainability check. The results of the interviews revealed that, in general, there is strong support for the government to implement a sustainability check for the highly diverse tourism attractions within the entire state. In this context, the interviews indicated the difficulties and individual particularities which would have to be considered when implementing a comprehensive sustainability check for different types of tourism attractions. The operationalization of the sustainability concept, such as ecolabels and guidelines, builds the foundation for the implementation of sustainable development.

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INTRODUCTION

According to Enzensberger (1964), tourism destroys what it seeks, indicating emphatically that tourism and the carrying capacity necessarily have to be reconciled. The rise of income in large parts of the western industrial countries together with the reinforced global transport network which are mainly conditioned by the increase of disposable time, has caused the tourism sector and especially the number of arrivals to increase enormously since the 1980s (Mowforth & Munt, 2009; Bieger, 2006). Similarly, to other mature industries, the tourism sector's fordistic modes of production were established as a result (Smeral, 2005). Tourism destinations, suited to these 'economies of scale', were little but partially accommodated to the regional circumstances and frequently led to transgressions of the regional carrying capacities (Hall, 2008). In this context, the concept of carrying capacity refers to the number of tourists that a destination is able to accommodate without negative impacts on the environment, the society and the utilization of renewable resources (Telfer & Sharpley, 2008; Hunter, 1997).

However, parallel to these progresses an awareness for the negative impacts of tourism emerged. Up to that point the focus was on the positive (mostly economical) impacts of tourism, but little by little the negative impacts on the environment, the population and the culture were also examined within a sustainable development of tourism (Steinecke, 2006). With the accession to the political Agenda 21 of the government representatives of 182 nations, at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, the term 'sustainable development' was officially stated (Baumgartner, 2008). Based on this conference, the term was manifested as a leading concept for miscellaneous future-oriented strategies (Luft, 2007). Since then many governments have embraced sustainability "as their fundamental development policy" (UNWTO, 1998, p. 21).

Thus, the 2011 newly elected federal state government of Baden-Württemberg in Germany determined the realization of the concept of sustainability as one of their guiding principles including the sustainable tourism development of the region. In response to the growing importance of sustainability, the government of the federal state of Baden-Württemberg (BW), a significant tourism destination within Germany, intends to implement and facilitate a sustainability check for tourist destinations and attractions. Earlier research has indicated a need to utilize holistic and more collective approaches to sustainable tourism to promote its objectives. These approaches represent substantial gaps in the literature and have been suggested for both future research and practice (Bramwell, 2011). Therefore, the aim of this study is a) to provide insight into the perception of sustainable tourism, b) to consider its different operationalization approaches, to examine the ways how to implement it in tourism destinations or attractions and c) to determine specific sustainability criteria in the context of regional sustainable tourism practice.

LITERATURE REVIEW

Sustainable Development and Tourism

With the publication of the report 'Our Common Future', by the World Commission on Environment and Development - also known as the 'Brundt-land-Report' – the term 'sustainable development' was coined (Becker et al., 1996; Ritchie & Crouch, 2005). Since this release, sustainability has been one of the central themes of discussions on tourism and management policies (Saarinen, 2006). A sustainable development herein is defined as follows:

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Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987).

This 'concept of a sustainable development' on a scientific and a political level has been considered as the essential merit of the Brundtland-Report which brought it to the attention of a much wider audience (Mundt, 2011). Nevertheless, "the commonly accepted definition of sustainable development … has not been translated effectively into action" (Butler, 1998, p.31). The discussion on sustainable development was first really taken further by the United Nations Conference on Environment and Development (UNECD) in Rio de Janeiro in 1992, popularly known as the 'Rio Earth Summit' (Berry & Ladkin, 1997). Due to this conference and the emerged global action plan, called 'Agenda 21', a particularly influential basis for implementing sustainable development on a local, national and international level was outlined as a global paradigm (Miller & Twinning-Ward, 2005; Spenceley, 2008). The basic idea was that the municipality level, featuring residents and representatives of industries and organizations, should scheme for the next century based on the Rio declaration (Aronsson, 2000).

Even the movements towards certifications of tourism enterprises emerged as a result of the Agenda 21. It initially emphasized the need for all kinds of businesses to mitigate global environmental problems and to comply with environmental regulations and policies (Sasidharan et al., 2002). Especially with the commencement of mass tourism in the 1980s, comprehensive plans have been elaborated simultaneously to minimize the negative tourist impacts and to maximize its positive effects (Steinecke, 2006). One problem in the development of these concepts is the variety of approaches. With the diverse range of interpretations and viewpoints (e.g. Soft Tourism, Ecotourism, Qualitative Tourism), it is not surprising that there is little agreement on the definition of sustainable tourism (Mowforth & Munt, 2009). Butler gives an overview of different definitions and points out that "one result [of the many definitions] has been that the wide acceptance of the term (…) in many cases is simply acceptance of the phrase but not its implications" (Butler, 1999). Despite the theoretical foundation the adapted forms of tourism largely represent marketing-oriented niche approaches (Losang, 2000). A serious environmentally friendly and socially compatible meant tourism cannot be reduced to a niche segment. It is not a safe assumption that fordistic forms of tourism are necessarily unsustainable. It is rather naïve (and might be harmful) to believe that e.g. nature-focused tourism is always sustainable. It could be argued that small-scaled tourism development of tourism has less impact than other forms, but very often those small-scale development are located in sensible environments with high vulnerability and low carrying capacities. Even though the effects might be small on an individual tourist level, in toto the impact might severely damage reproducibility of the social, economical and ecological systems (Butler, 1999). Therefore the concept of sustainability not all has to incorporate all three dimensions but also the location endowments and carrying capacities.

However, this is not the case in an enormous number of concepts (Becker et al., 1996). Only with the development of 'sustainable tourism', which is based on the extension of the concept of 'soft tourism' by the triple bottom-line sustainability, a holistic approach has been created to reduce the above mentioned impacts (Losang, 2000; Schianetz et al., 2007). According to the World Tourism Organization 'NWTO', 'sustainable tourism' is about considering the current and future economical, social and environmental impacts and needs to address the needs of visitors, the industry, the environment and the host communities. In order to achieve a sustainable development of tourism, it is necessary to consolidate the environmental, economic and socio-cultural aspects, in which all three dimensions will be brought into line (UNWTO, 2012). From the UNWTO's perspective, one cannot assume a fundamental social

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change as it already established. In fact, a holistic management is necessary in order to be able to implement a sustainable development (Baumgartner & Röhrer, 1998).

Due to the increased nature of travelling, accompanied by the negative effects of tourism, there is a need to create sustainable tourism products. Only by preserving the authenticity of the experience and the quality, tourism will continue to be a successful industrial sector on a national level (Lund-Durlacher, 2007). Although numerous destinations and regions are already affected by the negative impacts of tourism, the number of travelers is unlikely to decrease significantly, due to their individual needs and their satisfaction (Buckley, 2012). However, this brings about the need to prioritize sustainable tourism products and to create a preference for services among travelers (Lund-Durlacher, 2007). In this context, numerous operational approaches have been developed for the support and the documentation of sustainable development.

Operationalization Approaches of Sustainability in Tourism

The functional elements of the sustainability concept, such as ecolabels and guidelines, build the foundation for the implementation of a sustainable development. Only the formulation of assessable measurement parameters can ensure the evaluation of the achieved objectives (Losang, 2000). "The need for performance indicators in plans and management strategies for tourism development has been noted by several scholars Getz (1982), Gunn (1994), Inskeep (1991) and the World Tourism Organization (1993) (…). Without such indicators, the use of "sustainability" is useless." (Butler, 1999). In many cases due to imperfect markets in tourism, where often markets fail to incorporate externalities and the nature of public goods prevents resources of being allocated efficiently, government intervention might be necessary (Blake & Sinclair, 1999). Even if the focus of tourism development is necessarily the local level (Middleton & Hawkins, 1996), especially in the case of consumer protection (and information) as well as standardized monitoring systems supported by national an regional governments may well be advocated. In recent years, many comprehensive indicators have been developed, which help to attain the requirements placed on the possibilities for the evaluation of sustainable tourism development. However, there has been a necessary distinction between the indicator systems, which form the basis for planning-related decisions; certification schemes, which represent the foundation of labeling and labels themselves (ibid.).

Indicators and indicator systems have a long tradition. An indicator (from the Latin "indicare" for "to indicate") describes a measurement parameter of facts that cannot or can hardly be measured themselves (Schnorr-Bäcker, 2007). They essentially have the functions of simplifying, quantification and communication (Baumgartner, 2008). An indicator system is a set of different key figures that intends to give information and indications on certain topics (Schnorr-Bäcker, 2007). Thus, they are measured or monitored for the detection of a changing status of a particular phenomenon (Angelevska-Najdeska & Rakicevik, 2012; Miller, 2001). These facts can be used during all phases of a planning and decision making process and to help understand the current status. They can be applied for the analysis and the explanation of tangible problems as well as for monitoring; but, they also serve as a means of predicting the impacts and developments (Roberts & Tribe, 2008).

Indicator systems are often very closely connected to a sustainable development. Thus, besides the living and working conditions in a region or country also the potential of economical progress, with regard to sustainability and social justice are staying in the focus. However, the scope of the systems and the number of indicators varies considerably (Schnorr-Bäcker, 2007). Indicators of sustainability

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must also take into account the interconnectivity of tourism systems besides the elements of traditional indicators (Roberts & Tribe, 2008).

Indicator-based measurement of sustainability in tourism is criticized by several scholars. Main topics of concern (Castellani & Sala, 2010) are (1) vague and arbitrary definitions making a common set of indicator with respective targets impossible. (2) There is no globally accepted conceptualization of sustainable tourism development, rather those concepts are influenced by local settings with different environmental, economic or social conditions. (3) Indicator-based measurement of sustainability also struggles with the long-term view, making data availability challenging and very often data on several aspects, e.g. quality of life are missing. Basically, the majority of indicator approaches is oriented towards the general guidelines of sustainability reporting which are implemented not only by the tourism industry, but also by many other companies and industries. Further, companies in various industries are increasingly recognizing the benefits of a sustainable economic management and therefore are integrating the concept of sustainable development in their business strategy. There is also a proliferation of interest by the stakeholders for information on how and which areas the three dimensions of sustainability can be implemented. In response to these changing expectations, companies are increasingly releasing a sustainability report (Clausen et al., 2002).

A key success factor of sustainability reporting is credibility. Systematic sustainability reporting gives comparable data with agreed disclosures and metrics. Although sustainability reports are voluntarily published by the company and do not have to correspond to a generally standardized form; specific principles should receive attention during the creation (Clausen et al., 2002). These principles and guidelines have been developed by different approaches and initiatives in recent years. Also in this context, governmental institutions might be of help with their reputation. As one of the most important players, the Global Reporting Initiative (GRI) needs to be considered (Gries, 2008).

With the "Global Sustainable Tourism Criteria*"* there has been close attention paid to the indicator system respective of a code of conduct specifically developed for the tourism industry (GSTC, 2008). It has set itself the goal of promoting the operations of sustainability in tourism by a credible measurement and communication. In 2007, the Global Sustainable Tourism Council (GSTC) began as a coalition of over 40 organizations with the development of criteria and now is considered a global leader in the field of sustainable tourism. The global initiative is committed to promote a sustainable, economically fair and responsible tourism that respects the environment and the society (GSTC, 2012 a). The criteria and indicators of the GSTC were developed on the basis of already recognized criteria and approaches. These include the UNWTO indicators for destinations, the GSTC set of criteria for hotels and tour operators and other recognized principles and guidelines, certification criteria and indicators (GSTC-Travel Forever, n/s). According to the company, the initiative had a close look at over 60 existing regulations during the development stage with a total of 100,000 experts being called to state their position on more than 4,500 criteria which then needed to be analyzed (GSTC, 2008). That way, possible indicators could be examined for their relevance and practicability and also for their applicability in a variety of destinations. With this information the GSTC developed the global criteria for sustainable tourism (GSTC-Travel Forever, n/s).

To correspond to the definition of sustainable tourism, destinations have to follow a multidisciplinary, holistic and integrated approach which contains criteria of the following four main objectives: demonstrate sustainable management; maximize social and economic benefits to the host community and minimize negative impacts; maximize benefits to communities, visitors and cultural heritage and minimize negative impacts; maximize benefits to the environment and minimize negative impacts. The total of 45 criteria of these four areas should lead to a common understanding of sustainable destinations.

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They represent minimum requirements which should represent a target for any tourism management organization aiming for sustainability.

The GSTC strives not only to develop and to establish a worldwide standard of tourism criteria for the implementation of sustainable development. Rather, one of the GSTC's main tasks is to synchronize numerous certification programs in the existing market (Rainforest Alliance, 2012). Over time, requirements and standards have been set for the identification and the accreditation of existing sets of regulations and certification programs in sustainable tourism. So the GSTC Accreditation Board is constantly anxious to identify and to check certifications and regulations as to whether they are credible, transparent and impartial and correspond to the GSTC criteria for sustainable tourism. Thus, it is a universal benchmark for clarity, consistency and credibility in sustainable tourism and certification services (GSTC, 2012 b).

Since the Earth Summit in 1992, certification programs have been elaborated in order to measure and define sustainability in many industries (Kroshus Medina, 2005). Generally a certification is understood as the audit of entire businesses, operational procedures or products in regard to the fulfillment of certain criteria (Busse & Riehle, 2003). This is an important issue, because they rely "on having a credible message that is remembered by the market and is crucial to purchasing decisions" (Font, 2007, p. 397). A certification is usually approved by a certification mark or a label (Busse & Riehle, 2003). Many companies, especially in the tourism industry, nowadays see great advantages in undergoing a certification. In addition to valuable information about the company itself, which can be used for an increase of the profitability, a positive corporate image, financial market advantages and even government subsidies are anticipated too (Dimitropoulos, 2012).

For tourism service providers, a certification system also represents a guide for improving the environmental and social compatibility of those who are acting on behalf of their own companies. In addition to that, a certification should intend to encourage the implementation, as well as the continuous improvement of corresponding measures (UNWTO, 2004). The range of sets of criteria of certification systems can be seen as the foundation for the certification and thus for the entire audit process. Here, the audit process can take place at three different levels of evaluation (Lund-Durlacher, 2007). The simplest, but also at the same time most subjective manner of evaluation, is the self-evaluation. It is a pure self-assessment of the company based on the set of criteria. At the second level, an evaluation can be carried out by the costumer. An evaluation by an external inspecting authority verifying compliance with the criteria forms the third evaluation level (ibid.). For Sallows & Font (2004) it is only a meaningful and genuine certification system if independent and external inspecting authorities are both attending the certification process. It should follow that the service or the product's conformity to the criteria and thus the processes or the management system would then be certified through the established set of criteria and the process would then be completed with the awarding of a label or a logo (Sallows & Font, 2004).

Certification systems can be characterized not only by the choice of evaluation but also by their respective orientation. Therefore static output-oriented certification systems are measuring the achievement of predefined indicators corresponding to a threshold level; whereas, dynamic performance-oriented certification systems aim for a continuous improvement of the company's sustainability (Freyer & Dreyer, 2004; Font, 2005). Especially the performance oriented certification which enables small businesses to participate in the documentation of sustainable development (EUROPARC Federation, 2012).

In general, the certification process terminates with the award of a label, which is composed of a logogram, symbols or icons. This label or logo simply communicates the corresponding sustainability threshold and renders the certification of a company or product visible to the travelers. Therefore, the labels usually serve as an orientation for them. They offer some kind of security or assurance, which

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states that products and providers meet the required standards that correspond to certain criteria (UNWTO, 2004; Buckley, 2002). Accordingly, labels are seen as a marketing tool that takes the pressure off consumers during their purchase. Nevertheless, the required integral and equal consideration of all three dimensions of sustainability in the majority of certification systems has not been fulfilled. Thus, social, cultural and institutional conditions as well as the quality are often analyzed and integrated insufficiently (Baumgartner, 2002). Moreover, tourists rarely pay attention to labels – possibly due to a certain level of opaqueness (Buckley, 2002).

In summary, substantial questions remain for the concept and implementation of sustainable tourism as part of a successful regional tourism strategy. For this study, sustainable tourism is viewed as a multidisciplinary and holistic interpretation (GSTC, 2008) rather than viewing sustainable tourism as representing a niche tourism market (e.g. eco-tourism products). Regional implementation or operationalization have been vague and lack globally accepted standards for the wide range of tourism-related businesses and attractions (Castellani & Sala, 2010). Indicator-based evaluation systems and current certifications appear to lack credibility and vary by evaluation method and orientation towards sustainability in the tourism sector (Freyer & Dreyer, 2004; Font, 2005).

Therefore, this study assesses several issues related to regaional implementation of a tourism sustainablity strategy and potential certication for the Baden-Württemberg region in Germany. Specifically, the study assesses 1) whether a regional sustainability check is deemed valuable, 2) implementation issues to consider at the regional level, and 3) the perceived value of exisiting tourism sustainability certifications.

In this study, a regional sustainability check is defined as an audit process of an integrated approach which contains criteria of four main objectives: 1) demonstrate sustainable management; 2) maximize social and economic benefits to the host community and minimize negative impacts; 3) maximize benefits to communities, visitors and cultural heritage and minimize negative impacts; and 4) maximize benefits to the environment and minimize negative impacts.

METHOD

The leisure and tourism industry is not only internationally considered as a growth engine, but it also makes up for an important economic sector in Germany that contributes significantly to employment, income and regional development. According to calculations by the Federal Ministry of Economics and Technology, the tourism sector in Germany roughly offers 2.9 million jobs directly dependent on it and generates a gross value added of around 214 billion Euros in 2010 (BmWi, 2012). Apart from this purely economic importance of tourism in many regions, it has a structural facilitative or stabilizing function and provides development opportunities for structurally weak areas. Further the economic strength of the tourism industry enables capabilities of a sustainable development (DTV, 2012). In response to the growing importance of sustainability, this circumstance induced the government of the federal state of BW, Germany, to implement and facilitate a sustainability check for tourism attractions. Therefore, the fundamental implication of the current study is to assess sustainability checks and/or criteria for tourism attractions and identify their potential within a sustainable development of tourism.

The first objective was to examine the market of existing certifications and eco-labels and, thus, to examine if a current certification can serve as a basis for a sustainability check of tourism attractions in Germany. The second objective was to gain insight into the role of sustainability checks and criteria as an emerging theme in sustainable tourism development in Germany, especially in BW. Therefore,

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qualitative semi-structured interviews were conducted with 18 experts of the tourism industry in Germany to better understand the requirements and expectations of such a sustainability check. To be able to consider the full range of relevant actors in tourism in BW, the selection of experts was based on the systematization of tourism destinations. According to the various categories, experts from diverse fields were interviewed from all over Germany. Interviewees were addressed as to their role as experts in certain fields of activity or as representative of certain groups. In addition to several industry associations, representatives of various tourism organizations and companies, individual consumer protection and environmental associations as well as existing certification schemes were included.

The interviews contained sections seeking information related to (a) the difference and global understanding of sustainability and CSR; (b) possible certifications that can serve as a basis for the sustainability check; (c) the future procedure of the sustainability check and (d) the ideal approach and final impulses. Semi-structured interviews with 23 questions in the four previously mentioned sections were chosen in order to be able to ask supplementary questions to gain more descriptive responses and understanding of more complex opinions and experiences.

RESULTS

Desk research on existing certifications and eco-labels revealed that presently the tourism industry features more than 100 national and international certification systems and labels which evaluate and award the enterprises and their tourist attractions a different aspect of sustainability (Hamele, 2012). The description of these systems and labels tend to focus on what they intend to achieve rather than an accurate definition of what they are (Kozak & Nield, 2004). To counter the challenge of the variety and complexity of existing certifications, various certification systems have been compared (Lund-Durlacher, 2007; Hamele, 2012).

The comparison is based on the requirements and key objectives of the 'Global Criteria for Sustainable Tourism'. GSTC considers existing certifications on the basis of credibility, transparency and objectivity. Furthermore, also according to the GSTC requirements, a "real" sustainability label must equally cover all three dimensions of sustainability. By comparing existing systems and labels that are awarded internationally and/or in Europe, it became obvious that the largest part of the certifications is focused on the ecological dimension, while the economic and and the social issues are either insufficiently addressed or ignored (Hamele, 2012).

After reviewing the certifications on this criteria, it is noted that only the systems of 'TourCert' and 'Green Globe' are qualified for further detailed examination since only these two consider holistically all dimensions of sustainability and are approved by GSTC (GSTC, 2012 c; Zimmer, 2012). While the international label 'Travelife' likewise regards all three sustainability areas, since its specific focus is on hotels and apartment buildings, it could not be examined more closely (Hamele, 2012). As a leitmotif (leading motif), it is deemed that the more extensively a certification system assesses the three dimensions of sustainability, the more efficiently and effectively it can contribute to sustainable development in tourism and therefore serve as a possible foundation for the sustainability check.

TourCert is a nonprofit organization for the sustainability certification of tourism enterprises. Certified businesses obtain the CSR Label "CSR TOURISM certified" (TourCert, 2012 a). It is a management system label that distinguishes the social, environmental and economical sustainability of tour operators throughout Europe. Since 2012, TourCert also certifies travel agencies (Hamele, 2012). It is monitored by

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an independent and voluntary CSR Certification Council. This council consists of representatives from industry, science, environment, development as well as politics. It also develops the CSR certification policy, which defines the requirements for the CSR system and determines the review and certification process (TourCert, 2012 a; TourCert, 2012 b). For the receipt of the label it is necessary for companies to publish a sustainability report according to the guideline "CSR Reporting in Tourism" guideline. Additionally, the business/organization has to build a CSR management system, in which a CSR improvement program and a CSR mission statement are rooted. Furthermore, there has to be a sense of determination from the person responsible for CSR in the organization (TourCert, 2012 c).

The CSR reporting standards have more than 67 indicators and focus mainly on the relevant aspects of small and medium-sized enterprises in tourism. This can be regarded as a minimum requirement for sustainability reports (Kate et al., 2008). The guide is based on the "forum anders reisen" criteria and is also dependent on the GRI guidelines. Likewise, the core contents from the sustainability reports by the Federal Ministry for the Environment (2007) are taken into account (KATE, 2008). The public sustainability report has to be updated every three years (TourCert, 2012 c).

Green Globe is an international certification system, which was established in 1993 in Los Angeles, California (USA) and is approved by GSTC (Green Globe, 2012 a). The institution is a member of UNWTO and, since 1999, a shareholder of the WTTC (World Travel & Tourism Council). Green Globe is represented in 86 countries with 17 offices and recognized in 187 countries. So far, Green Globe has certified worldwide more than 1,000 companies (Zimmer, 2012). Due to these alliances and a relatively massive marketing campaign, the recognition within the tourism industry is one of the strengths of Green Globe (Buckley, 2001).

The label certifies companies of travel sales for tour operators, destination management organizations, the MICE and the hospitality industry. It is also aimed at the spa and health centers, cruise ships and other transport companies or suppliers of tourism enterprises (Green Globe, 2012 b). The Green Globe Standard is divided into four main sections with a total of 41 individual criteria and 337 indicators. These include 70 percent of the criteria and indicators for the environmental dimension and the remaining 30 percent is made up of the social and economical dimensions (Zimmer, 2012). The themes addressed are made up of sixteen environmental criteria, ten criteria for sustainable management as well as nine social/economic issues and four criteria concerning cultural heritage (Green Globe, 2012 c). The criteria for tourism bodies, such as hotels, convention centers and golf courses are varied and tailored to their needs. This is a dynamic certification process, which is tested annually and updated or expanded as needed by an international advisory board (Griffin & DeLacey, 2002). The fulfillment of the criteria is ensured on site by examination of an independent third party every two years (Kate et al., 2008). The accredited Green Globe auditors are professional environmental or sustainability consultants who have taken the training for the Certification (Green Globe, 2012 d).

Findings of the Interviews With Tourism Experts Regarding Requirements and Expectations on a Sustainability Check

The implementation of a sustainability check within the tourism industry of an entire state like BW represents innovation, so far. To implement such a project successfully, a solid basis of support and acceptance by the industry is necessary. With the help of 18 expert interviews, it was possible to consider both recommendations and concerns of the industry. Based on the five sections which are described in the method, the results and the findings of the interviews are discussed in general in the following account.

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By the topic of (a) Sustainability/CSR, it was possible to get an impression of the organization's or association's comprehension of sustainability and, thus, create a basis for the detailed questions of possible certification. So with 15 experts, there is an agreement that the concept of sustainability is in accord with the foundations: economy, ecology and society. This definition has been complemented by one interviewee with the addition that this triad must take place "in the light of the burden of the world and the respect for the finite nature of resources". In practice, this understanding is not yet widely established. Frequently, the term sustainability is exclusively associated or equated with the term ecology. To change this situation, it needs further educational work and information (of the employees and the customers) by the industry and politics. Mobility was cited by the majority of experts as one of the most important aspects of sustainability in tourism.

In the social sector, many participants see a need to improve the existing structures and to increase social justice (based on working hours as well as on the local population). "In this context, also the subject of skilled worker shortage and salaries should be considered." Therefore, it is stringently required to provide and to extend the right, basic conditions for the employees in tourism. The fact that this project could not yet become prevalent was also confirmed by an expert's statement that the issue of Corporate Social Responsibility (CSR) in tourism in BW, so far, is not looming large. Nevertheless, it should be considered in the selection of criteria for a sustainability check. Only in this way, it is possible to increase the acceptance and improve existing circumstances whereby a superior quality of service will ultimately be allocated.

The economical dimension is, according to the experts, especially reflected by the regional creation of value. Consequently, numerous companies have recognized that an increase in efficiency levels can often be supported by the use of local products. Therefore, customers experience sustainability not as a limitation of comfort and consumption, but as enrichment. This was confirmed by a survey of tourists in the Black Forest region of BW in 2011 (Beer et al., 2012). According to the survey, more than half of the respondents inquired as to the origin of local products. Sixty percent surveyed indicated that they were going to buy local products at the end of the holiday to take home and 79.3 percent of the tourists were willing to pay more for local products. The use of regional products is therefore often worthwhile for the companies.

Whether a sustainability check for the entire industry is considered as being useful, if the implementation can build on an existing certification as well as deciding on which specific criteria should be adapted for BW, could be determined by the second topic (b) Certification. In general, the majority of experts think that a sustainability check is helpful in order to raise awareness. Certification may improve the company's view of the issue of sustainability. However, this begs the question of whether the companies would view further certification as an advantage or a disadvantage. In addition to the cost savings (by compliance of the criteria) and improved image (externally, but also internally among employees), the marketing aspect is seen as particularly helpful for the participating companies. "Even if, it would not be a unique feature it would at least be a distinguishing feature." Therefore, the purpose of a certification is to analyze, to reflect and to improve one's own company and its actions, with the destination route to be prepared for changing conditions and requirements in the market.

The possible burdens and excessive bureaucratic demands, especially for small and medium-sized enterprises, are considered as a disadvantage, notably when consistent standards are predefined "from above". It must be the independent desire of the enterprises to submit to the certification process. Accordingly, ten of the experts in this tourism context consider advanced training to be a very relevant part of the project.

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In general, the implementation of the sustainability check in the entire tourism industry in BW is defined as difficult by 16 of the 18 experts. According to one of the experts, "a uniform certification is difficult to implement and a great aspiration, but if the whole industry and all those responsible will back the project, it can definitely be implemented." It also has to take into account in the set of criteria a significant variety of business types and visitors. The implementation for an entire industry is also considered as problematic due to the different boundary systems of the attractions. Consequently, a nature park, due to its expansiveness, is not comparable to a museum. One option here would be the certification of the organization's management (company certification). Attractions, such as national parks or biosphere reserves, currently can only be certified on the basis of their administration. A certification of all partner companies and partner hosts can only be realized after a few years.

In addition to the skepticism about whether consistent certification for the entire diversity of tourism destinations would be feasible, three experts also expressed general doubt if a sustainability check is meaningful at all at the current time. In view of the plethora of labels, the marginal advantage tends to decrease more and more. One of the experts even indicated that such a label just serves "to calm the bad conscience." Therefore, other certification models are deemed neither necessary nor useful. Three experts were not inclined to award a seal of approval, but focused more on the organization of the process, "since there is nothing all-encompassing, and most companies are only sustainable in certain sub-areas but not in a whole."

The remaining experts, who agreed the project made sense, were asked for their views regarding which existing certifications could be used as a foundation for the sustainability check. Generally, for the experts arose the question of: "Are the certifications and seals of approval (labels) relevant to the current market and do they improve the companies' reputations"?

On the one hand, concerns have been expressed since the public has little or no awareness of the existing certifications in tourism. One of the interviewees pointed out that "the existing certifications are hardly perceived and have no reputation". On the other hand, since the implementation of the sustainability check would be relatively quick to accomplish and the business could work with a clean definition (i.e. an established system), it would be useful to adapt the existing certification. According to statements of seven experts, currently the most meaningful and best solution is to award a comparable existing certification to a business in order to enable it to label itself with existing Baden-Württemberg branding. Still, it was relatively difficult for the respondents to name an existing certification which could serve as the foundation for the sustainability check. Eight experts couldn't name any certification on their own, partly because the certifications aren't known and partly because the existing ones weren't assessed as adequate.

The "Green Globe" certification was the top contender, mentioned five times by the experts. Still, this is a relatively small number, considering that 18 experts were interviewed. Four experts named the "ServiceQuality Germany" certification as a basis for a further configuration. However, its specialty is not in the area of sustainability. Also, the "EMAS Certification" was nominated three times. The certification of "Viabono", the "VDR Certification for Green Hotels" and the "DEHOGA Environmental Check" were each mentioned. But, these certifications are limited to particular areas of tourism (e.g. hotels) and do not consider all three dimensions of sustainability in an adequate and balanced way.

Further, suggestions have been given to the Global Sustainable Tourism Council regarding the research on existing certifications. To get an overview of the whole range, according to some experts, it is absolutely necessary to orientate yourself towards these international standards. In this context, the certification system "TourCert" has been mentioned as a possible basis for the future sustainability check.

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However, a detailed review of systems is needed to make sure, that it is a "real" sustainability certification which could be extended if necessary. Even though the comment was made that the development of new certification would not be synergistic and sustainable, four experts contemplated the idea to develop new certification as existing systems are currently unavailable or not compatible.

Finally, the experts were asked for their opinion on whether certification should be adapted in specific aspects or criteria for BW. The clear message was that it was less about BW specifics, but rather about industry-specific criteria, which should not overcharge the small businesses, in particular. Thus, the experts consider it more important to adopt the seal of approval (label) than to adapt the criteria. "The adaption of criteria is not crucial, but the certification should clearly contain the brand Baden-Wuerttemberg. This is after all a guarantee of quality for the tourists." This guarantee should also be supported by the use of local products. The regional purchase should be reflected by including it in the criteria, but this cannot directly be regarded as Baden-Württemberg-specific. Rather, such criteria are about consistent standards that only have to be adapted to the particular region (origin of the products, etc.)

Within the third topic (c), details on the future procedure were discussed. The focus here was on the further development of a possible set of criteria and the implementation of the audit process. Within the interviews, 13 of the experts argued in favor of a performance-oriented certification system. Notably in an industry-wide implementation of the sustainability check and the whole diversity of tourism destinations, it is virtually impossible to orientate themselves exclusively by "hard facts". One statement was that "certain requirements must be met, but it also has to be pragmatic."

Especially for companies that have so far been dealing very little with the subject and are only just beginning to implement sustainable measures in their operations, a performance-oriented approach is better and more meaningful. A uniform output-oriented set of criteria is for the majority of the respondents also not realizable due to the different tourism destinations. There is an agreement that "the criteria of a nature park are not comparable to the criteria of the Europa Park". This requires a performance-oriented certification system which is the only solution to be able to cover the entire industry.

However, four of the experts expressed doubts whether a performance-oriented system is sufficient. Therefore, a combination of performance and output-oriented criteria was proposed. Particularly, in the field of energy consumption, adherence with specified minimum standards deemed necessary. Here, although the process may be involved in the development, but at the end of the certification process a clear figure should demonstrate on which level each company is located. Only a few experts could provide accurate information on the content of the criteria. According to all respondents, it is important that all three dimensions are considered in the development of the criteria catalog.

In general, the number of criteria is not necessarily denominated as relevant, but it should be kept in mind that a reduced number is necessary to allow a practical implementation of the check (Schianetz & Kavanagh, 2008). One of the experts encapsulated it with the statement "as little as possible, as much as necessary." But, besides that, it's much more important to create awareness among the participants of the topic and to support the development. However, according to all the experts, this is only possible with transparent and credible criteria.

Furthermore, the audit process has a great importance in this context. Thus, a credible implementation of a sustainability check is possible for all respondents with an independent audit process. "Within a self-evaluation, there are too many ways to enhance the facts." Only a neutral panel with independent auditors and experts is able to guarantee the sincerity and credibility as well as the transparency of such a procedure. From experience, such an audit is especially relevant to the customer. Therefore, it is strongly recommended not to make use of self-evaluation. It is also important to the experts that certification

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is granted only for a specific period. Hence, there should be a re-certification every two to three years, by which the companies would need to demonstrate significant advancements in the respective areas.

All experts agreed that certification should not be dependent on cost. However, there was a disagreement regarding the financing of such check. There was agreement only to the point that certification should not result in a significant additional burden for the businesses. As the financial situation of the tourism companies in BW is very different, a graduation of prices, depending on size and turnover, will be considered to be reasonable and fair.

At the end of each interview, the experts were asked for the ideal approach and final impulses in section (d). Here, it was again pointed out that at the beginning of the implementation of the sustainability check, a clear definition of the concept of sustainability should be defined and there has to be a precise definition of the objectives. For many businesses, the issue is not yet tangible. Therefore, it should be made clear at first as to which measures and implementations should be required by the companies. What would it mean to the company to implement sustainability in their strategies on a short-term basis? It should also be clear what is associated with the check and what is actually wanted to be achieved.

In the opinion of the experts, a broad dialogue process should be organized in which the participants can get involved in the industry. The whole project should also be implemented success-oriented and as one interviewee described it "not only because it is written in the coalition agreement of the government". Ultimately, the question of the future organization and integration into the existing tourism campaigns should be clarified. The implementation of the sustainability check must be well coordinated. According to the statement of eleven experts, it therefore makes sense to locate the marketing of the label at the national Tourism Marketing GmbH Baden-Württemberg (TMBW).

DISCUSSION

After a thorough examination of the concept of sustainability in tourism, the analysis of operationalization approaches (especially of existing certification systems) and the evaluation of the results of the expert interviews, it is now possible to enunciate recommendations for the selection of the tourism attractions, as well as for the future implementation and the processing of the sustainability check.

Set of Criteria and Certification

Certification, such as the planned sustainability check for BW, on the one hand, conduces to a sustainable development of tourism in the state and, on the other hand, to the certified attractions and businesses. One of the crucial questions that needs to be clarified is whether established and meaningful certification systems exist in the market which can serve as the basis for the check or whether the development of an entirely new system is necessary.

After thorough consideration of the operationalization approaches and following the confirmation of the experts in the industry, it is considered advisable to use an existing certification system as the basis for the sustainability check at this time. The adaptation of an established system allows not only a faster implementation, but also ensures compliance with international standards and experiences that have been developed over the years.

The criteria of the Global Sustainable Tourism Council are considered as a guiding principle in tourism worldwide. This global initiative is committed to promote a sustainable, economically fair and

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responsible tourism that respects both the environment and the society and, thus, defines the minimum requirements for sustainable tourism

By comparing existing systems and labels, it became apparent that the majority of certifications focus on the ecological dimension and that the ecological and the sociocultural dimension are not or only insufficiently considered. This is also reflected in the fact that very few certifications were awarded by GSTC and thus do not meet the international standards in the field of sustainability. Only the two certifications by Green Globe and TourCert have been selected for the sustainability check. Both systems are well established but are also rigorous processes that put high requirements on the businesses. They differentiate themselves less by different sets of criteria and indicators than by their respective orientation. While Green Globe mostly acts on an international level in large companies and chains, TourCert focuses more on small and medium-sized enterprises.

Due the prevailing structures in the tourism industry in BW, this focus would speak for the election of the TourCert certification as a foundation. Another advantage is the aspect that TourCert is a German organization, whose office is located at KATE in Stuttgart. If the decision falls onto TourCert, then the organization and the implementation of the sustainability check takes place directly in the state. The organization is virtually "in the midst of events". Moreover the TourCert certification is in some areas of tourism still in the starting blocks and therefore provides the opportunity to make appropriate adjustments, as well as the possibility to create or expand the system that would be used for the sustainability check. In the case of an internationally active and oriented system such as Green Globe, this would only be conditionally possible and with appropriate expenditure of time.

At the beginning of the certification process, an analysis of the respective companies should be compiled, where the developments are documented at the bottom. Based on percentage targets for improvement, companies can then be certified because of their positive development and optimize their own performance. Here, the application of a multi-level label, depending on the level of development of the company, would be conceivable, which is also suggested by some experts.

On the basis of these considerations and the belief that only a performance-oriented system is useful, it can be said that not the elaboration of the criteria catalog, but the process is of prime importance. So the experts confirmed in the interviews that the focus of the set of criteria must be in due consideration of the three dimensions of sustainability. Referring now to the criteria of the GSTC and the accreditation of the individual certifications, it can be stated that both TourCert and Green Globe comply with this demand.

Since sustainability is arranged as a global concept and the GSTC criteria have been established in particular for the tourism industry; a complete revision of criteria, especially for BW, does not make sense and rather is regarded as a step backwards. Especially, because acceptance in the industry would only be achieved if the set of criteria is confirmed by GSTC. Therefore, in appendix 1, the GSTC set of criteria for hotels/tour operators and destinations (GSTC original versions see appendix 2 and 3) is adapted and extended to a set of criteria for attractions. This catalog covers all three dimensions of sustainability and consists of so-called minimum requirements or criteria that are internationally elaborated and approved. Also, the existing certifications according to the GSTC-standard (Green Globe and TourCert) cover these criteria from an industry perspective.

A completely new development is therefore not necessary. It should be enhanced that sustainability as a global concept is not operationalized through regionally specific indicators. However, if mandatory criteria with thresholds should be used, these limits could be adjusted. Thus, it would be possible to define limits (e.g. in the energy sector) specifically for BW in cooperation with the relevant experts (e.g.

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share of renewable energies needs to be over 20 percent). However, a region-specific set of indicators is not considered as appropriate by the interviewed experts.

Label

It has already been shown that the process of a certification terminates with the awarding of a label. This is usually made of words and/or symbols that render the certification of a company or product visible to the travelers. They contribute above all to transparency during the search by travelers for environmentally and socially sustainable offers. This aspect is important because only through information and knowledge, the habits of tourists can be modified and so sustainable offerings become increasingly in demand.

Also, the planned implementation of a sustainability check throughout the tourism industry in BW, can increase the traveler's desire for sustainable tourism and thus contribute to an increase in demand. In this context, it is important to say that the label signifies a certain guarantee of quality. Tourists, who decide to visit a tourist attraction or a company due to its label, require the continuance of certain standards. By established systems such as Green Globe and TourCert, it is possible to consider these required standards for the certification of companies.

The label is a communication tool that offers the greatest value only through the creation of a brand. It is clearly perceived by its visibility and thus strengthens the tourism destination BW and enables sustainable tourism.

To make the label Baden-Württemberg-specific for the customer, it is possible to build on the existing campaigns and brands of tourism in the country. It seems to make sense to connect the sustainability check to the campaign "Green South" of the TMBW because of the general topic. The project "Green South" is a new brand of the destination BW. The focus of this 'label' is on the marketing of environmentally acceptable, climate-friendly and highly sustainable holiday offers (TMBW, 2012). Hence, this campaign would offer the optimal framework for the sustainability check in BW.

CONCLUSION

The intended implementation of the sustainability check in BW is judged favorably, due to the diverse aforementioned reasons. The results of the expert interviews reveal that in general there is strong support for the government to implement a sustainability check for the highly diverse tourism attractions in the entire state. In this context, the interviews indicate the difficulties and individual particularities which have to be considered by implementing a comprehensive sustainability check for different types of tourist attractions. For example, theme parks have different expectations on such a sustainability check in comparison to a nature park. However, criteria need to be consistent and profound for all types of tourism attractions.

At the beginning of this realization it is very important to clarify the term 'sustainability' and to determine an exact agreement of its objectives. So it is necessary to explain to the tourism participants that this certification won't just facilitate sustainable tourism, but it will also be a benefit and a progress for companies and thus for the guests.

Henceforth, right from the start it is indispensable to make sure that the certification does not lead to an enormous additional drawback or to bureaucratic excessive demand, especially of small and medium-sized enterprises. Additionally, it has to be the company's own desire to get themselves certified. Furthermore

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a comprehensive certification for the entire industry is only feasible as a performance-oriented system, because of the range of attractions. Such a system also offers advantages concerning the stakeholder's acceptance. The audit process should be organized by independent auditors, based on a consistent and profound set of criteria which considers the three dimensions of sustainability. The set of criteria has to orientate itself towards the global GSTC-standards. Enhancements of this set of criteria are possible, but they should not stay in the focus. For the purpose of an expeditious implementation, a high acceptance in the industry seems to be important. This circumstance will be achieved with the help of an existing system and an unmodified set of criteria.

The explicit recommendation is to bank on an existing certification system with an established process and to obtain a unique position via the assigned label at the end of the audit process. This particular label, in the case of BW, could be linked to the brand "Green South" and thereby go viral. A distinct "Baden-Württemberg-Branding" clarifies again the implementation of the check for the entire federal state and the whole tourism industry.

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Chapter 68
Decision Making in Local Energy Planning: A Review

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ABSTRACT

The current financial and economic crisis, as well as the wider socioeconomic and environmental pressures, including climate change among others, put seriously into question the traditional development patterns. This is particularly true for the local and regional authorities, who face a number of challenges as regards growth, jobs and sustainability. These pressures create high expectations for coordinated actions and holistic interventions to address comprehensively the problems toward a competitive economy. In this context, this Chapter describes the main issues of the decision making in local energy planning. The policy context and relevant initiatives are outlined. A detailed review of existing methodologies for local energy planning, as well as standard techniques and methods (participatory approach, aspiration level, multi-criteria decision support, robustness analysis, indicator-based assessment frameworks) are presented. The need to support the local and regional authorities in the decision-making process for the development, implementation and monitoring of their Sustainable Energy and Climate Action Plans, especially within the framework of the Covenant of Mayors for Climate and Energy (a first-of-its-kind global initiative of cities and towns) is highlighted.

INTRODUCTION

The current financial and economic crisis, as well as the wider socioeconomic and environmental pressures, which include climate change, scarcity of natural resources, demographic change, social division, accelerated technological change, and many more, put seriously into question the traditional patterns of living, consuming, and sharing resources (Koepper et al., 2009). These pressures create high expectations for coordinated actions and holistic interventions to address comprehensively the problems of modern society and competitive economy. In particular, with regard to energy and environment issues, integrated

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approaches and methodological frameworks are the key challenge for policy and decision-makers in order to embark them on strategies toward sustainable development and scientifically optimize energy concepts for the future (Doukas et al., 2012a; Deilmann and Bathe 2009; Stigson et al., 2009).

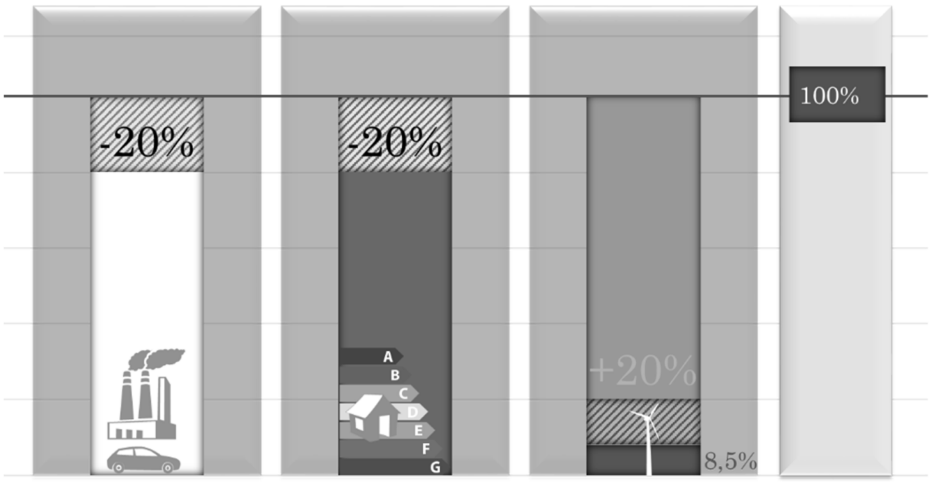
The importance of taking immediately action to prevent and address climate change and its environmental impacts is explicitly recognized both on political and on social level (Omer, 2008). A number of studies, such as the Stern Review on the economics of climate change (Stern 2007) reaffirms the enormous costs of inaction, as well as other relevant researches (Oxfam International 2007; UNDP 2007; UNFCCC 2007; World Bank 2009; Lund, 2007) note that developing countries will need more than 50 billion US dollars per year to tackle climate change, and far more if global emissions are not cut rapidly. In addition, the communication of the European Union (EU) in 2005, "Winning the battle against global climate change," indicated that the benefits of limiting climate change outweigh the costs of taking action (EC, 2005). Thus, mitigation of climate change and its environmental impacts is technically feasible and affordable, provided that not only an integrated and comprehensive approach in community and national policy level be followed, but also the emissions producers act immediately.

The EU had always put high in its agenda activities related to the attainment of economic growth and prosperity. The EU 2020 sustainable development vision provides an opportunity to support the global fight against climate change (EC, 2011a). The EU Climate and Energy Package (EC, 2008) has set very ambitious targets for sustainable development, known as the "20-20-20" targets for 2020 (Figure 1).

In the context of Europe 2020 strategy, a comprehensive strategic approach has been put forward for the next decade to foster inclusive and sustainable growth in Europe and to provide a framework for the EU to emerge strengthened from the current financial and economic crisis (EC, 2010c). Moreover, EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030 (EC, 2014):

- A 40% cut in greenhouse gas emissions compared to 1990 levels.
- At least a 27% share of renewable energy consumption.
- At least 27% energy savings compared with the business-as-usual scenario.

Figure 1. "20-20-20" targets for 2020



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The Europe 2020 Strategy has been implemented in partnership with Europe's regions and communities, as the key actors who can close the "delivery" gap (EU, 2013).

National prosperity is created, not inherited. The European municipalities have considerable importance, particularly with regard to new policies for local energy planning and sustainable development (Porter, 1990).

In this context, this Chapter presents a detailed description of the problem statements for sustainable local energy planning. A detailed review of existing methodologies and tools for local energy planning is presented and discussed. In this respect, the need to support the local and regional authorities in the decision making process for the development, implementation and monitoring of their Sustainable Energy and Climate Action Plans, especially within the framework of the Covenant of Mayors for Climate and Energy (a first-of-its-kind global initiative of cities and towns) is highlighted.

Apart from the introduction, the paper is structured along five sections. Section 2 provides a description of the policy context and relevant initiatives for sustainable development at local/regional level. Sections 3 and 4 are devoted to the presentation of the decision making problem for local energy planning. Section 5 is devoted on the relevant literature review of existing methodologies and tools for the development of Sustainable Energy and Climate Action Plans. Finally, the last section just summarizes the key issues that have arisen in this Chapter.

POLICY CONTEXT AND RELEVANT INITIATIVES

The European cities should be places of advanced social progress and environmental regeneration, as well as places of attraction and engines of economic growth based on a holistic integrated approach in which all aspects of sustainability are taken into account (EC, 2011c). A number of European initiatives have been launched related to these ideas, as presented in the following paragraphs.

The municipalities, as consumers, demonstrate their willingness to implement sound local sustainable energy policies, especially through their participation in the Covenant of Mayors initiative[1]. The Covenant is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. The new "Global Covenant of Mayors for Climate and Energy", a newly merged initiative between the Covenant of Mayors and the Compact of Mayors, aims at becoming the largest movement of local governments committed to going beyond their own national climate and energy objectives. By their commitment, Covenant signatories aimed to meet and exceed the European Union 20% CO_2 reduction objective by 2020. New signatories now pledge to reduce CO_2 emissions by at least 40% by 2030 and to adopt an integrated approach to tackling mitigation and adaptation to climate change (CoM, 2017a).

The Energy-efficient Buildings Public Private Partnership in research (EC, 2010b), launched under the European Economic Recovery Plan, represents the initial and highly strategic step of a longer term set by the industry to create more efficient districts and cities while improving the quality of life of European citizens. This initiative aims to address the challenges that the European construction sector and its extended value chain are facing in their ambitious goal of researching new methods and technologies to reduce the energy footprint and CO_2 emissions related to new and renovated buildings. Specific attention will be given to the development and integration of design and simulation tools, new materials, building systems and equipment and ICT for energy efficiency. In addition, the Directive 2010/31/EU (EPBD recast) has pointed out the leading role of the public sector in the field of energy performance

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of buildings, as new buildings occupied and owned by public authorities should be nearly zero-energy buildings, after 31 December 2018.

The European Innovation Partnership (EIP) on Smart Cities and Communities (SCC) was launched in July 2012 to achieve a meaningful large-scale deployment of smart city solutions in Europe, focusing on the intersections of ICT, energy and transport (EC, 2012). The European municipalities themselves have also taken a very pro-active role and launched the Green Digital Charter in 2009. The municipalities signing up to the Charter commit to reduce the carbon footprint of their ICT and roll-out ICT solutions which lead to more energy efficiency in areas such as buildings, transport and energy. The SCC partnership bridges the areas of energy and ICT with the objective to catalyse progress in the areas of energy production, distribution and use; and ICT are intimately linked and offer new interdisciplinary opportunities to improve services while reducing energy and resource consumption and Greenhouse Gas (GHG) and other polluting emissions. The SCC will go beyond coordinating research and innovation projects and will tackle demand side measures such as enhancing new business models for energy and ICT services.

The Smart Cities Stakeholder Platform is essentially about promoting innovation. It aims to accelerate the development and market deployment of energy efficiency and low-carbon technology applications in the urban environment. The Platform supports the EU towards its goal of an 80% reduction of GHG emissions by 2050 and the Europe's primary energy technology policy, the SET-Plan.

The European Energy Research Alliance (EERA) Joint Programme on Smart Cities was launched in September 2010. Its main objective is the development of scientific tools and methods that will enable an intelligent design, planning and operation of the energy system of an entire city in the near future. An integrated approach will be adopted for the planned research activities in order to capture the interfaces between all the relevant elements of the energy system, such as thermal and electric energy networks, buildings, energy supply technologies and the end-user.

Finally, two of the flagships of Europe 2020 strategy are the Digital Agenda for Europe and the resource-efficient Europe:

- **Digital Agenda for Europe (EC, 2010a):** The Digital Agenda for Europe provides a policy framework aiming at delivering sustainable economic and social benefits from a digital single market based on fast and ultra-fast internet and interoperable applications. In this context, the EU promotes the effective use of ICTs to address societal challenges in energy, climate, and resource efficiency. This includes initiatives in areas such as sustainable cities, energy efficient buildings, smart energy grids and climate change management. Cooperation between the public authorities and ICT sector is essential to accelerate development and wide-scale roll out of ICT-based solutions for smart grids and meters and near-zero energy buildings. The ICT sector should deliver modelling, analysis, monitoring and visualisation tools to evaluate the energy performance and emissions of buildings, cities and regions. For the different grids to work together efficiently and safely, open transmission-distribution interfaces will be needed.
- **Resource-Efficient Europe (EC, 2011b):** The flagship initiative for a resource-efficient Europe under the Europe 2020 strategy supports the shift towards a resource-efficient, low-carbon economy to achieve sustainable growth. To enjoy the benefits of a resource-efficient and low-carbon economy, three conditions need to be fulfilled:
    - First, coordinated action in a wide range of policy areas, action in need of political visibility and support;

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- Secondly, urgent action due to long investment lead-times. While some actions will have a positive impact on growth and jobs in the short-term, others require an upfront investment and have long pay-back times, but will bring real economic benefits for the EU economy for decades to come;
- Thirdly, necessary is the empowerment of consumers in order to move to resource-efficient consumption, to drive continuous innovation and ensure that efficiency gains are not lost.

DECISION MAKING PROBLEM FOR LOCAL ENERGY PLANNING

Europe will not be able to reach its commitments to alleviate climate change without the full participation and involvement of the European municipalities. Not only does the local population need to be able to make the right energy choices, but most of the renewable and energy efficiency options, from wind farms, to solar, to combined heat and power, will require the willing participation of communities (FREE, 2013).

At the 6th European Summit of Regions and Cities in Athens (7-8 March 2014) the Bureau of the Committee of the Regions adopted a declaration on the mid-term review of Europe 2020, titled "A Territorial Vision for Growth and Jobs" (CoR, 2014a). The political declaration argues that the future success of the EU's growth strategy hinges on better engagement of local and regional authorities. In addition, a handbook has been developed as a part of the follow up to the adopted Committee's opinion on the role of local and regional authorities in achieving the objectives of the Europe 2020 strategy (CoR, 2014b).

As mentioned above, the Covenant of Mayors for Climate and Energy constitutes a first-of-its-kind global initiative of cities and towns committed transparent climate action. The Sustainable Energy and Climate Action Plan is the key document in which the Covenant signatory outlines how it intends to reach its long-term CO_2 reduction target. The target sectors are the buildings, equipment, facilities and transport. The sustainable energy policy may also include actions related to the local electricity production (development of photovoltaics, wind power, combined heat and power, improvement of local power generation) and local heating/cooling generation (EC, 2010d). Nowadays, the Covenant of Mayors initiative counts more than 7,200 signatories. In addition, more than 5,600 Action Plans have been submitted (CoM, 2017b).

According to Marinakis et al. (2017a), Action Plans' elaboration and development is a decision making problem (Figure 2). The decision maker, namely the local authority (the Mayor and Municipal Council), in collaboration with the Analyst (Technical Manager) should identify all the actions and measures that will be integrated in the Action Plan of the local community, taking into consideration the baseline energy and CO_2 emissions inventory. They should also identify the overall goal of CO_2 emissions reduction by 2030 (at least 40%).

Active role in the planning process have interested stakeholders, such as energy centres, investors, companies, representatives of the local market and citizens. According to Renn et al (1993), stakeholders, experts and citizens should each contribute to the planning effort, through their particular expertise and experience. The benefits of combining participatory methods with analytical tools are widely acknowledged (Kowalski et al., 2009; Madlener et al., 2007).

Despite the high number of signatories, the lack of proper information and communication about the Covenant of Mayor's initiative and the obligations arising from its signing seems to be preventing the realization of the initiative's full potential (Christoforidis et al., 2013; 2011). In local and regional environments, fulfilling the Covenant's commitment of submitting a Sustainable Energy and Climate

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Figure 2. Decision-making process for the elaboration and development of sustainable energy and climate action plans



Action Plan within a one-year timeframe can come with very challenging constraints. Some communities, and in particular those which are most remote, depopulated or dependent on agriculture, already face particular challenges as regards growth, jobs and sustainability (Marinakis et al., 2012a, 2012b; Doukas et al., 2012b). These challenges include lower income levels, an unfavourable demographic situation, higher unemployment rates, a slower development of the tertiary sector, weaknesses in skills and human capital, a lack of opportunities for young people and a lack of necessary skills in parts of the agricultural sector and food processing industry (Marinakis et al., 2012c; EU, 2012; EC, 2006). This situation has been aggravated by the financial and economic crisis in the current years.

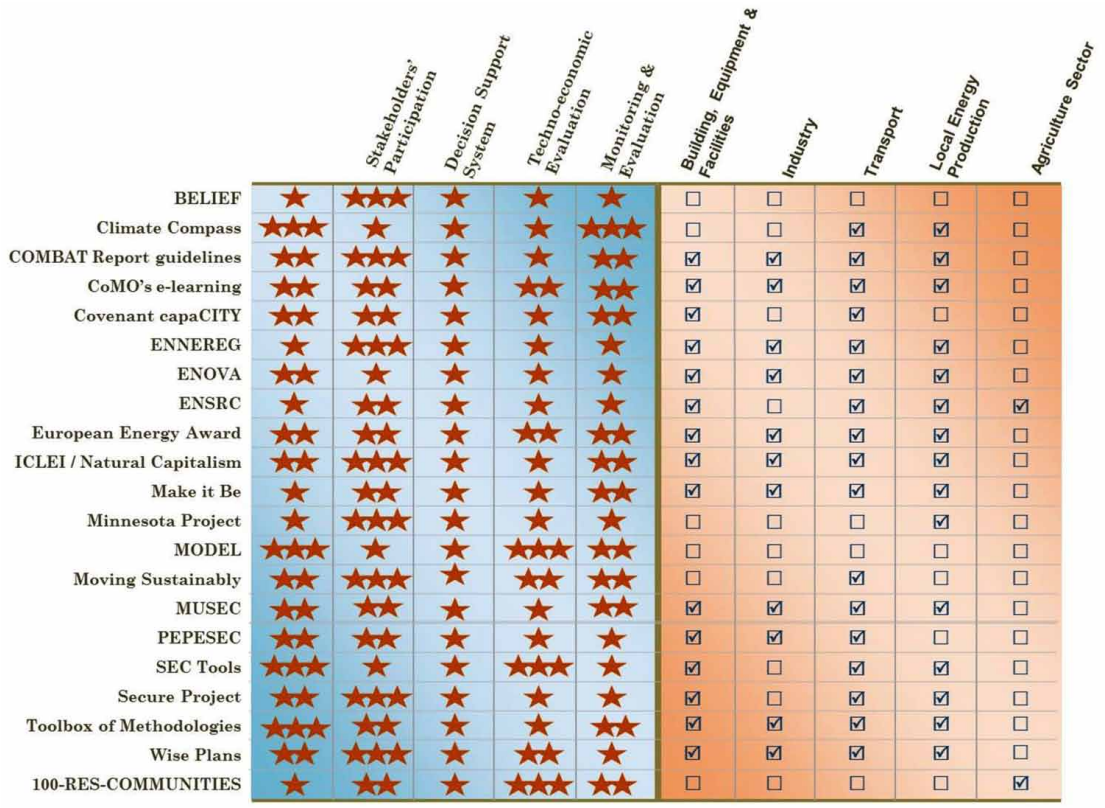
REVIEW OF EXISTING METHODOLOGIES AND TOOLS

Tools and Methods for Action Plans' Development

In the international literature, many existing studies propose methodologies and tools for the Action Plans' development and elaboration from relevant activities and mainly Intelligent Energy Europe (IEE) co-financed projects (Marinakis et al., 2017b). A first study was presented by Bertoldi et al. (2009). Figure 3 presents an overview of all the available methodologies and tools that have been developed so far (CLIMATE COMPASS, 2006; COMBAT, 2008; CoM, 2013; ENNEREG, 2013; Covenant CapaCITY, 2013; ENOVA, 2012; ENSRC, 2011; MAKE-IT-BE, 2011; Moving Sustainably Project, 2011; TMCE, 2011; 100-RES-COMMUNITIES, 2010; Energie-Cites, 2008; MODEL, 2008; PEPESEC, 2008; SEC-Tools, 2008; SECURE, 2008; European Energy Award, 2007; ICLEI, 2007; MUSEC, 2007; Wise Plans, 2007; Minnesota Project et al., 2003).

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Figure 3. Tools and methods for the development of sustainable energy and climate action plans (Marinakis et al., 2017b)



There are methodologies that lay emphasis on the collection of energy data, while others provide alternative methods for stakeholders' engagement in the development of Action Plans. At the same time, some methodologies provide targeted guidance for different sectors of Action Plans, such as industry and transport. Moreover, relevant tools provide a series of guidelines, such as "Toolbox of Methodologies on Climate & Energy" (TMCE, 2013)", "Covenant capaCITY Training Platform (Covenant CapaCITY, 2013)" and "CoMO's e-learning (CoM, 2013)".

However, available methods and tools are not always well-adapted to cities and local/regional communities (Marinakis et al., 2017b, 2015). Moreover, they do not offer an integrated framework for the development of Sustainable Energy and Climate Action Plans and especially the selection of the appropriate combination of renewable energy and rational use of energy technologies.

Participatory Approach

All members of the society have a key role in establishing a common vision for the future and defining the paths that will make this vision come true. Indeed, their views should be integrated in the alternative Scenarios for the region. In this respect, the participatory approach can stimulate the behavioural changes that are needed to complement the Action Plans' measures.

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The benefits of combining participatory methods with analytical tools are widely acknowledged (Kowalski et al., 2009; Stagl, 2007; Munda, 2004; Polatidis & Haralambopoulos, 2004; Geurts & Joldersma, 2001). Different ways to consider participatory approach have been identified, such as "Information", "Consultation", "Deciding together", "Acting together" and "Supporting independent community initiatives" (CTB, 2014). In any case, the participation in planning could improve the quality, acceptance and effectiveness of the alternative action plans for the region.

Aspiration Level

The local authorities set the minimum longer-term target in percentage of CO_2 emissions reduction. According to the Covenant's guidelines, the target should be a minimum of 20% reduction by 2020 or 40% reduction by 2030. However, the local authorities can define a different longer-term target. This means that the examined actions and measures for the region should achieve this longer-term target. To this end, an aspiration level regarding CO_2 emissions reduction of each alternative is used, working as a filtering for the identification of feasible Scenarios.

A number of studies exist on the aspiration level approach (Nowak, 2007). More specifically, Wang and Zionts (2006) examined the relationship between aspiration levels and their mapped-to solutions in the MCDA context. Yun et al. (2004) presented an aspiration level approach using generalized data envelopment analysis and genetic algorithms in multiple criteria decision making such as engineering design problems. In the study of Granat and Makowski (2000), the specified aspiration levels are used for the generation of component achievement functions for corresponding criteria, which reflect the degree of satisfaction of results.

Multicriteria Decision Support

Multiple Criteria Decision Aid (MCDA) methods can be an important supportive tool in policy making, providing the potential to evaluate the alternatives' implications to the environmental, economical and social axes (Doukas et al., 2010; Wang et al., 2009). In decision-making involving multiple criteria, the basic problem stated by analysts and decision-makers concerns the way that the final decision should be made (Doukas et al., 2007). The main idea of the available MCDA methods, is to create a more standardized and structured process for decision making (Doukas et al., 2014; Greening and Bernow, 2004).

In the international literature, there are studies that present applications of Multicriteria Analysis on specific issues related to sustainable energy planning (Table 1). However, none of these studies offer an integrated framework for the Action Plans' development and especially the selection of the most appropriate sustainable renewable energy and rational use of energy technologies at local - regional level.

In the traditional aggregation paradigm, the criterion aggregation model is known a priori, while the global preference is unknown. On the contrary, the philosophy of disaggregation involves the inference of preference models from given global preferences (Siskos, 2001). The philosophy of preference disaggregation in multicriteria analysis is to assess/infer preference models from given preferential structures and to address decision-aiding activities through operational models. The existence of the preference model assumes the preferential independence of the criteria for the decision maker (Keeney and Raiffa, 1976), while other conditions for additivity have been proposed by Fishburn (1966, 1967). This assumption does not pose significant problems in a posteriori analyses, such as disaggregation analyses.

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Table 1. MCDA in energy and environmental issues

Method	Authors	Application Area
Analytic Hierarchy Process (AHP)	Balo & Şağbanşua (2016)	photovoltaic System Design
	Sindhu et al. (2016)	recognition and prioritization of challenges in growth of solar energy
	Domenech et al. (2015)	electrification systems for rural communities
	Lanjewar et al. (2015)	assessment of alternative fuels for transportation
	Erol & Kilkis (2012)	energy source policy assessment
	Meyar & Vaez (2012)	energy policy making
	Awasthi & Chauhan (2011)	sustainable transport solutions
	Shen et al. (2011)	renewable energy sources
	Tegou et al. (2010)	environmental management
ELECTRE	Mousavi et al. (2017)	renewable energy policy
	Jun et al. (2014)	selection of wind/solar hybrid power station
	Rojas-Zerpa & Yusta (2014)	electric supply planning in rural remote areas
	Catalina et al. (2011)	multi-source energy systems
	Haurant et al. (2011)	photovoltaic plants
	Özkan et al. (2011)	solid waste management system
	Papadopoulos et. (2008)	decentralised energy systems
	Beccali et al. (2003)	decision-making in energy planning
Multi-Attribute Utility Theory (MAUT)	Volvačiovas et al., (2013)	public buildings retrofits strategy
	Kalbar et al. (2012)	wastewater treatment technology
	Kambezidis et al. (2011)	renewable energy sources
	Voropai & Ivanova (2002)	electric power system
	Pan et al. (2000)	strategic resource planning
PROMETHEE	Kuang et al. (2015)	evaluation of source water protection strategies
	Ghafghazi et al. (2010)	district heating system
	Cavallaro (2009)	concentrated solar thermal technologies
	Terrados et al. (2009)	renewable energy planning
	Tsoutsos et al. (2009)	sustainable energy planning
TOPSIS	Aalami et al. (2010)	demand response programs
	Boran et al. (2012)	electricity generation
	Lee & Lin (2011)	energy performance of buildings
UTA	Marinakis et al. (2017)	local energy planning
	Sola & Mota (2012)	industrial motor systems
	Demesouka et al. (2013)	wastewater treatment
	Kholghi (2001)	wastewater planning management

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Robustness Analysis

The evaluation models of the multicriteria analysis are generally based on a set of acceptances, assumptions and estimations. These elements are often characterized by a high degree of uncertainty, given the complexity and uncertainty of the decision making environment (Hites et al., 2006). In this respect, another important issue is the robustness of the evaluation model (Roy, 2010). This fact has caused the intense interest of the research community. The recent studies focus on the development of integrated procedures for the robustness's analysis and measurement in different multicriteria analysis methods, as well as how these methods can adapt existing techniques to achieve the formation of stable solutions (Mavrotas et al., 2015; Siskos & Tsotsolas, 2015; Fliege & Werner, 2014). Some of the most recent UTA-type methods are UTA^{GMS}, GRIP, RUTA, extreme ranking analysis and robustness measurement control (Greco et al., 2008; Figueira et al., 2009; Kadzinski et al., 2013; Kadzinski et al. (2012); Kadzinski & Tervonen, 2013a, 2013b; Greco et al., 2012).

Indicator-Based Assessment Frameworks

In May 2014, the Covenant of the Mayors published a special guide for the monitoring of Action Plans. In this context, the "Implementation Report" should include quantitative data regarding the measures implemented, their impact on the energy consumption and the CO_2 emission. Additionally, an analysis of the actions' implementation should be enclosed, including the required corrective measures. Consequently, use of indicators is necessary for evaluating the progress of the Sustainable Energy and Climate Action Plan.

The indicators are a decision making methodological tool, as they quantify and simplify phenomena, in order to provide a better understanding of a complex reality. They represent mainly quantitative information and they elaborate different and multiple data (Androulaki et al., 2016). Different research teams have examined the basic parameters for the selection of the indicators (Rees et al. 2008, Niemeijer & de Groot, 2008). The selection of the indicators strongly depends on the nature and the goal of the researchers and the decision makers. During the selection of the indicators, criteria concerning the completeness, the adaptability and the appropriateness must be taken into account.

The literature review for the development of energy related indicators shows that the most important attempts, are located in big international organizations, focused on the following fields: environment, sustainable development, energy use and energy efficiency. "OECD (Organization for Economic Development and Cooperation)" operates in the field of environmental information; it has managed to develop a collection of directly related indicators and many collections of indexes for various fields (e.g. indicators for energy-environment, indicators for transportation-environment, etc.) The indicators for energy-environment have been developed to promote and to strengthen the integration of environmental worries in the development of the OECD countries' energy policy.

In practice, the scientific community uses composite indexes. Namely, the value of a composite index is a function of two or more individual indicators which are related to a system or a phenomenon (OECD, 2002). The proper description of such an index requires a careful selection of the individual indicators and their weighting factors. One of the main composite indexes commonly used is the Environmental Performance Index (EPI, 2015). It is a method of quantitative and numerical comparative evaluation of the environmental performances of a country and its policies.

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The development of composite indexes in the field of sustainable energy planning is limited in the international literature (Evans et al., 2009; Vera & Langlois, 2007; Afgan et al., 2000). Brown & Sovacool (2007) suggested an energy sustainability index to evaluate energy policy. Abouelnaga et al. (2010) have studied the sustainable nuclear energy indicator, while Afgan et al. (2005) focused on the modelling of sustainable development indicator.

CONCLUSION

Nowadays, sustainable energy policy has been a challenge for the local authorities. The contribution towards addressing the climate change problem, through the communities' CO_2 emissions' reduction and the creation of sustainable jobs, strengthening the extraverted economic activity at local and regional level, can comprise the success measure of this particular effort. One of the bets to be won includes the liberation of local authorities from their role to promote infrastructure projects without central planning and their connection with sustainable development's strategic goals. The disengagement from the unilateral economic development may be achieved through the progressive dissemination of renewable energy and rational use of energy actions.

The European cities have to work towards the direction of strengthening the areas' benefits, by taking advantage of existing opportunities at national and European level, in order to achieve sustainable development. As a result, the decision making problem of Action Plans' elaboration and development within the framework of Covenant's initiative is an important component in local authorities' operation towards the creation of sustainable energy communities.

The cities and communities possess a significant potential for renewable energy and rational use of energy projects implementation in order to proceed towards energy sustainability. Although the local authorities demonstrate their willingness to implement sound local sustainable energy policies, especially through their participation in the Covenant of Mayors' initiative, it seems that this underlying potential remains largely unexploited. Indeed, the lack of technical capacity and the limited resources are the most important barriers for the local and regional authorities.

However, available methods and tools are not always well-adapted to cities and local/regional communities. They do not offer an integrated framework for the development, implementation and monitoring of the Sustainable Energy and Climate Action Plans and especially the selection of the appropriate combination of renewable energy and energy efficiency actions and measures. As a result, there is the need for a methodological framework, appropriately customised to the local and regional communities' characteristics, addressing especially the interested stakeholders who are not "experts" in the field, saving resources and time. The methodology should be a useful instrument for local and regional authorities, facilitating sustainable local energy planning and decision making process.

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ENDNOTE

[1] The CoM initiative is a voluntary agreement of the municipalities to go beyond the EU objectives in terms of CO_2 emission reduction. Available at http://www.eumayors.eu/index_en.html.

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Chapter 69
How Can ICTs Contribute Towards a More Sustainable Future?

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ABSTRACT

Since antiquity technological innovations endanger environmental balance and there is major need to keep this balance in check. Any new technology generates more business activity, leading to increased resource extraction and waste and directly affecting natural ecosystems. Thus technological progress and economic growth are based on unsustainable practices. In the last few decades, information and communication technologies (ICT) accelerated globalized business activity by making the world smaller, more connected and smarter. ICT gradually transformed all aspects of human life including work, learning, and leisure; it has a global impact on business processes and practices, communication, logistics and transportation, finance, and commerce among other aspects. This resulted in wealth accumulation, resource depletion and social divide which have led to problems, directly and indirectly, such as scarcity of natural resources, global warming, climate change, population growth, and increasing youth unemployment. This chapter outlines some of the challenges of the new technologies and ICT practices. It proposes a practice-oriented framework for adoption of more sustainable ICT strategy in companies.

INTRODUCTION

Historically, human progress and development of technologies have created a negative impact on environmental stability and integrity of ecosystems. For 10 millennia, technological innovations have fundamentally transformed the human life. Innovations gradually leaded to resource extinction, environmental exploitation and represent a global trend for the future. In the beginning of 21st century, people could not even imagine the world without technologies. However in order to continue to benefit from technologies people have to make substantial changes in their current business practices and general perceptions. Financial and economic global crises, combined with frequent natural disasters make planning of busi-

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ness operations unpredictable with markets being unstable and investments riskier. In the same time, global economic activity has tripled in size since 1980, and is predicted to quintuple in the next 50 years.

The concepts of sustainable development were defined 30 years ago. However, only recently businesses and social communities have opened the discussion for a truly sustainable future. Do we still have time to reverse the global trends? Some of the most urgent problem areas for businesses nowadays are: scarcity of natural resources and their rising prices; fuels; minerals; fresh water; energy; environmental factors (ecosystems integrity, waste management and global warming effects, increased number of natural cataclysms); and social factors (cost of living, increased world population, aging society, mobility and migrations). More generally, politicians, researchers, and companies still miss the holistic approach for coping with increased sustainability challenges. The high complexity of the term "sustainability" makes possible for myriad different interpretations. Moreover, different contexts of applying sustainable concepts and tools lead to overall misunderstanding and perplexity.

Globalization and fast emergence of new technologies resulted in accelerated production and consumption models that provoked irreversible economic, social, and environment changes. New technology-based innovations formed the backbone of the recent economic growth, fueling the market competition and catalyzing social and environmental footprints around the globe. Information technologies transformed the logic of business operations and accelerated the globalization processes. Nowadays information technologies are practically involved in every aspect of human activity including business, education, communication, and entertainment. More specifically, IT plays and increasingly important role in innovations and R&D processes; cost-effectiveness and efficiency; customer services; and finally they have general impact on business competitiveness. Information technologies represent a unique expanding economy sector having large influence on overall economic activity.

Widely spread across businesses all over the world, usually ICT can have very detrimental influence on organizational environmental footprint (Jenkin, Webster, & McShane, 2011). Information technologies have short product life spans (e.g., laptops, 3–4 years; networks, 5–7 years); their manufacturing and disposal have resulted in toxic hotspots; and a large portion of organizations' electricity costs (and concomitant greenhouse gas emissions) is due to IT energy use (e.g., office buildings, 26%; data centers, 95%) (Jenkin, Webster, & McShane, 2011). In contrast to other technologies, information technologies, and especially information systems, have a large potential to reverse the negative impact. As discovered by Gartner (2007), ICTs are responsible for about 2% of global carbon emissions. The main contributing sectors within the ICT industry include the energy requirements of PCs and monitors (40%), data centres, which contribute a further 23%, and fixed and mobile telecommunications that contribute 24% of the total emissions. However, the majority of researches cited by Molla et al. (2008) believe in the potential of technologies to create sustainable business and society. It is estimated that 'Green' IT/IS can have positive impact on the environment with the potential to reduce global emissions by 15% (The Climate Group, 2008). Even dominating corporate reports in the field of green IT/IS speculate that IT has a potential to create new competitive opportunities, to reduce carbon emissions, and to improve overall business efficiency (Molla et al., 2008).

The objective of the chapter is to identify the current trends of ICT and to propose a concise holistic framework for companies to enhance their development and implementation of green IT technologies. Moreover, there is a discussion of several practical aspects and examples. It starts with a short overview of recently emerged concepts of green, sustainable and clean technologies, focusing on green IT. Some related concepts are then discussed as well as sustainable development, sustainable and eco-innovations, sustainable manufacturing. The second part proposes a holistic model for ICT development and imple-

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mentation in companies. There it highlights the possible role of ICT to enhance companies and business organizations to approach sustainability in a practical and affordable manner. As information technologies play increasingly important roles in any aspect of the business, education and social development, IT can have major influence on sustainable development in micro-aspects. This chapter also discusses different approaches for implementation of information technologies in business settings for improving sustainable development and elaborates on a general framework for sustainable business. Finally there is a general overview of how information technologies can lead to number of sustainable transformations in business, educational and manufacturing processes, and business practices.

BACKGROUND

The background part of the chapter outlines the basic trends and terms that are emerging in research and professional/business literature in the last years. Sustainable development, sustainable manufacturing and sustainable and eco-innovations is presented as general and fundamental concepts that are influencing development of ICT sector. After that some more attention is put on different technologies aspects – green and clean. Finally detailed analysis is made on Green IT and the number of its modifications – green information systems, green networks and green computing.

Sustainable Development

Sustainable development is a well-used oxymoron as the concepts of growth endanger sustainability. The issue of sustainability is extraordinary in both magnitude and complexity and as such is one of the greatest challenges faced by modern society (Ramani et al., 2010). In 1986 sustainable development was defined as a political concept in the Brundtland Report as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). Sustainability goes beyond the ecological aspects and scarcity of natural resources, as it also includes social and economic stability (Harmakoorpi, 2009). At the 2005 World Summit it was assumed the "three pillars" of sustainability (environment, social, and economic), built on the concepts of the triple bottom line (TBL), developed by John Elkington (1994). The triple bottom line attempts to incorporate financial, environmental, and social capital into a comprehensive framework that can help companies analyze their current processes, innovate, and identify new sources of revenue and cost reduction. According to the research of Arena et al. (2009), along with economical, ecological and social development, technological development should be considered as well. In summary, sustainable development stands for (Filho, 2000):

- Systematic, long-term use of natural resources;
- The modality of development that enables countries to progress, economically and socially, without destroying their environmental resources;
- The type of development which is socially just, ethically acceptable, morally fair and economically sound; and
- The type of development where environmental indicators are as important as economic indicators.

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According to Seliger, Kim, Kernbaum, & Zettl (2008), sustainability is a directive to enhance human living standards while improving the availability of natural resources and ecosystems for future generations. Although important and politically accepted, the concepts of sustainability often miss practical implementation in companies and social communities. Some of the key problem issues with sustainability can be summarized as:

- Too theoretical,
- Too broad,
- Too recently recognized,
- No personnel to deal with,
- It demands substantial resources,
- It lacks scientific base, and
- Too much of a fashion-word (i.e. fad) (Jucker, 2002).

In general, people are generally not aware of sustainability ideas and principles. Although there is widespread popularity of the term "sustainability" in political and social documents, several studies in UK and Germany revealed that people cannot cite any meaningful description of the sustainability (Jucker, 2002). Due to the broad and complex scope of sustainability, people are rather concerned for environment issues and wildlife protection, putting the focus away from economical and social development. Thus to progress with sustainable development, people need to consider practical issues and case studies, best practices and good examples. This will enable them to go into specifics and understand sustainability as something relevant to them, valuable and achievable.

Sustainable Manufacturing

Manufacturing industries are largely promoted to become a driving force for the creation of a sustainable society (OECD, 2009). It is recognized that manufacturing companies can design and implement integrated sustainable practices and develop products and services that contribute to better environmental performance. Moreover, many other challenges to traditional manufacturing companies exists (Anityasari, 2008) and these include increased risk for overproduction, due to fast evolving customer requirements; constant need to frequent up-to-date knowledge; expansion of business scope from design and manufacturing to provision of complex services; and end-solutions approach. Hence, manufacturing should adapt to increased expectations.

Sustainable manufacturing is a business practice of the industrial sector, which expands all the company's processes and decisions into the broader social and natural environments in which the company operates in and affects with its actions. This is executed with the explicit objective of reducing or eliminating any negative impact, while pursuing the desired level of technological and economic performance (Leahu-Aluas, 2010). The US Department of Commerce defines sustainable manufacturing as "...the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound..." (Leahu-Aluas, 2010).

Following the detailed literature review of Arena et al. (2009) about the state-of-the-art in sustainable manufacturing, there have been outlined different factors and sub-factors for sustainable manufacturing. The authors identified several sub-dimensions of sustainable manufacturing grouped around 4 dimensions:

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1. **Ecological:** Resources – materials, energy, water; depletion and pollution – emissions, biodiversity and waste; human behaviour and activities: products and services, compliance, transport,
2. **Economical:** Economic performance, indirect economic impact, market presence,
3. **Social:** Work practices and work conditions, diversity and equal opportunities, relations with the community, social policy compliance, consumer health and safety and human rights, and
4. **Technological:** Increasing the productivity of natural resources, shift from overconsumption to biological models, moving from ownership to solution-based business models, reinvesting in natural capital.

The life cycle analysis (LCA) addresses all phases of the product life cycle, including the design phase, raw material production phase, manufacturing phase, distribution phase, usage phase, and end of life phase. LCA aims to maximize total product performances during the product lifetime. The life-cycle approach advocates for the attainment of total product performance, not only from an economics perspective but also from social and environmental perspectives.

Eco-Innovation and Sustainable Innovations

Some of the concepts of sustainability discussed above include idea of eco-innovation. The definition of eco-innovation, provided by Reid & Miedzinski (2008), states that "eco-innovation is the creation of novel and competitively priced goods, processes, systems, services and procedures designed to satisfy human needs and provide better quality of life for everyone, with a whole-life-cycle minimal use of natural resources (materials including energy and surface area) per unit output, and a minimal release of toxic substances." However, eco-innovation and sustainable innovations are not synonyms.

Harmaakorpi (2009) claims that sustainable innovation is an umbrella term and stands for: ecologically sustainable development; participatory innovation (including customers, employees, users and the general public); continuous innovation (the ability to continuously regenerate and break boundaries); global innovation (innovation in global cooperation using knowledge distributed everywhere); innovative management (or management encouraging innovation in organizations and society). The authors Maxwell, Sheate, & van der Vorst (2003) highlight that sustainable innovation is innovation aiming to generate benefits that are collective in terms of the environment, society and economy while reflecting a new out-of-the-box approach that very often challenges traditional systems.

Thus many scholars understand sustainable innovations as a form of disruptive innovations that are continuously changing and threatening existing economic and social models. This explains why it is extremely difficult for companies and politicians to accept, and work for, this fundamental change, and why they often prefer to substitute the term with eco-efficiency, dematerialization and ecology-friendly production (Charter, 2004). Arvidsson & Mannervik (2009) also discuss the need for revolutionary change in the innovation system, emphasizing that the old dominant conceptual model for innovations is outdated and has to be replaced by a new one.

Clean/Green Technologies

Hart (1997) decomposes sustainable development into clean technologies (i.e., environmentally sustainable technologies) and sustainable vision (i.e., plan for moving towards sustainable development) as part of the sustainability portfolio. "Clean technology" stays for the concept that both efficiency and

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productivity can be increased by using new processes, products and services, while at the same time reducing greenhouse gas emissions and protecting natural resources (DCTI, 2013) Thus Clean technologies are competitive with, if not superior to, their conventional counterparts. Many also offer significant additional benefits, notably their ability to improve the lives of those in both developed and developing countries. The Deutches CleanTech Institute, together with KPMG and institute developed a complex framework (DCTI, 2013) including: environmentally friendly energy and energy storage; solid waste management, sustainable water management, sustainable mobility, resource efficiency, energy efficiency.

"Green" has become a popular term for describing things that are good for the environment, generally healthful and economically sensible (Prothero & Fitchett, 2000). Green in the modern business language is the color of environment, future-orientation, ethical and responsible business. In the professional literature, terms like green IT, green IS, green networks and green computing emerged, often used as synonyms.

Green IT

One of the widely accepted definitions proposed by Watson et al. (2008) is based on the differences between green IT and green IS. In general, information technologies transmit process or store information. Therefore, green IT should focus on energy efficiency and equipment utilization. That is why Molla et al. (2008) considers green IT mainly as data center efficiency and narrowly defined green IT as technologies and tools to reduce power, cooling and real estate costs, associated with data centers operations (Molla et al., 2008).

Among popular definitions is that of Watson et al. (2008): 'Green IT' addresses energy consumption and waste associated with the use of hardware and software, tends to have a direct and positive impact. Examples include improving the energy efficiency of hardware and data centers, consolidating servers using virtualization software, and reducing waste associated with obsolete equipment (Watson, Boudreau, Chen, & Huber, 2008).

From practitioners' points of view, a global survey conducted in 2009 highlight that to companies Green IT means lowering electric and cooling costs and promoting sustainable energy practices (Accenture, 2009).

After providing an overview of green IT definitions in literature, Molla et al. (2008) proposes holistic conceptualization of green IT from 4 perspectives: sourcing perspective (purchase green technologies); operation perspective (energy efficiency); service perspective (overall services for sustainability as measuring and analytical tools for greenhouse gas); and an IT life management perspective (waste and life-cycle management).

From a supply chain perspective green supply chain refers to integrating environmental thinking into the product design, sourcing, manufacturing, warehousing, distributing and end of life product management aspects of a supply chain. Thus, from a strategic perspective, green strategy articulates a business' intention to cultivate good environmental stewardship while at the same time pursuing economic goals (Olson, 2008).

Green IS

Green information systems represent an integrated and cooperating set of software using information technologies to support individual, group, organizational or societal goals. Therefore, green IS refers to the development and use of information systems to support or enable environmental sustainability

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initiatives and, thus, tends to have an indirect and positive impact. Examples include: collaborative group software and telepresence systems to enable remote meetings and reduce the negative environmental impacts associated with travel; environmental information systems to track and monitor environmental variables such as waste, emissions, toxicity, water consumption, and carbon footprints; and supply chain systems to optimize product routing and transportation, thus reducing the amount of energy consumed moving products (Watson, Boudreau, Chen, & Huber, 2008).

Some other relevant definitions include green computing, defined by Talebi and Way (2009) as "a discipline that studies, develops and promotes techniques for improving energy efficiency and reducing waste in the full life cycle of computing equipment from initial manufacture, through delivery, use, maintenance, recycling and disposal in an economically realistic way" (Talebi & Way 2009). Chilamkurti, Zeadally, & Mentiplay (2009) describe Green Networking as covering all aspects of the network (personal computers, peripherals, switches, routers, and communication media). Energy efficiencies of all network components must be optimized to have a significant impact on the overall energy consumption by these components. Consequently, these efficiencies gained by having a Green Network will reduce CO_2 emissions and thus will help mitigate global warming. The Life Cycle Assessment (LCA) of the components must be considered. LCA is the valuation of the environmental impacts on a product from cradle to grave.

KEY ASPECTS OF GREEN IT/IS

Green IT

Some of the common criteria for defining what green products include: energy use, greenhouse gas production, raw material source, emissions (air, water), waste production, water usage, land use, end of life, toxicity, use and exposure. Any of these metrics is complex to measure and to estimate along the end-product value chain. Many of the authors and definitions above point out that green IT is mainly focused on energy efficiency and equipment utilization. Green IT substantially addresses issues related to reduced energy consumption and waste management. Moreover, one of the major concerns is the rise of datacenters (Dunn, 2010). There are estimates that in 2020 they will be 5 times more datacenters than there was 2002. Another important aspect is related to electronic waste, including obsolete computer and television equipment, mobile phones, old cables and additional IT equipment. As the number of users of ICT devices constantly increase and the lifespan of these products is between 1-3 years, e-waste is constantly accumulating and it generates serious problems in the environment.

Therefore, according to (Watson, Boudreau, Chen, & Huber, 2008) Green IT can refer to:

- Designing energy efficient chips and disk drives;
- Replacing personal computers with energy efficient thin clients;
- Use of virtualization software to run multiple operating systems on one server;
- Reducing the energy consumption of data centers;
- Using renewable energy sources to power data centers;
- Reducing electronic waste from obsolete computing equipment;
- Promoting telecommuting and remote computer administration to reduce transportation emissions.

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Some recent technologies supporting Green IT include cloud computing, data centers, virtualization, social networks and Web 2.0, mobile computing and storage trends, nanotechnology and cooling systems, remote control systems, and energy management systems. The emphasis on services and cloud computing provide many promising technologies such as SaaS (software as a service), PaaS (Platform as a service), and IaaS (infrastructure as a service). In this case users don't need to purchase software licenses and up-dates or to install new programs on their computers, but can access the Internet and use the application services on-line (for example Google docs).

The list above can be largely improved as Green IT is perceived only as a final good or product, and rarely as part of larger ecosystem. The use of IT technologies is incremental as it depends on software development and software efficiency. People don't need ICT equipment per se; they require complex services involving multiple applications and supporting equipment. End-users, managers, system administrators and clients will purchase and use IT equipment only as a consequence of the services it will obtain. Therefore, Green IT should be analyzed from the service science perspective (Antonova, 2012), covering value co-creation processes with end-users. Taking into account this perspective, there should be highlight on the role of software development, quality assurance models, and studies of human-computer interaction and usability tests. Therefore Green IT should not put the focus on how to create new, better and energy-efficient equipment, but how to increase user satisfaction and utility from running quality and efficient software applications while saving time and efforts and improving quality of human-computer interaction. Many social practices can aid to improve ICT use. For example, limiting the use of Cc (i.e. Carbon copy) function on e-mails can significantly reduce the time for e-mail processing.

Green IS

Many researchers highlight the difference between green *in* IT and green *with* IT. Green IS generally refers to the design and implementation of information systems that contribute to sustainable business processes. Green IS, for example, helps an organization to (Watson, Boudreau, Chen, & Huber, 2008):

- Reduce transportation costs with a fleet management system and dynamic routing of vehicles to avoid traffic congestion and minimize energy consumption;
- Support team work and meetings when employees are distributed throughout the world, and thus reduce the impact of air travel. IS can move remote working beyond telecommuting to include systems that support collaboration, group document management, cooperative knowledge management, and so forth;
- Track environmental information (such as toxicity, energy used, water used, etc.) about the creation of products, their components, and the fulfillment of services;
- Monitor a firm's operational emissions and waste products to manage them more effectively; and
- Provides information to consumers so they can make green choices more conveniently and effectively.

Application of green information systems can lead to a substantial improvement in company performance and efficiency. Green IS has a greater potential than green IT because it tackles a much larger problem. It can make entire systems more sustainable compared to reducing the energy required to operate information technologies.

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With development of new high-technology products and services, and the emerging complex business models, the end-users can improve the overall use of products and services without the need to possess them. The key concepts of service science and value creation can enhance many green IS practices while leading to successful business models and practices. Green IS can substantially decrease the popularity of product possession models and promote service in use models. Moreover they can largely increase self-services and therefore optimize business expenditures, client satisfaction, and need.

HOW TO TRANSFORM GREEN IT/IS TO SUSTAINABLE IT/IS: INTEGRATIVE FRAMEWORK

In order to facilitate the adoption of Green IS/IT, different authors proposed several models for adoption and measurement of Green IT/IS. For example Philipson (2010) proposed a green IT framework – RMIT model, called Green IT framework. Here 4 IT concepts are covered (equipment lifecycle, end-user computing, enterprise and data centers, IT as low-carbon enabler) in 5 perspectives – attitude, police, practice, technology, metrics. Based on these sections, Philipson (2010) approaches a quantified methodology to survey respondents and identify a Green IT readiness index, allowing public authority to obtain data in order to compare different industries and different periods. However, the model proposed is focused mainly on the green IT perspective.

After analysing some of the key terms covered by Green IT/IS, it is critical to understand how companies can interpret and adopt sustainable IT/IS framework. From a practical standpoint, the model is based on the considerations that:

1. Sustainable IS/IT should cover all 3 aspects of sustainability – environment, economy and society, moreover, it should support both green IT/IS and green with IT/IS approaches;
2. Sustainable IS/IT should be produced by sustainable manufacturing practice and should facilitate sustainable manufacturing processes;
3. Sustainable IS/IT is a complex ecosystem of interactions, aiming to reduce resource use and improve overall efficiency, including many technological and business practices;
4. Sustainable IS/IT leads to short term and long-term business benefits and involve large pull of interconnections in company;

A sustainable IS/IT model should cover all substantial business processes of the IS/IT life-cycle. Therefore it includes management, social and technological aspects, which highlight the role of participants in the complex eco-system:

- Conception (R&D, eco-innovations), supply of raw materials (country of origin, quality, price, eco-aspects – suppliers screening);
- Delivery of raw materials (stock piles, delivery policy, SCM);
- Production (energy consumption, pollution, quality standards, production processes, employees (work conditions, office/production energy consumption, equipment) environment (environment screening);
- Delivery of final products (stock, delivery policy, SCM), trade agreements, service;

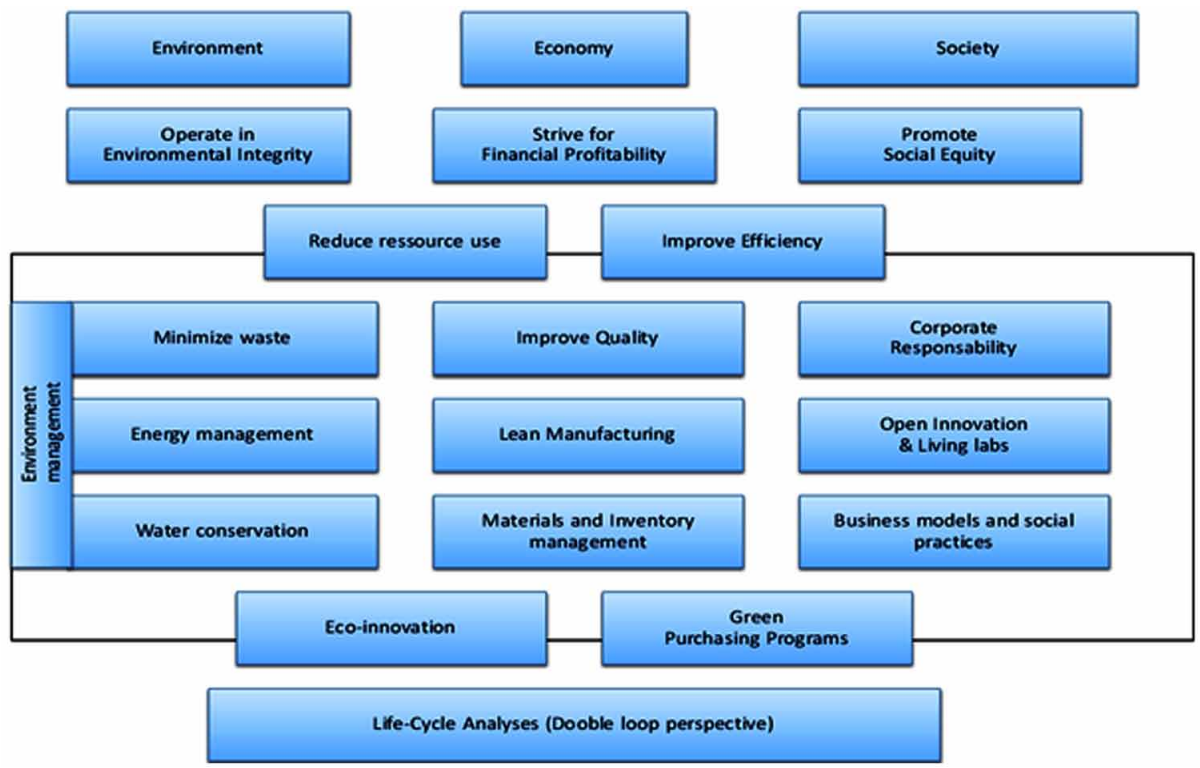
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- Marketing &after sale policy (promote durability, promote buy-back policy, repairing, guarantees, long-term service);
- Business models (provide products/services people want and need – accent on conception phase and user-co-creation; open innovation processes, attention on resource use, holistic vision of the company role in the economy; testing and evaluation, living labs;
- Main results - increase efficiency, increase services and not in products.

In consideration of these stated considerations, the model of sustainable IT/IS is proposed below with the aim to improve visibility of the key sustainability issues. The model combines TBL with increased efficiency and cost/resources optimization. More importantly, it cover LCA analysis and cradle-to-cradle approach, and facilitates companies through implementation of an IS/IT strategy and to easily identify how they use and deploy IT in their business. It aims to provide a general understanding of inter-relationship between various complementary terms within the Sustainability field. Finally the framework proposes a comprehensive and multidimensional challenge in defining the road ahead and the options for sustainable future development.

The reference model (Figure 1) includes 3 main reference fields – operate in environmental integrity, strive for financial profitability, and promote social equity. Companies should discover how IT/IS on one hand responds to these conditions and on the other hand leads to these in the context of their corporate use. The environmental management includes waste minimization, energy management and water

Figure 1. Sustainable IS/IT reference model



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conservation. Therefore companies should adopt practices and specialized systems to assess its energy efficiency and greenhouse gas effects. Time is another crucial resource and therefore companies need to consider that sustainable technologies are time-efficient and save/budget time for development, use and exploitation. Quality is a substantial part of any technology solution. The quality of IT/IS equipment is a prerequisite for use and intention to use the IT systems by users. At the same time IT/IS can support various quality assurance processes including assessments of value and quality obtained from end-users. Lean manufacturing approaches allow companies to focus on leading processes and features, concentrating on resources optimization and smarter technologies. For example new emerging practices as additive manufacturing (3D printing) can replace other much more energy-consuming technologies. Materials and inventory management requires careful policy for materials purchase, based on the principle of material substitution. Inventory management can be facilitated and improved by specific tracking and logistic systems. Corporate social responsibility (CSR) becomes a popular business practice as capability to comply with the mounting demands of different environmental groups and government regulations and practice socially oriented moral management is a major concern and an issue that might affect competitiveness. Open innovations and living labs can improve interactions between the company with end-users and third parties. Last, adoption of innovative business models and social practices will lead to substantial changes. Green purchasing programs and eco-innovations designate the continuous process of improvement, involving marketing and promotion factors across the supply chain. Life cycle analysis is the crucial element in any technology or product in the company as it shows its ecological footprint from the cradle till the final disposal.

DISCUSSION

Bleischwitz, Giljum, Kuhndt, & Schmidt-Bleek (2009) identified three main industrial areas that employ the majority of the earth resources and impacts ecology, economy and sustainable development in a global scale. The three industries are housing, mobility and food production, together with their overall supply chain and subsectors. Careful optimization of ICT use in these sectors could largely influence the production process and use of natural resources, chemicals and energy, change of consumer choice and customer habits, and can generally decrease waste and optimize the economic structure. Thus focusing a company's sustainable IS/IT practices and optimization of the information use in these specific sectors can lead to substantial improvement both in economy and ecology. Moreover, Bleischwitz et al. (2009) believe that companies will be the main drivers of eco-innovations and sustainable progress, propagating production and delivery of eco-innovative products and technologies and educating customers and citizens for sustainable use practices.

While ICTs continue to transform commercial, business and social practices on the global landscape, we can expect that new technologies will continue to emerge. Soon it is expected that new coming ubiquitous and pervasive technologies (such as augmented reality, additive manufacturing—3D printing, Internet of things, future internet and robotics) will bring many new challenges for sustainable development. These new IT/IS applications will substantially change the way products and services are designed, produced and consumed. Undoubtedly this will have larger impacts on the earth's ecosystems, employment, social divide and sustainable development as a whole. Robots and additive manufacturing systems can signifi-

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cantly reduce the need for a low-skill labour force. Moreover, today robots can replace the highly qualified work of surgeons, while smart toilet systems can become personal bio labs, transforming fundamentally the healthcare system. At the same time the youth unemployment is increasing globally, while public social systems and pension funds are put at risk from the very large aging population.

Historically technologies and new discoveries have been continuously transforming the business and have led to social unrest since the first industrial revolution. Thus "dehumanizing" business by applying more technology solutions should not mean that working places and jobs have to disappear, or that the social and economic divide should increase. New technologies lead to new level of development. The global economy realizes an expanding wealth accumulation according to the recent reports (Credit Swiss, 2013), reaching new levels of productivity and efficiency. New emerging technologies open many new opportunities. It can be expected there to be the emergence of a new sensor-enabled digital world, where the objects have "senses" to collect and process information, accumulated through hearing, seeing, communicating, reacting, deciding, memorizing and storing. This can lead on the one hand to minimizing resource usage and waste ("cost" oriented approach) and on the other hand, it can provide improved services, based on synergy of value networks for customers (becoming "profit-centers").

However, the fast implementation of technologies in different social contexts can threaten many professions, industries and economic sectors, so the society needs to set up new understanding about the "risk price" for technology adoption. Sustainable development should become priority to companies, the public and the entire society. Instead of continuing short-term production, companies have to reconsider how to improve the quality and durability of products and services in order to limit the waste of resources during its whole life-cycle and improving recycling and ecological balance. Thus in order to change the concepts of resource extraction and use, companies will need additional support to redefine production processes, business models and value-creation mechanisms. Therefore, companies should move from simple end-products to complex service sales, designing value co-creation experiences with clients while concentrating on revenue perspectives.

CONCLUSION

Since innovations and technologies have general impact on environment, and lead to substantial growth and exploitation of economic resources, sustainability is a key concern when designing and developing new products and services. ICTs should be considered in every sector - from employing electricity and energy resources, to responsible for substantial waste accumulation. On the other hand, ICT can improve many existing production and business practices that can lead to more sustainable business and technologies.

This chapter proposes a new model for understanding sustainable technologies, that can enhance companies to understand how sustainable their ICT strategies are and which aspects are covered. While discussing different concepts of ICT, the focus on green, eco or clean are just labels toward a more general paradigm shift. ICT has too often been considered a "driver for the business", and as such has been viewed in the silo of the specific project for which it is needed. By viewing ICT strategically across the entire organization and even fundamental social infrastructure, ICT can become the "engine of the business" (Accenture, 2009).

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KEY TERMS AND DEFINITIONS

Eco-Innovations: Innovations in products, services and processes that lead to more environment-friendly practices – including limiting and re-use of raw materials – decreasing waste and product disposal.

Green IS: Design and implementation of information systems that contribute for sustainable future in long-term, including technologies and business models that limit the resource use, increase energy efficiency and contribute for reconstitution of business and social practices.

Green IT: Cradle-to-cradle approach for information technologies, including design, implementation, deployment, use, recycling and disposal of IT devices (digital devices; computer-enhanced devices).

Sustainable Development: Development based on economic, social and technological progress, using limited consumption of natural resources, having minimal impact to the environment; Sustainable development should lead to the increase of humankind knowledge in order to cope on socially just and responsible for the future generations' way with environment limitations, resource use, overcoming natural and human-provoked crisis and cataclysms.

Sustainable Innovations: Innovations in products, services and processes that lead to more sustainable for the planet practices and long-term benefits. These innovations should cover the three pillars of sustainability – to be environmentally friendly, to be economically sound, to be socially just.

Ubiquitous and Pervasive Technologies: Digitally-enabled products and technologies that will enhance data and information collection, processing and delivery and Internet connectivity, increasing products usability and capacity for service delivery.

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Chapter 70
A New Barrier for the Future of Energy Market in Turkey: Internal Capital Adequacy Assessment Process (ICAAP)

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ABSTRACT

The Banking Regulation and Supervision Agency (BRSA) in Turkey has implemented a risk based framework since 2006, making bold moves of resulted in a stellar increase of capital adequacy in Turkish Banking System. But the enactment of the new law for the Internal capital adequacy assessment process (ICAAP) is evaluated as being quite an early adoption. The Bank for International Settlements (BIS) points that Turkey has early-adopted the implementation recommending further discussions for a reconsideration of the target capital adequacy ratio. The banks have already found it difficult to follow up high capital adequacy especially while financing energy projects, as the Turkish Banking system is preparing for the requirements of Basel III framework. Under the new regulation, the ICAAP is expected to decrease the capital adequacy of banks in Turkey. Meanwhile, the challenge in adopting ICAAP can be an additional barrier standing in the way to the development of energy market.

INTRODUCTION

Measures to promote the development and use of energy and energy efficiency deserve targeted attention, because not only do they promote sustainable approaches to energy development, but they are characterized on a geo-political level by the need for environmental and supply security, on an operational level by the need for issues like "cost". So, for example the importance of energy projects and energy efficiency has resulted in the development of specific targets in US. and EU, along with changes in legal frameworks and guiding principles to remove barriers to innovation and technology development and reducing expensive up-front costs (EBRD, 2010a).

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Global economy need to obtain sustainable and clean sources of energy which is an issue of financial challenges. In the last decade, the cost of renewables has decreased dramatically. Yet, large debt problems of the developed countries and a worldwide fear of risk and uncertainty still continues blocking investments and affecting global energy market and energy solutions. Especially, developing countries face problems of energy sourcing due to costs and risks.

Turkey, as a developing country, implemented policies to improve renewables and energy efficiency in line with EU requirements. After the implementation of Energy Efficiency Law (EEL) in Turkey, Turkish engineering firms show considerable interest in energy savings projects. There is a growing sign of an energy efficiency implementation in Turkey. However, energy importation costs of Turkey still present a challenge leading to huge financial burdens. Turkey has still heavy risks of regulatory and financial aside the high potential of creative energy solutions (Okay, 2015).

The key issue is "banking" to energy finance enabling risky energy projects such as renewables, energy saving solutions, innovative energy and creative engineering. Nowadays, energy financing banks in Turkey are the highest ranked in discussions with the internal capital adequacy assessment process (ICAAP). ICAAP came into effect by 31st March of 2016 by the enforcement of Banking Regulation and Supervision Agency (BRSA) in Turkey. ICAAP is one of the most important and advanced guideline by Basel II which will have direct effects on financing risky energy projects. Therefore, it became a hot issue both in the banking and energy sector. Both sides have concerns of challenges, adoption and loss. What's more, it seems that the viewpoint of BIS, as an early adoption, consider and meet all these concerns.

This study has three main objectives. The first objective is to reveal the themes behind the internal capital adequacy assessment process in the light of Basel accords. In this context, the importance of risk management and supervision in the banking sector is presented in the background of the paper. The main focus of the chapter is to extend the internal capital adequacy assessment process regarding the energy project financing and risks that banks face in Turkey. The remaining problematic issues involve in this section where Turkey's facing heavy risks of regulatory and financial aside the high potential of energy solutions. There is still a huge need to improve the financial environment and awareness for energy projects and solutions in Turkey. The study concludes with the recommendations on new requirements about ratio changes in capital adequacy for banks regarding the problems consisting of energy finance in Turkey.

BACKGROUND

The banking sector is a highly sensitized system and has learned to its cost the risk of attracting adverse publicity through failings in governance. Banking is clearly a very special sub-set of corporate governance with much of its management obligations enshrined in law or regulatory codes. These factors put banks considerably into a more complex world than in other sectors. Banks attempt to comply with the same codes of board governance as other companies but, in addition, factors like risk management, capital adequacy and funding, internal control and compliance all have an impact (Okay, 2005). As a matter of fact, banks must be surrounded with risk management principles as a firewall. Capital adequacy and related issues of funding and internal control are all going along with risk management principles.

Risk management is a main concern for the front and middle office functions of banks that became increasingly important for fund managers in the volatile financial markets of today. The current trends in risk management are de-regulation of financial markets, increasing bank supervision and regulation and technological advances (Alexander, 2003). Especially, the item of increasing bank supervision and

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regulation is the major issue in risk management that has reached a generally accepted law in the world, the so called Basel implementations.

Basel accords are designed by Basel Committee on Banking Supervision (Committee) that was formed in 1974 with the participation of G10 countries, as a platform to provide member countries to share their knowledge and experiences in the field of banking (BRSA, 2016a). There has been a gradual extension of capital adequacy requirements to cover more types of risks: First credit risks (1988), then market risks (1996) and now operational risks (2004) (Alexander, 2003). In 1988, the Committee published the Basel Capital Accord (Basel-I) aiming to uniform different capital adequacy standards in different countries. Afterwards, Basel-II Accord was published in 2004, Basel-II.5 Accord in 2009 and Basel-III Accord in 2010, as to include the developments in financial markets and banking (BRSA, 2016a).

Before the Basel I Accord in 1988, regulators required only limited reporting of risks and imposed only some simple credit limits. The Basel I Accord introduced the first capital requirements for banks, but the requirements were product based – mainly for loans – with no offsets, netting or market sensitivities. The Basel I Amendment (1996) and the forthcoming Basel II Accord (2004) have introduced quantitative measures for capital adequacy that are risk sensitive, but not overly reactive to short term fluctuations (Alexander, 2003). Basel II is so special that it provides incentives to strengthen domestic supervision pushing banks to become more sophisticated in their management of risk (Powell, 2004). Besides Basel II intends to promote safety and soundness in the financial system, align regulatory capital requirements more closely with underlying risks, provide incentives for institutions to pursue more sophisticated and effective risk management, and demonstrate robust governance, processes, and controls to shareholders and institutions.

Risk management stand at a turning point when banks deal with energy projects. Third party financing is the most commonly used type for energy projects and it can be realized by a guaranteed saving contract. Country risk, credit risk and counterparty risk play a major role via projects with too high level of risk as for the case with energy projects. So, energy financers should have strong balance sheets. Energy financers in literature, are called Energy Service Companies (ESCOs). ESCOs may finance, or assist in financing an energy project (including renewable and sustainable energy projects) by providing an energy-improvement (saving, efficiency, conservation) guarantee. Recently, interest in ESCOs has increased due to increasing energy costs and economic penalties attached to excessive energy usage and related emissions (Akman, Okay, Okay, 2012).

On the other hand, banks must have strong assets to take on huge liabilities of clients that have long-term projects. This is extremely a big risk that points to a considerably significant size-based balance sheet to finance projects. Therefore, energy companies should be committed to risk management, as well. Energy projects should be managed with risk reduction methods like hedging instruments and venture capital. When energy companies need financial support to invest such risky projects banks analyze detailed financial statements before extending credit. Besides, banks should implement Basel II, and then Basel III (BIS, 2012).

The purpose of Basel II-III risk implementations is to provide an international standard and monitoring for legal authorities in risk measurement. Basel III, presents the latest upgrade of Basel Committee's reforms to strengthen global capital and liquidity rules with the goal of promoting a more resilient banking sector. The objective of the reforms is to improve the banking sector's ability to absorb shocks arising from financial and economic stress, whatever the source, thus reducing the risk of spillover from the financial sector to the real economy. The Committee's analysis has also covered further measures to mitigate the risks or externalities associated with systemic banks, including liquidity surcharges, tighter

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large exposure restrictions and enhanced supervision (BIS, 2011). Basel III is expected to restrict banks with heavy capital and liquidity requirements that will be unfavourable for renewable energy financing in the future.

Basel III is expected to be implemented globally between 2013 and 2019 (BIS, 2013). But the 2019 deadline can be suspended to another date because of a global economic and financial change as the risks and uncertainty rise in the world.

Internal Ratings-Based Approach (ICAAP)

Banks take on risks in order to gain return, therefore management system to identify and take on well priced risks becomes ever more important in today's competitive banking market. Basel II, Pillar 2 demands banks to put an internal capital adequacy assessment process in place. Like in any business enterprise that involves the commercial provision of products or services to meet a particular need, owners of banks require to be compensated for the resources that they invest to generate such services (Hazem, 2009).

Therefore, implementation of the Basel II Framework was crucial for serving as a catalyst to encourage greater cooperation and communication in global banking especially when Basel I became insufficient. While there are differences in supervisory approaches across countries, Basel II includes an important measure for promoting communication and transparency, a large and growing number of countries have put in place and made available to the public their Pillar 2 evaluation processes for a bank's internal capital adequacy and assessment, in short ICAAP (BIS, 2007).

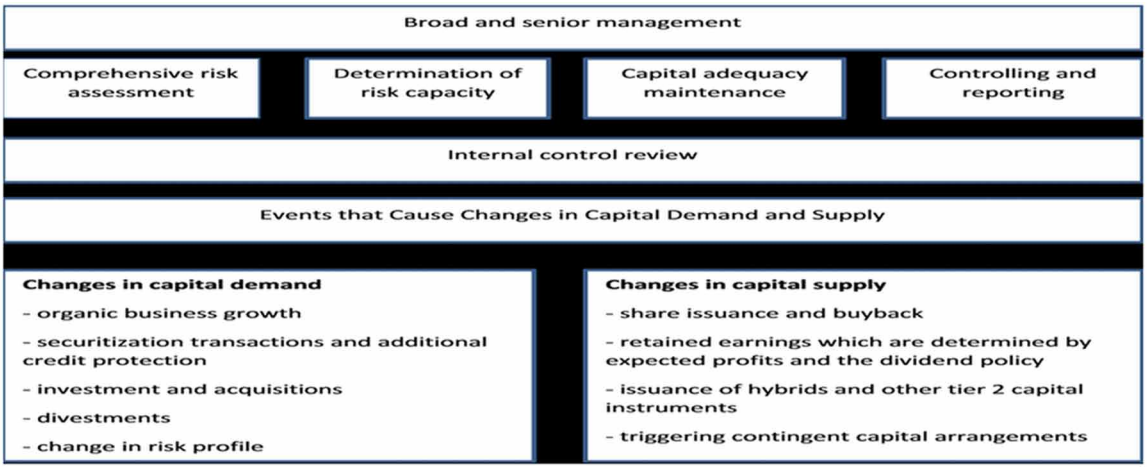
By undertaking an ICAAP, banks are more equipped to assess the level of capital needed to support current and future risks, including a buffer for stress scenarios. Well-run banks view it as a core strategic activity that safeguards operations including in times of stress, rather than as a compliance exercise (IFC, 2016).

ICAAP is an advanced capital management for measuring the capital adequacy of banks by the legal authority. A thorough and comprehensive process, ICAAP is a vital component of a strong risk management programme. ICAAP should produce a level of capital adequate to support the nature and level of the bank's risk. It is the role of the supervisor to evaluate the sufficiency of the bank's internal assessment and to intervene where appropriate. When assessing whether a bank is appropriately capitalised, bank management should ensure that it properly identifies and measures the risks to which the bank is exposed. In addition, the ICAAP should incorporate stress testing to complement and help validate other quantitative and qualitative approaches so that bank management may have a more complete understanding of the bank's risks and the interaction of those risks under stressed conditions. A bank also should perform a careful analysis of its capital instruments and their potential performance during times of stress, including their ability to absorb losses and support ongoing business operations. A bank's ICAAP should address both short- and long-term needs and consider the prudence of building excess capital over benign periods of the credit cycle and also to withstand a severe and prolonged market downturn. Differences between the capital assessment under a bank's ICAAP and the supervisory assessment of capital adequacy made under Pillar 2 should trigger a dialogue that is proportionate to the depth and nature of such differences (BIS, 2009).

Pillar 2 has been implemented by the international regulator to take into consideration such sources of risk that are not part of Pillar 1 and may be difficult to quantify. Large organisations are already required to develop a comprehensive framework to assess the overall adequacy of their capital allocation with regards to the key risks their business model is exposed to. Under this framework, banks also have to

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Figure 1. ICAAP principles
(Source: KPMG)



elaborate a capital planning aligned with their strategic and business plan. This capital planning has to be performed over a certain horizon of time, usually between 3 and 5 years, and is comprised of a base case with at least three different stress scenarios, including an identified worst case. This is to test the resilience of the bank's capital base (loss absorption capacity) under severe stress conditions. Last but not least, banks have to demonstrate that the ICAAP framework is embedded in their decision-making process and that it is not a one-time compliance exercise but rather a critical governance tool for top management. This could be an important change, as well as a challenge, for organisations that did not perform ICAAP exercise in the past because they may now have to consider additional capital requirements (Deloitte, 2015).

FINANCIAL BARRIERS FOR ENERGY MARKET IN TURKEY

Turkish Banks Financing Energy Projects

Studies of compliance of Turkey with Basel standards have been started with capital measurement method based on Basel I published in 1989. Various studies regarding compliance with Basel II standards have been conducted and numerous regulations have been prepared since 2005. Then, Turkey was accepted as Committee member as of May 25, 2009. Regulations on own funds, capital adequacy, liquidity, leverage and capital buffers in line with Basel III were entered into force between years 2013 -2015 (BRSA, 2016a).

The participating Turkish banks and the EBRD together created a powerful brand for sustainable energy finance, and built a lasting relationship through which new partnerships were created to finance larger projects (EBRD, 2014). However, the banks have already found it difficult to follow up high capital adequacy especially while financing energy projects, as the Turkish Banking system is preparing for the requirements of Basel III framework.

Turkish banking system, with 52 banks, is growing after 2013 as shown in Table 1. Indeed, the branches and staff are fastly growing with 12.269 branches and 217.504 as of December 2015. There has been an

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Table 1. Banks in Turkey

Banking Sector	2013	2014	2015/6
Total of Banks	49	51	52
a) Commercial Banks	**30**	**32**	**32**
-State	3	3	3
-Domestic Private	10	10	9
-Foreign	17	19	20
b) Dev. & Inves. Banks	**13**	**13**	**13**
-State	4	4	4
-Domestic Private	6	6	5
-Foreign	3	3	4
c) Participation Banks	**4**	**4**	**4**
-State			1
-Domestic Private	1	1	-
-Foreign	3	3	3
d) SDIF Banks	**2**	**2**	**3**
Branches	11.986	12.210	12.298
Staff	214.263	216.880	218.341

Source: BRSA

important change in the asset composition of banks' balance sheets in recent years. Banks are increasingly invest in loans (especially in consumer and SME loans) while decreasing their securities portfolio. For the liability side, the main funding source is traditionally deposits although the share of interbank liabilities has been increasing (BRSA, 2016c). At the same time, with its diversified branch network and strong customer base, banking system has reached a strong profitability in recent years (BRSA, 2015).

Despite the banking sector's high capital adequacy and profit after the adoption of Basel accords, lastly Basel II, lending volumes remain depressed. This is primarily because of the risk-averse approach of the new banking system and contrarily much attributed private sector and its capital inadequacy. Unfortunately, Basel II was not implemented by the private sector in Turkey. Only large-sized firms in private sector are on the platform to establish an energy market. If they come together to form joint ventures with domestic firms or established foreign energy companies, the result might change. If not, then energy financers should have strong balance sheets. Energy companies must have strong assets to take on huge liabilities of clients that have projects of 7-10 years. This is extremely a big risk that points to a considerably significant size-based balance sheet to finance projects. Therefore, they should be committed to risk management. Turkish private sector -consisting of %99 small and medium sized (SMEs) - maintains the effects of weaknesses and inadequacies for years that provide insight on the limits to firm growth and sustainable investment. Companies in Turkey do not use risk management tools. Without risk management, SMEs in Turkey especially have to bear size risk, credit risk, capital inadequacy, regulation risk, technology risk and country risk (Okay, 2014).

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The banks in Turkey struggling to meet the demand of energy industry. Some Turkish banks, unfortunately low in number, with EBRD and World Bank together created initiation to build programmes for energy finance as shown in Table 2 (detailed in section Solutions and Recommendations). However, the number of subsidy support provider and launched programmes are not that powerful enough to influence energy market in Turkey with a huge demand in energy inspite of a potentially dynamic and strong banking system regarding quantitative and qualitative specifications.

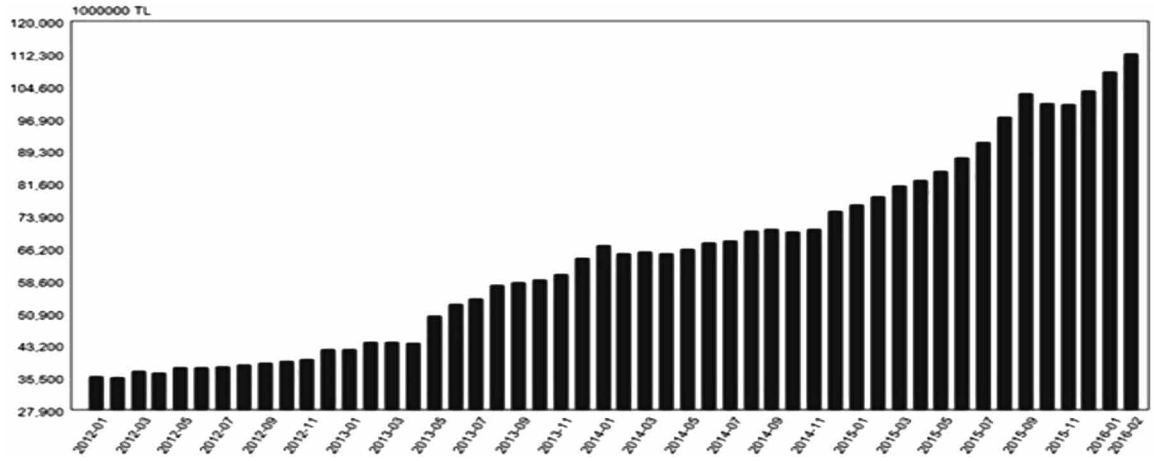
At the same time, Turkish banks are pressing for solutions to non-performing loans. Loan defaults are on the rise and banks are facing difficulty floating US$ 50 billion of total credits to the energy sector (Dilek, Schlissel, 2016).

Table 2. Banks Financing Energy in Turkey

BANKS FINANCING ENERGY PROJECTS	Enery Projects (Programme)
Akbank	MIDSEFF, TURSEFF
Garanti Bank	MIDSEFF, TURSEFF
Is Bank	MIDSEFF, TURSEFF
Vakıfbank	MIDSEFF, TURSEFF
Denizbank	MIDSEFF, TURSEFF
Yapı Kredi Bank	MIDSEFF, TURSEFF
Finansbank	MIDSEFF
TEB	French Development Agency
TSKB	Renewables (no programme)
Turkiye Finans	Renewables (no programme)
Halkbank	Renewables (no programme)

Source: Energy Institute www.enerjienstitusu.com

Figure 2. Energy Credits Rise in Turkey
Source: Turkey Data Monitor



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THE NEW BARRIER: ICAAP AND TURKISH BANKING SECTOR

Issues, Controversies, Problems

After the EEL and related subsequent regulations, one of Turkey's hot issue in the energy sector was –and still is– to establish an ESCO market. The next step will be to draw interest for international investment in the market. Without foreign capital, with merely the support of international financial institutions, the market will not be able to prosper because this is primarily a risk-based capital system that Turkey is trying to master. One of the most important difficulties that local companies face in Turkey is capital inadequacy, and therefore, they are unable to act as market makers (Okay, Okay, Akman, 2013).

On October 23, 2015, the BRSA issued sixteen new and amended regulations and communiqués in accordance with the Basel Committee's Regulatory Consistency Assessment Program (RCAP) in an effort to further harmonize Turkish banking rules with Basel III criteria. This most recent package of changes introduces Basel III standards for capital adequacy calculations and risk-weighting methods along with a new set of rules for banks' risk management disclosures for financial statements (Keskin, 2015).

One of the criteria called as ICAAP that came into effect by 31st March of 2016 is evaluated as being quite an early adoption. BIS points that Turkey has early-adopted the implementation recommending further discussions for a reconsideration of the target capital adequacy ratio. The related team of BIS considers the implementation by the BRSA of the Internal Ratings-Based (IRB) approach for credit risk to be compliant with the Basel framework. During the assessment process, the team identified a number of deviations, which were subsequently rectified by the BRSA. Currently there are no IRB banks in the Turkish market. However, many large domestic banks, mostly subsidiaries of international banks, are already using an IRB model for their internal risk management and lending process. These models were typically developed by their parent banks and received the IRB approval from their home authorities. The banks are in the process of calibrating and adjusting those models in order to appropriately capture the risks of the local market in Turkey, before submitting them for regulatory approval by the BRSA (BIS, 2016a).

Capital adequacy approach of Basel is a fairly enabling subsidy system for banking sector offering credits in a healthy way. But ICAAP is expected to decrease the capital adequacy of banks in Turkey. Meanwhile, the challenge in adopting ICAAP can be an additional barrier standing in the way to the development of energy market.

Besides, analysts expect non-performing loans in Turkey to rise in the coming years, weighing on earnings at a time when buffers have been reduced. Rapid credit growth leads to growing ratio of bad debt in the Turkish banking sector. Many loans are foreign currency denominated, increasing risk. Regulatory changes have helped reduce credit risk, and banks look well-positioned to absorb shock in all but a severe crisis. However, banks are aware of the growth in non-performing loans' volumes after years of rapid credit expansion, and are right to look to address the issue (Oxford Group, 2015).

On the other hand, lira depreciation also erodes bank capital ratios because foreign currency assets represent a higher multiple of lira-denominated equity. Fitch estimates that a 10% fall in the lira results in a 50bp fall in sector capital adequacy ratios, which reached 14.8% at end-August 2015. Banks in Turkey wishing to open new branches must operate with a 12% minimum regulatory capital ratio, meaning that banks still have significant capacity to absorb the direct hit to capital from further moderate depreciation (Caspien Energy, 2015). So, ICAAP can narrow the new investment on energy projects during a prohibition period in the banking system.

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BRSA will calculate capital adequacy, a 50% risk weight that will be applied to required foreign exchange reserves at the Central Bank, up from 0%. This is expected to decrease Turkish banks' overall capital adequacy ratio by around 100 basis points. Banks operating in Turkey, however, will face further regulatory constraints from March 2016 onwards, particularly in capital adequacy ratios, as their foreign exchange liabilities are no longer treated as risk free (Keskin, 2015).

Although banking system stands still and Turkish government taking measures to deal with the growing demand for energy, barriers remain to the development of energy efficiency and renewable energy. Turkish banks have already found it difficult to follow up high capital adequacy, as BRSA leading the sector for the requirements of Basel III framework. Banks in Turkey continued to struggle in a period of two sides cut. Some banks focused on strategies to solve this problem by developing agreement of collaboration for launching initiations of programmes in financing energy projects. EBRD programme is one of them for influencing large energy projects. The participating Turkish banks and the EBRD together created a powerful brand for sustainable energy finance, and built a lasting relationship through which new partnerships were created to finance larger projects.

Evidence through the assessment of EBRD in Turkey shows that:

- Investors lack familiarity with energy efficiency projects, and therefore misjudge the benefits and risks of such projects. Private sector investors often associate energy efficiency projects with high financial and technical risks and poor financial returns. In addition, upfront transaction costs which may arise from energy audits and feasibility studies can discourage investors. These costs can be increased by a lack of experience among the engineering service companies that would develop such projects.
- Banks are not familiar with sustainable energy projects and have insufficient capacity to evaluate them. Most local banks have limited capacity and experience in identifying, evaluating, and processing energy efficiency and renewable energy projects. As a result, they offer few, if any, financial products designed specifically to finance sustainable energy projects, and require substantial technical assistance to develop such products.
- Financial resources and dedicated lending facilities are scarce. Sustainable energy measures require long-term funding. In recent years financial institutions have had limited access to long-term financing, and in Turkey banks have traditionally relied on short-term financial products (EBRD, 2014).
- At the same time, according to World Bank local private sponsors of generation projects based on renewable energy resources face the following barriers:
- Higher pre-investment costs, relative to conventional power generation projects, due to the lack of technically reliable information on renewable energy resources and the costs of pre-feasibility, detailed feasibility engineering design, etc.
- Lack of medium-to-long term debt financing that is necessary to achieve financial viability for such small but capital intensive infrastructure projects, which tend to have longer payback periods and need debt with long maturity.
- Uncertainty about whether the soon-to be privatized distribution companies will enter into bilateral contracts to purchase electricity from small renewable power generators (World Bank, 2008).

Beyond all these barriers, unfortunately Turkey faces some tough political and economic issues that shoulde be considered. Although Turkey -as an east-west corridor- with potential supplies from

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Central Asia and the Middle East is a excellent source capable of delivering further energy supplies to the European energy market, for a long while affected by the political risks. (EBRD, 2010b). Additionally, Turkey's ongoing economic halt because of global economic turbelence had already changed the investment environment.

But, the last development with detrimental effects of coup attempt on July 15 2016 eroded both the national and international outlook of Turkey. Therefore, Turkey's ability to attract foreign direct investment and to capitilize on its geographical position as an "energy bridge" to Europe will be tested in the near future.[1]

At the same time, Standard and Poor's, following the attempted coup in Turkey, announced a negative report lowering ratings regarding to a prediction of heightened unpredictability that could constrain capital inflows into Turkey's externally leveraged economy. As a result, on July 20, 2016 S&P lowered foreign and local currency sovereign credit ratings on Turkey to 'BB/B' and 'BB+/B', respectively, from 'BB+/B' and 'BBB-/A-3'. S&P's negative outlook refers its view on political uncertainty and raising risks could further weakening in the investment environment, potentially intensifying balance-of-payment pressures (Standard & Poor's, 2016).

Also, Fitch Ratings highlighted the political risks after the coup attempt (Fitch, 2016a). Besides, Fitch mentioned that Turkish bank risks could increase following the coup attempt (Fitch, 2016b). Although, mentioning the risks that could affect the financial environment, Fitch gave fair rating to Turkey after the coup attempt one month later, but revised outlook to negative. Fitch Ratings has affirmed Turkey's Long-Term Foreign and Local Currency Issuer Default Ratings (IDR) at 'BBB-'. According to Fitch, political uncertainty is expected to impact economic performance and poses risks to economic policy but the banking system is consistent with Turkey's investment grade rating, with a 'bbb' on Fitch's Banking System Indicator because the sector functioned smoothly through the coup attempt and deposit outflows were minimal (Fitch, 2016c). Finally, Fitch Ratings has revised the outlooks to negative from stable on 18 Turkish banks, while affirming their Issuer Default Ratings (IDRs). In addition, the ratings of those banks' financial subsidiaries, which are driven by institutional support, are affirmed and their outlooks are revised to negative (Reuters, 2016).

On the other hand, Moody's placed Turkey's Baa3 long-term issuer and senior unsecured bond ratings on review for downgrade. The review is driven by the need to assess the medium-term impact of the failed military coup on Turkey's economic growth, policymaking institutions and external buffers, given the existing challenges in all of these areas (Moody's, 2016a). However, Moody's review of Turkey's Baa3 rating remained ongoing. But, Moody's view remained that even though the coup failed, it is likely that it will exacerbate existing challenges in business climate, policymaking institutions and growth prospects. The rating agency planned to conclude the review within 90 days of its announcement on 18 July (Moody's, 2016b). Then lastly, Moody's has downgraded the Government of Turkey's long-term issuer and senior unsecured bond ratings to Ba1 from Baa3 and assigned a stable outlook. This concludes the review for downgrade that was initiated on 18 July. The drivers of the downgrade are as follows:

1. The increase in the risks related to the country's sizeable external funding requirements.
2. The weakening in previously supportive credit fundamentals, particularly growth and institutional strength. At the same time, Moody's has downgraded the long-term debt and deposit ratings of 14 banks and confirmed the ratings of three others (Moody's, 2016c).

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SOLUTIONS AND RECOMMENDATIONS

Turkey's banks have proved resilient over the past 10 years, the result of prudent regulation and sound balance sheets, fostering confidence in the overall Turkish economy. But, the deteriorating financial performance of energy companies has burdened the banking sector (Dilek, & Schlisse, 2016).

Therefore, Turkey should take into account the necessary measures in order to provide a robust system against criterias like ICAAP maintaining a stable environment both for the energy market and financial services. Tukish banks should find foreign investors or international subsidy agencies to develop collaboration for launching initiations of programmes in financing energy projects. The current programmes are unlikely to be sufficient to influence and flourish energy market in Turkey.

For instance, in 2007-2009 REEP identified the areas of opportunity for the financial sector to engage and accelerate its participation in renewable energy projects, particularly at a micro and small-scale level. This was classified as an awareness raising effort to accelerate investments in renewable energies and promote the sustainable use of energy in the future. It was a project of € 100,000 including co-funding from United Nations Environment Programme (UNEP), Comision Nacional de Actividades Espaciales (CONAE). REEP conducted a market opportunity assessment and a review of existing financial products; developed a strategy to increase awareness, engagement and capacity building of the financial sector; hosted a consultation meeting with the main stakeholders within the energy and financial market monitoring and evaluating the results and piloted a project that implements the strategies within one of the programmes that CONAE is is currently developing: solar water heaters.

REEP's expectations can be a guideline for government and energy financing banks in Turkey:

- At least one commercial bank engaging in financing small scale renewable and energ efficiency
- Projects;
- Increasing the interest and awareness of local banks in the sustainable energy business (Expression of interest from at least three local banks);
- Contributing to clarifying the renewable energy market opportunities in Mexico aiming to increase the awareness and engagement of the local financial sector and consequently accelerate investments;
- Contribute to the design of future government initiatives to increase investment in the sustainable;
- Energy (REEP, 2009).

Similarly, there are some energy initiatives in Turkey like Turkish Sustainable Energy Financing Facility (TURSEFF) but these kinds of organizations should be fastly growing. The launch of TURSEFF marked the entry of the European Bank for Reconstruction and Development (EBRD) into Turkey's sustainable energy market, laying the foundations for a series of sustainable energy finance operations that continue to grow. The EBRD used its own funding, as well as financing from the Clean Technology Fund (CTF) and the European Union to support five major Turkish banks, Akbank, Denizbank, Garantibank, Isbank, and Vakifbank, as they created lending products for sustainable energy, developed a project pipeline, assessed loan requests, and verified the implementation of projects (EBRD, 2014).

Another initiation is The Turkish Mid-size Sustainable Energy Financing Facility (MidSEFF) launched by the European Bank for Reconstruction and Development (EBRD) with the support from the European

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Investment Bank (EIB) and European Commission (EU) will provide a total of EUR 1 billion in loans through seven Turkish banks (Akbank, Denizbank, Finansbank, Garanti, Isbank, Vakifbank, Yapikredi) for on-lending to private sector borrowers, for financing mid-size investments in renewable energy, waste-to-energy and industrial energy efficiency (MIDSEFF).

What's more, BIS fairly offers a target change for adapting the upgrades of capital adequacy system especially in ICAAP. BIS points that Turkey has early-adopted the implementation recommending further discussions for a reconsideration of the target capital adequacy ratio, as stated before. While the Assessment Team is confident that the Turkish regulation is compliant with the Pillar 2 standard, the team notes that its implementation is still at a relatively early stage in Turkey. As the BRSA and the banks build up further experience with ICAAP, the team recommends further discussing with the BRSA the effective implementation of the Pillar 2 regime during a future RCAP assessment. That would also allow the interaction, if any, between the Pillar 2 regime and the target capital ratio to be reconsidered. In addition, regulations do not allow signposting within the disclosures, and require that all disclosures are audited. These two measures may enhance the ease of use, comparability, and accuracy of data reported by Turkish banks. When a bank's capital adequacy ratio falls below its internal capital requirement ratio (calculated according to the ICAAP framework), the bank shall promptly submit to the BRSA an action plan that will satisfy the internal capital requirement ratio. This plan enters into practice once approved by the BRSA. At the end of the period foreseen in the plan, a new ICAAP report is prepared and results of the action plan are submitted to the BRSA (BIS, 2016a).

Still, resonsideration of target ratio in the banking system, awareness of reforms with cultural understanding and education are crucially important for the adoption of Basel accords, no matter how hard to implement advanced solutions like ICAAP, organizations and initiatives in order to prosper both energy market and financial environment that is so needed. But first of all, Turkey needs to have a revision of economic outlook by rating firms to a more stable and predictable domestic political and security environment and implementation of reforms that address structural deficiencies in the economy.

FUTURE RESEARCH DIRECTIONS

Basel III, IV, and More?

Global trends in financial markets are changing our perception of financial risks. Some risks, such as operational, business and systemic risks are now becoming relatively more important. It is evitable that institutions change in response to these trends that the need for consolidated risk reporting in large complex banking organisations introduces a new challenge and risk aggregation properly accounts for dependencies between risk factors (Alexander, 2003).

As the global risks and crises continue to increase, the emphasis and evolution of banking regulations and risk management implementations will certainly be upgraded. Basel III or even IV and maybe more will replace the current legislations in time. This section is a hypothetical study on the future of financing mechanisms in risky energy projects. The future research of the study depends upon policy-makers, awareness of risk management and maintenance of banking supervision.

Over time, as management scientists and economists state that 'good risk management' will evolve towards, simply, 'good management'. Risk control will be based on a business model which focuses on

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the net costs and benefits to the entire organization; risk management decisions will be based on utility functions that properly reflect the risk tolerance of the organization – and, assuming risk tolerance differs across organizations, an heterogeneous population of risk managers may co-exist in stable equilibrium (Alexander, 2003).

Also this section highlights the long road for Turkey on the way to modernize energy market and financial environment to prosper risky projects. The roadblocks to higher performing clean energy technology are not just challenges of engineering design but are also limited by scientific understanding. Innovation relies on contributions from basic research to bridge major gaps in our understanding of the phenomena that limit efficiency, performance, or lifetime of the materials or chemistries of these sustainable energy technologies (US Department of Energy, 2008). But beyond that, energy market needs a solid financial environment justified with the upgraded risk management implementations. Financial environment can only be provided by a strong banking system that is supervised by a legal authority monitors the current economic and financial conditions globally and nationally for taking precautions.

For instance, despite high electricity prices (among the highest in Europe) demand is growing faster in residential and commercial sector more than tripling (in the past years) and is expected to double in 15 years until 2025 (EBRD, 2010b). Therefore, risk culture and awareness of risk management must be raised in private sector as well as banking for a healthy system nurturing all parties that adopt regulations like Basel III, IV and more even advanced guidelines like ICAAP without shocks in order to provide investment and even foreign direct investment with favourable financial solutions leading to cheap energy to everyone.

The purpose of Basel II-III risk implementations is to create an international standard that banking regulators can use when creating regulations about how much capital banks need to put aside to guard against the types of financial and operational risks banks face. Basel III is a response to prevent the weaknesses in the Basel II framework where it will lead tightening the risk management approach (Okay, 2014). Basel III could tighten banks' provision of long-term finance or result in increased interest rates. Either of these changes and tightened capital and liquidity requirements are likely to limit the amount of capital available for renewable energy financing from banks in the future. Together, these are threats to renewable energy deployment because limited financing may prevent the energy projects (Narbel, 2013).

In a number of areas, the Turkish rules go beyond the minimum Basel standards. Especially, the structure and binding nature of prudential regulations in Turkey are outlined in greater detail in the RCAP assessment report on the Turkish risk-based capital requirements for banks. Although these elements provide for a more rigorous implementation of the Basel framework in some aspects, they have not been taken into account for the assessment of compliance under the RCAP methodology as per the agreed assessment methodology (BIS, 2016b).

According to the Tenth Development Plan covering the period 2014-2018 includes the goal of boosting domestic savings, as the most reliable and lasting financing source; directing the growing domestic savings to productive investments; and reducing extravagancy, with a view to ensuring a high and stable growth dynamic. In this scope the BRSA has been assigned as the authority responsible for containing the growth in consumer loans through macro-prudential measures, and raising the share of commercial loans in total loans through differentiation of loan costs and other encouraging and discouraging measures (BRSA, 2014).

By the way as stated before, Basel III is expected to be implemented globally between 2013 and 2019 (BIS, 2013). But the 2019 deadline can be suspended to another date because of a global economic and

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financial change as the risks and uncertainty rise in the world. And as for Turkey, the priority nowadays will be national security and stability. Therefore, implementations regarding the banking sector might be suspended for the short run. Afterall, ICAAP was planned to be launched in 2014 but was postponed to 2016 (BRSA, 2014).

CONCLUSION

Despite the high regulatory performance, capital adequacy and stability after the adoption of Basel accords, the Turkish banking sector is under pressure preparing for the requirements of Basel III framework. Banks in Turkey are headed for the preparation of ICAAP which is only one change but still comprehensive process that can have large effects in a complex system leading to results even in the energy market. Challenge in adopting ICAAP can be an additional barrier standing in the way to the development of energy market, whereas the Turkish banks already found it difficult to follow up high capital adequacy. At the same time, BIS announced that Turkey has early-adopted the implementation recommending further discussions for a reconsideration of the target capital adequacy ratio. It is expected that BIS and BRSA shall together identify an accurate target for capital adequacy in order to provide an adoptable ICAAP in Turkey which will directly influence and improve energy market, in the end.

But nowadays, the major priority is to eliminate the political and security concerns regarding the coup attempt of 15th July 2016 in Turkey. The government blissfully took back control after the failed coup attempt. However, it caused detrimental effects on the economic and financial well-being. The cost of coup attempt is estimated as $ 100 billion according to Trade Ministry of Turkey. Therefore, it is urgent to control the welfare of the economy rather than the necessity of the ongoing structural state anyway.

Besides, the Turkish government declared a state of emergency to conduct the necessary measures preserving stability. Although, Turkish economy remain calm after the coup attempt, the credit rating firms' approaches seem somehow reserved, highlighting political and financial risks. Reforms regarding the banking sector might be suspended for the short run in order to regain stability and national security. After recapturing factory defaults of stability and regular economic activity, government should attain reforms that provide a favourable environment both for the energy market and financial services and proceed with the banking implementations and ICAAP with no worry of all parties.

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KEY TERMS AND DEFINITIONS

Banking Regulation: Legal measures and restrictions for banks designed to improve the effectiveness and stability in the banking sector.

Basel: Basel Committee on Banking Supervision in Europe declares recommendations on banking regulation and issued the Basel accords called Basel I, Basel II and Basel III. The accords are widely accepted in the world banking industry.

BRSA: Banking Regulation and Supervision Agency in Turkey that is addressed as a legal authority to improve effectiveness in regulation and supervision of the banking sector.

Energy Finance: Financial solutions for renewable energy, efficient energy projects and technologies in the energy market.

Energy Market: All public and private enterprises that involve in the energy industry working for production and sale of energy.

Energy Projects: Investments of all sources of renewables, clean and creative energy saving solutions and technologies.

ICAAP: Internal Capital Adequacy Assessment Process is a banking guideline that is issued by Basel II.

Risk Management: Understanding, assessment and mitigation of risks in order to prevent financial loss and uncertainty especially in financial services and banking.

Turkey: Turkey is a country located between Europe and Asia.

ENDNOTE

[1] This route is attractive to many players as a way to diversify supply to markets. The ongoing privatization process also offers interesting opportunities for energy investors (EBRD, 2010b).

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Section 7
Emerging Trends

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Chapter 71
Sustainable Consumption Trends in the World in the Context of Green Economy and Sustainability

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ABSTRACT

Nowadays, sustainable growth and development are main economic policies for the countries all over the world. Decreasing natural resources, deepening environmental pollution and global warming problems are red alert of our planet. Every single country on the earth has the responsibility to protect our planet. So, increasing environmental awareness caused new tendencies in consumer behaviors. Countries aim not to pollute or harm the environment while improving their economic performance and life quality by green economy. Besides, by sustainable consumption, it is aimed to support personal sustainable development. In this context, sustainable consumption trends and the reflections of green economy applications in the world will be discussed in this chapter. In addition, developed countries and developing countries will be compared with each other through results of global ecological footprint.

INTRODUCTION

Harmful and careless human exploitation of the natural environment has caused massive pollution. Since the unplanned expenditure of natural resources has occurred rapidly, the problem of sustainability problem has developed into one of the world's most crucial issues (Barr "& Gilg, 2006). When the nations of the world tried to find alternative ways to protect economic growth and sustainability, they realized a crucial fact: improvement and development must be sustainable.

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Development, however, had widely-varied meaning for each nation in each time period. Though the definition varied, development always included not only economic features, but also non-economic features, such as the quality of life. In fact, a growth that is harmful for the environment and the ecological system cannot be sustainable (Meadows et al., 1972).

The history of sustainable development is relatively new, stemming from the early 1970s. Sustainable development and the creation of a clean and unspoiled natural environment took on importance only after the foundation of the United Nations Environment Programme (UNEP). This event marked the first time for the world's nations to mention *"ecological balance"* and *"the future of humanity"* at the United Nations Conference on the Human Environment, which was held during 5-6 June, 1972 in Stockholm (Johnson, 2012).

In 1980, The World Conservation Strategy (IUCN) introduced the idea of sustainable development and emphasized the challenges of integrating development and the environment, as well as the responsibility of conserving natural resources for the coming generations. However, The World Conservation Strategy was not successful enough in its environmental strategies. More specifically, the strategy could not explain conservation strategies in a suitable matter to influence economic policies or how misguided economic policies might harm the environment.

Following this effort, the World Commission on Environment and Development (WCED, also known as *The Brundtland Commission*), created by the UN as a result of a General Assembly resolution in 1985, published *Our Common Future* in 1987. The report mentioned sustainable development as a tool of economic policy. The report emphasized sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The Brundtland Report defined the relationship among population growth policies, poverty eradication, technology, and distribution of goods harvested from natural to explain sustainable development. The report also emphasized the growing role of developing countries in improving and restructuring the environment. The report suggested that these countries improve their development policies, taking into consideration long-term growth with sustainable natural resources. More specifically, the report's intent was to achieve economic development for the global economy: satisfying the needs of the present generation without harming the next generation's resources.' (Republic of Turkey, Ministry of Foreign Affairs, 2015).

Toward the end of the 1980s, environmental awareness increased, thanks to these reports and the meetings of those commissions who created the reports. In 1988, according to Pearce et al. (2012), the environment was the second-most important issue to the world's political leaders at 93%, right behind unemployment, which ranked highest, at 98%. After these issues, price stability followed with 90%, arms limitation at 85%, agricultural surplus at 70%, a single European market at 63%, European political unification at 57%, and EC expansion to include Turkey at 27% (Pearce, Markandya & Barbier, 2012).

In the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, sustainable development took on importance both for global and for national policies. In two decades, many developments had taken place to tackle this issue, but most countries had not implemented much of the agenda. Most of the countries found it difficult to apply the UNCED decisions.

To improve their sustainable development agenda, the United Nations developed two broad themes during the United Nations Conference on Sustainable Development, in 2012 (UNCSD, or Rio+20): an institutional framework for sustainable development and a green economy as it contributes to the eradication of poverty (Puppim de Olivera, 2012). In the Rio+20 summit, a green economy was described as a key component of sustainable development since it contributes to poverty eradication, food safety,

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sound water management, universal access to energy services, ocean management, improving resilience, disaster preparedness, public health, and human resource development (Great Britain: Parliament: House of Commons Environmental Audit Committee, 2012:12).

Though it sounds noble, this development was not a huge step forward. Many environmentalists considered it a trade-off between sustainable development and environmental protection on one side, and economic development on the other. Despite the fact that many improvements on sustainable development had occurred all around the world, those improvements were still too weak to satisfy expectations. Furthermore, an excessive expenditure of natural resources brought about irreversible losses of the environment, particularly in biodiversity. After all these losses, the only thing that can be done is to save and protect the rest of the vulnerable population which is yet unspoiled.

The issue, then, that countries should take into consideration regarding sustainable development is to set sustainable economical and poverty eradication policies which have reversible and less-harmful impact on the environment and on biodiversity. To achieve a sustainable and inclusive economic development process with almost no trade-off will be difficult indeed. Furthermore, since there has been only weak institutional support for these policies until now, few improvements have been observed all over the world (Puppim de Olivera, 2012). The world, therefore, has a long way to go. To ensure sustainable development with fair income distribution on a global level, powerful international institutions will be needed on various levels. Existing institutions must also change their policies and put sustainable development on their agenda (Puppim de Olivera, 2012).

In this chapter, we will examine sustainable consumption together with the implications of a green economy. We will propose a holistic perspective for sustainable consumption alongside a green economy on a global level. According to the purpose of this chapter, we will answer the following research questions in a three basic parts using the conceptual research method:

- What is a green economy?
- How has the concept of a green economy developed historically on a global level?
- What does sustainable consumption mean?
- What are the main trends of sustainable consumption in the world?
- What is the result of an ecological footprint for developed and developing countries?
- How can we evaluate the indicators of a green economy parallel to sustainable consumption?

THE FIRST STEP FOR SUSTAINABILITY: A GREEN ECONOMY

In today's environmental politics, the countries that try to set targets and to implement sustainable development confront the term "green economy." That term was first used in the paper "Blueprint for Sustainable Economy," prepared by David Pearce, Anil Markandya and Ed Barbier at the London Environment Economics Centre in 1989. The United Nations Environment Program (UNEP) defined a green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (United Nations, 2010). In other words, a green economy has a structure covering private and public investments which target increases in employment and income while decreasing carbon emission and pollution. The investments should also improve productivity without any trade-off on biodiversity and the ecosystem (UNEP, 2011). In brief, a green economy is a must for sustainable development.

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Alternative philosophies to those which propose that a green economy will best solve the world's economic and ecological problems include environmental economics, ecological economics, ecosocialism and ecofeminism. The following table illustrates how these philosophies differ from that of green economics:

As illustrated in Table 1, there are links between these different strands of economic philosophies that give importance to the environment in different ways. By searching the footprints of these economic philosophies, it can be said that green economists have a different orientation than other schools of thought, such as those who espouse ecofeminist and ecosocialist points of view. More specifically, green economists engage in studies which allow them to undertake straightforward comparisons between the land available and the demands on the resources. The components of a green economy can be summarized as follows (State of California EDD, 2010:11):

- Generating and storing renewable energy: goods and services with alternative energy usage such as wind, solar energy, biofuel, biomass and geothermal.
- Recycling used materials: cooperation between consumers and producers in both preferring recycling goods and running recycling or wastewater factories.
- Energy efficient production, distribution, construction and maintenance.
- Education and improving awareness.
- Natural and sustainable production.

The target for launching a green economy is to develop the economy and increase investments while increasing environmental quality and social coverage. To reach such a target, it is critical to set the objectives which are necessary for private and public investments, as well as those covering broader environmental and social criteria. Furthermore, the basic indicators that are related to the economical performance, such as the gross domestic product (GDP), should be arranged with respect to pollution, depletion of resources, decrease in ecosystem services, and the loss of natural capital for the poor (UNEP, 2011).

In 2009, the UN General Assembly decided to arrange a 2012 summit to celebrate the 20th anniversary of the first Rio World Summit (1992). The summit was to be called "Rio+20" and would also take place in Rio de Janeiro. The two basic topics for Rio +20 were "Green Economy in the Context of Sustainable Development and Poverty Eradication" and "International Framework for Sustainable Development." With these topics taking central stage, a green economy would then be ensconced firmly in international policy agenda. Today, it is an inevitable necessity to analyze the relationship between a green economy and sustainable development (UNEP, 2011).

Table 1. Alternative economic and environmental philosophies

Economic Philosophy	How It Differs From Green Economics
Environmental economics	Based on a conventional economic paradigm, a numerical approach, gives less importance to values
Ecological economics	Based on a unified discipline of ecology and economics, gives less importance to spiritual values
Ecosocialism	Emphasizes equality but supports materialism
Ecofeminism	More theoretical than policy-driven. Although it shares principles and values, it covers a limited area.

Data source: Cato, 2009:8.

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According to the European Environment Agency (EEA) Report (2009), with increases in income for people who are from European Union (EU) member countries, the people's level of consumption also increased. In other words, there is an increasing trend toward consumption among EU consumers. This increase was supported by the nations' business firms (EEA Report, 2009). On the other hand, with respect to the population growth in these countries, they have basic differences. In terms of consumption trends, the consumers' attitudes are not sustainable, since around 15 tonnes per capita of material were used for production to satisfy European consumers. Until 2020, this amount will be increased by one quarter. Parallel to this situation, waste in the EU will increase despite an increase in recycling and a decrease in landfills. For sustainable development and for improving the quality of life for its people, the EU also recognized the importance of sustainability for both consumption and production (EEA Report, 2009:36-37). With respect to sustainable development, the EU included Sustainable Development Strategies (SDS) in the *Review of the EU* in July 2009. The EU emphasized SDS strategies, and the member countries decided to combine SDS policies with the other policies in 2007. The EU also set targets for the years up to and including 2010. The basic issues were as follows (European Commission, 2013):

- Controlling climate changes and improving clean energy.
- Sustainable consumption and production.
- Sustainable transportation.
- Protection of natural resources.
- Improving public health.
- Social inclusion, eradication of poverty.
- Controlling migration.
- Challenges of SDS.

Although sustainable development had been on the political leaders' agenda since 1997, in June 2001 with setting SDSs in the EU, the issue became more crucial.

The green sector, however, is still relatively small in scale. In 2010, for the green economy, the estimated value of products and services was $2 trillion (2.7 percent of the global GDP) while profit was $530 billion. Nearly 10 million people were employed in the green sector worldwide. If we look at the separate countries (Porfiriev, 2013:5-6), we will observe the following:

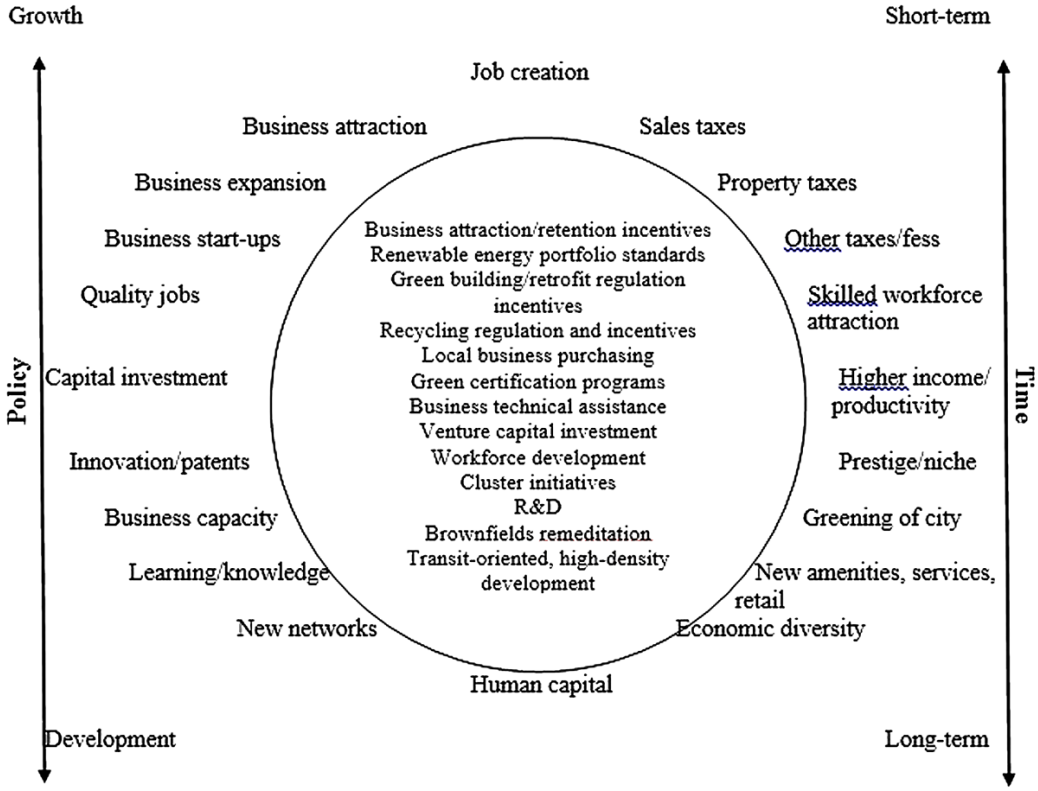
- The green economy generates more than $600 billion (4.2 percent of the GDP) with three million people in the USA employed in this sector.
- In Japan, the green economy generates 3.4 percent of the GDP with 1.5 million people employed in this sector.
- In the EU, the green economy generates 2.5 percent of the GDP with 3.4 million people employed in this sector.
- In Germany, 4.8 percent of the GDP comes from the green economy (the country is one of the most important eco-friendly product exporters in the world. For example, the country sells 12 percent of the world's climate control equipment).
- The UK gets $240 billion from the green economy, comprising 8.8 percent of its GDP. This rate was the highest in the entire world during 2009.

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Figure 1 illustrates common development goals among the world's nations. On the growth side, the common goals are job creation, as well as expanding and growing businesses, thus expanding the tax base (Chapple, 2008:4-5). At this point, sustainable development should be differentiated from sustainable growth. Although they are different subjects, they are interconnected. If a society does not improve its real income per head, that society will have difficulty in developing. If the other aspects are ignored, but just income per capita and growth are considered, that economy will, too, not be considered as a developing economy.

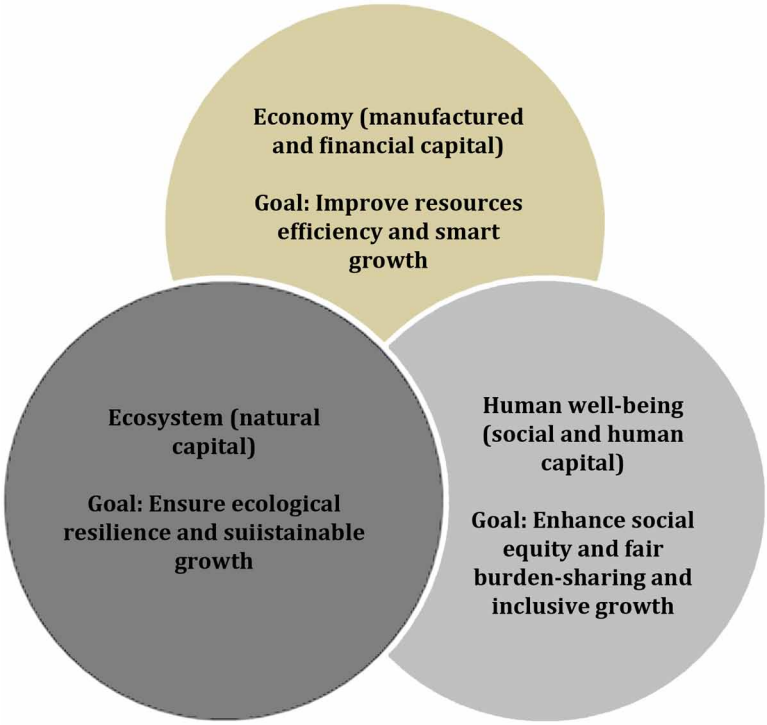
Also, while a nation's economy is developing, growth should not be ignored. So rational economic development, together with an acceptable economic growth may be a solution of the development-growth dilemma (Pearce, Markandya & Barbier, 2012:30). Then it is important to follow proper economic growth with environmental protection. In other words, sustainable development does not mean sacrificing a nation's economic growth for improving the environment. Therefore, the main goal is to prepare the future of a sustainable environment without greater sacrifices to the nation's economic growth (Pearce, Markandya & Barbier, 2012:31). As illustrated in Figure 2, there must be a combination of three basic targets. The goal of an economy should be sustainable growth partnered with protecting resources and caring for the well-being of its citizens.

Figure 1. Common economic development goals
Source: Chapple, 2008:5.



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Figure 2. The green economy concept in the context of sustainable development
Source: European Environment Agency (EEA), 2011:10.



More specifically, a green economy targets the improvement of human well-being and social equity while reducing environmental risks and ecological scarcities. In other words, a green economy is more resource-efficient, has a lower carbon footprint, and is more socially inclusive. A green economy is a combination of economic growth and economical sustainability accompanied by progress in social development. Thus environmental protections and development should be organized in a way that the result will be a win in both areas. That win-win solution handled with a willing role in delivering the economically viable products, processes, technologies and services, will help a nation transition to a green economy.

It is a fact that natural resources and green capital are the basic drivers of globalization. Although today technical innovation is the major target, natural capital is the physical basis for wealth. Green capital and globalization brought with it complex legal principles and laws about using resources, access to resources, and benefit sharing. At different organizations such as Rio+20, a large number of state and non-state actors consolidated their power to create a new economic era. With large natural resource reserves and their growing populations who are ready to consume, emerging countries such as China, India, Brazil, and South Africa engineer their economic growth. Their way of economic growth may differ from and even conflict with the green economy and sustainable development model created by the developed countries. Although the basic targets of emerging countries are growth and industrial development, social equality cannot be neglected. Social equality becomes a reality by distributing a nation's resources equally.

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The interdependence of countries requires cooperative solutions for the governance of natural resources (Blanco & Razzaque, 2012:3-4). When countries realize the importance of sustainable development and the environment, they can become prosperous. Many of those who have become prosperous enacted stimulus packages taking those two factors into consideration.

SUPPORTING A GREEN ECONOMY: GREEN PRODUCTS, GREEN CONSUMERS, AND SUSTAINABLE CONSUMPTION

According to the EEA Report (2009), with the income increase for people who are from EU member countries, their consumption level also increased. In other words, there is a trend towards increased consumption among citizens of EU member countries. This increase has been confirmed by the nations' firms (EEA Report, 2009). Hyper-consumption, however, without regard for natural resources and ecological balance has brought humanity to the brink of ecological disaster. In terms of their consumption trends, the attitudes of the consumers are not sustainable, since around 15 tonnes per capita of material were used for production to satisfy European consumers. Until 2020, this amount will be increased by one quarter. Parallel to this situation, waste in the EU will increase despite increased recycling and less use of landfills.

To boost sustainable development and to improve the quality of life, the EU recognized the importance of sustainability for both consumption and production (EEA Report, 2009:36-37). The European Environmental Agency (EEA, 2011) gave an explanation for what would constitute a balance of growth with environmental and sustainable development concerns. Furthermore, cities all over the world are also realizing the importance of consumption-driven economic development by adopting three green policies: green standards and regulations for energy use, green building incentives and environmentally preferable purchasing. These strategies may help build a green economy if they are mandatory.

In addition, building awareness among citizens and corporations is another important aspect of these strategies. They also result in economic development by building expertise in technologies such as green building operation and energy use evaluation. R&D's and education are other parts of these strategies. Supporting green innovation and developing new markets for green products are additional strategies that can lead toward the goal of a green economy. Similarly, a solar panel installation tax credit is another way of promoting green strategies (Chapple, 2008:3).

It was seen that "green economy" targets of large world economies promoting sustainable development on a macro level were not effective enough on consumer behaviors on the micro level, since the overwhelmingly unsustainable level of consumption stands as the basic obstacle blocking sustainable development. Despite the fact that producers use nonpolluting technologies and production systems with the support of the nations' green policies, all these attempts must be supported by consumer behavior (Peattie, 2010). In this context, sustainable consumer behavior should become widespread in order to be successful in building a green economy and in maintaining sustainable development policies. In the context of sustainable development, consumer groups who are environmentally aware may change their consumption habits on the micro level by changing the products they formerly bought to more environmentally friendly ones.

Thus, consumer behavior regarding their demands should be dependent not only on satisfying personal needs and wants, but also on ethics: conserving resources, reducing waste and improving society (Young et al, 2010). Sustainable consumption should be done in a way that while satisfying personal

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needs, one should take into consideration that those goods should be produced by consuming as few of nature's resources as possible and harming the environment as little as possible (OECD, 2002).

There is indeed historical precedent for such changes in consumer behavior. Sustainable consumer behaviors actually go back to the 1960s, when this type of consumption was considered as "waking up." In the 1970s, sustainable consumption was marked by consumers' desire to protect the environment, while in the 1980s, consumers began to realize that without a change in their behavior, the earth had only "limited time' left. In the 1990s, environmentally friendly consumer behavior was regarded to give consumers "power in [the] market." This movement improved as the years went by from the 1960s to the 1990s (Kalafatis et al, 1999:42).

The first academic research on sustainable consumption was conducted in the 1970s and 1980s. What we now know as sustainable consumption was then usually defined as "decreasing consumption and non-excessive consumption" (Follows & Jobber, 2000:724). Although the term "sustainable consumption" was first heard during the protests of green consumer activists in the 1980s, widespread usage of this term started with the United Nations Conference on Environment and Development (UNCED) in Rio de Janerio in the 1990s. With the advent of the 2000s, the "green product" concept became popular both among consumers and producers. Firms that could predict the improving market share of green products changed their products and production channels accordingly (Candan & Yıldırım, 2013).

Sustainable consumption can reach its highest point with increased environmental sensitivity on the part of producers. If "consuming less (Jackson, 2005)" becomes a habit for ordinary consumers, this habit will bring with it a new attitude to buy environmentally friendly products. Basic needs, of course, must be satisfied whenever necessary. Consumers also need to be able to find these products in the market. At this point, the production of environmentally sensitive products is crucial for sustainable consumption (Mowen, 1993). Even though consumers care about environment, if they cannot find the goods they need in the market, they will have to purchase less environmentally friendly goods. Thus, environmentally sensitive products must be ready for purchase and easy to find in the market.

Generally, less-polluting products are considered as environmentally sensitive products (Ottman, 1993). Additionally, recyclable non-polluting goods which consume natural resources at a lower rate than others are also considered as environmentally sensitive products (Shamdasani et al, 1993:488). Environmentally sensitive products can be in many categories such as food, textile, electronics, etc. For example, if an electronic device is environmentally friendly, it must save energy. Similarly, an environmentally sensitive agricultural product must be organic, with recyclable packaging (Dangelico & Pujari, 2010).

The basic properties of environmentally sensitive products and services are as follows (Moisander, 2007:405):

- They should not be harmful to human beings or animals.
- There should not be pollution during production, consumption and disposal.
- Energy consumption should be low during production, consumption and disposal.
- The product should not cause unnecessary waste due to excessive packaging or short wear life.
- The product should not cause excessive usage.
- The production process must not harm or animals.
- Products should not contain materials that harm the animals or the environment.

According to the Organisation for Economic Co-operation and Development (OECD) (2009), environmentally sensitive products are ones which have less or limited harmful effects on air, water, and

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other natural resources (Lin & Huang, 2012:11). The products that are considered as environmentally friendly may be sometimes confusing for consumers. Therefore, the environmental benefits of these products should be defined clearly.

Certification, then, can be a good way to categorize products as "green." Otherwise, consumers may be confronted with "green marketing myopia." Green marketing myopia means that environmentally sensitive consumers may be cheated by producers who sell their products as if they are environmentally sensitive, when in fact they are not. If there are no legal controls on labeling, markets became full of fake "environmentally friendly" products (Ottman et al, 2006). For this reason, certification is crucial.

Actually, there already exist several green certifications to protect both producers' and consumers' rights. Green certification is the process of preparing a generalized standardization by using a variety of science-based methods (Green Building Alliance (GBA), 2013). Today, there are many green certifications. The most popular ones are as follows (Vierra, 2014):

- **Energy Star:** Energy-consuming products.
- **WaterSense:** Showerheads, toilets, faucets, urinals, and valves.
- **Forest Stewardship Council:** Forests and forestry products.
- **Scientific Material Content Certification:** A wide range of products (i.e. carpets, textiles, wood products, insulation, and more).
- **Green Seal:** Covers a wide range of products (paints, adhesives, lamps, electric chillers, windows, window films, occupancy sensors).
- **Cradle to Cradle:** Covers a wide range of products (metals, fibers, dyes, plastics).
- **Greenguard:** Indoor air quality with a focus on children and schools.

Many studies have concluded that consumers who prefer to buy green products have a high regard for the environment. Furthermore, "green consumers" have a higher sensitivity for environmental protections (Young et al., 2010; Schultz & Zelezny, 1999; Karp, 1996; Dietz et al., 2002; Hedlund, 2011; Thogersen & Grunert-Beckmann, 1997; Şener & Hazer, 2008; Thogersen & Grunert-Beckmann, 1997; Poortinga et al., 2004; Vermeir & Verbeke, 2008). Green consumers make a bigger effort to find environmentally sensitive products. Most of them are willing to take on the added cost burden of purchasing such products (Straughan & Roberts, 1999; Laroche et al., 2001; Young et al., 2010). If there is a question about the product's carbon footprint, though, this may affect the consumers negatively.

In addition, there is an important reason for the consumers to choose environmentally sensitive products or not: price-quality equilibrium (Lin & Huang, 2012). Because of this issue, producers should be careful about quality-performance-price equilibrium (D'Souza et al, 2007).

It should also be kept in mind that one of the most important obstacles to sustainable consumption is unsustainable consumer behavior and preferences (Peattie, 2010). Purchasing preferences and consuming behaviors of households may affect the environment in a negative or positive way in the long run, depending on their choices (OECD, 2002:3). Therefore, the number of green consumers and green products should be increased, since this may result in more widespread awareness of sustainable consumption and an increasing application of green economic policies.

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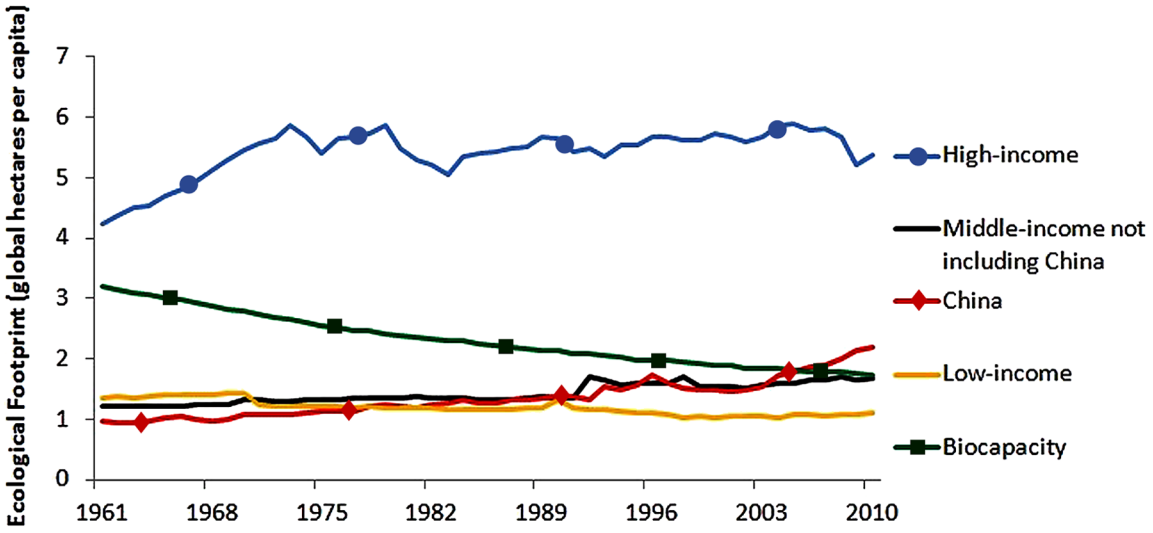
SUSTAINABLE CONSUMPTION TRENDS AND THE WORLD'S ECOLOGICAL FOOTPRINT

For more than 40 years, demand exceeded actual need. The ecological footprints of the world's nations show the consequences of this disastrous situation (World Wildlife Fund (WWF) Report, 2014). An ecological footprint for consumption can be defined as: "independently from the geographical region which provides the natural resources, renewable resources are those that are used to produce consumable production for people and societies." An ecological footprint for production can be defined as: "the usage of a certain country or geographical region's biological capacity" (WWF, 2012).

To analyze the total consumption and ecological footprint of the earth, the WWF calculated each of the world's countries' ecological footprint per capita, their average expenditure of goods and services per capita, as well as the correlation between these data and local natural resources to satisfy these needs. The results showed that the highest footprints were mostly in 25 high-income countries that have the highest carbon release into the atmosphere (WWF Report, 2014). According to the scenario created by the UN, "if the increase in population and consumption trends continues as it was without changing; in the 2030s, to satisfy the needs of humanity we will need two earths." (Global Footprint Network, 2015a).

In Figure 3, the ecological footprint per capita in different country groups for 1961-2010 is given. According to the figure, higher-income countries had much higher ecological footprints than middle- and lower-income countries. Furthermore, global biocapacity hectares per capita has decreased dramatically and steadily from 3.2 in 1961 to almost 1.5 in 2010. In other words, global biocapacity per capita lost half of its value in 40 years. This drop is explained with the higher increase in world population as compared to its biocapacity productivity (Global Footprint Network, 2015a).

Figure 3. Ecological footprint per capita in high-, middle- and low-income countries
Source: Global Footprint Network, 2015b.



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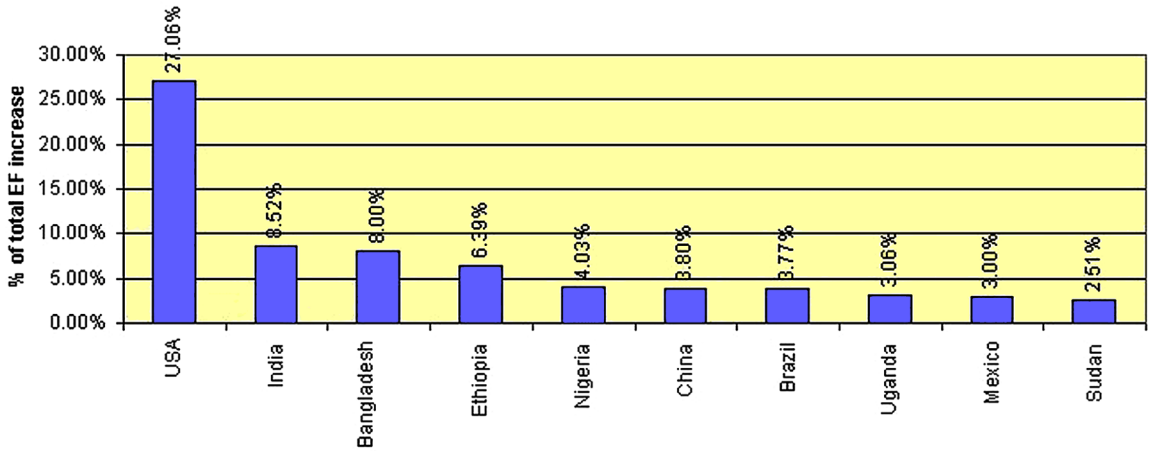
More specifically, National Footprint Accounts (2010) revealed the National Ecological Footprint and Biocapacity for 2007. According to the study, ecological footprints of consumption are different for high-income, middle-income and low-income countries. The average ecological footprint for high-income countries was 6.1 in 2007. For middle- and low-income countries, however, the ecological footprint was only 2.0 and 1.2, respectively. The high-income countries were the USA, Canada, Oceania, and the European countries; low-income countries were African, Asian, Latin American and the Caribbean countries. The highest scores belonged to the US and Canada, while the lowest score belonged to African and Asian countries (Global Footprint Network, 2015b).

According to Global Footprint Network data, after the global financial crisis in 2008, high-income countries' average demand on nature decreased sharply. Despite this decrease, their footprints were still more than three times those of middle-income countries and almost five times those of low-income countries (Global Footprint Network, 2015b). Furthermore, in a few high-income countries, the per capita footprint started to rise in 2010, since governments provided economic stimulus packages worth billions of dollars to help stimulate their economies. During that time, however, middle- and low-income countries' per capita ecological footprint stayed almost the same (National Footprint Accounts, 2014).

In Figure 4, the top ten countries which contribute to the global ecological footprint increase and to the percentage of the world's total ecological footprint for the period from 2008 to 2050 period are estimated. According to the figure, the USA will have the highest increase in its ecological footprint with 27.06%. India follows the USA with a rate of 8.52%. While Bangladesh has 8%, Ethiopia has 6.39%, China and Brazil have near-identical scores at 3.8% and 3.77%, respectively.

Despite the fact that economic growth provides an increasing level of welfare in nations and in people, such growth will drain scarce natural resources. On the other hand, with the growing global trend toward the middle class, the trend of conspicuous consumption may cause potential side effects and obstacles to sustainable development. If these obstacles are overcome, though, sustainable development will be even more successful (World Business Council for Sustainable Development (WBCSD), 2008). By considering the effects of hyper consumption, countries must take care to reduce their ecological footprint to promote improvements in sustainable development. As the preferences of households may

Figure 4. Top 10 contributors to the global ecological footprint increase 2008-2050
Source: Population, Consumption, and our Ecological Footprint, 2015.



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change the consumption patterns of their countries, it may be a good idea to start at the household level. Changing consumption patterns of households is crucial in order not to exceed the limits of the earth's biological capacity.

At this point, consumer behaviors and purchasing habits should be changed. Production firms should support sustainable production.

To change consumers' purchasing patterns, many countries began targeted projects. Those projects target consumers to improve their environmental sensitivity and to give them more information that will empower them to choose environmentally sensitive products. For example, PERL (The Partnership of Education and Research about Responsible Living), Carrotmob, and Nudging—all projects to educate consumers—have gone worldwide in their scope. Furthermore, Sustainable Connections (United States), LivingSmart (Australia), The 10:10 (the United Kingdom), Slow Food (Italy), and Eco-Action Points (Japan) have introduced regional projects to stimulate environmental sensitivity (United Nations, 2010).

Several countries have also funded research to analyze consumers' sensitivity to and tendency to purchase green products. For example, GMS/Deloitte (2009) commissioned a survey to categorize US consumers according to their green purchasing behaviors. They created five green clusters: "committed, proactive, influenced, unsure, and aware." 6498 shoppers were included in the survey. According to the answers, 54% of the questionnaires were from consumers who were more aware of green products and were ready to buy these products. For the committed participants, it was important to buy green products. For the other groups, though, buying green products had little importance. For consumers unaware of environmental concerns, green products do not have any priority. Furthermore, consumers who are unaware of environmental concerns choose green products only as a last choice. In the survey, the purchase rate of green products was analyzed for many product categories. Respondents preferred green products by 33% for groceries, by 28% for household cleaners, by 19% for paper products, by 12% for meat, fish, and poultry, by 11% for health and beauty, by 11% for pet products, and by 8% for electronics. The preference rate for purchasing green textiles, however, was low, at only 3% (GMA & Deloitte, 2009).

Similarly, National Geographic and Globe Scan surveyed sustainable consumer behaviors in different countries in 2008 and 2010. According to their results, there is an increasing trend toward sustainable consumption. These surveys created an index named "Greendex" and calculated the Greendex score for each country. The highest scores were given to the emerging countries. The consumers with the highest awareness of sustainable consumption were located in India, Brazil, China, Mexico, Argentina, Russia, Hungary, South Korea, Sweden, Spain, Australia, Germany, Japan, the UK, France, Canada, and the USA. The restriction of those studies were the number of people that participated in the survey, since only 17,000 participants were questioned in total. As the number of participants was limited, the concluding idea cannot represent whole countries (National Geographic & GlobeScan, 2010).

Parallel to these results, according to Euromonitor International Global Consumer Trends Survey (2013), the sustainable consumption trend has increased all over the world. 16,300 participants and nine major developed and emerging markets were included in the survey. Participants were asked to answer the questions via the Internet. More than half of the participants in Germany, the UK, Russia, China, France, USA, Japan, Brazil, and India indicated that they check if a product is environmentally sensitive or not before they purchase it (Kasriel-Alexander, 2014).

The EU Commission conducted a similar survey in December 2012 to analyze the consumption patterns towards environmentally sensitive products. Twenty-seven countries and 25,568 people participated in the survey (Belgium, Czech Republic, Bulgaria, Denmark, Estonia, Greece, Spain, France, Ireland,

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Italy, Republic of Cyprus, Lithuania, Latvia, Luxembourg, Hungary, Malta, The Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, and the United Kingdom). Fifteen percent of the participants indicated that they never prefer environmentally sensitive products, 26 percent indicated that they often prefer green products, and 54 percent of the participants indicated that they sometimes buy green products. Ninety-five percent of the participants agreed to use green products to protect the environment (European Commission, 2013).

According to the National Geographic and Globe Scan Greendex research results (2014), consumers' sensitivity from 18 countries (Brazil, Argentina, South Africa, Australia, South Korea, Japan, China, India, Russia, Hungary, Sweden, Canada, USA, Mexico, Germany, Great Britain, France, and Spain) increased as time went by. The survey had been done annually since 2012. According to the survey results, there is an increasing level of environmental sensitivity in 11 countries. The participants also confessed that they felt guilty when they harm the environment. They were also aware of global warming and its disastrous effects on humanity. In addition, they complained about the lack of governmental and industrial protections for the environment.

On the other hand, though, in most of the countries, consumers' sensitivity towards green products and preferring them to purchase has decreased since 2012. The basic reason for that decrease was weak promotional campaigns for green products. The tendency to purchase green products was mostly in developed countries (National Geographic & Globe Scan, 2014).

Finally, Sustainable Academy and Schneider Electric conducted a study on "Green Consumption" in Turkey in 2012. 1334 participants, all over the age of 15, were included in the survey. According to the results, just 13 percent of the participants always prefer green products. The participants complained about their lack of knowledge about green products. Additionally, the high prices of green products were considered as the biggest hindrance for consumers who might have otherwise purchased such products. Demographically, females, high income groups, and people with higher levels of education preferred green products (Sustainability Academy and Schneider Electric, 2012).

As expressed in these surveys, most of the consumers were unhappy with environmental pollution. Although they believe that sustainable consumption is very important, almost half of the participants neglected consuming green products. Therefore, to increase the sustainable consumption trend, people should be convinced to buy green goods. In other words, there must be a correlation between the intent to purchase green products and the actual purchase of sustainable products.

According to the Geographic and Globe Scan (2009) results, the Greendex score was 43.7 for the USA, while India scored 59.5. The top scores went to developing countries such as India, Brazil and China, Argentina, and South Korea. Japan, the USA, and Canada received the lowest scores. The survey results emphasized that the decreasing cost of the products and the increasing concern for the environment motivated the consumers in passing years (UNEP, 2010:28). It should be noted that the developed countries should do more for the earth and improve their green policies to protect the environment and the future of humanity. In addition, the consumer trends of middle class people in developing countries can be changed to become more environmentally sensitive by policies and promotional campaigns that educate and motivate consumers about the benefits of green products.

While developing countries launch strategies and policies to encourage growth of a green economy, their success must be examined as time goes by. We must wait for a while since existing research does not have enough data to determine the level of success. Despite the fact that the ecological footprint is low in developing countries, one must take into consideration that people have lower purchasing power in those countries since their income level is low.

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There is also a correlation between the Human Development Index and the sustainable footprint of every developing country (WWF Report, 2014:19). Similarly, in the Ewing et al. (2010) "Ecological Footprint Atlas 2010" research, the authors emphasized the correlation between the Human Development Index and the ecological footprint. In the study, the correlation between the Human Development Index and the ecological footprint was analyzed for 1980, 1990, 2000, and in 2007 for African, Asian, European, North American, Latin American, Oceanian and Caribbean countries. According to the results, there was not much change in passing years. The Human Development Index and ecological footprint rates were high for European countries, while those variables were low for African and Asian countries (Ewing et al., 2010).

CONCLUSION

According to most studies, developed countries have higher ecological footprints than middle- and lower-income countries. Also, as economical power and growth increase, environmental pollution also increase. In the last decade, there have been many conferences and meetings on renewable energy, green consumption, and controlling environment pollution in order to leave a livable earth to the next generations. Decreasing fossil fuels, using renewable or solar energy, green packaging, as well as increasing productivity and biocapacity are all worthy efforts to help create a sustainable world. All these efforts, however, are far behind the work it will take to reach sustainability. Furthermore, there are many obstacles and costs that nations must overcome to initiate sustainable development. In addition, the developing countries which have great enthusiasm about development and growth may have difficulty if they ignore the sustainability of natural resources. Even though these countries choose development and growth policies, they must also care for their natural resources and for the future of humanity.

For a sustainable world, the countries should first take on the responsibility of building a green economy; secondly, the people should take on the responsibility of sustainable consumption. Any policy created to further the green economy should be supported by the individuals living in that nation. Making the goal to create a green economy a team effort should boost the health of the environment and decrease consumption.

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KEY TERMS AND DEFINITIONS

Ecological Footprint: A indicator that shows the quantity of waste that people generate while they meet their daily needs.

Green Consumer: A type of consumer who buys green products such as ecological, organic or energy-saving products and therefore consumes fewer natural resources.

Green Economy: A economic policy to create sustainable growth while protecting the environment and promoting social justice.

Green Product: A product that consumers prefer because it helps to protect the environment during the manufacture, use, and disposal of the product. Generally organic, ecological, recyclable, and energy-saving products are called green products.

Sustainability: A lifelong skill that provides daily needs for the current generation while protecting the next generation's needs.

Sustainable Consumption: A type of consumer behavior that promotes buying green, ecological or energy-saving products or consuming less to protect the environment and natural resources.

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Chapter 72
Modern Optimization Algorithms and Applications in Solar Photovoltaic Engineering

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ABSTRACT

This chapter is devoted to main tendencies of optimization in photovoltaic (PV) engineering showing the main trends in modern energy transition - the changes in the composition (structure) of primary energy supply, the gradual shift from a traditional (mainly based on fossil fuels) energy to a new stage based on renewable energy systems from history to current stage and to future. The concrete examples (case studies) of optimization PV systems in different concepts of using from power electronics (particularly maximum power point tracking optimization) to implementing geographic information system (GIS) are considered. The chapter shows the gradual shifting optimization from specific quite narrow areas to the new stages of optimization of the very complex energy systems (actually smart grids) based on photovoltaics and also other renewable energy sources and GIS.

INTRODUCTION

All processes in surrounding material world and life on Earth are driven by energy. Vaclav Smil, author of many books on energy, wrote: "…energy's role in world history seems to be a natural proposition, with history seen as a quest for increased complexity made possible by mastering higher energy flows" (Smil V., 2004). This may be because of an extraordinary difficulty and exceptional nature of the coming energy transition—but, given the enormous challenges of ushering in a post-fossil world, it may also

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be because of the possibility of an unprecedented and persistent commitment to a rapid change (Smil V., 2010).

Any process can be analyzed in terms of its underlying energy conversions; any object, as well as any bit of information, can be valued for its energy content and for its potential contribution to future energy transformations (Smil V., 2008).

Energy and information are including in the infrastructure of whole activity of modern humankind. Energy and communicative revolutions are the main driving forces in the human development. Education and information are also connecting by very strong relationship. Very often these technologies are considered separately. It is totally incorrect and inappropriate. Table 1 shows roughly the main steps of appearing the new energy, communicational and educational technologies.

Before the industrial revolution, our energy needs were modest. The level of development civilization is characterized by the rate of liberation from nature influences. The history of civilization and liberation from nature influences is the history of new types of energy conquest.

This work is stimulated by the modern trends or diffusion in developing the most important sphere of humankind activity – energy and new computer technologies. Last decades traditional electrical power industry, which basic principles were formed more than hundred years ago, is changing and transforming very fast.

Table 1. Energy, communicative and educational revolutions

Years Ago (Very Approximately)	Communicative and Educational Revolutions	Energy Revolutions	Stages of Development
10^6	Oral communication through language	Conquer of fire, biomass	Forming human society based on additional to biological type energy sources Renewable energy – first stage Exchange information between people
10^5	Picture and symbol communication	Solar energy, animal energy	
10^4	Writing (from internal biological memory to external recorded memory)	Wind and hydro energy (from muscles to machines)	
10^3	Book printing, forming of scientific systems Forming schools and universities	Mechanical energy, Thermal energy (coal, oil, gas)	Using fossil fuels (accumulating solar energy) Human civilization, scientific and technology revolutions
10^2	System of education Mass media, radio, TV	Steam energy, electrical energy, atomic energy	
10^1	Computers, Internet, MOOC	Photovoltaic revolution	Current technology revolution (informatization, robotization, artificial intelligence) Extra planetary activity
Now	Practically total interconnectivity Satellite communication Mobile communication Mass open education	Smart grids, Energy mixt Decentralized energy Space technologies	
Near future	Global earth and near space communication Internet of things Big data technology	Mixt of traditional energy and renewable energy – second stage, new sources of energy Thermonuclear energy Global energy system	Energy and information everywhere Moon and Mars exploitation
Future	Trends of dominating distributed energy and information networks integrating by smart technologies Global technologies and Internet of everything including energy, artificial intelligence		Solar energy for the future of mankind
Far future	Widen areal of mankind from Earth to near space		

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We are now in the period of a transition as a process of successful technical and infrastructural innovation. Energy transitions can be also studied as specific subsets of two more general processes of technical innovation and resource substitution. Transition from an energy supply dominated by nuclear and fossil fuels to a world relying mostly on non-fossil fuels and generating electricity by harnessing renewable energy flows is thus definitely desirable and, given the finite nature of fossil resources (Smil, V., 2010).

Any anthropogenic energy system—that is any arrangement whereby the humans use the Earth's resources to improve the human species chances of surviving and to enhancing their quality of life (and, less admirably, also to increase their individual and collective power and to dominate, and to conquer and destroy others biological species)—has three fundamental components: natural energy sources, their conversions, and a variety of specific uses of the available energy flows.

Technological and social developments of humankind have been well supported by the discovery of new sources of energy and its proper application in day-to-day life. Since the first installation of electricity grids more than 100 years ago, our society has been driven by this convenient source of energy. Most of this electric energy is produced from fossil-fired power generation plants using carbon-based fuels, such as gasoline in the transportation industry. Burning of fuel looks like burning fire on the dawn of humankind in spite we have already now many technologies direct converting fuel energy into electricity (fuel cells), heat into electricity (thermo-elements), solar radiation into electricity (solar cells) and others.

In today's modern era, however, demands development of new and more efficient technologies for next-generation electrical grids and shifting of the focus of power generation to cleaner and carbon-free sources. Both the exhausting of carbon-based fossil fuels and environmental pollution created by the burning of fossil fuels are responsible for this desirable shift power engineering to so called green energy sources. Possible sources of such clean and renewable energy are solar, nuclear, wind, geothermal energy and many others. It is worth mentioning here that the world consumes less energy in one year than the amount of energy Earth surface receive from sunlight in one hour (13 terawatts).

Solar energy represents one of the most significant energy solutions to avoid and even to eradicate our addiction to oil.

1. SOLAR ENERGY, PHOTOVOLTAICS

Solar cells are devices that directly convert solar radiation into electricity by photovoltaic effect. Let us start from the early beginning of photovoltaics. In 1839 French scientist Edmond Becquerel discovers the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes placed in an electricity-conducting solution—electricity-generation increased when exposed to light.

At the beginning of 1930th one of the greatest Russian scholar A. F. Ioffe concentrated on semiconductor physics and formulated many important practical tasks of direct converting solar energy. In result it was created the world level school of semiconductor physics, which further lead to elaborating the most efficient solar cells on heterostructures (Strebkov, D. S., 2005).

It seems obvious that capturing solar energy is going to be the main trend for the last few decades. In line with this expectation, research on solar cell science and technology has taken a huge jump in recent years. Since the first demonstration of the solar cell in 1954 by Bell Laboratories, much progress has been made in this field. The initial more or less practical solar cell by Bell was a silicon p-n junction cell.

In 1960, solar cells were essentially unique, handmade, cost approximately $1000 per peak Watt of power and were used almost exclusively for space applications. In 1970, cells were manufactured in

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batch processes, cost approximately $100 per peak Watt, were primarily used in space applications, but were making an entry into standalone applications.

In 1980, larger quantities of solar cells were produced in larger batch processes, cost approximately $10 per peak Watt, saw significant terrestrial applications (primarily stand-alone, remote devices), and began to be used for grid connected residential applications.

Today, different varieties of solar cells are being studied including amorphous silicon, microcrystalline silicon, polycrystalline silicon, cadmium telluride, copper indium selenide/sulfide, organic/polymer, dye-sensitized solar cells and many others. Actually three generations are considered in the book (M.A. Green, 2006) and many new concepts are appearing now

In spite the practically modern silicone cell dates back to 1954 and was developed at Bell Labs, it should be mentioned the first silicon solar cell was made entirely by accident in early 1940 when Russell Ohl, a researcher at Bell telephone Laboratories in New Jersey, made an important discovery. When he shone a flashlight onto a piece of silicon he was studying, the needle of the voltmeter connected across jumped to a surprisingly large reading.

Today, we are on the threshold of continuous-process manufacturing and photovoltaic modules are beginning to be purchased (in large orders) for approximately four dollars per peak Watt. In the United States, there are several thousand (mostly very small) residential systems and a few central power stations in operation or under development—primarily in California. In addition, there is a rapidly growing market for photovoltaic consumer products such as watches, calculators, radios, televisions, battery rechargers, and so on.

As our conventional source of energy—fossil fuel—rapidly depletes, the search for alternative energy sources has become an integral issue in modern industrialized society. Unavoidably, the world's energy demands and cost will rise. To keep pace with these demands, unlimited energy sources must be researched and optimized. The rapid depletion of non-renewable fossil resources will not continue, since it is now or soon will be technically and economically feasible to supply all of man's need from the most abundant energy source of all, the sun. [Green energies and the environment]

The predicted world energy demand will reach 28 TW by 2050 and 46 TW by 2100. The deployment of solar cells as a source of electricity will have to expand to a scale of tens of peak terawatts in order to become a noticeable source of energy in the future (Coby S.Tao, 2011), that is why even natural resource limitations to terawatt-scale solar cells are considered now and possible solutions are discussed (Tyukhov, 2012).

Solar photovoltaics (PV) have been growing exponentially since 2007, doubling in capacity every two years. This means that annual installation rates have mushroomed from less than 4GW in 2007 to 42GW in 2014 – a more than ten-fold increase in just seven years (Green, J, 2014).

2. DIFFERENT MPPT TECHNIQUES FOR OPTIMIZATION PHOTOVOLTAIC SYSTEMS

PV generation systems have two major problems: the conversion efficiency of electric power generation is low, and the amount of electric power generated by solar arrays changes continuously with weather conditions (Berrera et al., 2009; Sreekanth et al., 2012). Moreover, because of nonlinear I-V and P-V characteristics of PV systems, their output power is always changing with weather conditions, i.e., solar radiation, atmospheric temperature and also nature of load connected (Fangrui et al., 2008; Emad et al.,

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2010). Maximum power point tracking (MPPT) is essential as there is a probable mismatch between the load characteristics and the maximum power points (MPPs) of the PV module in order to ensure optimal utilization of solar cells (Xiao et al., 2004; Ashish et al., 2007). Using of MPPT leads to reduce the cost of energy generated by PV panels (Hohm et al., 2000).

2.1 Conventional MPPT Under Uniform Insolation

A large number of techniques have been proposed for tracking the MPP of PV systems. There are many techniques available in the literature such as fractional open-circuit voltage and short-circuit current (Fangrui et al., 2008), the Artificial Neural Network (ANN) technique (El Sayed, 2013), and the Fuzzy Logic control (Eltamaly, 2010; Eltamaly et al., 2010). Also, it was demonstrated in (Ibrahim et al., 1999) technique to track the maximum power using look-up table in the microcomputer. Another common approach is to use the array power as the feedback. The popular tracking methods based on this approach are widely adopted in PV power systems (Faranda et al., 2008) which include but not limited to, perturb and observe method (P&O) (Koutroulis et al., 2001; Ioan et al., 2013), the incremental conductance method (INC) (Xiao et al., 2004; Esram et al., 2007) and the hill climbing method (HC) (Weidong et al., 2004). These techniques are widely applied in the MPPT controllers due to their simplicity and easy implementation.

2.1.1 Hill Climbing (HC) Technique

The advantage of the hill climbing MPPT technique is its simplicity. It uses the duty cycle of boost converter as the judging parameter when the task of the maximum power point tracking is implemented. When the condition $dP/dD = 0$ is accomplished, it represents that the maximum power point has been tracked (Xiao et al., 2004). The flow diagram of the HC algorithm is shown in Figure 1. The duty cycle in every sampling period is determined by the comparison of the power at present time and previous time. If the incremental power $dP > 0$, the duty cycle should be increased in order to make $dD > 0$. If $dP < 0$, the duty cycle is then reduced to make $dD < 0$. The main problem associated with this technique is because of the tradeoff between the stability of the system in constant radiation period and lack of fast response in rapidly changing radiation. The constant radiation period needs very small value of change in duty cycle, ΔD to prevent high oscillation of power around the maximum power point which reduces the energy captured from PV. On the other hand, the rapidly changing radiation needs higher value of duty cycle for fast tracking the maximum power. HC technique has been simulated in the PSIM software package as shown in Figure 2.

Where; ZOH is zero-order hold block; 1/Z is unit delay block (a unit delay block delays the input by one sampling period); and Sign is sign function block (The output of the sign function block is the sign of the input. When the input is positive, the output is 1. When the input is 0, the output is 0. When the input is negative, the output is -1.)

2.1.2 Incremental Conductance (INC) Technique

Among all the MPPT strategies, the incremental conductance technique is widely used due to the high tracking accuracy at steady state and good adaptability to the rapidly changing atmospheric conditions (Fangrui et al., 2008). This technique employs the slope of the PV array power characteristics to track

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Figure 1. State flow chart of HC MPPT technique

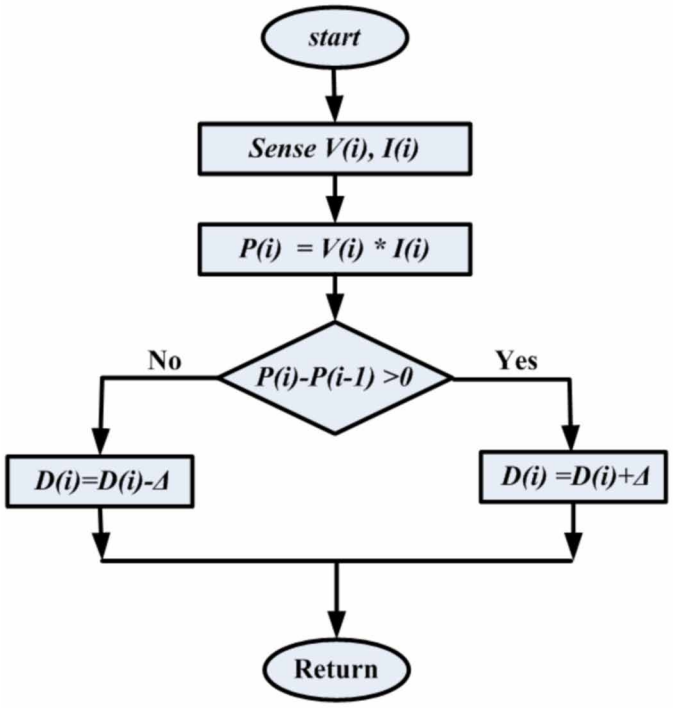
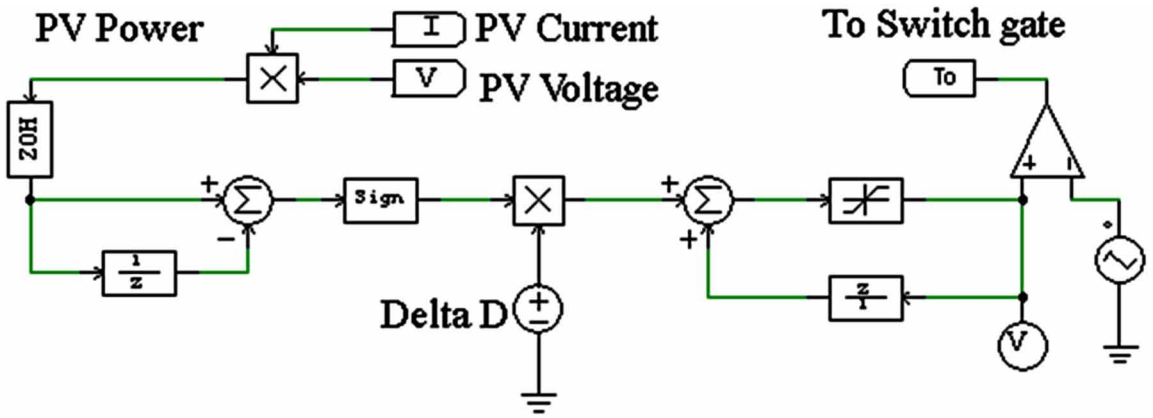


Figure 2. HC MPPT Control Technique using PSIM Software



MPP. The slope of the PV array power curve is zero at the MPP, positive for values of output voltage smaller than the voltage at MPP, and negative for values of the output voltage greater than the voltage at MPP. The derivative of the PV module power is given as in (1), and the resultant equation for the error e is as in (2) (Abouobaida et al., 2012; Emad et al., 2011; Chen et al., 2014).

$$\frac{dP}{dV} = \frac{d(V \times I)}{dV} = I + V\frac{dI}{dV} = 0 \tag{1}$$

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Also,

$$\frac{dI}{dV}+\frac{I}{V}=\frac{I(i)\text{ - }I(i-1)}{V(i)\text{ - }V(i-1)}+\frac{I(i)}{V(i)}=0\ e=\frac{I(i)-I(i-1)}{V(i)-V(i-1)}+\frac{I(i)}{V(i)} \tag{2}$$

Therefore tracking the MPP requires the following procedure as shown in Figure 3. It can be implemented by a simple discrete integrator with the error signal e as the input, and a scaling factor k. The function of the scaling factor k is to adapt the error signal e to a proper range before the integral compensator. As the operating point approaches the MPP, the error signal e becomes smaller, resulting in an adaptive and smooth tracking (Abouobaida et al., 2012).

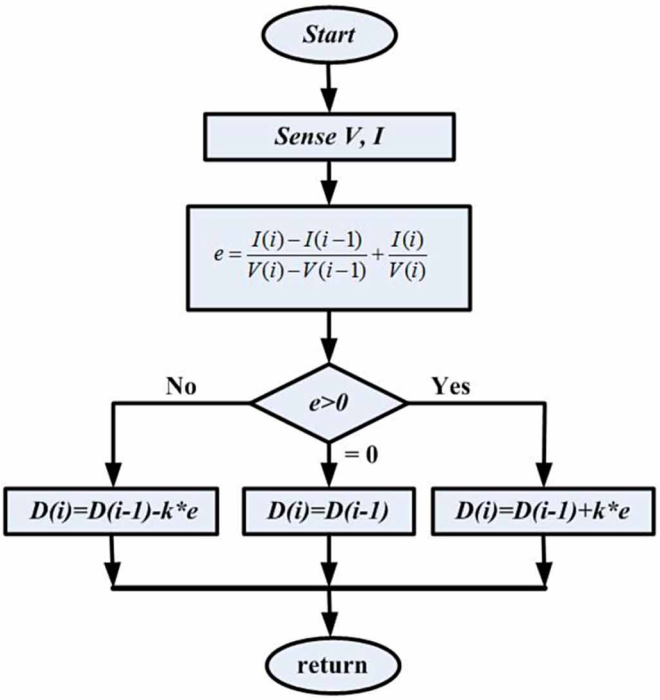
To improve, both, the MPPT speed and accuracy simultaneously a modified dynamic change in step size for INC is introduced (Fangrui et al., 2008). This technique improves the performance of INC technique but at a cost of increased complexity of the control system.

INC technique was simulated in the PSIM software package as shown in Figure 4.

2.1.3. Perturb and Observe (P&O) Technique

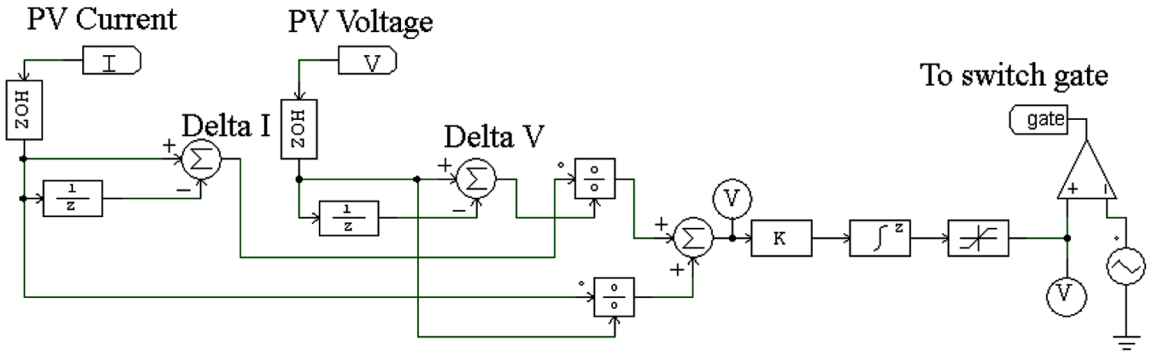
P&O is the most frequently used technique to track the maximum power due to its simple structure (Ioan et al., 2013). This technique operates by periodically perturbing the PV module terminal voltage and comparing the PV output power with that of the previous perturbation cycle (Faranda et al., 2008). As

Figure 3. State-flow chart of INC MPPT technique



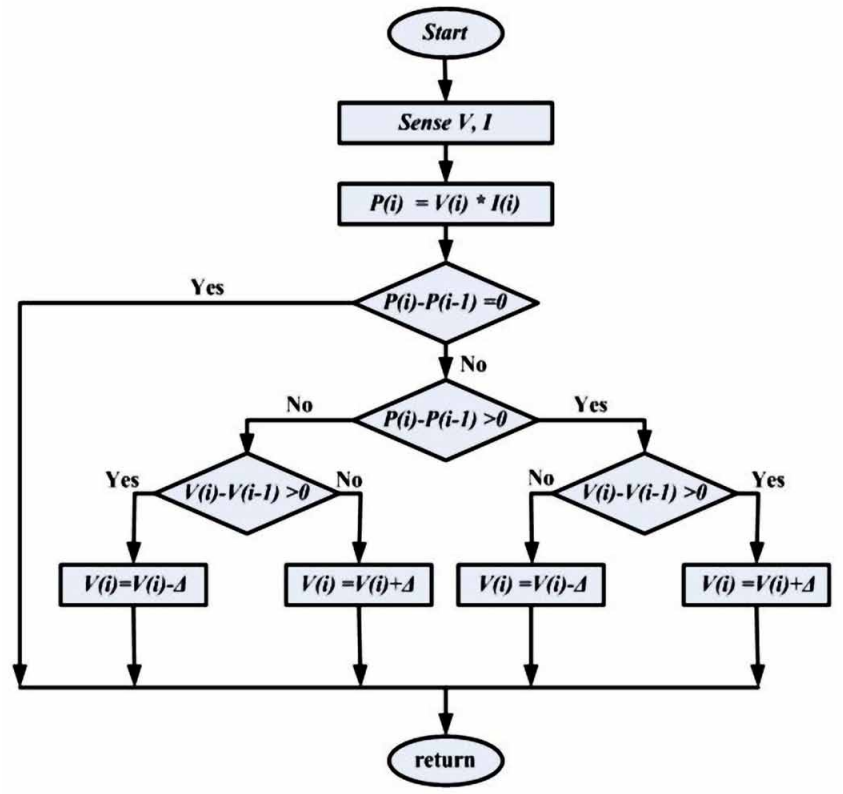
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Figure 4. INC MPPT Control Technique using PSIM Software



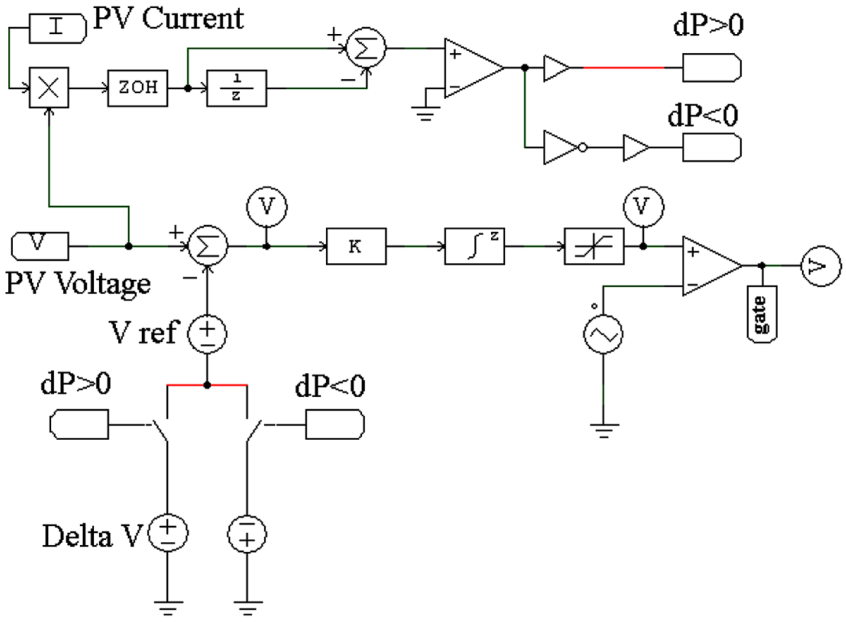
shown in Figure 5 if the PV module operating voltage changes and power increases the control system moves the operating point in that direction; otherwise the operating point is moved in the opposite direction. The flowchart of this technique is shown in Figure 5. PSIM software package has been used to simulate this technique as shown in Figure 6. A common problem in this technique is that the PV module terminal voltage is perturbed every MPPT cycle; therefore when the MPP is reached, the output power oscillates around the maximum, resulting in power loss in the PV system. To remedy this problem, a modified P&O technique has been introduced in (Al-Diab et al., 2010) by multiplying the change in the

Figure 5. State flowchart of P&O MPPT technique



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Figure 6. P&O MPPT control technique using PSIM software



duty cycle by dynamic constant depending on the previous change in the extracted power as shown in (1). Another technique (Amrouch et al., 2007) used ANN to predict this multiplying constant. These techniques increase the complexity of the system and may cause more oscillations in stable weather conditions.

2.1.4. Fuzzy Logic Controller (FLC) Technique for PV MPPT

FLC has been introduced in many researches as in (Gounden et al., 2009; Ben Salah et al., 2008; Altasa et al., 2008; Khaehintung et al., 2004; Karlis et al., 2007; Veerachary et al., 2003; Rajesh et al., 2014) to force the PV to work around MPP. FLCs have the advantages of working with imprecise inputs, not needing an accurate mathematical model, and handling nonlinearity. The details of using FLC in MPPT of PV system is shown in (Eltamaly, 2010). The error signal can be calculated as shown in (3). The value of ΔE is calculated as shown in (4). The model of the proposed system has been simulated in co-simulation between PSIM and Simulink software packages. The idea behind using co-simulation is the easy simulation of FLC in Simulink and power circuit in PSIM.

$$E\left(n\right)=\frac{P\left(i\right)-p\left(i-1\right)}{V\left(i\right)-V\left(i-1\right)} \tag{3}$$

$$\Delta E\left(i\right)=E\left(i\right)-E\left(i-1\right) \tag{4}$$

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The detailed logic, theory and implementation of this model can be found in (Eltamaly, 2010) and (Eltamaly et al., 2010). The output power from the PV system and the voltage are used to determine the E and ΔE based on (4) and (5). The inputs to a FLC are usually E and ΔE. The range of E and ΔE are fixed judiciously based on trial and error. These variables are expressed in terms of linguistic variables or labels such as PB (Positive Big), PM (Positive Medium), PS (Positive Small), ZE (Zero), NS (Negative Small), NM (Negative Medium), NB (Negative Big) using basic fuzzy subset. Each of these acronyms is described by mathematical membership functions, MF as shown in Figure 7. Once E and ΔE calculated and converted to the linguistic variables based on MF, the FLC output, which is typically a change in duty cycle, ΔD of the power converter can be looked up in a rule base given in Table 2. A triangular membership function can be used for both inputs and output variables, as it can easily be implemented on the digital control system. The linguistic variables assigned to ΔD for the different combinations of E and ΔE are based on the power converter being used and also on the knowledge of the user.

These linguistic variables of input and output MFs are then compared to a set of pre-designed values during aggregation stage. The proper choice of If-then rules or Fuzzy inference is essential for the appropriate response of the FLC system. The inference used in this work is tabulated in Table 2. Some researches proportionate these variables to only five fuzzy subset functions as in (Eltamaly et al., 2010). Table 2 can be translated into 49 fuzzy rules IF-THEN rules to describe the knowledge of control as follows;

R_{25} : *if E is NM and* ΔE *is PS the* ΔD *is NS*

R_{63} : *if E is PM and* ΔE *is NS the* ΔD *is PS*

…..

R_{51} : *if E is PS and* ΔE *is NB the* ΔD *is NM*

Defuzzification is for converting the fuzzy subset of control form inference back to values. As the plant usually required a nonfuzzy value of control, a defuzzification stage is needed. Defuzzificaion for this system is the height method. The height method is both very simple and very fast method. The height defuzzification method in a system of rules by formally given by (5):

$$\Delta D = \left(\sum_{k=1}^{m} c(k) * W_k \right) / \sum_{k=1}^{n} W_k \tag{5}$$

where

ΔD = change of duty cycle
$c(k)$ = peak value of each output
W_k = height of rule *k*.

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In the defuzzification stage, FLC output is converted from a linguistic variable to a numerical variable. This provides an analog signal which is ΔD of the boost converter. This value is subtracted from previous value of D to get its new value.

PSIM model showing the calculating E and ΔE and the inputs to Simulink is shown in Figure 8. The simulation model showing the output signal from FLC in Simulink to PSIM and the switching circuit that control the switch is shown in Figure 9. The simulation model of the proposed system in Simulink is shown in Figure 10. Where; SLINK1 is the name that used in Simulink for the input to PSIM part of simulation

Figure 7. A fuzzy system with two inputs, 1 output and 7 MFs each

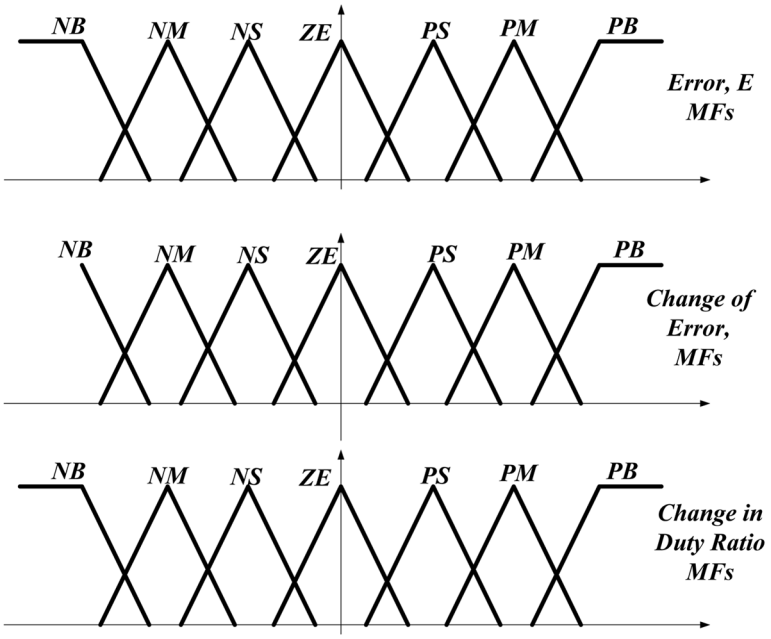


Table 2. Rules for a fuzzy system with 2-inputs and 1 output with 7-membership functions

ΔE E	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

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Figure 8. PSIM model showing the calculating E and ΔE and the inputs to Simulink

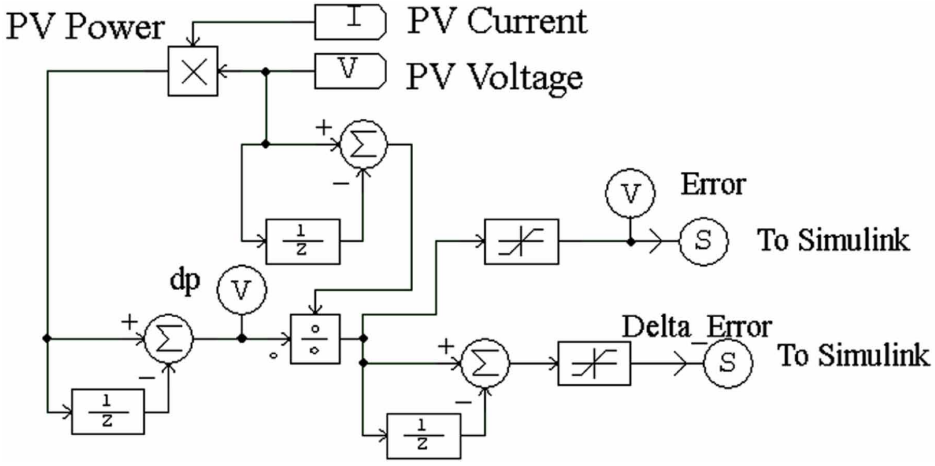
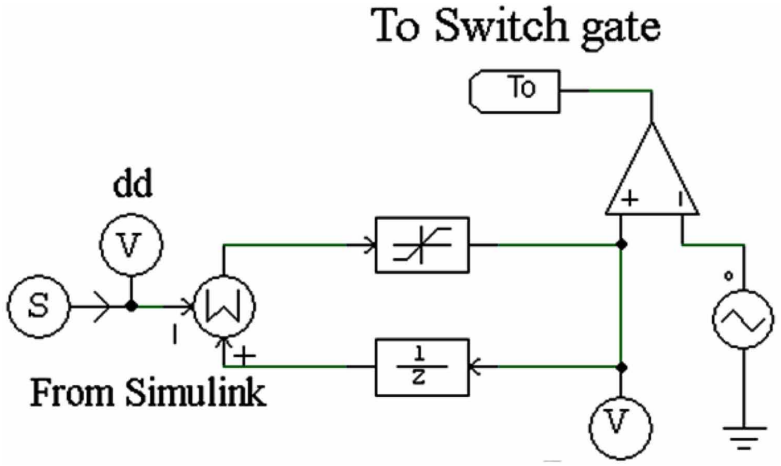


Figure 9. Simulation model of output signal from FLC in Simulink to PSIM and the switching circuit

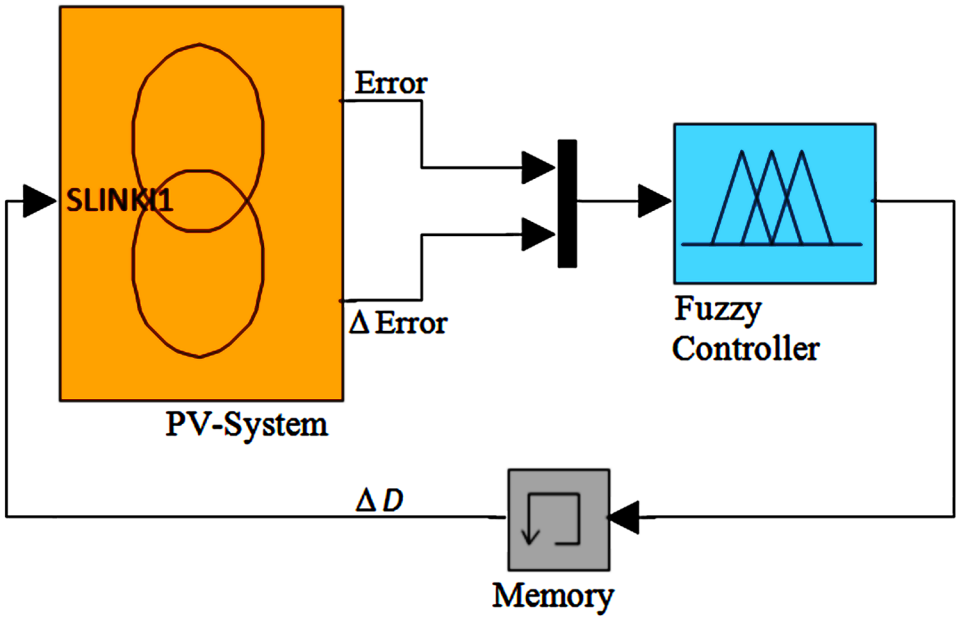


2.2. Soft Computing MPPT Under Partial Shading Conditions

PV system comprises multiple modules interconnected in series and in parallel to create a system with the desired rating. Therefore, the probability for occurring partially shaded condition (PSC) is extremely high. PSC is a phenomenon which is taken place when a part or the whole PV module receives a non-uniform irradiance (Ahmed and Salam, 2014). Ideally, the PV system should be installed in a shade free location. However, it is usually installed in urban and sub-urban areas and PV modules are subjected to partially shadow which is caused by clouds, trees due to wind, neighboring buildings and utilities. Under this condition, the power against voltage (*P–V*) characteristics of PV system exhibits multiple local peaks and one global peak which is required to be tracked, this phenomena reduces the effectiveness of conventional maximum power point tracking (MPPT) techniques (Liu et al., 2012; Sarvi et al., 2015). Large efficient conventional MPPT techniques have been proposed to track maximum power point (MPP)

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Figure 10. Simulink simulation model of FLC MPPT



to improve the conversion efficiency of a PV system under uniform solar irradiance (Ma J. et al., 2013). These techniques include hill climbing, incremental conductance, fuzzy logic control (FLC), perturb & observe, and neural network (Liu et al., 2012; Tey et al., 2014). However, these techniques are highly efficient in tracking the MPP under uniform irradiance, fully illuminated system, where there is only single MPP that exists in the P–V curve, while they are not suitable for tracking the global MPP under PSC (Sarvi et al., 2015) and the efficiency of the PV system decreases (Tey et al., 2014). The idea of using global MPPT based on meta-heuristic optimization techniques algorithms such as genetic algorithms (GAs), Ant Colony Systems (ACS), Artificial Bee Colony (ABC), Artificial Immune Systems (AIS) and particle swarm optimization (PSO) have been presented in (Tey et al., 2014; Sundareswaran et al., 2014; Sundareswaran et al., 2015; Tajuddin et al., 2011). A global MPPT based on cuckoo search algorithm for PV system under PSC has been presented in (Ahmed and Salam, 2014); the authors exploit the significance of the Lévy flight to speed up the algorithm for reaching the global MPP. A modified PSO–MPPT has been presented in (Ishaqu et al., 2012) to minimize the steady state oscillation generated by unstable environmental conditions like change in solar irradiance, change in load and partial shading of PV system. Various extra coefficients have been added to conventional PSO to speed its performance in tracking the global power extracted from the PV system (Daraban et al., 2013); the disadvantage of adding these extra parameters is increasing the algorithm time consumption. A genetic optimization algorithm has been used to determine neuron numbers in multilayer perceptron neural network (ANN) (Kulaksız et al., 2012). A technique based on artificial bee colony has been proposed in (Kinattingal et al., 2015) for global MPP tracking in a PV power generation system. A new MPPT algorithm based on a colony of fireflies for quickly tracking global MPP in partially shaded A PV array has been presented in (Sundareswaran et al., 2014). The tracking procedure consists of positioning the fireflies in the possible solution space and based on the PV power output, the flies move to promised regions (Sundareswaran et al., 2014). An algorithm combines PSO and *P&O* for tracking the global MPP for the PV system has

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been proposed in (Sundareswaran et al., 2013). Varying step size decreased response time and oscillations around the MPP. Ideal size for ANN structure with five neurons in hidden layer was obtained. In (Paraskevadaki et al., 2011) the effect of partial shading on PV module has been analyzed; additionally, a mathematical formula to calculate the shadow effect on the main electrical characteristic of PV module and the MPP of voltage and current has been provided. Modified Differential evolution technique (Tajuddin et al., 2011) able to deal with large and rapid fluctuations of solar irradiance and reached the global MPP under various PS conditions. Average efficiency of 99.6% was attained during tests of partial-shading conditions. Proposed Ant colony optimization (ACO)-based MPPT technique (Besheer et al., 2012) uses heuristic algorithm to find global MPP with simpler control system and low cost. Simulations verified that the technique was successful and robust to various shading patterns. A method for tracking the global MPP of PV system based on the measurements of the PV array open-circuit voltage has been presented in (Lei et al., 2011) while the method described in (Kazmi et al., 2009) is dependent on the solar radiation or PV array short circuit current. A two stage method to track the global MPP of the shaded PV system has been developed in (Kobayashi et al., 2006). In the first one the point of operation moves nearest to the global MPP and in the second one it converges to the actual global MPP.

PV cell is an electrical device that converts the energy of light directly into electricity through the PV effect. They are connected in series and parallel to step up the voltage and current of PV module respectively. PV cell has a complex relationship between solar irradiance, temperature, and the load; so it exhibits a nonlinear output efficiency characteristic known as the P–V curve. Therefore, MPPT techniques should be developed in PV systems in order to maximize the output power (Chen et al., 2014; Rezk et al., 2015). Normally, numbers of PV modules are connected in series and parallel to form a PV array and the total output power is the combination of the power generated from each PV module. PSC is a common phenomenon occurred due to the shadows of buildings and clouds. If there is one or more of the PV modules are partially shaded, the shaded PV modules will consume the power generated by the rest of the PV modules and dissipates heat and cause hot spots (Tey et al., 2014; Chen et al., 2014). Under this condition, the current available in series-connected PV modules is limited by the current of the shaded PV module. This can be avoided by using bypass diodes which are placed in parallel with each PV module. The bypass diodes are reversing biased and have no impact under normal conditions (Tey et al., 2014). On the other hand, they are forward biased and carry the current instead of the PV module under shadowing effect. Figure 11 shows the power against voltage and the current against voltage curves of PV system, respectively, under different cases of PSC. This condition is given by four PV modules connected in series with solar irradiances as shown in Table 3.

Table 3. Different partial shading patterns

Shadow Pattern	First PV Module G_1, w/m^2	Second PV Module G_2, w/m^2	Third PV Module G_3,w/m^2	Fourth PV Module G_4, w/m^2
Case 1	1000	1000	1000	1000
Case 2	1000	1000	800	800
Case 3	1000	1000	800	400
Case 4	1000	800	400	200

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From Figure 11 it can be seen that, the *I–V* curve under PSC have multiple steps, while the P–V curve has multiple peaks. Also, the number of peaks is equal to the number of different irradiance levels incident on the PV modules.

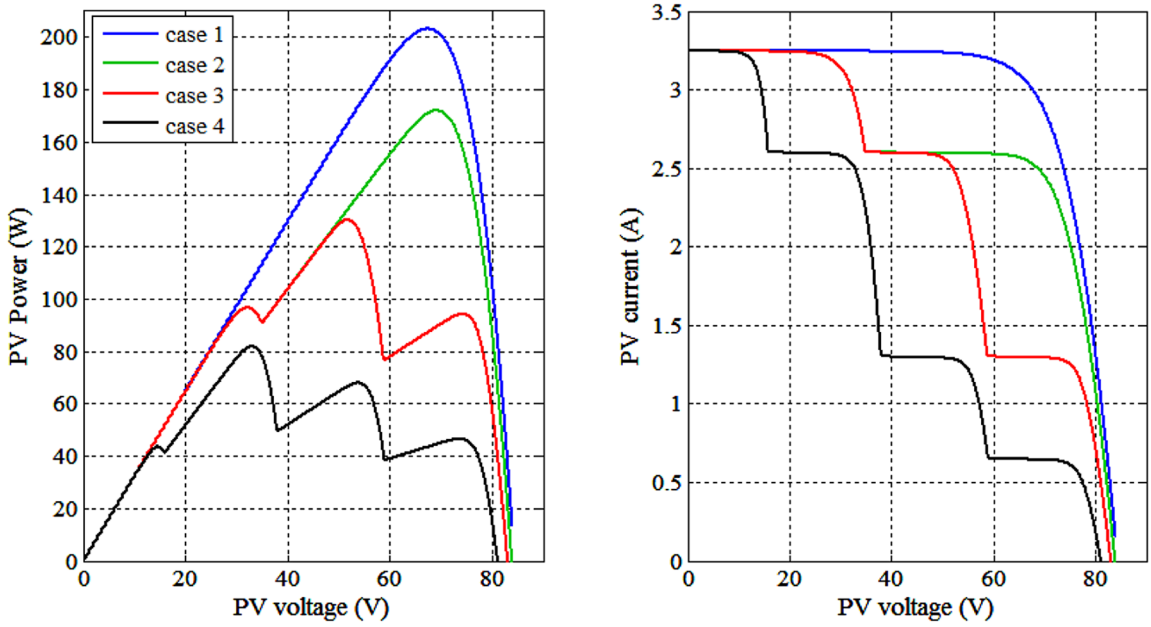
2.2.1. PSO–Based Tracker

PSO is a population–based evolutionary technique that has been recently used for global MPPT under PSC (Sarvi et al., 2015). It was inspired by the behavior of birds, which comprise a swarm of particles, and each particle suggests a candidate solution by exchange the information obtained in their respective search process to find the best solution (Boutasseta, 2012). These particles move in the search-space according to simple mathematical relation, exploiting their position and velocity. The position of the particle is affected by the agent position, which suggests the best solution through the current particles (local best), Pbest, as well as the best solution suggested through the entire population (global best), Gbest. In this work, the particle swarm position is defined as the duty cycle of the DC/DC boost converter, and the fitness value evaluation function is taken as the PV system output power. The particle position di is updated by the following relation;

$$d_i^{k+1} = d_i^k + v_i^{k+1} \tag{6}$$

where the velocity component v_i represents the step size at iteration k+1 and is calculated by using the following expression:

Figure 11. Power against voltage and current against voltage curves of PV system under uniform irradiance and different partial shading patterns



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$$v_i^{k+1} = wv_i^k + c_1 r_1 \left(P_{best} - d_i^k\right) + c_2 r_2 \left(G_{best} - d_i^k\right) \tag{7}$$

where *w* is the inertial weight, c1 and c2 are the acceleration coefficients, r1 and r2 are random values that belong to the interval of [0, 1], Pbest is the best position of particle i, and Gbest is the best position in the entire population (Mirhassaniet et al., 2015). A basic problem with the conventional PSO can be traced to its random nature. It can be seen that the last two terms in (2) is totally dependent on random numbers. The modified velocity equation by (Ishaque and Salam, 2013) can be written as the following;

$$v_i^{k+1} = wv_i^k + P_{best} + G_{best} - 2d_i^k \tag{8}$$

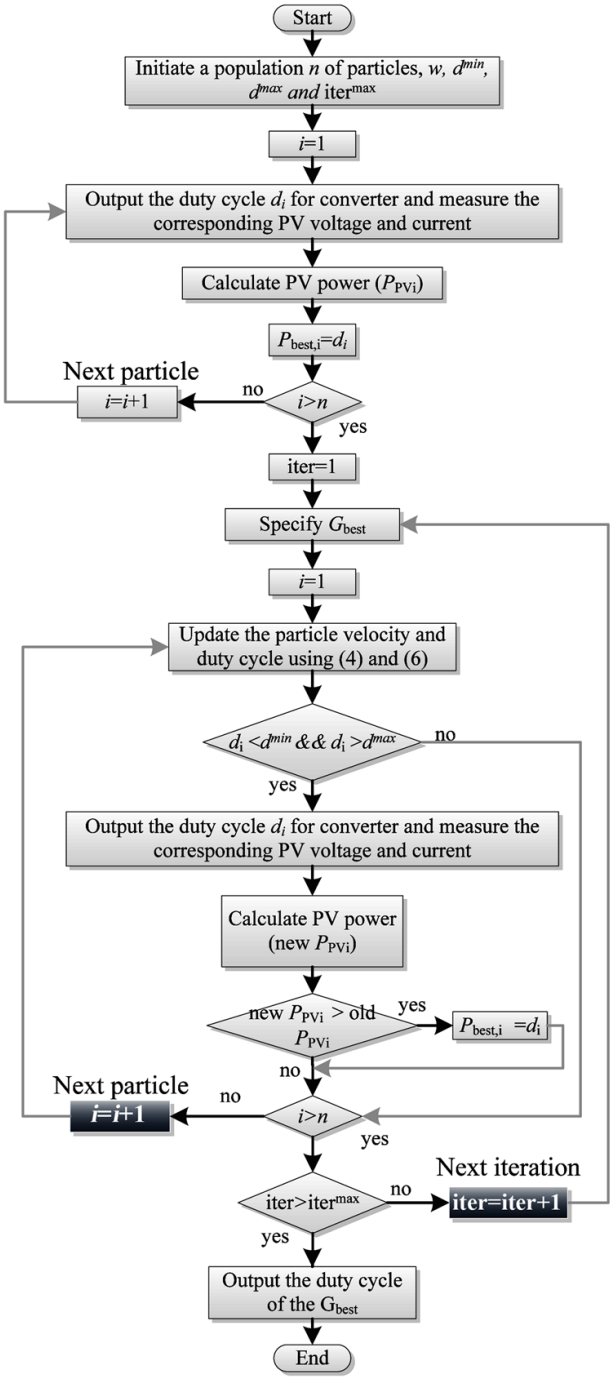
Figure 12 shows the flowchart for searching mechanism by PSO–based tracker. Using a larger number of particles result in more accurate MPP tracking even under complicated shading patterns. However, a larger number of particles also lead to longer computation time. Therefore, a tradeoff should be made to ensure good tracking speed and accuracy. Firstly appropriate variables have to be selected for the search. The total number of particles is defined as n, in this work; the particles are defined as the duty cycles of boost converter. The particles can be placed on fixed position or be placed in the space randomly. The generated samples are applied to the PV system and the corresponding PV voltage and current are measured. These values used to calculate the PV power (fitness value) of particle i. If the current power of particle i is better than the best fitness value in history p_{best}, set current power as the new best fitness of particle i. Then, choose the particle with the best fitness value of all the particles as the G_{best}. After evaluation of all particles, the velocity and position of each particle in the swarm should be updated using (1) and (3). Finally, if the maximum number of iterations is reached, the algorithm will stop and give the obtained G_{best} solution, which represents the optimum value of the duty cycle corresponding to global MPP (Liu et al., 2012).

2.2.2. Teaching-Learning Based Optimization (TLBO)

TLBO is proposed by Reo and Patel in 2010 (Rao and Patel, 2013) It is a population based technique that uses a population of candidate solutions to proceed to the optimal solution (Rao et al., 2015). TLBO simulates the traditional teaching-learning process of a classical school. A group of n students is considered the population and different subjects offered to the students are analogous with the different design variable of the optimization problem. The results of students are analogous to the fitness values of the optimization problem. The best solution in the entire population is considered as the teacher (Rao and Patel, 2013). The teacher tries to improve the individuals by changing the during the teacher and student phases, where an individual is only replaced if his new solution is better than his previous one. The process of TELBO is divided into two stages. During the first stage, called teacher phase, a teacher imports knowledge directly to his students. During the second stage, called student stage, a student may learn with help of fellow students. Overall, how much knowledge is transferred to a student does not only depend on his teacher but also on interaction amongst students through peer teaching (Cerpinsek et al., 2012). The process of TLBO can be summarized as follow:

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Figure 12. Flowchart for searching mechanism by PSO–based tracker



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In the teacher phase, a teacher conveys knowledge among the students and makes an effort to increase the mean result if the class (Rao and Patel, 2013). A good teacher is one who brings his students up to his level in terms of knowledge. But in practice this is not possible and a teacher can only move the mean of the class up to some extent depending on the capability of the students (Rao et al., 2015).

Suppose there is one subject (design variable) offered to n number of students. In this work the student represented by the duty cycle of boost converter di and the fitness value represented by the PV output power. At any iteration *i*, $d_{\text{i,mean}}$, is the mean value of the students. Since a teacher is the most experienced and knowledgeable person on a subject, the best student who is identified as a teacher for that iteration i. the teacher will put maximum effort into increasing the knowledge level of the whole class, but students will gain knowledge according to quality of teaching delivered by a teacher. The existing solution is updated in the teacher phase according to the difference between the value of the teacher di,best and the mean value of the students $d_{\text{i,mean}}$ as follows:

$$d_{i+1} = d_i + r\left(d_{i,best} - T_F d_{i,mean}\right), \tag{9}$$

where $d_{\text{i+1}}$ is the updated value of d_{i}. Accept $d_{\text{i+1}}$ if it gives a better function value. All the accepted function values at the end of the teacher phase are maintained, and these values become the input to the student phase (Rao and Patel, 2013). T_{f} is a teaching factor that decides the value of mean to be changed, and r is a random number in the range [0 1]. The value of T_{f} can be either 1 or 2.

In the student phase, TLBO simulates the learning of the students through interaction among themselves by discussing and interacting. A student will learn new information if the other students have more knowledge than him (Rao and Patel, 2013). During this phase, one student d_{x} tries to improve his knowledge by peer learning from arbitrary student d_{y}. In the case that d_{y} is better than d_{x}, d_{x} move toward d_{y} according to (10). Otherwise, it is moved away from d_{y} according (11).

$$d_{new} = d_x + r\left(d_y - d_x\right) \text{if } P_{\text{pv}}(d_y) > P_{\text{pv}}(d_x) \tag{10}$$

$$d_{new} = d_x + r\left(d_x - d_y\right) \text{if } P_{\text{pv}}(d_x) > P_{\text{pv}}(d_y) \tag{11}$$

If student d_{new} performs better by following Eq (10) and (11), he will be accepted into the next iteration. The algorithm will continue its iterations until reaching maximum number of iterations (Cerpinsek et al., 2012).

The searching mechanism by TLBO–based trackers as fellow; firstly appropriate variables have to be selected for the search. The total number of learners is defined as n, in the current work; the learners are defined as the duty cycles of boost converter. The initial duty cycles (learners) are applied to the PV system and the corresponding PV voltage and current are measured. These values used to calculate the PV power (fitness value) of each learner *i*. Then, choose the learner with the best fitness value of all the learners as the teacher. After evaluation of all learners, the duty cycle is updated in the teacher phase according to (9). Afterwards, select randomly any two learners and update the duty cycle according (10) and (11). These steps are executed for a certain number of iterations until the all nests reach at the best solution which represents the optimum duty cycle corresponding to global MPP.

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2.2.3. Differential Evolution (DE) Based Tracker

DE, which is proposed by Storn and Price, is one of the best population based techniques used for global optimization because of its simplicity and efficiency. Basically, a population of n particle is required in DE and little iteration needed to reach the optimal solution. The algorithm starts with an initial random population and implements mutation, crossover, and selection operations to update the population during the evolution toward the optimum solution (Tey et al., 2012; Salam and Saad, 2013). It implements mutation and crossover processes to yield a trial vector dui for each target vector. Thereafter, a selection operation is executed between the trial vector and the target vector. There are several mutation strategies, each of which is suited for obtaining particular results. The one used in this work is called DE/best/bin. The mutation, crossover and selection operations of this DE algorithm are explained as follow.

The duty cycle of boost converter is used as a target vector and the PV power as the fitness function. The target vectors are distributed on fixed positions with equal distance ranging over their corresponding feasible limits [d_{min}, d_{max}]. The initial population of duty cycles is send to the boost converter. Next, the fitness function values of population are evaluated by measuring PV system current and voltage correspond to each target vector. The measured current and voltage are then used to calculate the PV system power pi which is used as fitness function. After the initialization step finished, the highest PV power is selected as P_{best} and corresponding duty cycle di is saved as the best one D_{best}. Next, two different population members are randomly selected. The, a mutation factor F is used to weight the difference between the selected target vector and the weighted difference is added into the best duty cycle to generate mutated particle or so called donor vector d_{vi}. The mutation process is given by (Tey et al., 2012; Salam and Saad, 2013);

$$dv_i = D_{best} + F \times (d_{r_1} - d_{r_2}) \tag{12}$$

where indexes r_1, and r_2 represent mutually different integers that are randomly generated over [1, n], and F is the scaling factor.

In this work, if a one component of a mutant vector violates the boundary constraint, this component is reset as follows:

$$du_i = \begin{cases} du_i = d_{\max} & \rightarrow \quad \text{if } du_i \text{ greater than } d_{\max} \\ du_i = d_{\min} & \rightarrow \quad \text{if } du_i \text{ smaller than } d_{\min} \end{cases} \tag{13}$$

After the mutation process, the trail vector dui is generated by making use of a binomial crossover operation on the target vector di and the mutant vector d_{vi}. The condition used in crossover process is described as the following;

$$du_i = \begin{cases} dv_i & \text{if } rand \le C_r \\ di \end{cases} \tag{14}$$

Cr is the crossover control parameter in rang of [0 1]

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After crossover, the selection stage is reach. It is conducted by comparing the target vector di against the trial vector d_{ui}. Each trial vector dui is assessed through PV system and P_{ui} have to be measured. However, the value of dui may remain as d_i after crossover and P_{ui} is also equal to P_i. Therefore, only the P_{ui} which does not have the same duty cycle as P_i measured again from the input of boost converter. This process helps to reduce the searching time. When all values of the P_{ui} are obtained, it is compared to P_i. From comparison, the duty cycle which corresponds to higher value of power is used as the next target vector according to the following;

$$d_{i+1} = \begin{cases} du_i & \text{if } f(du_i) \geq f(d_i) \\ di & \text{otherwise.} \end{cases} \tag{15}$$

The iterations are carried out until a termination condition is met. The searching mechanism of DE-based tracker is shown in Figure 13.

2.2.4. Cuckoo Search Based MPPT Technique

Cuckoo Search represents a new optimization meta-heuristic technique recently developed by Yang and Deb (Yang and S. Deb, 2009). The key mechanism in cuckoo breeding is brood parasitism. This is the act of laying eggs in the nests owned by other birds, which may or may not be of the same species. There are three types of brood parasitism, which are termed intraspecific, cooperative and nest takeover (Payne et al., 2005). If the host bird discovers the cuckoo egg in her nest, it may destroy the egg or abandon the nest and build a new one elsewhere. In order to increase the probability of having a new cuckoo and reduce of abandoning eggs by host birds, cuckoos use several strategies such as imitating the colors and patterns and devolving the capacity of cuckoo to mimic the call of host bird to gain access to more feeding opportunity. The model described in (Yang and S. Deb, 2009) has been based on three proposed rules which are;

1. Each cuckoo lays one egg at a time and deposits it into a random nest,
2. The best nests contain the highest quality eggs pass to the next generation,
3. The number of host nests is fixed and there is always a probability that the cuckoo egg is discovered by the host. If an egg is discovered, the host bird throws it out of the nest.

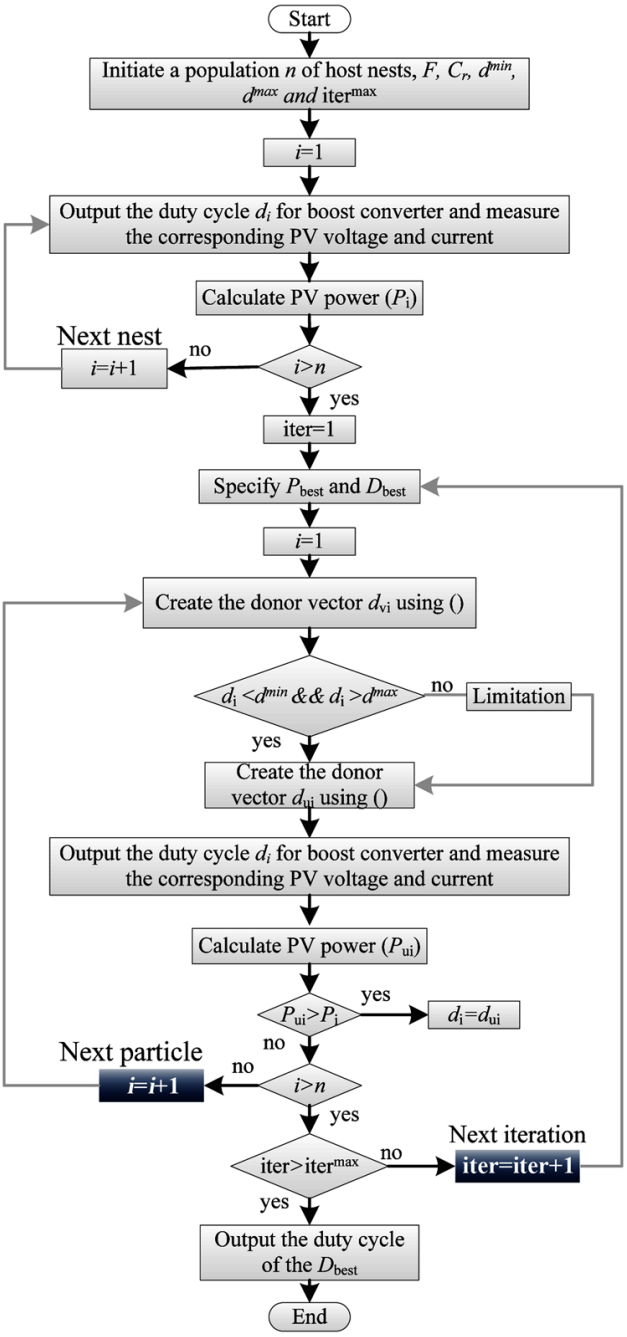
One of the most powerful features of CS is the use of Lévy flights to generate new eggs. A Lévy flight is a random walk, characterized by a series of instantaneous laeps generated by a probability density function. Mathematically, a Lévy flight is a random walk where step sizes are extracted from Lévy distribution according to a power law as follows:

$$Lévy\left(\beta\right) = l^{-\beta} \tag{16}$$

where l is the length of flight and $1< \beta <3$. New eggs are provided by performing a Lévy flight from a randomly selected egg. The new egg is then represented by the coordinates reached at the end of the flight. A coefficient α is used to control the size of the Lévy flight. When a Lévy step is generated, it is

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Figure 13. Flowchart for searching mechanism by DE-based tracker



first multiplied by α before it is used to generate a new egg. There are important controlling parameter to be adjusted; the fraction of eggs to be abandoned in each generation. In this work, the fraction of eggs to be discarded $p_a = 0.25$ were used, as suggested by (Yang and S. Deb, 2009). The proposed strategy in this work is that finding the optimum duty cycle of boost converter corresponding to global MPP under different partial shading patterns. Therefore the duty cycle is used as a variable to be searched,

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independent variable. The PV output power is used as the fitness function, objective function. According the Lévy flight, the duty cycle is updated based on the following relation (Yang and S. Deb, 2009):

$$d_i^{k+1} = d_i^k + \alpha \oplus Lévy\left(\beta\right) \approx d_i^k + k_{\text{Lévy}} \times \left(\frac{u}{\left|v\right|^{1/\beta}}\right)\left(d_{best}^k - d_i^k\right) \tag{17}$$

where β=1.5, kLévy is the Lévy multiplying coefficient (selected as 0.1), *u* and *v* are determined from the normal distribution curves.

$$u \approx N\left(0, \sigma_u^{\,2}\right) \quad and \quad v \approx N\left(0, \sigma_v^{\,2}\right) \tag{18}$$

where the variable σu and σv are defined as follows:

$$\sigma_u = \left(\frac{\Gamma\left(1+\beta\right) \times \sin\left(\pi \times \beta/2\right)}{\Gamma\left(\frac{1+\beta}{2}\right) \times \beta \times 2^{\frac{(\beta-1)}{2}}}\right)^{1/\beta} \quad and \quad \sigma_v = 1 \tag{19}$$

Based on the above mentioned rules, the searching mechanism for CS–based tracker can be summarized in Figure 13. Considering fixed numbers of the host nests (*n*) initially population is generated as a duty cycle of boost converter d_i=d_1, d_2,…,d_n. The duty cycles are applied in the PV system and corresponding PV voltage and current are measured. The measured PV voltage and current are then used to calculate the PV power which used as the fitness function. The duty cycle corresponding to the maximum value among the fitnesses is considered as the current best nest (d_{best}). Then Lévy flight is performed and new nests are generated as in (9). New fitnesses values are tested through the PV system. Afterwards, the worst nest is randomly destroyed with a probability Pa, this process emulates the behavior of the host bird discovering the cuckoo's eggs and destroying them. The new nest is replaced the destroyed one via Lévy flight, then the PV power is measured and the current best the current best nest is selected. These steps are executed for a certain number of iterations until the all nests reach at the best solution which represents the optimum duty cycle corresponding to global MPP.

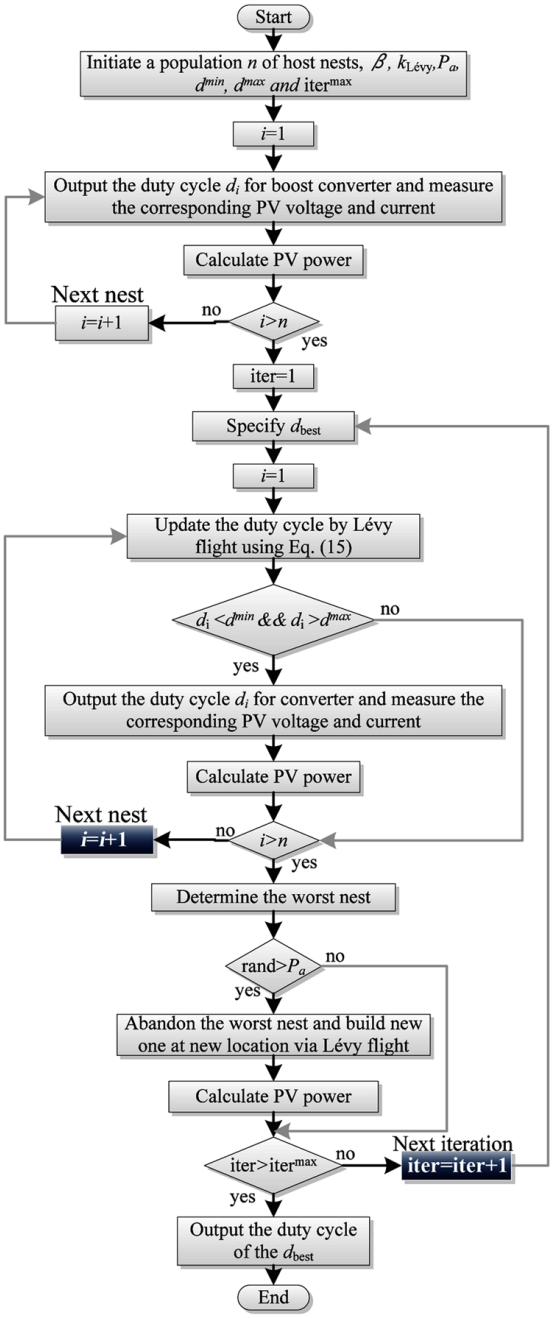
2.3. Summary

Judging by the amount of recent work, it can be concluded that the MPPT is still a very active research area. There are rooms for improvement, particularly when dealing with partial shading conditions. For uniform insolation, there is an increasing trend in combining the conventional methods with soft computing techniques.

As for the partial shading, it appears that the EA methods are the most promising. The PSO, which has a very similar structure to HC has proven to be a viable option. However, there are still potential

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Figure 14. Flowchart for searching mechanism by CS-based tracker



areas of concerns for EA, particularly the selection of appropriate evolutionary control parameters such as population size, mutation factor etc. This may be resolved with the assistance of other optimization technique such as ANN. There is also a need to consider the viability of EA methods when it comes to real time implementation. The way forward is to find an effective method such that the search space

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can be narrowed, so that the computational time is reduced. Furthermore, there are several more EA techniques, which are yet to be exploited fully, for example the differential evolution (DE) and TLBO.

3. SOLAR ENERGY AND RENEWABLE ENERGY

For reliable energy supply using only PV systems is unpractical because of needs too much accumulating equipment. More practical solution especially for decentralized electricity energy supply is using combination of renewable energy different types. Renewable energy (REN) is defined as energy that is produced by stable or intermittent natural energy currents - such as sunlight, wind, rain, waves, tides, and geothermal heat—that are naturally replenished within a time span of a few years (Lund H., 2010). Henrik Lund even asks: how can society convert to 100 percent renewable energy?

Hundred percent of renewable power is foundation for next step of human evolution. The time has come to abolish the combustion of coal, oil and gas for energy generation worldwide, along with the nuclear power threat (Peter Droege, 2009).

The main unpleasant features of renewable energy are low density, space distribution and time intermittence.

Decentralized electricity generation and fluctuating availability pose a challenge on grid stability. This section provides understanding of interaction between PV and other REN systems. Optimization of combined renewable energy sources (different types of converters) for standalone electrical power supply is an important practical task.

The use of renewable energy sources (RES) for autonomous power supply is characterized with a number of features that must be considered when specific systems are creating and designing. The low energy density of renewable energy flows, their variability over time, on the one hand, and the non-uniformity of the load curve the consumers on the other, requires the use of additional equipment - energy storage devices and "smart" devices with the appropriate software and hardware for control income and outcome energy. Energy storage compensates unevenness between energy generation and energy consumption by storing it in periods of surplus energy and energy from in deficit moments. However, accumulating system increases the cost of energy supplying, despite the lack of fuel in the total expenses for such systems. So, the effective way to solve this problem is the combined use of renewable energy sources.

The combined use of the different renewable energy sources allows compensating the intermittent character of RES, to reduce the capacity of the accumulating system units, and, consequently, reduce its cost. However, due to territorial inequity of energy currents from RES, different equipment performances, and variable demands of energy consumers, the optimal configuration of the autonomous power supply combined system (in terms of its economy) is not the same for different places (geographical positions) of operation. The developed methodology and software package allow determining the optimal structure and parameters of the combined power system taking into account all the above factors. The system of computer mathematical package MATLAB with the block of visual simulation Simulink has been developed and used for finding the optimal configuration of the system combination for specific geographic locations.

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3.1. Outline of a Case Study

Simultaneous using of multiple energy sources allows to compensate uneven coming of renewable energy, which, in turn, can significantly reduce the capacity of the generating units, as well as storage capacity in such systems and, consequently, reduce their cost.

Planning and designing of such systems should also take into account the uneven territorial distribution of renewable energy resources. Thus, the problem of determining the optimal structure and parameters of the autonomous power supply combined system (APSCS) from renewable energy sources (APSCS-RES) with the real geographical and climatic conditions, characteristics of the equipment using and the characteristics of the energy consumer, including the expected variable graphics power consumption is arising. In this case, the optimality criterion must be the minimum cost of the system generating electricity.

In the example of a particular case, we consider the solution of the optimization problem for a system that can use only three renewable energy currents: solar, wind and small watercourse. Choice of data sources due to the possibility of increasing the reliability of uninterrupted power supply consumer as micro-hydro which is a relatively stable source of energy, and the installation of photovoltaic (PV) with a wind power unit (WPU) which help each other due to the synergistic effect. Moreover the existence of such sources as the sun and the wind is wide available and small streams flowing in abundance across the expanses of many countries. This result allows applying this methodology to solve optimization problems with a wide range of sources, as well as the relatively stable sources can be considered as geothermal, biomass and others.

3.2. Software Elaborating for Case Study

The solution of described problems is obtained by means of modern specialized software - computer systems Mathematics (CSM). The package MATLAB with visual simulation Simulink was chosen for this system, which is implemented software system that determines the optimal structure and parameters APSCS on the basis of three renewable energy: solar, wind, micro-hydro, taking into account the actual climatic and geographical conditions, characteristics of the equipment used and the characteristics of the consumer, including the expected variable graphics of electric power consumption, according to the criterion of the minimum system cost.

The developed complex consists of two interrelated parts:

- Sub-programs created in the m-file MATLAB;
- Mathematical models APSCS-RES created in Simulink.

The first part determines the optimal composition and preliminary parameters APSCS-RES, which are calculated on the basis of average values from the generalized expressions, and some dependencies are not taken into account, because the variability in the time is very difficult to express by the simple means. Accordingly, in the second stage there is a need to simulate the operation APSCS-RES throughout the calculating period: to analyze its operation, verify the optimal parameters, make corrections and adjustments. Moreover, the simulation can accurately determine the coefficients of power plants usage that characterize the climate conditions in selected areas and time characteristics of the equipment in order to solve the optimization problem.

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The methodology developed in the first part of the software package implements the principle that determines the optimal structure and parameters APSCS-RES. The unknown parameters are the power of installed plants based on renewable energy sources $N_{\text{res}}^{\text{inst}}$ and storage capacity $C_{\text{ab}}^{\text{inst}}$ according to their type and their size range. From the available n unknown variables (corresponding to the standard size range) a certain amount of ξ (ξ <n) must enter in the optimal solution. In this case, each target variable (discrete value) corresponds to a binary variable δi. Thus, if as a result of solving the problem δi = 1, the variable and, therefore, appropriate that variable setting of the standard series, is part of the optimal solution, if δi = 0, then no.

Taking into account that the optimality criterion, i.e. extreme value of the objective function is a minimum cost, the objective function takes the following form:

$$\begin{aligned}
&c_{\text{pv}} \cdot N_{\text{pv1}}^{\text{inst}} \cdot \delta_{1} + c_{\text{pv}} \cdot N_{\text{pv2}}^{\text{inst}} \cdot \delta_{2} + \ldots + c_{\text{pv}} \cdot N_{\text{pv}\,l}^{\text{inst}} \cdot \delta_{l} \\
&+c_{\text{wind}} \cdot N_{\text{wind1}}^{\text{inst}} \cdot \delta_{l+1} + c_{\text{wind2}} \cdot N_{\text{wind2}}^{\text{inst}} \cdot \delta_{l+2} + \ldots + c_{\text{wind}} \cdot N_{\text{wind}\,g}^{\text{inst}} \cdot \delta_{l+g} \\
&+c_{\text{hydro}} \cdot N_{\text{hydro1}}^{\text{inst}} \cdot \delta_{l+g+1} + c_{\text{hydro}} \cdot N_{\text{hydro}\,2}^{\text{inst}} \cdot \delta_{l+g+2} + \ldots + c_{\text{hydro}} \cdot N_{\text{hydro}\,p}^{\text{inst}} \cdot \delta_{l+g+p} \\
&+c_{ab} \cdot C_{\text{ab1}}^{\text{inst}} \cdot \delta_{l+g+p+1} + c_{ab} \cdot C_{\text{ab}\,2}^{\text{inst}} \cdot \delta_{l+g+p+2} + \ldots \\
&+c_{ab} \cdot C_{abf}^{\text{inst}} \cdot \delta_{l+g+p+f=n} \rightarrow \min
\end{aligned} \tag{20}$$

where,

c_{wind} , c_{hydro}: the specific cost for installed capacity in Watts for PV, wind turbines and micro hydro respectively, rub/W;

c_{ab}: unit cost of installed capacity accumulating battery at a voltage U_{ab}^{nom} for the entire life of the APSCS-RES, rub. / A • h;

$N_{\text{pv1}}^{\text{inst}}, N_{\text{pv2}}^{\text{inst}}, \ldots N_{\text{wind}\,l}^{\text{inst}}$, $N_{\text{wind1}}^{\text{inst}}, N_{\text{wind2}}^{\text{inst}}, \ldots N_{\text{wind}\,g}^{\text{inst}}$, $N_{\text{hydro1}}^{\text{inst}}, N_{\text{hydro}\,2}^{\text{inst}}, \ldots N_{hydrop}^{\text{inst}}$: installed capacity of PV, wind turbines and micro-hydro, respectively, in W;

$C_{\text{ab}\,1}^{\text{inst}}, C_{\text{ab}\,2}^{\text{inst}}, \ldots C_{\text{ab}\,f}^{\text{inst}}$: accumulator battery (AB) installed capacity at a nominal voltage U_{ab}^{nom}, A•h;

$\delta_{1}, \delta_{2} \ldots \delta_{l}$, $\delta_{l+1}, \delta_{l+2}, \delta_{l+g}$, $\delta_{l+g+p+1}, \delta_{l+g+p+2}, \delta_{l+g+p+f=n}$: binary variables corresponding number of standard sizes PV, wind turbines, micro-hydro and AB, respectively.

For determining the unit cost of AB during the life time of APSCS-RES the number of substitutions is taking into account produced during this time, due to the limited number of charge-discharge cycles

$$k_{\text{ab}}^{\text{sub}} = \frac{T_{\text{APSCS-RES}}^{\exp l}}{\left(\text{Q}_{\text{ab}}^{\text{u.r.p.}} \,/\, \text{Q}_{A.B}^{\text{u.r.}}\right)}, \tag{21}$$

where

$T_{APSCS-RES}^{\exp l}$: the life APSCS-RES years (we took in calculations 20 years);

$\text{Q}_{\text{ab}}^{\text{cdd.}}$: the number of charge-discharge cycles at a given depth of discharge;

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$Q_{\text{ab}}^{\text{cd.}}$: the number of charge-discharge cycles, the average for the year (in the calculations is equal to 365, in average one full cycle per day).

In this case, the unit cost of AB, determined during its life APSCS-RES is found by the following expression:

$$c_{\text{ab}} = c'_{\text{ab}} \cdot k_{\text{ab}}^{\text{sub}} , \tag{22}$$

where c'_{ab} : the unit cost of battery at a voltage U_{ab}^{nom}, rub. / A • h.

The system of restrictions is a condition to ensure uninterrupted power supply to consumers. This is the equation of energy balance, made up for the average daily hours for each calendar month of the accounting period (years):

$$\begin{aligned}
&k_{pv}^{fac}(\Delta t_i^j)\cdot N_{\text{pv 1}}^{\text{inst}}\cdot k_n\cdot\delta_1\cdot\Delta t_i^j + k_{pv}^{inst}(\Delta t_i^j)\cdot N_{\text{pv 2}}^{\text{inst}}\cdot k_n\cdot\delta_2\cdot\Delta t_i^j + \dots\\
&+k_{pv}^{inst}(\Delta t_i^j)\cdot N_{\text{pv }l}^{\text{inst}}\cdot k_n\cdot\delta_l\cdot\Delta t_i^j + k_{wind}^{inst}(\Delta t_i^j)\cdot N_{\text{wind 1}}^{\text{inst}}\cdot k_n\cdot\delta_{l+1}\cdot\Delta t_i^j +\\
&+k_{wind}^{inst}(\Delta t_i^j)\cdot N_{\text{wind 2}}^{\text{inst}}\cdot k_n\cdot\delta_{l+2}\cdot\Delta t_i^j + \dots + k_{wind}^{inst}(\Delta t_i^j)\cdot N_{\text{wind }g}^{\text{inst}}\cdot k_n\cdot\delta_{l+g}\cdot\Delta t_i^j +\\
&+k_{hydro}^{inst}(\Delta t_i^j)\cdot N_{\text{hydro 1}}^{\text{inst}}\cdot k_n\cdot\delta_{l+g+1}\cdot\Delta t_i^j + k_{hydro}^{inst}(\Delta t_i^j)\cdot N_{\text{hydro 2}}^{\text{inst}}\cdot k_n\cdot\delta_{l+g+2}\cdot\Delta t_i^j + \dots,\\
&+k_{hydro}^{inst}(\Delta t_i^j)\cdot N_{\text{hydro}p}^{\text{inst}}\cdot k_n\cdot\delta_{l+g+p}\cdot\Delta t_i^j + k_{ab}^{inst}(\Delta t_i^j)\cdot C_{\text{ab 1}}^{\text{inst}}\cdot U_{ab}^{nom}\cdot k_n\cdot\delta_{l+g+p+1} +\\
&+k_{ab}^{inst}(\Delta t_i^j)\cdot C_{\text{ab 2}}^{\text{inst}}\cdot U_{ab}^{nom}\cdot k_n\cdot\delta_{l+g+p+2} + \dots\\
&+k_{ab}^{inst}(\Delta t_i^j)\cdot C_{\text{ab }f}^{\text{inst}}\cdot U_{ab}^{nom}\cdot k_n\cdot\delta_{l+g+p+f=n} \geq W_H(\Delta t_i^j)
\end{aligned} \tag{23}$$

where

$k_{pv}^{fac}(\Delta t_i^j)$, $k_{wind}^{fac}(\Delta t_i^j)$, $k_{hydro}^{fac}(\Delta t_i^j)$: the capacity factors PV, wind turbines and micro-hydro, respectively, for an interval of time;

$k_{ab}^{fac}(\Delta t_i^j)$: coefficient of AB during the time interval Δt_i^j;

$k_l = 0,93$: the coefficient of losses of energy conversion system;

Δt_i^j: a time interval corresponding to the i-th hour diurnal (i = 1,2 ... 24) j-th month (j = 1,2 ... 12) Δt_i^j h;

$W_{gp}(\Delta t_i^j)$: the amount of electrical energy required for guaranteed power consumers during the interval Δt_i^j W • h:

$$W_{gp}(\Delta t_i^j) = N_{\text{cons}}^{\text{av}}(\Delta t_i^j)/k_n\cdot\Delta t_i^j + N_{\text{on}}^{\text{av}}(\Delta t_i^j)\cdot\Delta t_i^j + N_1^{\text{av}}(\Delta t_i^j)\cdot\Delta t_i^j \tag{24}$$

where

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$N_{\text{cons}}^{\text{av}}(\Delta t_i^j)$: the average amount of power consumers during the interval Δt_i^j, W (defined by schedule of consumer load);

$N_{\text{on}}^{\text{av}}(\Delta t_i^j)$: average value of the power of their own needs in a time interval Δt_i^j, W;

$N_{\text{l}}^{\text{av}}\ (\Delta t_i^j)$: the average power loss in the system during the interval Δt_i^j, W.

It should be noted that the utilization rate of energy discharge coefficient $k_{ab}^{fac}(\Delta t_i^j)$ corresponds to the $k_{ab}^{fac}(\Delta t_i^j)$ AB and it cannot be larger than the coefficient of the depth of discharge $k_{ab}^{dd.}$ (to take into account equal to 0.6), as in this case, during the hours of AB discharged more than adopted by the depth of discharge.

Total number of constraints from i = 24 and j = 12 is 12 • 24 = 288.

Utilization rates for each time interval determined on the basis of climatic and geographical conditions and the characteristics of the selected areas of the; $N_{\text{wind1}}^{\text{inst}}, N_{\text{w inf 2}}^{\text{inst}}, \ldots N_{\text{wind } g}^{\text{inst}}$; $N_{\text{hydro 1}}^{\text{inst}}, N_{\text{hydro 2}}^{\text{inst}}, \ldots N_{\text{hydro } p}^{\text{inst}}$ equipment used by a mathematical model of the system.

$C_{\text{ab 1}}^{\text{inst}}, C_{\text{ab 2}}^{\text{inst}}, \ldots C_{\text{ab } f}^{\text{CAB}}$: limitations of the capability of the equipment used, the following:

$$\delta_1 + \delta_2 + \ldots + \delta_l \le 1,$$

$$\delta_{l+1} + \delta_{l+2} + \ldots + \delta_{l+g} \le 1,$$

$$\delta_{l+g+1} + \delta_{l+g+2} + \ldots + \delta_{l+g+p} \le 1 \tag{25}$$

$$\delta_{l+g+p+1} + \delta_{l+g+p+2} + \ldots + \delta_{l+g+p+f=n} \le 1.$$

The first line corresponds to the standard size range of the PV, the second - of wind turbines, the third - the micro-hydro, and the fourth - the battery. This is possible quantity of facilities which can be selected from the corresponding range of power alone.

The boundary conditions are not recorded because the possible values of discrete variables are given, and the values of binary variables can only be 0 or 1.

With such a formalization of the optimization problem one cannot guarantee the accuracy of the results, because they do not take into account certain factors.

First, the ratio of depth of discharge (energy) AB depending on the desired energy outputted and determines the discharge capacity of the battery.

Second, inaccurate representation of AB in (23) as an independent energy source to consider introducing additional constraints arising from the fact that AB is a source of energy, the development of which is directly dependent on the production of generating units based on renewable energy. Thus, the average annual production power plants based on renewable energy must exceed the required annual average load factor taking into account the losses of electric energy for compensation. However, it is difficult to estimate accurately the amount of energy to be compensated. Thus, due to the above factors,

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the solution of the optimization problem by classical methods of linear programming results are not very accurate results, so the composition and parameters APSCS-RES determined by successive iterations.

The proposed method of calculation is to step through the energy balance equations created for the average daily hours for each calendar month of the accounting period (23) with the accumulation of ($-C_{\text{ab}}^{T} \cdot U_{ab}^{nom}$) and generation ($+C_{\text{ab}}^{T} \cdot U_{ab}^{nom}$) energy by AB:

$$\begin{aligned} &k_{pv}^{fac}(\Delta t_i^j) \cdot N_{\text{pv}}^{\text{inst}} \cdot k_l \cdot \Delta t_i^j + k_{wind}^{fac}(\Delta t_i^j) \cdot N_{\text{wind}}^{\text{inst}} \cdot k_l \cdot \Delta t_i^j + \\ &+k_{\Gamma}^{ucn}(\Delta t_i^j) \cdot N_{\Gamma}^{\text{ycT}} \cdot k_l \cdot \Delta t_i^j \pm C_{\text{ab}}^{\text{B}}(\Delta t_i^j) \cdot U_{ab}^{nom} \cdot k_l \geq W_H(\Delta t_i^j) \end{aligned} \tag{26}$$

where

$$+C_{\text{ab}}^{\text{B}}(\Delta t_i^j) \cdot U_{ab}^{nom} = k_{ab}^{disch}(\Delta t_i^j) \cdot C_{\text{ab}}^{\text{ac}}(\Delta t_{i-1}^j) \cdot k_{ab}^{changC}(\Delta t_i^j) \cdot U_{ab}^{nom},$$

$$-C_{\text{ab}}^{\text{B}}(\Delta t_i^j) \cdot U_{ab}^{nom} = k_{ab}^{ch} \cdot C_{ab}^{inst} \cdot U_{ab}^{nom} \cdot \eta_{ab} \tag{27}$$

where $C_{\text{ab}}^{\text{ac}}(\Delta t_{i-1}^j)$: energy accumulated in the previous time by AB, defined in the previous step as:

$$C_{\text{ab}}^{\text{ac}}(\Delta t_{i-1}^j) = \pm C_{\text{ab}}^{\text{B}}(\Delta t_{i-1}^j) + C_{\text{ab}}^{\text{ac}}(\Delta t_{i-2}^j) \tag{28}$$

$k_{ab}^{changC}(\Delta t_i^j)$: coefficient characterizing changes in battery capacity based on the current discharge current is determined by the coefficient of discharge $k_{ab}^{disch}(\Delta t_i^j)$, which in turn is determined based on the required power compensation;

$k_{ab}^{ch}(\Delta t_i^j)$: coefficient characterizing the nominal charging current AB;

η_{ab}: efficiency of the batteries.

Since usually only efficiency of charge-discharge cycle is available it is counted only once during charging.

When checking each step takes into account the total amount of energy that can accumulate over the AB Δt_i^j:

$$\left| \sum_{i,j=1}^{288} \pm C_{\text{ab}}^{\text{B}} \cdot U_{ab}^{nom} \right| \leq C_{\text{ab}}^{\text{inst}} \cdot U_{ab}^{nom} \cdot k_{ab}^{\text{dd}} \tag{29}$$

where k_{ab}^{dd}: the coefficient of the depth of discharge of batteries.

Verification is required for all possible combinations of APSCS-RES with specified standard series equipment is used in it.

The second part of the software system, which determines the usage settings and adjusts the composition and parameters of APSCS-RES, a mathematical model and the modeling process is the means of

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APSCS-RES under different operating conditions. The model is based on the principle of hierarchy; it is a basic block, in groups (subsystems) are functionally related units within the subsystems of the first level, second level are subsystems, etc.

Using the background information that characterizes the real climatic and geographical conditions of operation, the corresponding blocks in the model, the data are generated determining the flow of renewable energy (solar, wind and Small River). Credibility is defined as the quantity of data characterizing renewable resources, and data characterizing the unequal distribution of them in time, given how predictable patterns (day, night), and random factors (cloudy, windless days, hours). The other model blocks directly characterize the functioning process APSCS-renewable energy sources and define the characteristics of the equipment used, and especially the consumer, based on graphs of consumption of electrical energy.

The simulated time of working RES APSCS, due to the frequency of recurrence of renewable energy resources, is equal to one year and is divided into n = 8760 time slots (Δt_i) with a duration of one hour. Detailed description of the mathematical model is presented in paper by Simakin V.V. (Simakin V.V., 2011).

3.3. Calculation Procedure of Concrete Example and Results

The following describes the basic procedures and procedures developed complex.

1. The data relating to the renewable energy equipment and consumer are entered. The energy flows inherent to renewable energy sources are generated and the work APSCS-RES is simulated under these conditions with the help of the mathematical model of the system. Power generating devices are set equal to 1 kW, capacity AB - arbitrary. The simulation determines the values of the capacity factor of power plants APSCS-RES ($k_{pv}^{fac}(\Delta t_i^j)$, $k_{wind}^{fac}(\Delta t_i^j)$, $k_{hydro}^{fac}(\Delta t_i^j)$) and the amount of electrical energy needed to power consumer ($W_H(\Delta t_i^j)$) at different time intervals.
2. The variants of configurations of APSCS-RES are defined to meet the certain conditions of operation, distributed in order of increasing cost, and prefound the optimum composition and parameters of the system.
3. It checks received at the second stage of options APSCS-RES until a configuration satisfying the demand of 100% coverage of the load.

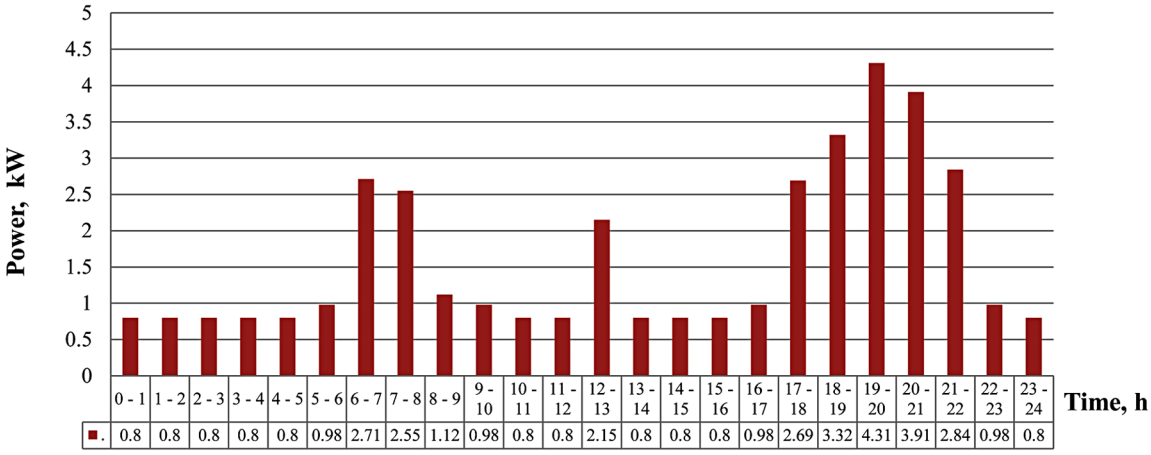
Once the final result is displayed that allows you to get a lot of additional information that characterizes the work of APSCS-RES, as well as a look at the overall picture of the system, evaluate its operation to a new qualitative level.

The effectiveness of the use of combined power from those in the example of renewable energy sources has been evaluated for several case study in the CIS with the help of the developed software system.

Fife geographic locations were taken for analysis: Sochi, Makhachkala, Bishkek (formerly Frunze, Kyrgyzstan), p. Ust-Kokshov (Altai), p South Kuril (Far East). Four rural houses modern buildings were selected as a consumer to which electricity from APSCS-RES is provided by Practical guidance (Practical guidance, 2008). The area of each house equals 300-360 m^2, daily consumption - 8,15 kW • h. Respectively a graph of the total daily load equal to, 32.6 kW • h is shown at Figure 15. According to the guidelines for the design of power supply agriculture (Guidance, 1981) the load factor was used:

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Figure 15. Daily energy consumption diagram (consumer load)



winter - 1, spring - 0.8; summer - 0.7; autumn - 0.9 in the seasonal distribution. Type of equipment used in APSCS-RES PV consisting of fixed PV modules optimally oriented to the south, vertical-axis wind turbine type, micro-hydro sleeve-type. Two types of AB considered: with lead-acid and lithium-iron-phosphate.

Specific costs of power units generated by renewable-energy installations APSCS were assumed: cpv = 110 rub/W; cwind = 100 rub/W; cwind = 75 rub/W, cAB la = 206 rub/A • h, cAB LiFePh = 280 rub/A • h (UAB = 12 V), which corresponds to the real market values presently. Parameters of power electronics: $k_p = 0,93$ The parameters for lead-acid AB: $k_{ab}^{ch} = 0,2 \times C$, $\eta_{ab} = 0,8$, $k_{ab}^{dd} = 0,6$ for the lithium-iron-phosphate $k_{ab}^{ch} = 0,5 \times C$, $\eta_{ab} = 0,94$, $k_{ab}^{dd} = 0,77$.

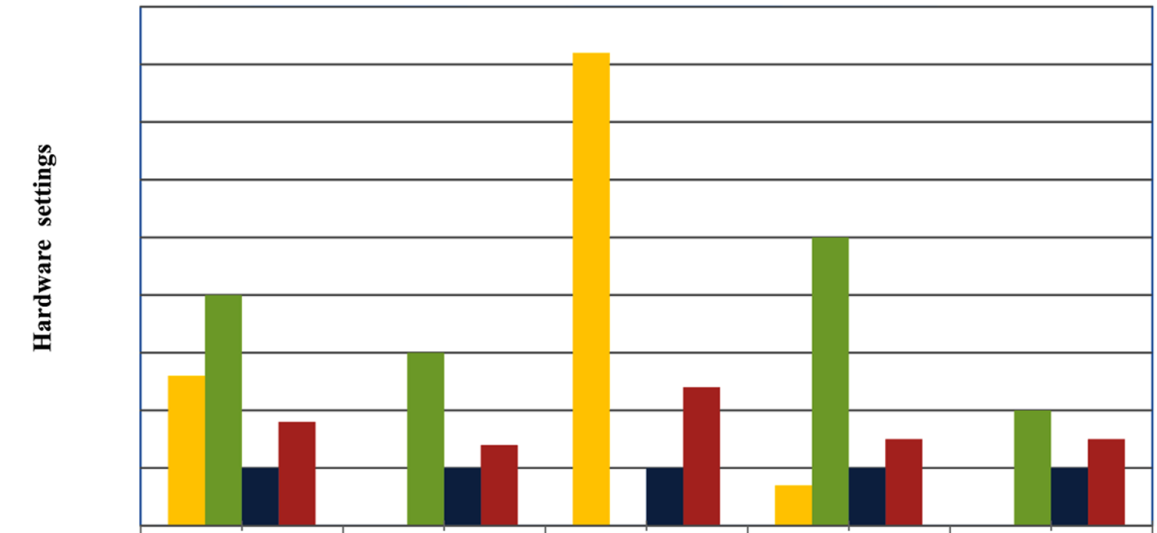
Optimization parameters APSCS-RES defined for the five selected geographical locations are shown in Figure 16. Contingent resources of water flow were selected based on the fact that the available head and flow of water can get through micro-hydro power of 1 kW. Because the energy generated by the micro-hydro is the cheapest, its capacity is determined in all cases, the maximum available. However, the energy generated by the micro-hydro is not enough to cover the load of the consumer and requires additional sources, which in the case of the city of Makhachkala and part of the South Kuril were wind turbines, in the case of Bishkek - PV, while in Sochi with. Ust-Kokshov are optimal, given the micro-hydro, and wind turbines, and PV.

The optimal configuration study was carried out while the limiting sources were used on the example of the city Sochi (Figure 17). It is evidently that the combined use of renewable energy allows to reduce the installed power plants. If to look at the total cost of power plants (Figure 17 column 1, 6, 7, 8), the most expensive it will be for electric power through wind turbines and significantly less if use the PV. Combination PV allows reducing costs by a factor of 2.2 compared with only wind turbine and 1.6 as compared with PV. Their combined use with a micro-hydro can have a 2-fold more reduction in the costs of power plants for electric power consumers in the district of Sochi.

If to analyze the total cost of power plants in the five selected points (Figure 18 column 1 - 5) the most cost-effective electricity will be to consumers in Makhachkala and in the South Kuril village. And in the second case, power supply, despite a slightly lower utilization rate of wind turbines, their more

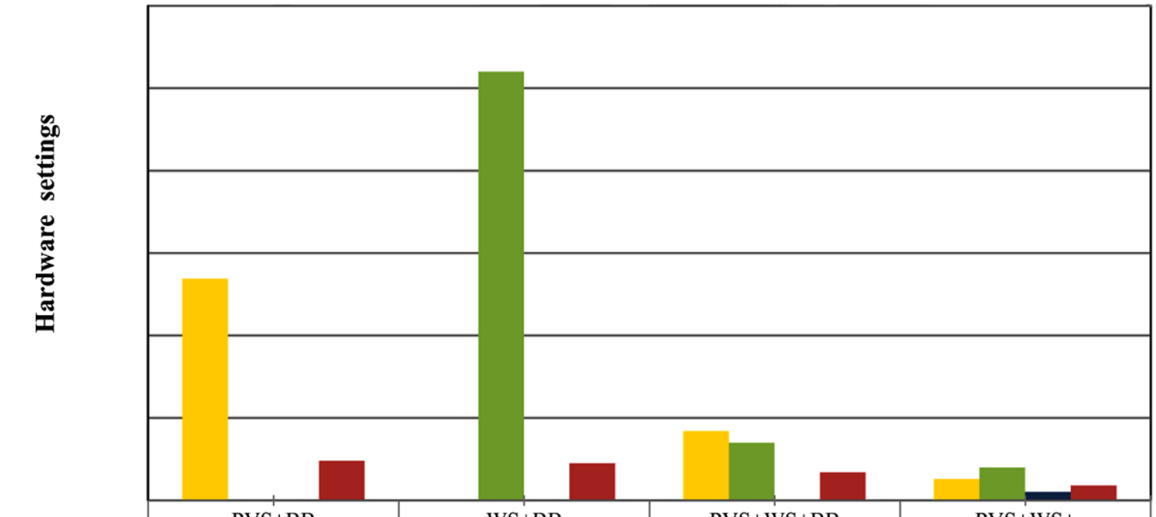
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Figure 16. Results of optimization parameters APSCS-RES defined for the five selected geographical locations



	c. Sochi	c. Makhachkala	c. Bishkek	v. Ust-Koksa	v. Y-Kurilsk
PVS, W	2600	0	8200	700	0
WS, W	4000	3000	0	5000	2000
microHS, W	1000	1000	1000	1000	1000
BB, A·h	1800	1400	2400	1500	1500

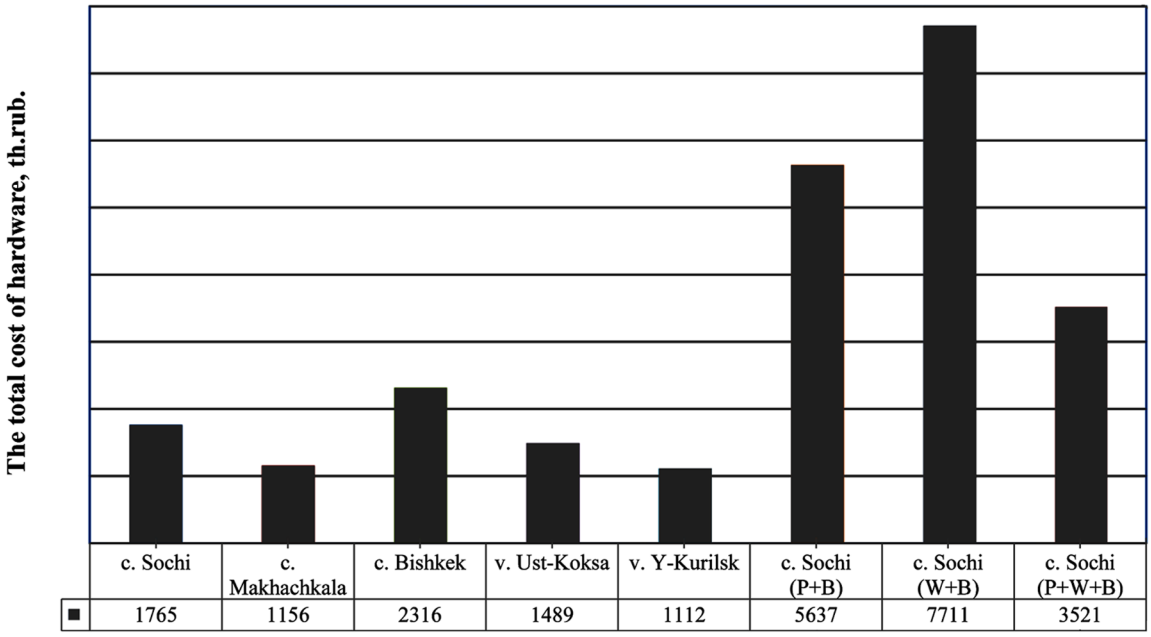
Figure 17. Economical estimations of systems with different share of RES in total electricity generation for Sochi district



	PVS+BB	WS+BB	PVS+WS+BB	PVS+WS+ microHS+BB
PVS, W	26900	0	8400	2600
WS, W	0	52000	7000	4000
microHS, W	0	0	0	1000
BB, A·h	4800	4500	3400	1800

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Figure 18. The total cost of power plants based on APSCS-RES under different operating conditions



profitable because of the best time distribution according to production of electrical energy by wind turbines and consumption generated energy.

The effect of seasonal factor of the load on the optimal configuration APSCS-RES was investigated on the example of Ust-Koksha village (Figure 19). For given the seasonal load factors in Ust-Koksha, along with a micro-hydro, the predominance of the wind turbines power is optimal, due to the coincidence of the seasonal increase in the load and generation of wind turbines. In the case where the load is not changing by season and throughout the year is constant, the optimal capacity of wind turbines and PV are comparable.

All results are presented for APSCS-RES using lithium-iron-phosphate AB, as the total cost of renewable energy power plants and AB in this case were 34% less in comparison with the use of more traditional for lead-acid AB. Thus, the superiority of lithium AB is already significantly in the field of power engineering, and without regard to their weight and size.

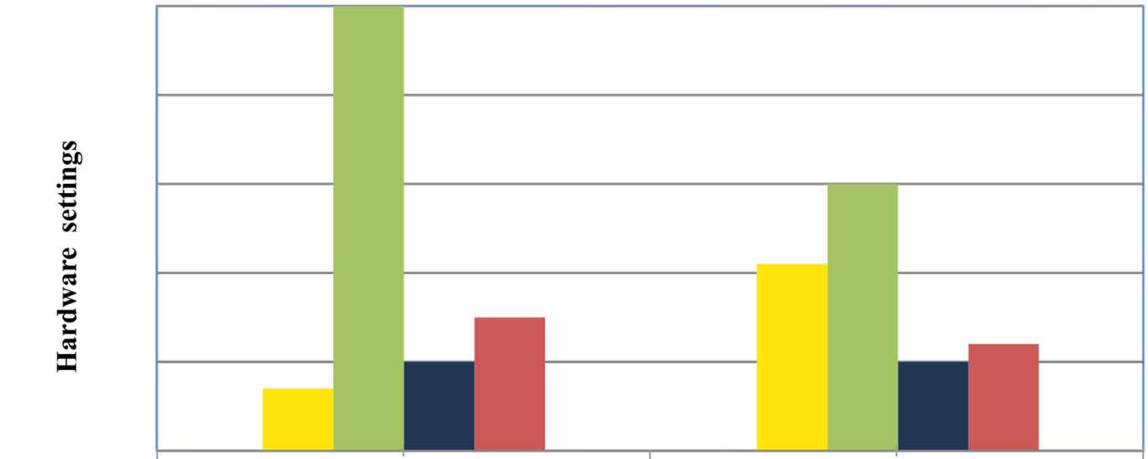
3.4. Summary

The technique and software package that allows any user to determine the optimal parameters of the combined systems of autonomous power supply using only renewable energy sources such as solar, wind and water. Results of optimization studies, conducted with the help of the program complex showed a significant dependence of the optimal structure and parameters APSCS-RES on many factors, which should certainly be taken into account when designing such systems.

For example, the Sochi shows how, under certain conditions the combined use of power plants based on renewable energy profitable. Combination PV multiplier to reduce costs by a factor of 2.2 compared with only wind turbine and 1.6 times as compared with a photomultiplier. Their combined use with a

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Figure 19. Influence of seasonal factor on optimal parameters of stand-alone power supply systems with RES



	v. Ust-Koksa with Ksez	v. Ust-Koksa without Ksez
PVS, W	700	2100
WS, W	5000	3000
microHS, W	1000	1000
BB, A·h	1500	1200

micro-hydro can have a 2-fold reduction in the costs of power plants for electric power consumers in the district of Sochi.

So, fluctuating and intermittent renewable energy production should be coordinated with the combination of RES, and also the size of the energy demand must be adjusted to the realistic amount of potential renewable sources. The implementation of 100 percent renewable energy systems is challenging task with the next step to integrate RES into existing energy systems on the large scale.

4. OPTIMIZATION OF GLOBAL-LOCAL MONITORING AND IMPLEMENTING CLIMATE-WEATHER CONDITIONS FOR SOLAR ENERGY

The main objective of this section is to describe activity associated with high technologies of real-time monitoring of the Earth surface and solar energy conversion. Geographic Information Systems (GIS) are currently being used to analyze the potential for producing electricity from renewable energy sources. Making decisions based on meteorological-geographical data is basic to human thinking nowadays. A geographic information system is a technological tool for comprehending geography and making intelligent decisions. Faced with grim predictions of energy supply and consumption, humankind is responding with tremendous efforts to capture and cultivate renewable resources (GIS for Renewable Energy, 2010).

Solar energy systems are becoming more widespread, cheaper and more efficient each year. At the same time, it is not very evident and clear what kind of solar energy system is most suitable for the concrete geographical location and weather-climatic conditions, what output parameters and characteristics concrete solar energy system will perform in real situations.

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4.1. A Case Study: Global-Local Monitoring of Climate-Weather Conditions for Solar Energy

A concept of global-local monitoring of climate-weather conditions for solar energy was developed firstly in (Tyukhov, 2012). A data acquisition system has designed and implemented with facilities for monitoring meteorological data and solar radiation. The system, using photovoltaic monitoring equipment and hardware–software complex "Kosmos–3M", was developed for taking images of the Earth from National Oceanic and Atmospheric Administration (NOAA) satellites and for handling these images, analyzing many important geographical and meteorological parameters for forecasting of incoming solar radiation. With the help of the proposed monitoring system it is possible to study not only weather but also climatic aspects using solar energy in case of long-term collecting data at least during 10–30 years.

According to Renewables 2013 Global Status Report, renewable energy markets, industries and policy frameworks have evolved rapidly in recent years (Renewables 2013 Global Status Report, 2013). Solar photovoltaic (PV) stands out as having undergone one of the greatest technological developments. It offers the greatest potential for being competitive in the market (Trillo-Montero D., 2014, European Photovoltaic Industry Association (EPIA), 2013). PV market saw strong year, with total global operating capacity reaching the 100 GW in 2012. On the other hand the concentrating solar thermal power (CSP) market continued to advance in 2012, with total global capacity up more than 60% to about 2550 MW. The Middle East and North Africa region saw significant new developments in 2012 as the Egyptian Solar Plan, approved in July 2012, setting a target for 2800 MW of thermal CSP and 700 MW of solar PV by 2027 (Renewables 2013 Global Status Report, 2013). Europe is still the world leader in PV electricity generation, and for the second year running it has been the largest new source of installed generation (European Photovoltaic Industry Association (EPIA), 2013). In markets outside Europe, such as China, Japan or the USA, the percentage of installed power is still very small compared with their enormous potential. Moreover, there are large parts of Africa, Middle East, Southeast Asia or Latin America where this type of installations is only beginning now to be developed (Trillo-Montero D., 2014).

PV applications in developing countries have the potential to become a major force for social and economic development. Many isolated sites are not yet connected to the conventional electrical grid and face severe problems of water for domestic consumption and irrigation purposes (Benghanema M, 1999). Egypt and Russia are situated among the countries, which are better placed for the utilization of solar energy.

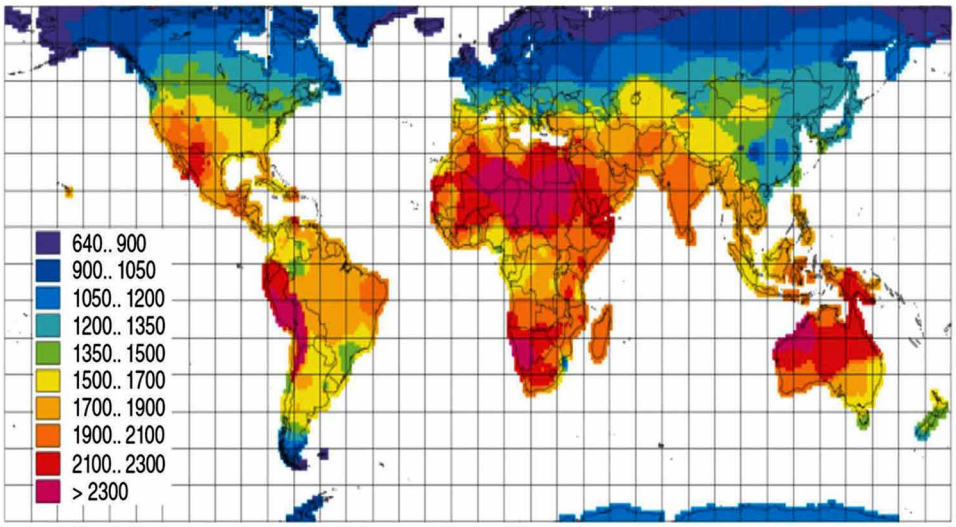
Egypt has a high solar radiation intensity—the annual global solar radiation of over 2000 kWh/m^2: areas appear in red or pink (see Figure 20, including Egypt) (Rezk, H, 2013, Dousoky, G.M., 2010). Moreover, Egypt has large areas of low-cost land. It has been estimated that Russia's gross potential for solar energy is 2.3 trillion tce. The regions with the best solar radiation potential are the North Caucasus, the Black Sea and the Caspian Sea areas, and southern parts of Siberia and the Far East. This potential is largely unused, although the possibilities for off-grid solar energy or hybrid applications in remote areas are huge (Strebkov D., 2000, Energy in Russia, 2013). Prediction of the solar radiation coming onto the earth's surface at the given geographical location, depending on the cloudiness, is particularly very important when large solar power plants are used as energy sources for power supply, giving a significant contribution to the power grid system based on conventional sources (Tyukhov, I, 2009, Tyukhov, I., Vignola. F., 2008). Knowing the arrival of solar radiation will allow for planning of system operators of grids. Many factors like cloudiness, atmospheric transmissivity, latitude and orientation of the Earth relative to the Sun, time of day, slope and the surface orientation determine the spatial and

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temporal distribution of the aspect of solar radiation on a surface. At the same time, the availability of solar radiation data from meteorological stations is more restricted, for example, than for precipitation and temperature. Solar resource assessment is a significant input for a wide range of different solar system applications. Solar radiation assessment is the most important for operational purposes of the big solar plants working in combination with the utilities. The aim of this paper was to design and develop a software application that enables users to perform an automated analysis of data from the monitoring of photovoltaic systems. This application integrates data from all devices which are already in operation such as environmental sensors and meters, and which record information on typical PV installations (Trillo-Montero D., 2014).

Solar radiation and other environmental parameters are needed in the design of solar systems; it is difficult to obtain these data for remote areas (Mukaro, R, 1999). Developing new technologies aimed at solving the world's energy and climate change challenges, and environmental problem demand young people with a good background in solar energy (Tyukhov, I, Schakhramanyan M, 2008). Satellite imagery is widely used to study and solve problems in many industries, including the assessment of natural resources of the Earth, mapping, forestry and agriculture, etc. Currently, analysis and collection of meteorological data mainly benefited from surface, upper-air, radar and satellite observations. Remote sensing by satellites allows quickly covering large areas of capturing Earth images, and provides acceptable accuracy and high visibility materials (Kasyanov, O.V., 2014). Analysis and short-term forecasting of atmospheric processes on successive series of satellite images of the clouds to identify the characteristic features of the evolution of cloud structures and the direction of their movement were considered in (Bespalov, D.P., 2011). Authors (Chubarova N.Y., 2008) measured the arrival of natural ultraviolet radiation under actual cloud conditions and the absence of clouds. Study of theoretical and experimental methods of forecasting and evaluation of solar radiation as a function of cloud resource space monitoring the earth's surface are also studied in (Hammer, A, 1999, Lorenz, E, 2012, Vignola, 2012).

Figure 20. Total global annual solar irradiance (Wh/m²)



**For a more accurate representation see the electronic version.*

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4.2. Components and Principle of Operation of Space Monitoring System

In the current manuscript, a computer-based data-acquisition system for monitoring both meteorological data and photovoltaic solar radiation is discussed. Data-acquisition system allows observing current incoming radiation and observing cloud motion using space technology; with this, one is able to predict cloudy or sunny sky and to make forecast for any solar application.

A block diagram of the proposed system is shown in Figure 21. The collected data are processed, displayed on the monitor and stored in the personal computer using the Lab-VIEW software and program APT Viewer 3.5. Lab-VIEW provides an easy-to-use graphical environment that permits the system operators to process easily the collected data, using complex data-processing algorithms, without detailed knowledge of the data acquisition system design like in (Koutroulis, E, 2003). The system shown in Figure 21 consists of solar photovoltaic module "FSM-25" installed on the roof of a University of Mechanical Engineering, Moscow (Umech), data acquisition device USB-6009 with output on a computer and software, developed in the graphical programming environment Lab-VIEW. The structure of devices and software for receiving and processing satellite images includes hardware-software complex "Kosmos-M3", which includes an antenna mounted on the roof of an Umech university, a receiver and program APT Viewer 3.5.

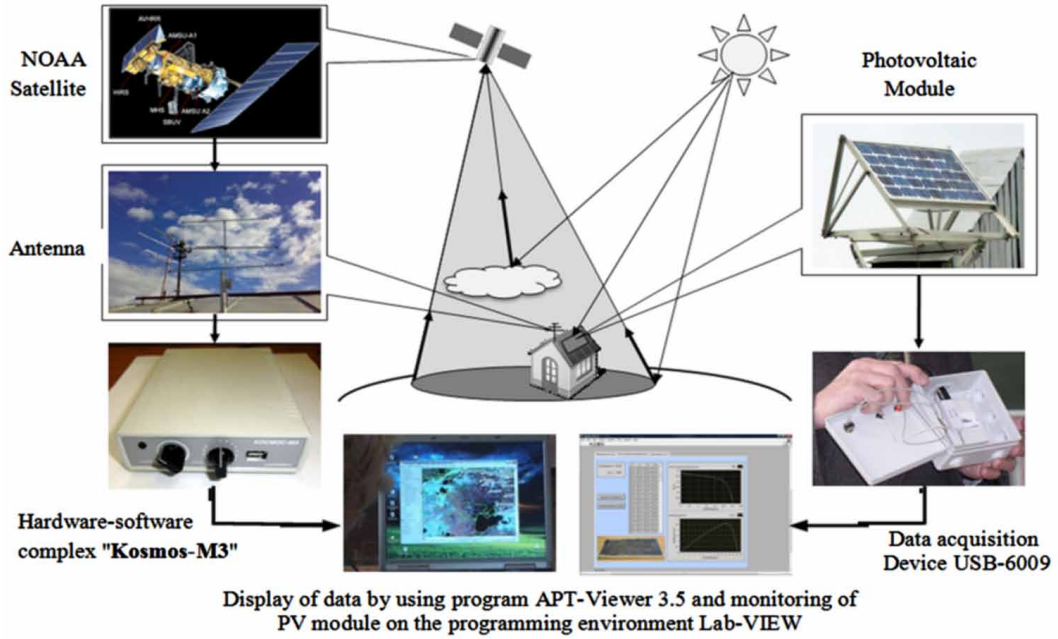
PV module FSM-25 is made of 35 multi-crystalline silicon solar cells in series and provides 26.7W of nominal maximum power at 1000W/m^2 and 25 °C (standard conditions). The installed PV module in the monitoring system is based on the silicone gel lamination technology. A new encapsulant developed at the All Russian Research Institute for Electrification of Agriculture (VIESH) was used in an attempt to increase the service life time of the module. The main factor determining the operational life of PV modules is the encapsulation material (encapsulant). Encapsulant is a protective material completely enveloping and isolating the photovoltaic cells from moisture, heat and mechanical damage and providing good optical contact between the surface of the PV cells and the protective outer coating. Silicone gel encapsulant allows better stress relaxation during thermal cycling of PV panels, compared to traditional solid EVA encapsulant. Silicone gel laminated PV panel with power reduction about 15% over 50 years service life is possible because of strongly reduced corrosiveness of solar cells in modules by silicone gel. Corrosiveness of solar cells is the main source of failures in EVA laminated PV panel (Poulek, V., 2012).

Typically, fixed (nonadjustable) PV arrays should be tilted toward south by an angle equal to the latitude of the array's location to capture the most year round solar energy. If the PV array is mounted with a tilt angle equal to the site latitude, it is perpendicular to the sun twice a year (on each equinox date) and very close to perpendicular for the weeks before and after the equinox; this makes the array perpendicular to the sun's position in the sky for the greatest number of hours throughout the year (Goswami, D.Y., 2000).

A satellite receiver and software were elaborated for demonstrating how GIS systems can be used, particularly for solar engineering projects. Complex consists of satellite antenna mounted at the roof of Umech, receiver of satellite signal and software of processing aerospace images of the Earth (Figure 21, left part). Software of the receiving complex "Kosmos–M3" is able to determine the temperature of underlying surface at any point of the image obtained; to measure distance from one point to another with regards the Earth's geometry; to determine surface area; selection of map layer and so on, to have real time images within interval 2–4-h interval. With the help of this complex it is possible to study the climatic aspects of solar energy if to collect data at least during 10–30 years.

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Figure 21. Schematic diagram of the hardware proposed data acquisition system



In general A hardware/software complex, Kosmos–M3 is designed under the supervision of Prof. M. Schakhramanyan for receiving Earth images transmitted from the National Oceanic and Atmospheric Administration (NOAA) series polar orbiting satellites (NOAA-12, NOAA-14, NOAA-15 and NOAA-17), and the Meteor satellites, in Automatic Picture Transmission (APT) format at a frequency of 137MHz (Tyukhov, I., Vignola. F., 2008). Kosmos–M3 is a portable, relatively inexpensive tool. It was designed to receive and process images of Earth sent by satellites in real time. These systems are quite useful for introducing certain modern technologies. Images can be received without payment of a fee, helping to minimize the expense involved in research cost in this subject matter. Basic capabilities of the multifaceted "Kosmos–3M" system include: receiving signal from NOAA satellites; digital processing of space images with geographical fixing, superposition of maps of cities and coordinate grid; finding of geographical coordinates at any point of space image; finding of temperature of underlying surface at given points; finding of albedo (reflection coefficient) at any point of space image; finding of upper boundary of clouds (cloudiness); forecasting of dangerous weather phenomena; defining wind fields in cyclones; precipitations forecast; measuring distances between given points; measuring surfaces (areas) and forming of electronic library of images of the Earth. Work is underway to use the "Kosmos–3M" cloudiness images to estimate the incident solar radiation values for evaluating terrestrial solar energy performance in real time. Such kind of system would have a wide variety of uses from the classroom to the field (Tyukhov, I, Schakhramanyan, M, Strebkov, D, 2009).

Solar radiation is scattered and absorbed by Earth's atmosphere and is reflected from the Earth's surface and clouds. Reflected light carries information about the properties of the underlying surface area and, particularly, about underlying clouds. This radiation is collected by the satellite receiver system and is transformed into an electrical signal and transmitted to an antenna for further processing (Figure 21 left part). Swath width is about 3000 km, and the spatial resolution of the image 4 km. There are

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tradeoffs related to data volume and spatial resolution. Our working experience showed that the swath width is quite big to see the whole picture (all cloudy and non-cloudy areas in a region) and quite small spatial resolution to see how clouds move on a specific place with enough accuracy. The higher resolution will complicate saving and analyze big numerical data for climatic investigations during long time of collecting information. Images of good quality with a single satellite can be captured 3–4 times a day. During receiving the image, the trajectory of the satellite in the web portal can be watched as shown in Figure 22 (Real time satellite tracking and prediction, 2012).

Table 4 shows an example of more detailed parameters on the image pixel by pixel. Thus, this system allows for local monitoring of incoming solar radiation and global monitoring of climatic conditions in real time. APT Viewer 3.5 program allows to monitor meteorological phenomena such as the appearance or disappearance of cyclones and anticyclones, wind speed and direction, temperature change of the land and water surfaces, temperature and height of cloud top forecast rainfall, cloud species, etc. as shown in Figure 23 (Shakhramanyan, M.A., 2009).

4.3. Monitoring Weather-Climatic Conditions and Data Processing

Solar radiation was monitored in real time, by measuring electrical energy generated by the photovoltaic solar module. Then this information compares with information received from satellites.

Predicting the incident solar radiation on the earth's surface in cloudy conditions is particularly important when large solar power plants are used as sources for power generating in order to allow for planning of power energy system operation.

PV module short-circuit current is the current when the voltage across the PV module is zero (i.e. when PV module is short circuited). This current is due to the generation and collection of light-generated carriers. For an ideal PV module at most moderate resistive loss mechanisms, the short-circuit current and the photocurrent are identical. Therefore, the short-circuit current is the largest current which may be drawn from the PV module. At normal levels of solar radiation, the short-circuit current can be considered equivalent to photocurrent, i.e. proportional to the solar radiation G (W/m^2). But this may result in some deviation from the experimental result, so a power law having exponent α to account for the non-linear affect that the photocurrent depends on. PV module short-circuit current is not strongly temperature dependent. It tends to increase slightly with the increase of the module temperature.

For the purposes of PV module performance, modeling this variation can be considered negligible. Then, the short-circuit current can be simply calculated by (Zhou, W., 2007):

$$I_{sc} = I_{sc0}\left(\frac{G}{G_0}\right)^{\alpha} \tag{30}$$

where I_{sc0} is the short-circuit current of the PV module under the standard solar radiation G_0; while I_{sc} is the short-circuit current of the PV module under the solar irradiance G; α is the exponent responsible for all the non-linear effects that the photocurrent depends on.

From (1) it can be concluded that the solar radiation can be estimated by the following equation;

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Figure 22. Satellite trajectory observation



$$G = G_0 \left(\frac{I_{sc}}{I_{sc0}} \right)^{\frac{1}{\alpha}} \tag{31}$$

The proposed monitoring system allows us to measure PV short circuit current and solar radiation. The data are transmitted and stored in a computer through data acquisition device USB-6009. The monitoring variables are processed and displayed in the computer screen using virtual instruments developed with Lab-VIEW in the real-time interface system (Forero, N, 2006). Figure 23 shows a computer interface used to display monitoring data of short circuit current and solar radiation. A print screen for monitored solar radiation is shown in Figure 24.

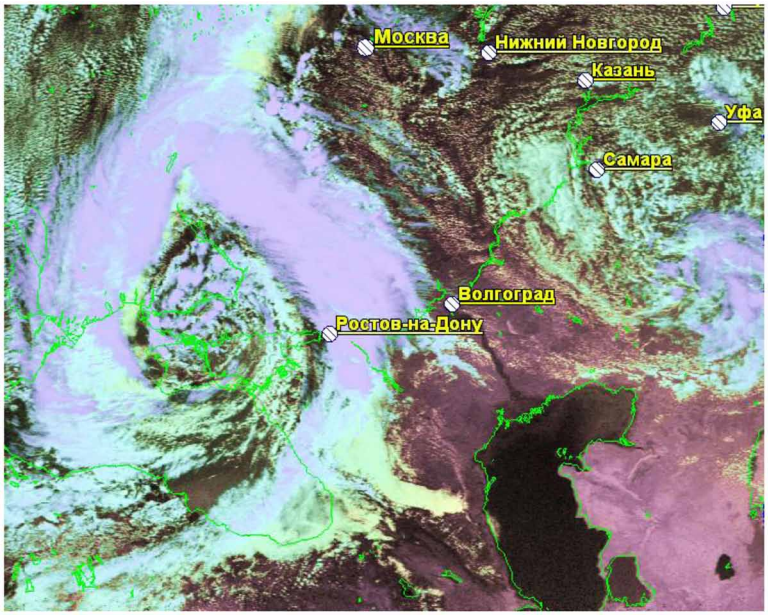
Simultaneously, the space image receiver allows to record information from satellite about weather conditions on the earth surface. Program APT Viewer allows monitoring the actual state of the weather situation, including the state of the atmosphere, the presence or absence of clouds on radio brightness parameters laid down in the program and settlement functions. In addition, it can be used “Cloud Atlas” to study the more properties of cloud cover (Bespalov, D.P., 2011).

4.3.1. Study the Effect of Clouds on Incident Solar Radiation

The recorded solar radiation from monitoring system can be compared to the pixel value of satellite image. This can provide ground true data for testing solar radiation derived from the satellite data (Tyukhov, I, Schakhramanyan, M, Strebkov, D, 2009). Figure 25 shows incident solar radiation and NOAA 15 satellite image taken at 16:46 in clear weather.

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Table 4. The pixels of different underlying surfaces in the picture and their parameters

The image from the satellite NOAA 18						
Pixels from image Meteo parameters						
Underlying surface	Cloud			Water	Earth	
AVHRR-2	16,13%	42,33%	9,93%	0,63%	0,63%	8,50%
AVHRR-4	– 51,14°C	– 20,28°C	– 1,74°C	8,38°C	26,85°C	16,09°C
Cloud top height	10 km	4 km	1 km	–	–	–
Precipitation 90’	9 mm	1 mm	–	–	–	–
The size of hail (clouds)	4 mm	–	–	–	–	–
The size of hail (land)	–	–	–	–	–	–

Notes: AVHRR-2 (Advanced Very High Resolution Radiometer): for surface albedo the 2nd spectral channel is used; AVHRR-4 —for surface temperature the 4th spectral channel is used; “precipitation 90” is an indicator of the average total amount of convective precipitation that may fall out in 90 min.

The measurements carried out in one of the sunny days. Due to the fact that in the absence of clouds demonstrable change between multiple images is not significant, there is shown only one satellite image recorded on the afternoon of the same day. From the shown figure it can be clearly seen that, solar radiation curve varies smoothly, reaching its peak at noon. On the other hand it can be seen some fluctuations on the curve, and these fluctuations are caused by various factors: the absorption and the scattering of dust, dry air molecules, a selective absorption of water vapor, carbon dioxide, etc.

Figure 26 shows the experimental measurement of solar radiation at cloudy weather. From the showed figure it can be seen that the values of incident solar radiation decrease with the time. There are also three satellite images at different intervals in time. First half of the day due to the variability of thickness of cloud layers there are sudden changes in availability of solar radiation; it changes from 278

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Figure 23. Computer interface to display the PV module short circuit current and solar radiation

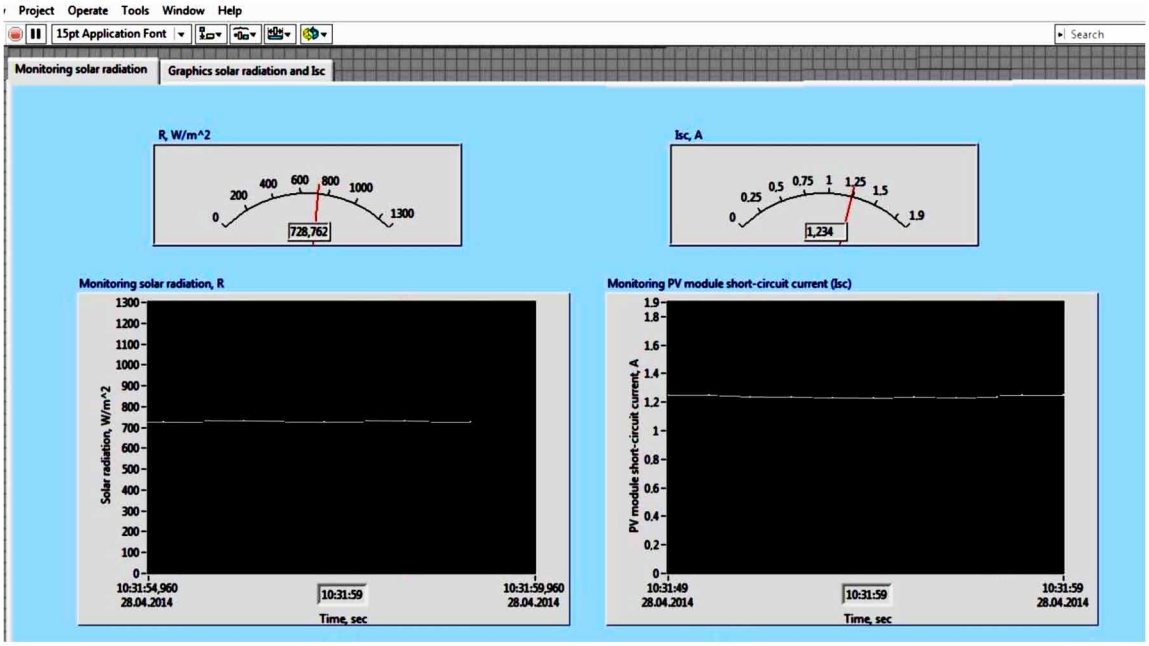
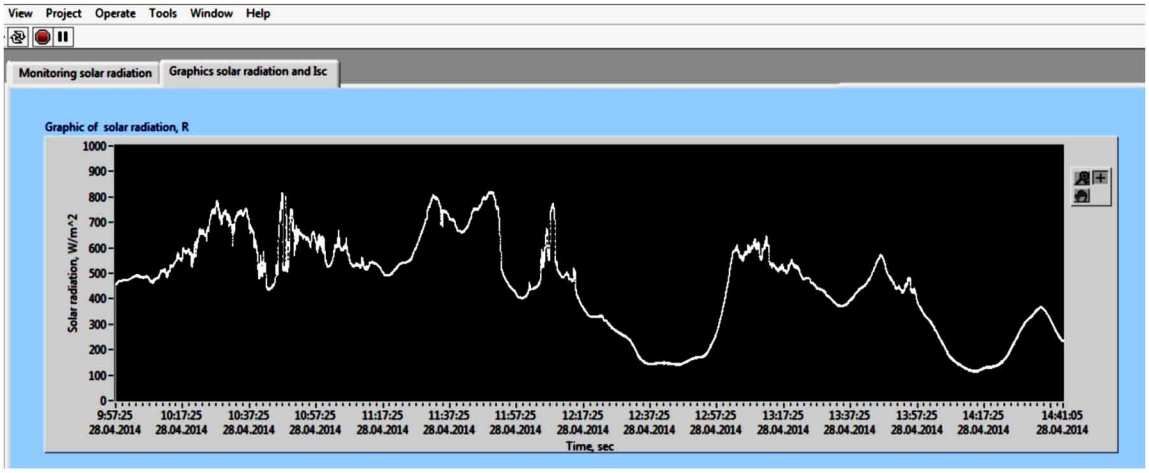


Figure 24. Monitoring solar radiation in specific day



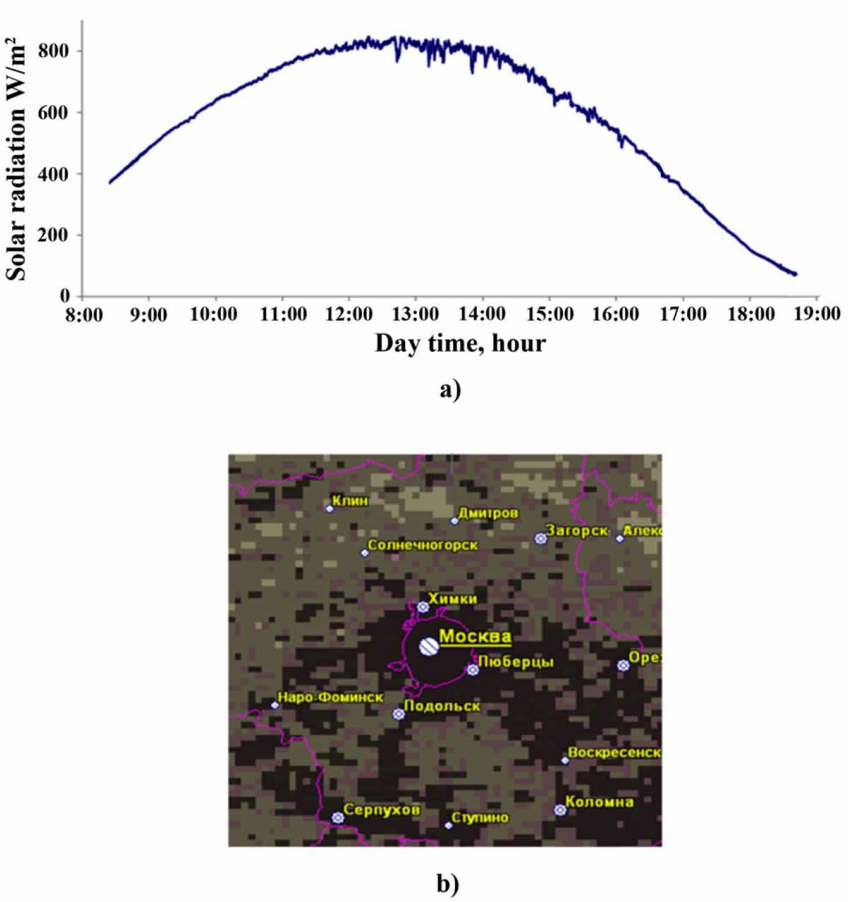
to 784W/m^2. Furthermore due to the appearance of dense layers of cloud, the solar radiation decreased and changed from 114 to 84 W/m^2.

4.3.2. Observing and Forecasting the Movement of Clouds

Predicting the incident solar radiation on the earth's surface in cloudy conditions is particularly important when large solar power plants are used as sources for power in order to allow for planning of system

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Figure 25. a) Incident solar radiation and b) NOAA 15 satellite image taken at 16:46 in clear weather in Moscow



operation. Considering Figure 26b it can be seen that, there is a clear cloudless weather until 13:00 at afternoon and then the weather changes to cloudy skies, which clearly illustrate the solar radiation curve advent of periodic dips. The process of cloud formations in the current site and the gradual movement of other clouds from different sides are shown in the following figure.

Figure 27 shows that four satellites images were taken during one specific day from two meteorological satellites at different time intervals and elevation angles of the satellites relative to the horizon.

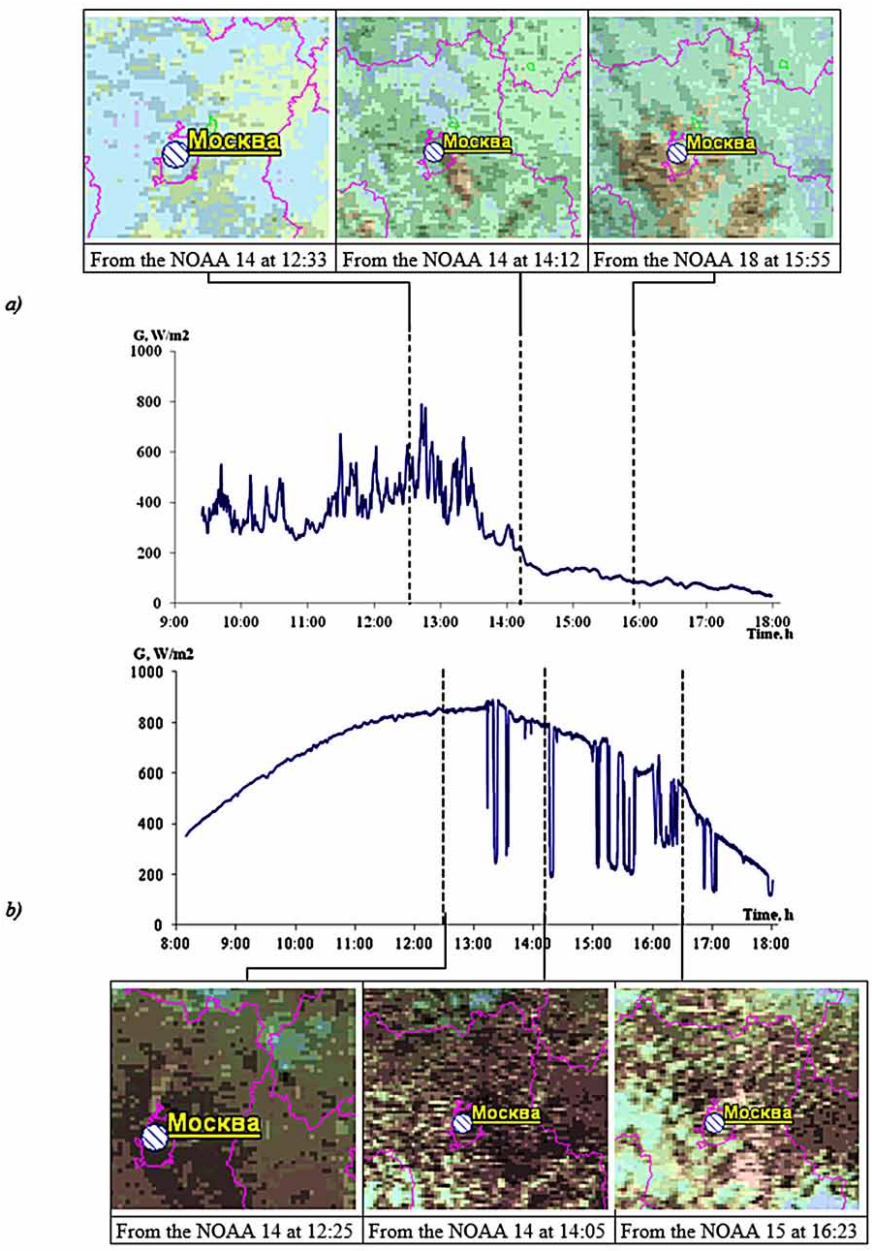
The results of measurement are shown in Table 5. Considering Figure 27 it can be seen the movement of the clouds, also directed towards the movement of wind, as forecast.

4.3.3. Three-Dimensional Modeling and Visualization of Clouds

Constructing a three-dimensional model of clouds and modeling of incident direct solar radiation in three-dimensional modeling software package allows to analyze not only the actual state, but also to obtain predictive information about cloud cover impact on solar power plants. The prediction and study of cloud cover impact on the incident direct solar radiation are particularly needed for concentrated

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Figure 26. Measured solar radiation and satellite images, taken in: a) clear cloudy overcast and b) variable cloudy weather in Moscow



solar power plants. Satellite images of the earth surface give a visual picture about the state of the cloud in the region under study. However, in case of partial cloud, using only satellite images is not able to determine the cloud cover impact on the incident direct solar radiation on specifically selected area or point on the earth's surface. This is due to the fact that the cloud shading may vary depending on the area, height and thickness of clouds, the location and angle of the sun above the horizon. For further information about cloud shadow modeling the incident solar radiation is needed, taking into account

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Figure 27. Monitoring of the movement of clouds on satellite imagery: 1—the image from the satellite NOAA 14, elevation angle of the satellite 30°; 2—the image from the satellite NOAA 18 elevation angle 25°; 3—the image from the satellite NOAA 14 elevation angle 57°; and 4—the image from the satellite NOAA 18 elevation angle 80

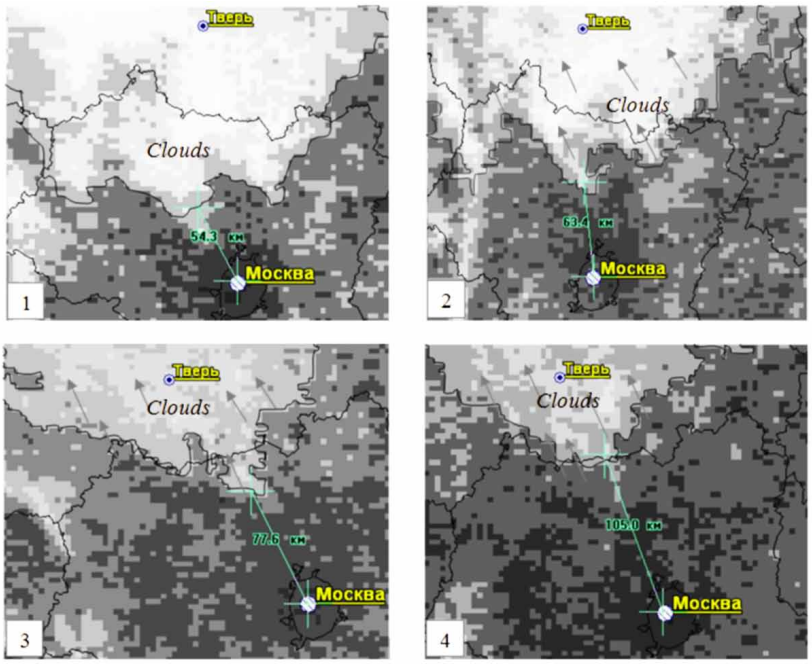


Table 5. The experimental results of clouds movements by proposed monitoring system

Nº Image	The Time of Receiving	Distance from Moscow to the Nearest Edge of the Clouds, km	Change in the Distance, km	Speed, m/s	Average Speed, m/s
1	11:50	54.3	-	-	6.25
2	12:25	63.4	9.1	4.3	
3	13:30	77.6	14.2	3.6	
4	14:05	105	27.4	13.1	

the velocity of cloud movement. Using three-dimensional (3D) modeling with aid Google Sketch Up program is considered the best way for simulating sunlight. Figure 28 shows the transformation steps of the satellite image into three-dimensional model. The height of the cloud layers and the temperature of the underlying surface are shown in Figure 28.

After receiving the necessary data on the size and exact location on the cloud space image, a three dimensional model is developed over the map. After that, by enabling the “Shadows” date and time are configured to accurately simulate the arrival of direct solar radiation and shadow clouds are considered in exactly the specified time. Figure 29 shows the result of converting a satellite image from the cloud space image into a three-dimensional model.

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Figure 28. The transformation steps of the satellite image into 3D model by using the Google Sketch Up program (satellite image taken in May 16, 2013 at 16:14)

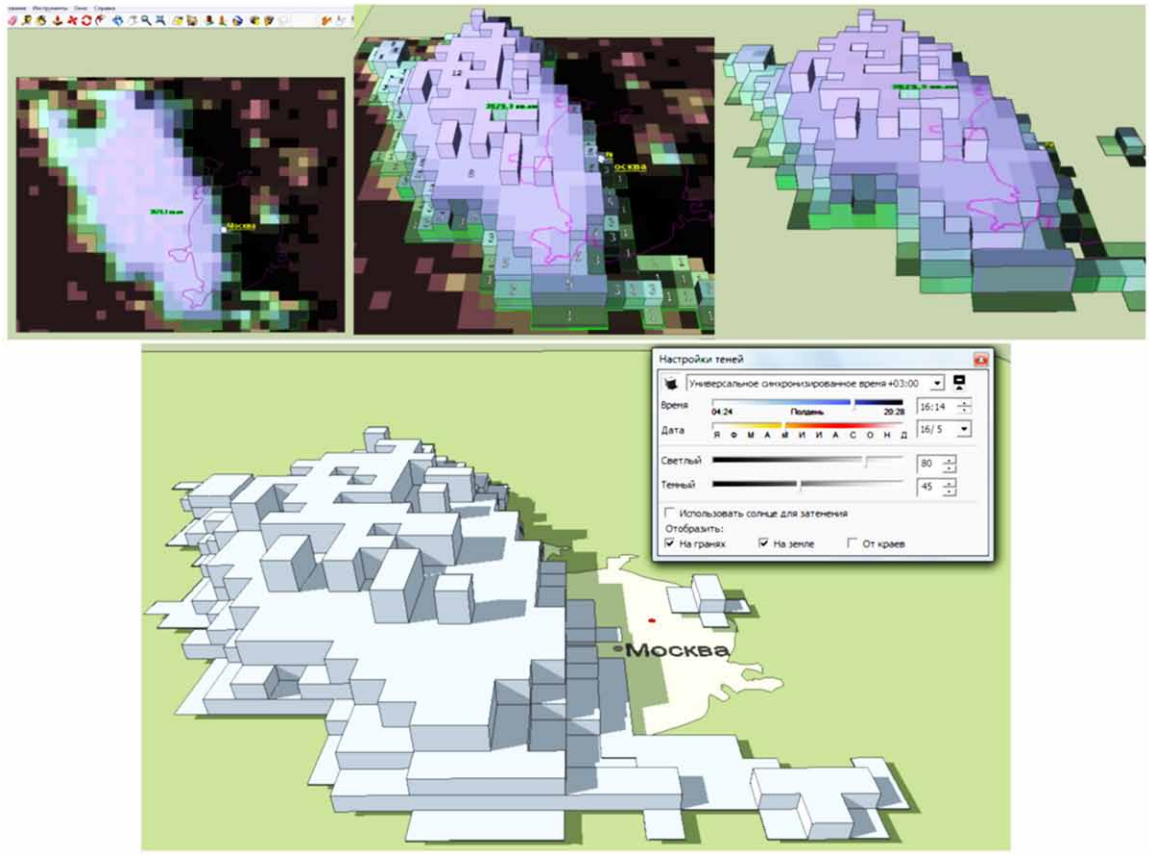
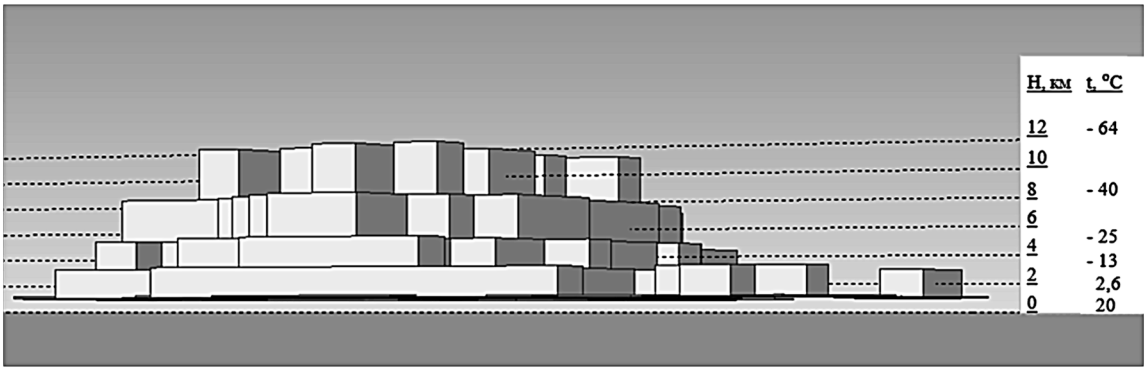


Figure 29. The height of the cloud layers and the temperature of the underlying surface: H—height above the Earth's surface; t—temperature



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4.4. Summary

An efficient solar monitoring system of meteorological data, photovoltaic solar radiation which enable forecasting sunny and cloudy hours, has been designed and implemented. The new type of PV modules with improved service life time was used because of reduced corrosiveness by using silicone gel laminated. This type of modules is a good candidate for long-term collecting data. By using simple Google Sketch Up program, a three-dimensional model of clouds has been constructed. Also, the height of the cloud layers and the temperature of the underlying surface have been determined for accurate forecasting of sunny or cloudy weather. The described technology and approach is useful not only for research but also for educational purposes because non-expensive components are involved. With the help of the proposed monitoring system, it is possible to study the climatic aspects of solar energy after long-term collecting data for many years. In future PV systems will be aggregating with other renewable systems and GIS systems designed for optimal collecting and distributing electrical power nets according the consumer demand.

CONCLUSION

The history of human civilization should be considered as the progressive development of new energy sources, their associated conversion technologies and info-communicative infrastructure. Solar energy is the best among the most infinitely available clean sources and photovoltaic conversion is the most appropriate direct conversion solar radiation into electricity.

Great progress in the development of solar cells design and technology allows creating practical PV systems. Optimization of PV systems was analyzed from the point of view of maximum power point tracking technologies (MPPT). The comprehensive comparison of different MPPT techniques for photovoltaic systems was carried out.

The optimization of renewable energy systems demands of combination of energy sources, accumulation and consumption. The case study of elaborated technique and software package allows any user to determine the optimal parameters of the combined systems of autonomous power supply using only renewable energy sources such as solar, wind and water. It was shown that fluctuating and intermittent renewable energy production can be coordinated with the combination of RES, and also the size of the energy demand can be adjusted to the realistic amount of potential renewable sources.

Renewable energy systems using information from GIS systems demands optimization of energy systems taking into account all renewable energy currents at real time regime. The case study of solar monitoring system of meteorological data, photovoltaic solar radiation which enable forecasting sunny and cloudy hours, has been designed and implemented.

It is extraordinary difficulty and exceptional nature of the coming energy transition—but, given the enormous challenges of ushering in a post-fossil world, it may also be because of the possibility of an unprecedented and persistent commitment to a rapid change (Smil, V., 2010).

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A general approaching to the challenging task of the implementation of 100 percent renewable energy systems with the next step to integrate RES into existing and future smart energy systems on the large scale were described. A modern concept of smart grid includes a variety of operational and energy measures and systems including smart meters, smart appliances, renewable energy resources, and energy efficiency resources. Electronic power conditioning and control of the production, distribution and consumption infrastructure are important aspects of the smart grid.

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Chapter 73
The Application of Crowdfunding to the Energy Sector

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ABSTRACT

Crowdfunding in energy begins as a response to reduced investments (both governmental and private) into the transition to decarbonized energy systems and to the spread of innovative business models and approaches conductive of greater participation of citizens and communities in distributed renewable energy projects. This chapter presents results of a worldwide overview of the use of crowdfunding in the energy industry. Evidence gathered from available energy crowdfunding platforms highlight a very new, but quite dynamic sector. The crowdfunding tool has been applied in most of its forms, ranging from peer-to-business lending to pure donation, with strong environmental and social mission and the explicit aim of increasing participation of citizens in sustainable energy investment. Evidence also shows that, despite maintaining their environmental and clean energy focus, some energy platforms have begun to move from niche, grass root initiatives into larger projects and collaboration with energy private sector and institutional finance.

INTRODUCTION

This chapter provides an overview and analysis of the development of crowdfunding within the energy industry. It looks into the trends and dynamics of this emerging sector and presents results of a worldwide review of energy crowdfunding platforms. It aims at providing a better understanding of the application of this innovative financing tool to the energy industry and of its performance to date. It intends to provide a reference analysis to policy makers, regulators as well as finance, industry and general public stakeholders about the state of the art of this emerging sector.

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ENABLING FACTORS

One of the drivers behind the growth and spread of crowdfunding worldwide has been the reduced access to capital to citizens and firms for new investments due to the financial crisis and restricted access to credit since the second half of the 2000s. Indeed, crowdfunding platforms have begun to spread around the world in 2008, along with other emerging alternative finance instruments outside the traditional banking sector, including mini bonds, social impact bonds, microcredit, impact investing. A similar trend has affected the energy sector, with the financial crisis impacting on investments in energy projects and infrastructures. In particular, both governmental and private investments in sustainable transition have been decreasing (Geels, 2013), despite the growing need for financial resources to support clean energy projects in response to climate change reduction policies and strategies. Thus, as in other sectors, crowdfunding in energy could be seen as an answer to the need to mobilize financial resources, and support the transition toward cleaner energy systems.

Another important enabling driver to the use of crowdfunding in the energy industry is the strong transformation undergoing in the sector since the late 90s. The restructuring and liberalisation of the industry has allowed the entry of new stakeholders in the energy markets. Contextually, climate change mitigation strategies and the need to decarbonize energy systems by increasing the proportion of renewable distributed generation and reducing energy use through the implementation of energy efficiency measures has set the basis for a shift in the energy system paradigm, from a centralized "top-down" system to decentralized generation, a "bottom-up" system. An immediate difference between the two paradigms is the role of the energy end user, who in a decentralized generation system could become both investor and generator. The modularity of renewable energy projects has allowed smaller size investments (than centralized generation plants) and the entrance in the energy market of new generators and investors (including citizens, local authorities, small firms) previously set outside of the industry mainly dominated by large energy companies (Kempener et al., 2015). This trend has been particularly evident for small/medium scale renewables and energy efficiency measures which have generally higher transaction costs (and comparatively low equity return rates) which makes them less appealing for large companies. In addition, large companies often lack for experience with small scale projects and can have split incentives: decentralized generation and energy efficiency can have a negative competitive impact on their core business. These changing scenarios have thus left space for the entrance of new and smaller players in the energy industry.

The transition to clean energy systems is challenging the role of old generators and utilities' business models. In Europe the share of renewables with dispatch priority in electricity markets in increasing which, in conjunction with post crisis reduction in electricity demand and fossil fuel generation overcapacity, has led to a reduction in wholesale prices and in the profitability of utility owned conventional power plants. Utilities are losing money on their electricity generation core business and gradually reducing their role of investors in energy systems.

Such transformation of the energy industry is also seen in the financial market. Utilities and large energy companies were traditionally seen as low risk investments by institutional finance (large investors, pension funds) as they operated in a regulated and stable market. However, the changing paradigm in the energy sector has seen the entrance of new players in the energy finance market and the development of new financing instruments, such as green bonds issued by development banks, corporate investors and municipalities or yieldcos (publically traded companies formed to own power plants and pass revenues to investors as dividends) (Frankfurt School-UNEP & BNEF, 2015). Utilities weight in the finance mar-

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ket decreasing, top 20 energy utilities were worth in 20013 less than half of 2008 value (of around €1 trillion) and have been the worst-performing sector in the Morgan Stanley index of global share prices (Gray et al., 2015; The Economist, 2013).

Nonetheless, much of the transition to decarbonized energy systems has been led by major investors and large companies, but smaller players as well as citizens and local communities are increasingly playing an active role in delivering clean energy investments. Decentralised energy is now part of governments' and societies' 'localism' agenda, as citizens, communities, firms, local authorities and other public sector organizations can become energy producers and not only 'passive' users of a service delivered. As such, they could fully harness benefits and incomes originating from energy investments implemented in their premises and territory. Indeed, the last decade has seen the increasing development of community energy and shared ownership approaches for investments in the energy sector worldwide (ILO, 2013, van der Schoor and Scholtens, 2015, Yildiz, 2014). These approaches are new business models and structures conductive of greater participation of citizens and communities in energy projects, as such are a form of democratization of energy investments and policy. However, it has been pointed out how such community led scheme are often under-resourced (Seyfang et al., 2014) and lacking of sufficient access to finance to scale up activities (Phimister & Roberts, 2012). Crowdfunding, which aggregate financial resources, people and potential investors on specific energy projects have the potential to expand the applicability and the scope of such type of approaches. It can guarantee additional source of funding, where conventional financing channels do not always deliver, through participatory approaches and enabling the possibility of reaching a higher number of potential investors thanks to the communication power of internet and social networks.

Through crowdfunding platforms, a company, a local authority or a community developing a renewable generation plant or an energy efficiency measure can not only raise capital but also involve citizens and other stakeholders in the investment, allowing them to invest, become shareholders and benefit from the return on the investment itself (according to the type of crowdfunding model adopted - see Section 2.2). Crowdfunding platforms allow people to invest even small amount of money on energy projects and proponents of projects to get access to a large audience of potential investors. It thus provides the possibility to those interested in investing in clean energy, but without suitable conditions (e.g. lack of sufficient capital or of a suitable area to develop the project) to directly contribute to CO_2 emissions reduction and benefit from the returns on the investment. In some cases, also thanks to its communication and public engagement potential, could help in gathering financial resources to support investments less suited for traditional project financing (such as smaller size investments or projects aiming at delivering long-term solutions such as regeneration, social housing or generation in remote areas).

Indeed, crowdfunding is an interesting financing tool for the energy sector and there exist several active platforms worldwide 'vertically' focused on the sector, which are already proving to be a powerful method to raise capital in particular for renewable energy projects.

A WORLDWIDE REVIEW OF THE SECTOR

This section presents results of a worldwide overview and analysis of crowdfunding development within the energy industry to date and of the initial results and trends coming out of this new and dynamic sector.

Energy crowdfunding platforms have been searched for and selected through analysis of online grey literature (McCann, 2013; Renewable Energy Crowdunding Conference, 2014; Solarplaza, 2014a, 2015,

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2014b) and systematic web browsing running Boolean keyword searches for the terms 'energy', 'renewables', 'crowdfunding', 'community shares, 'equity', 'solar', 'wind', 'biomass', 'energy efficiency', 'shared ownership' . The platforms identified and included in the review have at least one project focused on energy and, if not active yet, express clear focus on the energy sector in their mission.

Such systematic review has allowed identifying forty two energy related platforms worldwide. Through close reading of all published projects on each active platform (i.e. the published material on each project web page) a data base of 389 energy crowdfunding campaigns has been created, accounting for several variables including: project name; location; technology type; opening and closing date of the offer; target and amount of money raised; type of investment offered; returns guaranteed. Data have been gathered up to October 2015.

A New, but Dynamic Sector

The application of crowdfunding to the energy sector has been relatively recent, within the short lifetime of the crowdfunding sector itself which appeared as a wide phenomenon around 2008 when platforms such as Indigogo or Kickstarter (IndieGoGo, n.d.; Kickstarter, n.d.) have been launched. Table 1 lists the forty-two platforms searched for and identified worldwide. Apart from the pioneering experience of the German platform GreenVesting in the 2009, the first relevant platforms and campaigns have begun to appear in 2012 (the non-energy specific platforms such as Milaap and Microgenius despite being launched in 2010 and 2011 have both been publishing energy related projects only in 2015). Since then the number of initiatives and platforms have been increasing overtime. By July 2015 twenty-nine energy crowdfunding platforms were active with projects online and thirteen new platforms were in the pipeline.

Table 1. Platforms overview: country, launch date, and technology focus

Platform	Country	Launch	Platform Focus	Technology Focus
GreenVesting	Germany	2009	Renewables	Solar
Milaap	India	2010	General	Solar
Microgenius	United Kingdom	2011	General	Mix
Lumo	France	2012	Renewables	Mix
Crowdener.gy	Germany	2012	Renewables	Solar
WindCentrale	Netherlands	2012	Renewables	Wind
Greencrowd	Netherlands	2012	Renewables	Mix
Abundance Generation	United Kindom	2012	Renewables	Mix
SunFunder	USA/Tanzania	2012	Renewables	Solar
Bettervest	Germany	2013	Renewables and energy efficiency	Mix (Mostly Energy Efficiency)
Econeers	Germany	2013	Renewables	Mix
GreenXmoney	Germany	2013	Renewables	Mix
We share Solar	Netherlands	2013	Renewables	Solar
Gen Community	United Kingdom	2013	Renewables	Mix

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Table 1. Continued

Platform	Country	Launch	Platform Focus	Technology Focus
Trillion Fund	United Kingdom	2013	Renewables	Mix
Collective Sun	USA	2013	Renewables	Solar
Divvy	USA	2013	Renewables	Mix
Mosaic	USA	2013	Renewables	Solar
Village Power	USA	2013	Renewables	Mix
Enerfip	France	2014	Renewables	Mix
Lendosphere	France	2014	Renewables	Mix
LeihDeinerUmweltGeld	Germany	2014	Renewables	Mix
Duurzaaminvesteren	Netherlands	2014	Renewables	Mix
Veolis	Switzerland	2014	General	Mix
Solar Schools	United Kingdom	2014	Renewables	Solar
Clean Reach	USA	2014	Renewables	Ocean Energy
Re-Volv	USA	2014	Renewables	Solar
Coopernico	Portugal	2015	Renewables	Mix
GridShare	USA	2015	Renewables	Mix
Citizenergy	Europe	Non active	Renewables	Mix
Joukon Voima	Finland	Non active	Renewables	Mix
Crowd2win	France	Non active	Renewables	Mix
Benoolend	France	Non active	Renewables	Solar for rural electrification
Babyloan/Total	France	Non active	General	Rural electrification
GreenCrowding	Germany	Non active	Renewables	Mix
Ecomill	Italy	Non active	Renewables	Mix
Fundera	Italy	Non active	Renewables	Mix
Trine	Sweden	Non active	Renewables	Solar for rural electrification
Crowdgeneration	United Kingdom	Non active	Renewables	All
EnergyDonwell	United Kingdom	Non active	Renewables	Mix
Palmetto Direct	United Kingdom	Non active	Renewables	Mix
CrowdEnergy	USA	Non active	Renewables	Ocean Energy

Note: 'Launch' is the online launch date of the first energy project on the platform, despite several platforms have been reported to be conceived couple of years before the date of launch of the first campaign. Unique exceptions in the list are Milaap and Microgenius General platforms: platform launch date is reported, but their first energy related campaigns have been launched in 2015.

Europe, in particular Germany, United Kingdom and the Netherlands have been the initiators of the sector in 2012, with USA following in 2013 and currently hosting the highest number of energy related platforms (Table 2).

Crowdfunding in the energy sector is currently associated with and serves only clean energy investments, with most of the platforms specifically focused on renewable energy (the few non-thematic platforms listed in Table 1 have also published renewable energy projects). Platforms generally offer investments

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Table 2. Number of platforms per country

	USA	Germany	United Kingdom	Netherlands	France	Switzerland	Portugal	Italy	Finland	Sweden	India
Active platforms	8	6	5	4	3	1	1	-	-	-	1
Forthcoming platforms	1	1	3	-	3	-	-	2	1	1	-

in renewables energy projects from a mix of technologies, including solar photovoltaics, wind, biomass, hydropower and, in some cases, in energy technologies startups or energy related technological research and development projects. Investments in energy efficiency projects are much less common, apart from one German platform, Bettervest, which is almost totally concentrated on them. Some platforms are instead focused on a specific renewable technology, usually structuring their project scouting and communication strategy explicitly targeted on the renewable technology chosen. Clear examples are We Share Solar or Windcentrale in the Netherland, Mosaic and Sun Funder in the USA or Solar Schools in the United Kingdom whose respective descriptive slogans are as follows:

- "The Windcentrale enables households to produce their own sustainable energy with their own wind turbine" (Reitsma, 2014);
- "We are a crowdfunding platform for collective solar-energy initiatives", We Share Solar website (WeShareSolar, n.d.);
- "Turn sunshine into savings" or "The simplest home solar loans", Mosaic website (Mosaic, n.d.);
- "Financing solar beyond the grid", Sunfunder website (SunFunder, n.d.);
- "Powered by sunshine, funded by everyone", Solar Schools website (Solar Schools, n.d.).

How Are Different Crowdfunding Models Applied?

The landscape of renewable energy platforms is still fragmented, the concept of crowdfunding in energy is not a commonplace and platforms differ among themselves in particular in terms of the crowdfunding model chosen.

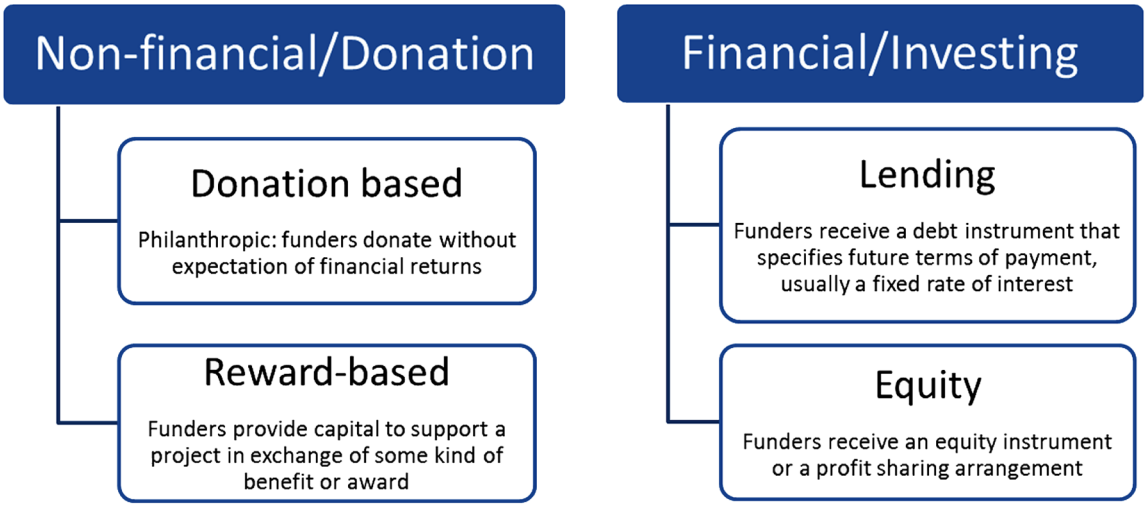
There exists several types of crowdfunding models and several classifications have been produced by previous contributions (EU Commission, 2014; Massolution, 2015; Pais et al., 2014; World Bank, 2013). For the purpose of this review and analysis crowdfunding platforms are grouped in two overarching categories (Figure 1), which differentiate themselves on the basis of the relationship between those who provide financial resources and those that receive the funds (i.e. recipients):

1. Non-financial or donation crowdfunding, where individuals' contributions are not associated with a financial return and;
2. Financial or investing crowdfunding, where financial instruments are sold in relation to companies assets and/or financial performance.

Non-financial crowdfunding can be pure calls for *donations* which are given without expectation of any financial returns or benefit, thus relying on altruistic motives. Typical donation campaigns are

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Figure 1. Overview of major crowdfunding models
Source: Author's elaboration.
Note: Other, less common models are recently gaining traction: 1. Hybrid models, platforms offering one or more crowdfunding models on a single platform; 2. Royalty-based model, where investors receive a royalty interest derived from intellectual property of the fundraising company.



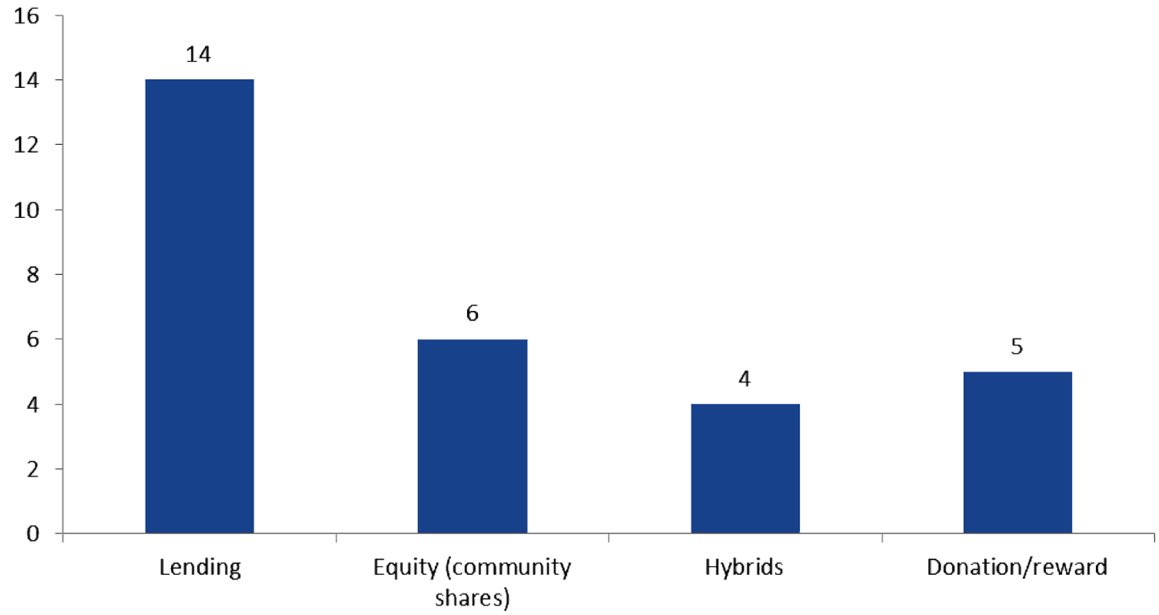
run for charitable or public interest causes. Another form of non-financial crowdfunding is the *reward based* model where individuals provide capital to support a project in exchange for some kind of benefit or award; such award could also be the product that will be produced with the capital collected (typical examples are musicians who raise funds to record an album in exchange of the copy of the album once released). Reward based crowdfunding has also been used extensively by businesses or innovators, often as a tool to assess demand for a new potential product or service by raising on crowdfunding platforms capital for pilot design and production. The main financial crowdfunding models are *lending* and *equity based* crowdfunding. With lending crowdfunding funders receive a debt instrument that specifies future terms of payment, usually a fixed rate of interest. Lending platforms can be peer-to-peer (i.e. lending among individuals) or peer-to-business (i.e. lending to support a business activity). With equity crowdfunding funders receive an equity instrument or a profit sharing arrangement. In this case the returns on the investment are dependent on the company's performance, thus potentially higher than the case of lending, but also accompanied with a higher risk.

In practice there are several variations of these basic models, but it is useful to use such categories to give a picture of how the crowdfunding tool has been applied to date within the energy sector. Over 80% of the active platforms are financial/investing platforms (twenty-four out of twenty 29 – see Table 3) with the remaining 20% dedicated to non-financial/donation models (Figure 2). Of the financial ones a good majority have adopted some sort of declination of the lending model (14 out of 24), some the equity/community share model (6 out of 24) and the remaining have adopted an hybrid model allowing investors to choose among different types of investing options (debt instruments, bonds, company equity or shares in local cooperatives).

But let's have a closer look: Tables 3 and 4 show how the twenty-nine active energy crowdfunding platforms are differentiated across models.

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Figure 2. Number of energy crowdfunding platforms per model
Source: Author's elaboration



The *lending platforms* in this context are all 'peer to business' meaning that, according to the definition above, some money is lent through the platform by the investor to support an energy related business or activity. Investments in renewable energy projects (and in few cases in energy efficiency projects) are solicited online by the platform providing the investor with a debt instrument which is then repaid and remunerated over time as a function of the revenues generated by the project. Payments of revenues are often administered by the platform itself which, in this case, acts as a sort of financial intermediary between the project developers and the wider investors (e.g. Abundance Generation, We Share Solar, Mosaic). In some cases, the remuneration is variable as a function of the revenues accruing from the sale of the electricity generated by the renewable project, which vary due to both the fluctuations in the generation itself (e.g. solar, wind are intermittent and variable renewable power) and the variability of electricity selling price. In other cases the remuneration guaranteed is fixed.

All lending platforms' mission and communication strategy emphasize the ethical and environmental dimension of the initiative; a quick browsing of slogans on platforms' websites provides the best evidence for it:

- "Investments that build a better world", Abundance Generation (Adundance Investment, n.d.)
- "Working together for a better future. Crowdfunding for energy efficiency and green technologies", (Econeers, n.d.)
- "Enerfip, la plateforme de financement participatif pour la transition énergétique", Enerfip (n.d.)

However, some platforms have a stronger ethical/social connotation, either in the type of investments they offer or/and in the way they structure investors' involvement and returns. To give some examples:

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Table 3. Financial active platforms

Financial			
Platform	**Model**	**Investor's Benefit**	**Country**
Abundance Generation	Lending	% of revenue of profit generated by the projects	United Kingdom
DuurzaamInvesteren	Lending	% of revenue of profit generated by the projects	Netherlands
Econeers	Lending	% of revenue of profit generated by the projects	Germany
GreenVesting	Lending	% of revenue of profit generated by the projects	Germany
Lumo	Lending	% of revenue of profit generated by the projects, plus use of the electricity generated	France
Mosaic	Lending	% of revenue of profit generated by the projects	USA
We share Solar	Lending	% of revenue of profit generated by the projects	Netherlands
Lendosphere	Lending	% of revenue of profit generated by the projects (higher % returns for investors living in the project area)	France
Enerfip	Lending	% of revenue of profit generated by the projects	France
Bettervest	Lending	% of revenue of profit generated by the projects	Germany
GreenXmoney	Lending	% of revenue of profit generated by the projects	Germany
LeihDeinerUmweltGeld	Lending	% of revenue of profit generated by the projects	Germany
Collective Sun	Lending (for no profit projects)	% of revenue of profit generated by the projects	USA
SunFunder	Lending (for rural electrification)	% of revenue of profit generated by the projects	USA/Tanzania
Crowdener.gy	Equity (Community Shares)	Financial returns proportional to the share owned	Germany
Gen Community	Equity (Community Shares)	Financial returns proportional to the share owned, plus surplus income reinvested in the community	United Kingdom
Microgenius	Equity (Community Shares)	Financial returns proportional to the share owned	United Kingdom
WindCentrale	Equity (Community Shares)	Financial returns proportional to the share owned, plus use of the electricity generated	Netherlands
Village Power	Equity (Community Shares)	Financial returns proportional to the share owned	USA
Coopernico	Equity (Community Shares)	Financial returns proportional to the share owned	Portugal
Trillion Fund	Hyprid (Lending, Equity, Community Shares)	Returns vary in accordance to the financial tool chosen (bonds, community shares, equity, funds)	United Kingdom
Greencrowd	Hybrid (Lending, Equity)	Returns vary in accordance to the financial tool chosen (loan or quity)	Netherlands
Veolis	Hybrid (Lending, Reward)	Benefits vary: % of the revenue of profit generated by the projects (Lending) or rewards provided (Reward)	Switzerland
GridShare	Hybrid (Lending, Equity, Reward)	Benefits vary: % of the revenue of profit generated by the projects (Lending) or rewards provided (Reward)	USA

- Collective Sun mainly supports solar projects development for non-profit entities, such as schools, churches, community centres and so on;
- SunFunder's mission is to unlock solar energy in emerging and developing countries to improve access to energy and rural electrification;

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Table 4. Non-financial platforms

Non-Financial			
Platform	**Model**	**Investor's Benefit**	**Country**
Milaap	Lending (for social value projects)	Loan without interests or repayment – high social value project	India
Re-Volv	Donation (plus Revolving Fund)	No monetary returns for investors. The lease payments are reinvested in a revolving fund, the Solar Seed Fund, to further finance community-based solar projects	USA
Clean Reach	Donation	No monetary returns for investors. Money collected are used for testing new technologies and organize thematic events	USA
Solar Schools	Donation	No monetary returns for investors. Money collected are used by a charity to install photovoltaic plants on UK schools	United Kingdom
Divvy	Donation/Reward	No monetary returns. Rewards provided	USA

- Lendosphere offers higher returns to investors living in the area of the project, thus emphasizing the importance of the involvement local community in the project.

The *equity crowdfunding* platforms active in the energy sector generally offer a form of *community shares*, usually for investments in renewables projects: investors give money in exchange of shares of the legal entity making a specific investment (usually a company or a cooperative), as such benefiting from returns on the investment itself through dividend payments and acquiring rights to participate to the legal entity activities (which vary according to the form of the legal entity, e.g. generally higher in the case of cooperatives (SpaceTec Capital Partners, 2014)). In the case of renewable generation and energy efficiency revenues accrue respectively from the sale of the electricity produced and the savings on the electricity bills.

Most of these platforms have a strong focus on community based projects, with a strong geographical characterization and with the explicit aim of increasing and improving the participation of local communities and citizens in the renewable energy investments accruing in their territories. Platforms such as Gen Community, Microgenius, WindCentrale, Village Power and Crowdener.gy explicitly shape their mission as well as scout and structure their projects in order to empower communities by offering them a stake and voting rights in the legal entities (usually cooperatives) making the renewable energy investment. Gen Community's projects also encompass a sort of revolving fund[1] which allow to reinvest surplus income from the project into other activities of community interest. WindCentrale also offers to investors the use of the electricity generated by the wind farms thanks to a partnership with an energy supplier (Reitsma, 2014).

Finally *hybrid platforms* allow investors to choose among different types of investing options: debt instruments, bonds, company equity or shares in local cooperatives. Each of the four hybrid platforms listed have its own peculiarity. Veolis is a lending platform, which has also launched some reward based campaigns to support energy technologies startups or energy related R&D activities. Greencrowd is also structured as a lending platform, mainly raising from online investors loan to finance the construction phase of renewable energy projects; however, it also offers equity instruments to finance initial development costs and/or to fund the equity component of a renewable investment funded through project financing. In this context equity is offered as a higher risk but higher return investment. Grid share of-

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fers a combination of loan, equity and reward, within the same projects. However, from the evidence presented online it is difficult to gauge whether the platforms is fully operational as very limited money has been raised to date and none of the projects has been funded. Trillion Fund instead looks as a successful case of hybrid platforms (see also Section 2.3). On Trillion Fund investors can browse among several types of investments, including:

- **Lending instruments:** Things such as bonds and funds (issued respectively by renewable energy company or investment funds) and direct loan to renewable energy projects.
- **Community Shares:** Shares in co-operatives or firms serving a community purpose.
- **Equity Investments:** Trillion Fund is the first platform to have launched a pure equity crowdfunding campaign, offering shares to capitalize Triodos Renewables, a renewable energy company developing projects across the UK.

In this case the platform acts as an intermediary, thus being responsible only for the crowdfunding campaign; payments of returns to the investment are then managed autonomously by the proponent of the project i.e. company, cooperative or investment fund.

Five of the active platforms are *non-financial/donation* (Table 4), four of which are strongly socially oriented, providing renewable energy projects to communities and no-profit in their respective countries, and one aiming at raising funds to support technological development in ocean energy (Clean Reach).

How Have Energy Crowdfunding Platforms Performed to Date?

Such high variability of crowdfunding models adopted raises the question of how have the different platforms performed to date. Is there a model more successful than another? What is the success rate of the projects? Is success affected by the returns offered and/or by other factors such as e.g. the ethical/social mission of the projects? Let's begin by looking at the evidence gathered on projects published to date by each active platform (data summarized in Table 5). Platforms performances differ quite substantially, in terms of both number of projects and amount of money raised. This is certainly an indication of how young and fragmented this sector still is. However, it is possible to highlight some initial trends out of the gathered evidence.

When data are aggregated by country, focusing on the most active in the sector (Table 6), United Kingdom stand out as the market leader, in terms of number of projects and money raised (both total amount raised and average project size). This is not surprising, considering United Kingdom leadership in the wider European crowdfunding market (accounting for market share of over 74% (Wadrop et al., 2015)). Netherland follows, with the next highest figures in terms of money raised, then USA and Germany whose numbers fall in a similar range.

Table 7 instead presents data aggregated by crowdfunding model. Lending platforms have been publishing the highest number of projects to date, which could have been expected considering they account for about 60% of the active platforms. However, equity/community shares and hybrids platforms seem to have better performed in terms of money raised (both total amount and average project size). Average returns offered to investors are comparable between lending and hybrid platforms and slightly higher for equity/community shares projects (which is again expected, as usually equity is remunerated at higher rates than debt). Thus, these data seem to show that despite lending platforms are the mostly implemented, they tend to attract smaller size projects and raise lower amount of money overall.

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Table 5. Performance of active platforms

Platform	Model	Number of Projects	Success Rate	Average Returns	Money Raised €
Abundance Generation	Lending	23	61%	7.49%	13,526,367
Mosaic	Lending	20	NA	NA	5,785,414
LeihDeinerUmweltGeld	Lending	19	89%	5.25%	4,029,050
Econeers	Lending	10	90%	5.34%	3,915,150
DuurzaamInvesteren	Lending	9	78%	5.68%	2,892,000
Bettervest	Lending	31	90%	7.21%	1,774,240
Lendosphere	Lending	16	94%	5.42%	1,446,990
We share Solar	Lending	8	63%	5.75%	1,075,574
GreenVesting	Lending	9	100%	5.33%	970,950
GreenXmoney	Lending	13	85%	4.54	277,550
Lumo	Lending	6	67%	3.00%	185,000
Enerfip	Lending	1	100%	NA	60,000
Collective Sun	Lending (for no profit projects)	4	75%	6.20%	254,769
SunFunder	Lending (for rural electrification projects)	34	100%	3.52%	986,238
Trillion Fund	Hybrid (Lending, Equity, Community Shares)	29	97%	7.60%	102,095,794
Greencrowd	Hybrid (Lending, Equity)	23	96%	4.88%	2,097,040
Veolis	Hybrid (Lending, Reward)	3	100%	2.50%	77,498
GridShare	Hybrid (Lending, Equity, Reward)	14	0%	6.38%	54,874
WindCentrale	Equity (Community Shares)	9	NA	3-8%	14,300,000
Village Power	Equity (Community Shares)	13	62%	NA	5,303,674
Gen Community	Equity (Community Shares)	2	100%	7.00%	1,351,516
Microgenius	Equity (Community Shares)	2	100%	NA	1,436,458
Coopernico	Equity (Community Shares)	7	86%	NA	267,600
Crowdener.gy	Equity (Community Shares)	5	80%	NA	181,800
Solar Schools	Donation	65	82%	-	691,976
Re-Volv	Donation (plus Revolving Fund)	3	100%	-	106,448
Divvy	Donation/Reward	4	50%	-	1-,423
Clean Reach	Donation	6	0%	-	5,698
Milaap	Lending (for social value projects)	15	NA	-	338

Notes:

1. Success rate is the percentage of the published projects which get successfully funded.

2. Money raised figure is the result of the sum of money raised in each single project published online. The survey thus assume that figures published by platforms for each project are accurate and factual.

3. Money raised figures for Mosaic and WindCentrale are taken from websites and grey literature, as information and data of specific projects is not available online.

4. Trillion Fund figure for money raised presented is conservative as three successful 'Fund' projects are not added to the figure as data not available online.

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Table 6. Performance by country

Country	Number of Projects	Money Raised €	Average Raised per Project €	Average Returns by Country	Number of Platforms
France	23	1,691,990	73,565	4.21%	3
Germany	87	11,148,740	128,146	5.53%	6
USA	98	12,406,537	126,597	6.29%	8
Netherlands	49	20,364,614	415,604	5.58%	4
United Kingdom	121	118,234,845	977,147	7.36%	5

Table 7. Performance by crowdfunding model

Model	Number of Projects	Number of Funded Projects	Money Raised €	Average Raised per Project €	Average Returns
Lending	203	153	37,179,291	243,002	5.39%
Equity (community shares)	38	31	22,740,049	733,550	7.00%
Hybrids	66	53	104,325,206	1,968,400	5.34%
Donation/reward	93	58	814,883	14,050	-

Note: 'Number of projects' figure for Hybrid platforms does not include three Trillion Fund successful 'Fund' projects for which data on amount of money raised is not available online.

However, a closer look reveals that the data presented above are strongly affected by the performance of two specific platforms: Trillion Fund in the United Kingdom and WindCentrale in the Netherlands. Indeed, Trillion Fund significantly outperforms to at least an order of magnitude all other energy crowdfunding platforms across the world (Table 5), thus being the main contributor of United Kingdom leadership in the sector. Similarly, WindCentrale is the largest platform in the Netherlands and the second biggest in Europe (Table 8), comparable only to Abundance Generation (second biggest platform in the United Kingdom - Table 5).

Moreover, disaggregating Trillion Fund performance data across their different project types (Table 9) it is quite striking to notice how the majority of the money has been raised through their lending projects, i.e. loans and funds issued by renewable energy company or investment funds. Average returns for such type of investments are also higher than average lending platforms returns (just above 5%).

Moving Trillion Fund lending projects from the hybrid model group to the lending one (Table 10) leads to very different results than above in terms of energy crowdfunding models' performances: lend-

Table 8. WindCentrale performance

WindCentrale	
Money raised €	14,300,000
Number of projects	9
Average return	3-8%
Average raised per project €	1,588,889

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Table 9. Trillion fund performance, by project type

Trillion Fund	Equity	Community Shares	Loan	Fund
Money raised €	4,747,208	6,972,470	34,017,910	56,358,206
Number of projects	1	9	13	3
Average return	9.5	5.29%	7.34%	15.13%
Average raised per project €	4,747,208	774,719	2,616,762	18,786,069

Note: Successful 'Fund' projects are in reality six, but three have not been included as data on amount of money raised is not available online.

Table 10. Performance by crowdfunding model – accounting for Trillion Fund lending projects

Model	Number of Projects	Money Raised €	Average Raised per Project €	Average Returns
Lending (with Trillion Fund's lending projects)	219	127,555,407	768,406	9.29%
Equity (community shares)	38	22,740,049	733,550	7.00%
Hybrids (no Trillion Fund's lending projects)	40	13,949,090	348,727	4.58%
Donation/reward	93	814,883	14,050	-

ing model is not only the more frequently applied by energy crowdfunding platforms, but it's also the best performing. Table 10 clearly shows how lending projects have been the highest in numbers, raised the largest amount of money (over 75% of the total raised to date) and for largest average project size. Returns offered are also the highest, although the 9.29% figure in Table 10 is slightly biased upper ward by the Trillion Fund's average returns to funds of 15.13%, without which average returns would stay around 6% (thus still slightly lower than equity/community shares' returns).

Compared to the financial platforms, donation/reward initiatives have raised much less money, but for a good number of projects overall. They sit in a fairly different category. In this contexts crowdfunding campaigns are smaller in size than in financial platforms as they are generally used to raise funds for rather small renewable energy projects, such as small/medium solar energy plants on schools roofs or solar for rural electrification projects (e.g. in the case of Milaap, the currently open campaigns would finance solar lamps for women empowerment in India and have set targets between a min of 80$ and a maximum of 250$).

The most successful of these platforms, e.g. Milaap (15 projects published in the first month of activity, August 2015) and Solar School (65 published projects, 53 of which successfully funded), offer very homogenous and replicable projects (i.e. solar lamps in the case of Milaap; solar projects on schools roofs mobilizing the interest of parents, local businesses, former students and wider local community in the case of Solar Schools) which allows them to raise money from a high number of similar small projects.

How Does It Compare With the Wider Crowdfunding Sector?

Overall the energy crowdfunding sector has raised about €165millions since 2012, which accounts for only 0,75% of the crowdfunding funding volume cumulated worldwide roughly over the same period of

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time (i.e. almost €23billions) (Massolution, 2015). However, it is interesting to notice that, despite being a still quite small market, the size of energy crowdfunding campaigns is almost double than the average wider worldwide crowdfunding (Figure 3). And this pattern is consistent across all models.

Moreover, the energy crowdfunding campaigns are also on average more successful. Figure 4 shows much higher success rates[2] for energy crowdfunding projects than wider crowdfunding averages, and across all models. The only exception is lending based campaigns showing the highest success rate

Figure 3. Comparing average crowdfunding campaign size, by model
Source: Author's elaboration, (Massolution, 2015).

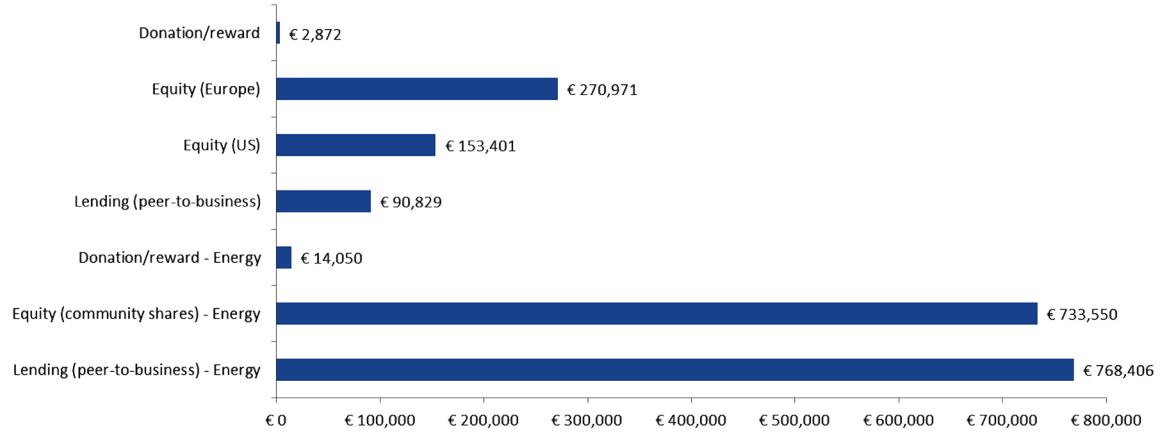
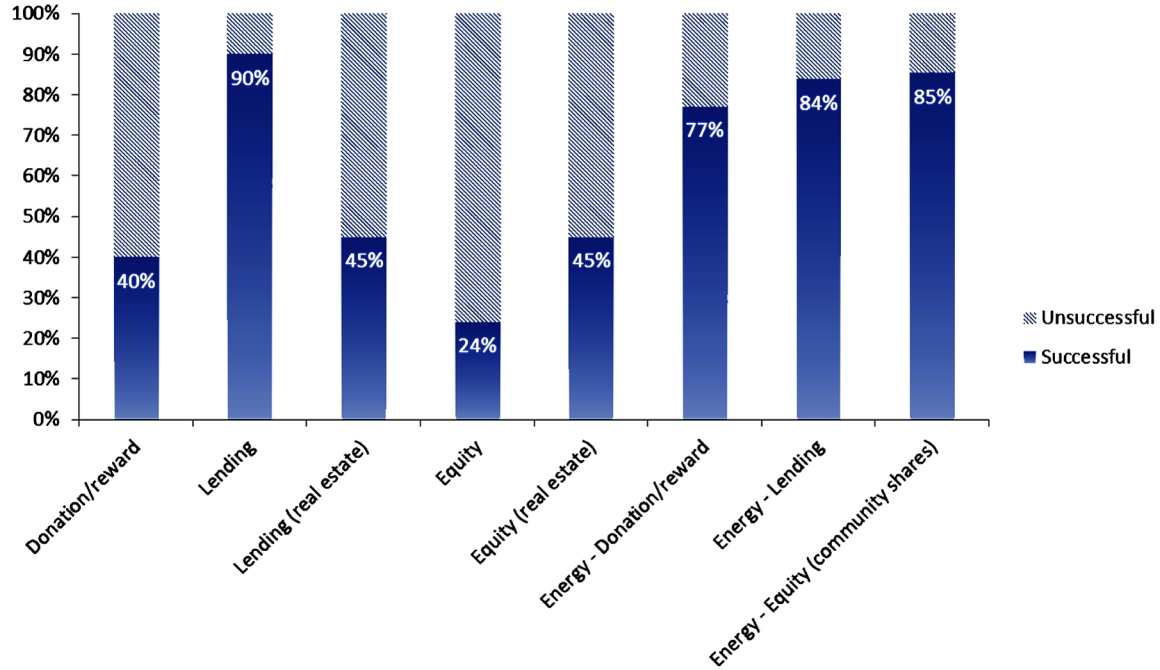


Figure 4. Comparing average success rate, by model
Source: Author's elaboration, (Massolution, 2015).



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(around 90% and above), mainly due to the popularity of peer-to-peer microloans (which have the highest success rate across all campaigns). However, the peer-to-peer microloan model has not been used in the energy sector to date, thus such figure is not directly comparable with the success rate of lending projects in the energy sector, which are instead peer-to-business. When lending in the real estate market (which is instead peer-to-business) is taken as a more realistic benchmark, energy crowdfunding sector still outperform the average global trend. Similarly, donation/reward and equity/community shares projects are also very successful in the energy sector. Success rate of the latter is particularly striking if compared with wider equity projects success rate (which is expectable due to the fact that they tend to be focused on innovative start-up businesses offering highly risky and volatile returns) and, even more striking, with equity projects in the real estate sector (which is instead characterized by less risky investment with relatively stable and foreseeable returns, such as the energy sector). A discussion of some of the potential drivers of such higher success rate are presented in Section 4.

SHAPING INVESTMENT DECISIONS

The review has highlighted how all energy crowdfunding platforms are characterized by a clear environmental and social mission both in the type of projects they publish and in their wider communication strategy. Some lending platforms have explicit focus on projects in developing countries for rural electrification or renewable projects for not-for-profit, and equity/community shares platforms emphasise the community and local nature of the investments they offer.

Indeed, crowdfunding in energy not only is mainly focused on clean and sustainable energy investments, but, as also previously noted, has also flourished within in a wider process of democratization of the energy sector, which has seen the development of several community energy and energy cooperative initiative across Europe and USA in particular (Kunze & Becker, 2014, ILO, 2013). These new approaches for renewable energy deployment bring forward forms of shared ownership of energy assets with the aim of maximising localization of economic returns and increasing communities' participation. Thus it would seem that the environmental, social/ethical and participatory characteristics of the investment are at least some of the drivers behind the decision to invest from the general public and the communities interested by the energy project (in particular in the case of community shares). However, this is definitely not the only driver. Most of the platforms are financial models, thus offering quite interesting monetary returns on the investments, on average in the 4% to 7% range.

It would be interesting to explore more in details what are the drivers behind investment decisions in energy crowdfunding as well as the investors' profiles. Which type of people and investors tend to approach investments on energy crowdfunding platforms? Are more the social and environmental commitments or the financial returns driving investment decisions? Unfortunately, data on investors profile and behaviour are owned by platforms under strict privacy controls and the sector is relatively young, thus publicly available analysis on this topic is still limited.

However, some initial evidence can be drawn from experience shared by some platforms. An analysis from a leading UK energy crowdfunding platform (Abundance Generation) points out that about 34% of their target investors are the so called 'ethical investors' (those that actively consider the impact of their investment activities, thus motivated by the 'green value' of the investment), but over 50% are 'financial planners' (experienced investors, who plan for their financial futures, thus less motivated by the sustainability cause and more by the returns on the investment and the possibility to choose among additional

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and novel investment options) (Abundance Generation, 2014). This UK experience seems to indicate that returns on the investments play a considerable role in making energy crowdfunding investments attractive. On the other hand, at the recent Energy Crowdfunding Conference (London, 5th November 2015) several platforms' representatives (among those Trine and Lendosphere) have emphasized the importance of communicating social and environmental impacts of investments to acquire investors and guarantee high success rates to their projects (Energy Crowdfunding Conference, 2015). Lendosphere also stated the success of their strategy of offering higher returns to people geographically closer to the project, which has to date allowed them to raise about 50% of the money among local people (Blais, 2015).

TRENDS: LOOKING INTO THE FUTURE

The analysis of the evidence gathered on energy crowdfunding platforms pictures a very new, but quite dynamic sector. The crowdfunding tool has been applied in most of its forms, ranging from peer-to-business lending to pure donation platforms. The strong environmental mission is a common place, with all platforms focusing on clean energy projects and most of them explicitly shaping their project scouting and communication strategy emphasising the ethical dimension of the initiative.

Indeed, the use of crowdfunding in the energy sector has begun as a fairly niche application to grass root and community energy projects, with the explicit aim of increasing participation of citizens in renewable energy investment. First ground-breaking campaigns are those launched by platforms such as WindCentrale (Netherlands), which in 2013 managed to raise €1.3 million in less than 13 hours from 1700 households in the Netherlands to finance a community owned wind turbine (Reitsma, 2014, Bayar, 2013); or Abundance Generation (United Kingdom), which is allowing citizens to invest in solar or wind plants with as little as £5 investment since 2012 (Abundance Generation, 2014). More recently platforms such as Lendhosphere (France), LeihDeinerUmweltGeld (Germany), DuurzaamInvesteren (Netherlands) or Village Power (USA) have managed to successfully raise millions of euros in renewable energy projects with explicit community and local focus.

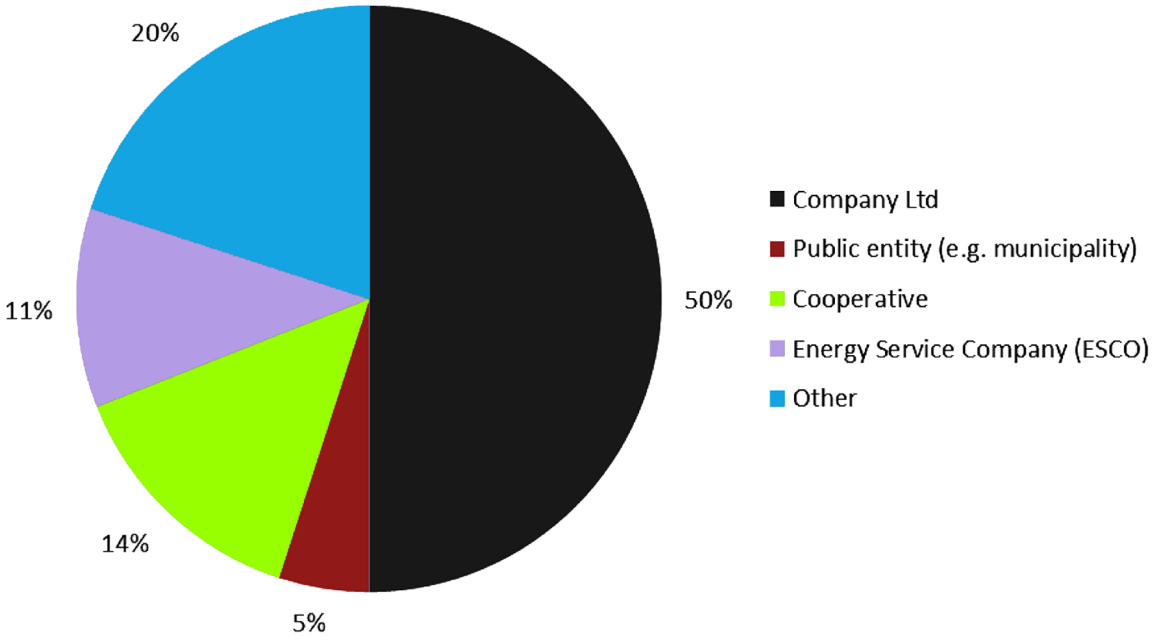
This local and social connotation is probably one of main elements guaranteeing higher success rate to energy crowdfunding campaigns than worldwide averages, in particular when compared to potentially less locally and socially characterized businesses such as real estate, where the driver to invest is likely to mainly be the financial returns offered. Evidence shows that funding from local population is more easily raised, and potentially lower returns is counterbalanced by the possibility of being involved in the project with some sort of participation or control rights (Yildiz, 2014; Dóci & Vasileiadou, 2015).

Evidence from forthcoming platforms also seems to indicate that the social and ethical advocacy of energy crowdfunding platforms will continue to drive the sector. The 2015 has seen the entry into the energy sector of the Indian micro lending platform Milaap as well as the announcement of several new platforms focused on raising funds for rural electrification projects in developing countries.

However, evidence presented in previous sections also shows how energy crowdfunding platforms, while maintaining their environmental and clean energy focus, have already been moving from niche, grass root initiatives into larger projects and collaboration with energy private sector and institutional finance. Results from a recent European survey among projects proponents (Figure 5) highlight how the majority of projects have been developed by private sector stakeholders, either limited companies or energy service companies (Klaes, 2015). In other words, crowdfunding has been used by energy project developers to finance new investments in the sector, despite with a participatory and shared ownership

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Figure 5. Company structure of projects proponents
Source: Author's elaboration, (Klaes, 2015).



approach. The case of Trillion Fund is a clear indication of this trend: structured finance instruments such as energy loans and funds coming along community shares on the same platforms.

Thus, how is the energy crowdfunding sector likely to develop in the future? What are the potential conditions to scaling up? Are larger companies, institutional investors and finance going to play a role in the future, along with locally sourced and community energy projects?

More generally crowdfunding, despite beginning as a grass root phenomenon, it has quickly scaled up and moved into financing innovation and providing seed capital for innovators and startups, raising money in the billion euros range and being increasingly used by established businesses to finance growth and expansion activities (Lehner, 2013; Mollick, 2014). The energy sector is already showing signs of similar trend: from small/medium locally characterized energy projects to larger projects, from energy cooperatives to private sector led campaigns often launched to support the expansion of renewable energy companies rather than single projects (in particular in the United Kingdom). Trillion Fund performance to date highlights the important role of structured finance and more institutional investors for scaling up the sector: over 50% of the total funding volume of worldwide energy crowdfunding sector (about €165 millions) has been raised only by 16 loan and fund campaigns launched by Trillion Fund in the last couple of years. Whether grass root, community approaches will coexists with more structured finance instruments in the scaling up of the sector is an open question to which we will get an answer only in the years to come.

On the other hand, utilities are in need of developing new business models as a response to the ongoing energy sector transition which is challenging their historical role of market makers and leaders. Could crowdfunding become an interesting tool for utilities or large energy companies?

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Some platforms are already collaborating with energy utilities as for example WindCentrale (which is partnering with the utility Greenchoice in order to offer to investors the use of the electricity generated by the wind turbine they own (Reitsma, 2014)) or Lendosphere (which had developed a project in partnership with Électricité de France (EDF) (Blais, 2015). Moreover, crowdfunding platforms are generally perceived to be a more democratic form of financing (Lehner, 2013), so they could for example become a tool for improving utilities' public image and accountability with final energy end users (i.e. their clients) or to fund (fully or partially) projects in their core business activities through a democratic, empowering and engaging financing tool. Indeed, crowdfunding, beside its primary role (of financing projects) has a strong marketing and communication function, which can favour its use by institutional actors, corporate and large companies in the energy sector for public advocacy and marketing activities. Some examples have already started to appear, as the recently announced partnership between the French oil company Total and the crowdfunding platform Babyloan to develop a crowdfunding platform dedicated to access to energy in developing countries (Total, 2015). As above, only the years to come will tell us whether such type of initiatives will be well received by the general public and will actually successfully become new business models for energy utilities and large energy companies along with other community led and bottom up approaches.

In conclusion, crowdfunding in energy is a novel sector, with large room from innovation, testing and standardization of business models (both for platforms themselves and projects launched on them). It is a highly innovative sector characterized by flexible and dynamic firm structures to keep the pace with fast market developments. Initially developed as a socio-technical practice in a niche, it is already showing signs of scaling up and is turning into a new business model, which can help in fostering and scaling up sustainable solutions in the future (Bocken et al., 2014, Vasileiadou et al.).

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ENDNOTES

1 A revolving fund is a legal 'vehicle' e.g. a company or a cooperative, which funds local energy investments (by which is also repaid) whose returns are further invested in local carbon reduction investments and community activities.

2 The success rate is the percentage of the published projects which get successfully funded.

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Chapter 74
CSR Strategies in Emerging Markets:
Socially Responsible Decision Making Processes and Business Practices for Sustainability

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ABSTRACT

The purpose of the chapter is to emphasize on the roles of businesses – as an effective (sustainable) development agent in emerging markets, on one hand, and of their CSR strategies – as an efficient sustainable development tool, on the other hand, in order to identify valuable business practices able to lead the emerging markets towards sustainability – through socially responsible decision making processes at business level. Having in the fore-ground the ideas of sustainability (which basically is a macro-economic concern) and responsibility (and especially its micro-economic correspondent that usually embraces the form of CSR), it will try to discover the general and specific features of the business models that capitalize the best the synergy between the social responsibility of business and the ensuring of sustainability in emerging markets.

INTRODUCTION

Generally speaking, businesses do not exist per se. They exist and operate in order to fulfill social needs (by delivering goods and services), and this is happening as long as they properly meet these needs. Basically, this kind of (socially responsible) behavior would be necessary and sufficient to ensure the sustainable development in emerging markets. But the reality of business is far from being so simple:

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shareholder value is still overrated, and the practice of CSR (as concern towards sustainability) is still in the shadow of profits (on the expense of sustainability itself). Ultimately, this kind of a zero-sum game is prejudicial not 'only' for sustainability, but also, on the long run, for businesses themselves – in terms of losing their legitimacy and, eventually, diminishing of their profits (Werther Jr, & Chandler, 2010).

Nevertheless, some encouraging good news have to be considered in order to draw the entire picture of the relationships between businesses and society as they are nowadays: research directions such as stakeholder relations management (Steurer, Langer, Konrad, & Martinuzzi, 2005); theories such as the bottom of the pyramid (Prahalad, 2006) and the business case for CSR (Carroll, & Shabana, 2010); concepts such as shared value (Porter, & Kramer, 2011); or even new business models that have emerged from these concepts and theories (Michelini, & Fiorentino, 2012). All (and each one) of these breakthroughs, if considered, will enable businesses to take the lead on breaking the vicious circle of unsustainability – by reinforcing their relationships with the society while gaining competitive advantage (Porter, & Kramer, 2006).

These shifts are particularly significant and worthy to be considered in the case of emerging markets and their businesses – forasmuch as they do not consider sustainability concerns and practices in terms of additional costs for businesses (which are rather difficult to be found and hardly to be justified in terms of effectiveness and efficiency), but as essential endeavors and tools leading to a never ending virtuous circle of sustainable competitiveness and development for both businesses and the society.

Having this broad approaching perspective in mind when arguing about both the reasons (to exist) and the purposes (to succeed) of businesses, there are some comforting premises which allow and favor an eventually bet on both businesses as an effective sustainable development agent and strategic CSR as an efficient sustainable development tool in emerging markets:

- Needs (in general) have the vocation of being synchronically unlimited and diachronically evolving (as the human kind is developing itself), forcing businesses to accordingly adjust their actions and behaviors in order to successfully survive;
- Each business is (more or less consciously) a network of internal and external networks, which is defined and governed by all the features and principles of complexity, including: co-evolution with the environment, linkages, contagions, self-organization, and the butterfly effect (Ramalingam, et al., 2008);
- The assumption (resulted from the extrapolation of the recent dynamics and trends registered by the emerging markets so far) that *over the next two decades, most of the world's growth is expected to occur in today's emerging markets* (Cavusgil, Ghauri, & Akcal, 2012);
- The real, significant and specific sustainability related problems, challenges and dilemmas that the emerging markets confront and try to deal with (Khanna, & Palepu, 2013);
- The relatively recent, but increasingly powerful concerns regarding the sustainable development, coming from academia, as well as from national and international bodies, and asking for sustaining nature, life support and community while developing people, economy and society (UN, 2013);
- The strong connections between sustainable development – as (national and) global desiderate – and CSR – as business practice that brings together, into a unique and contextually different framework, the economic, legal, ethical and philanthropic responsibilities of business (Johnson, 2012);

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- The growing pressure towards CSR reporting (of the economic, social and environmental impacts of business), transparency and accountability – coming from a variety of global actors and stakeholders: consumer groups, NGOs, formal and informal supranational structures and so on;
- The efforts, actions and concrete steps that both academia (Urip, 2010) and businesses (Pfitzer, Bockstette, & Stamp, 2013) have made towards integrating CSR into the business core in emerging markets.

All of the aforementioned dynamics and shifts are happening because *we live in a small world, where everything is linked to everything else* (Barabasi, & Frangos, 2002), and each agent is *competing with everyone from everywhere for everything* (Sirkin, Hemerling, & Bhattacharya, 2008). This kind of 'small world' could represent either the biggest opportunity or the highest risk for the emerging markets and their businesses (SMEs and MNEs as well) – which are all looking for sustainable development and competitiveness. On the other hand, it is well known that emerging markets have, all and each one of them, idiosyncratic features and development patterns, which are, in the same time, cause and effect of/for specific problems, dilemmas and constraints, and ask for particular approaches, strategies and solutions at business level (Kearney, 2012).

However, no matter the particular situation of each emerging market and/or business within it, the challenges of sustainable development – within the complex and networked global economy of nowadays – are forcing businesses to reconsider their strategies and business models in order to successfully survive. In this light, a systemic CSR approach could be the best solution businesses can come with. It will enable businesses to reveal themselves as effective (sustainable) development agent, by leveraging their potential through CSR strategies – acting, at their turn, as an efficient sustainable development tool.

Therefore, the chapter will argue the case for CSR strategies as socially responsible decision making processes and business practices for sustainability in emerging markets; accordingly, the chapter discusses the following main objectives:

- To outline the overall context of businesses in emerging markets – defined by the urge for sustainable development, and to place businesses – and their specific needs for CSR-related strategies – within it;
- To argue that the complex and networked global economy of nowadays defines the most appropriate framework for businesses in emerging markets in order to integrate CSR into their core strategy – while emphasizing the need for a co-evolutionary approach;
- To identify the particular challenges and opportunities of CSR and their vocation to determine strengths and/or weaknesses for businesses and their decision making processes in emerging markets;
- To develop a SWOT analysis, followed by possible solutions and strategies (resulted from the analysis of good practices in the field) – able to determine a critical mass of businesses toward integrating CSR into the business core and eventually to give direction to such a generalized behavior.

The new realities, dynamics and trends that characterize the global system in its search for sustainability, on one hand, and the (particular) challenges that emerging markets and their businesses have to confront with, as increasingly significant actors on the ever-changing global arena, on the other hand, highlight the importance of the topic this chapter covers. By taking an integrative and interdisciplinary

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approach (which is not exhaustive, but comprehensive), the chapter will try to fill a gap in the literature by enlarging the perspective – up to the complex and networked global economy, and the role of businesses in emerging markets, while offering significant insights – on the SWOT analysis, possible solutions and CSR strategies in emerging markets.

BACKGROUND

Since the Bruntland Report (1987) – arguing for development which *meets the needs of the present without compromising the ability of future generations to meet their own needs* (UN, 1987), sustainability has undeniable become a common presence on the global agenda. Although basically everyone (academics, politicians, non-governmental organizations, national states and international bodies) admits that the concept of sustainable development *strongly links environmental and socio-economic issues* (Hopwood, Mellor, & O'Brien, 2005), it is also true that *the expression 'sustainable development' has been used in a variety of ways, depending on whether it is employed in an academic context or that of planning, business or environmental policy* (Redclift, 2005).

But one thing is for sure now: the challenges of sustainability, as global concern towards a desirable 'end' of all humankind endeavors, have transformed all the global actors and each one of them into (consciously or not) global stakeholders, with different (and most often contradictory) needs and expectations, on one hand, pressures and influences towards satisfying these claims, on another hand (Carroll, 2004). In this context, responsibility seems to be the best answer businesses could give to these challenges (Waddock, Bodwell, & Graves, 2002), while local, specific practices are the most suitable 'means' in order to meet them (Oliveira, 2012). This kind of *think globally, and act locally* approach – integrating the concept of responsibility into the practice of business strategy – would be both a contribution to the broad sustainability imperative, and a solution for particular sustainability related issues, emphasizing on the role of responsible business.

However, during the last few decades, the relationships between responsibility and business have raised a lot of questions and controversies about what businesses are responsible for, and to whom, leading academia to different answers and arguments. Thus, Davis (1973) discussed about *the case for and against business assumption of social responsibilities*; Langtry (1994) analyzed *stakeholders and the moral responsibilities of business*; Utting (2000) argued about *business responsibility for sustainable development*; Whetten, Rands, & Godfrey (2002) questioned on *what are the responsibilities of business to society*; and Friedman (2007) argued that *the social responsibility of business is to increase its profits*. In the same time, different theories and (recommendations for) business practices have been developed, in order to achieve the responsible business desideratum: *stakeholder theory* (Donaldson, & Preston, 1995) and *stakeholder management* (Hillman, & Keim, 2001), the *triple bottom line* (Elkington, 1998), *the sustainable/holistic firm* (Knez-Riedl, & Mulej, 2008), the *social business* (Yunus, 2007), or the *ethical and socially responsible management* (Davidson, Wood, & Griffin, 2009), and so on.

Within this framework, corporate social responsibility (CSR) is the most common concept and practice which translate sustainable development at business level – because *CSR refers broadly to actions that business and corporations voluntarily undertake both to promote social and environmental goals and to minimize any potential social and environmental costs associated with their business activities* (Clapp, & Rowlands, 2014, p. 42). The strategic dimension of CSR is increasingly embraced and promoted by

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academia (Orlitzky, Siegel, & Waldman, 2011) – as it stands for *the incorporation of a holistic CSR perspective within a firm strategic planning and core operations so that the firm is managed in the interests of a broad set of stakeholders to achieve maximum economic and social value over the medium to long term* (Werther Jr, & Chandler, 2010, p. xiii). Accordingly, CSR (related) strategies could be conceptualized as (genuine and/or questionable – in terms of their motives) socially responsible decision making processes and business practices for sustainability.

Therefore, an abundant literature has been developed in the field of CSR, trying: to define the concept and its internal components (Garriga, & Melé, 2004; Dahlsrud, 2008); to argue for and/or against CSR (Campbell, 2007; Argandoña, 2012); to guide the business behavior towards CSR (Carroll, 1991; Young, & Makhija, 2014); to measure the impact CSR has – on the business itself and on different stakeholders (Peloza, & Shang, 2011; Epstein, & Buhovac, 2014); and to predict the future of CSR (Robins, 2005; Lee, 2008).

The abovementioned breakthroughs were both cause and result of/for new developments as regards the relationships between business and society, allowing for new business models to emerge and grow. For instance, Stubbs, & Cocklin (2008) have researched on *conceptualizing a "sustainability business model"*, while Birkin, Polesie, & Lewis (2009) argued for *a new business model for sustainable development*, and Varey, & Storbacka (2011) have sketched a *business model design for sustainable society*. But, unfortunately, they failed to entirely transform the business landscape. Therefore, besides the responsible business, the 'dark side' of the 'irresponsible' business still exists – some call it *corporate social irresponsibility* (Clark, & Grantham, 2012), while others argue about *irresponsible management practices* (Tyagi, & Vasiljeviene, 2013) or emphasize on *grey areas: irresponsible corporations and reputational dynamics* (Jackson et al., 2014) – and asks for more (theoretical) exploration, in order to properly (and practically) address to it, through consistent and articulated responsible strategies at business level.

The picture becomes more complicated when referring to the case of CSR strategies in emerging markets. Although a growing body of relevant and valuable studies has appeared (mainly) in the last decade (Baskin, 2006; Li, et al., 2010; Su, Peng, Tan, & Cheung, 2014), both the literature and the practice in the field of CSR strategies in emerging markets are younger, on one hand, while the solutions seem to be more diversified and less cohesive, on the other hand. This situation is due to a variety of reasons, such as: different approaching angles (authors and/or practitioners coming from different cultural backgrounds, valorizing their own knowledge and expertise and emphasizing on a specific theory when doing that), and different contexts (with specific needs and concerns, regulations, access to resources, perceptions on and behaviors towards CSR). That is why a closer and deeper look, in order to eventually identify both the proximate genus and the specific difference in terms of CSR strategies in emerging markets is more than necessary.

Accordingly, the study will progressively address the following problems and research questions: (1). the changing global (economic) environment – more and more characterized by complexity and interdependencies – which asks for new approaches as concern the relationships between businesses and society, based on co-evolution and symbiosis; (2). the impact that the complex and global economy has on the emerging market economies, and especially on the role of businesses in emerging markets – considering their search for both development and sustainability; (3). a SWOT analysis, followed by possible solutions and CSR related strategies in emerging market economies – in order to identify best practices, able to serve as behavioral guidance.

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The Complex and Networked Global Economy

Both sustainability (as continuous and never-ending desired outcome of all humankind endeavors) and responsibility (as permanent and context-related feature that has to define each agent's behavior) need to be placed and considered, in order to be properly achieved, within the general evolution framework that conditions them. As the process of (economic) globalization – which defined (with its cohorts of goods and bads, pros and cons) the last half of the twentieth century – has offered the fertile ground for the sustainability issue to sprout and become a global concern, the complex and networked global economy of nowadays sets new coordinates – in terms of opportunities and threats as well – for responsibility to occur.

Undoubtedly, *globalization is one of the most used, but also one of the most* mis*used and one of the most* conf*used, words around today* (Dicken, 2007, p. 3). Beyond all the theories and controversies that surround it (Held, & McGrew, 2007; Jones, 2010), and generally speaking, *globalization is a process that encompasses the causes, course, and consequences of transnational and transcultural integration of human and non-human activities* (Al-Rodhan, & Stoudmann, 2006). Very generous in their nature and expression, *the transformative powers of globalization reach deeply into all dimensions of contemporary social life* (Steger, 2013, p. xii): economic, political, cultural and ecological. As defining feature and major dimension of the globalization process, the *economic globalization refers to the increasing interdependence of world economies as a result of the growing scale of cross-border trade of commodities and services, flow of international capital and wide and rapid spread of technologies* (Shangquan, 2000); it also is the fuel which powers the engine of today's complex and networked global economy.

According to Maznevski, Steger, & Amann (2007) there are *four major sources of complexity that interact together to create today's environment: diversity, interdependence, ambiguity* and *flux*. In other words, myriads of different actors (individuals, on one hand, and all types of structures, on the other hand: companies, states, international bodies, interest groups) are playing their roles on the global arena, by continuously interacting with each other while constantly looking for information that is both abundant (generally) and rare (if talking in terms of relevance) in order to successfully survive; and all these premises change permanently – adding more complexity to the environment.

Therefore, *our economy, especially the global economy, is a complex system* (Homer-Dixon, 2011), proving all the properties Homer-Dixon (2011) claims to characterize such an entity: (a). *many components* – considering all the small-to-global companies that operate around the world; (b). *a high degree of connectivity between components* – the even existence of each company depends on a lot of connections with its stakeholders (suppliers, clients, employees, to name just a few of them); (c). *thermodynamically open* – each company evolves as a network of networks with variable architecture, never knowing exactly where it starts and where it ends in terms of its boundaries; (d). *information, matter and energy* – which are continuously flowing and fueling the system, in order to keep it vivid; (e). *nonlinear behavior* – as opposed to mechanical systems, the global economy as a complex system develops 'irrational behaviors', demonstrating that the butterfly effect not only works for meteorology; (f). *emergence* – the existence and evolution of the global economic system is more / different than its parts, developing a trajectory of its own – as 'nonlinear' and/or unpredictable result of all the above-mentioned features.

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Both the global environment – placed under the auspices of complexity, which characterizes *the behavior of macroscopic collections of such units that are endowed with the potential to evolve in time* (Coveney, & Highfield, 1995, p. 7) – and the global economy – which can be seen as a *complex network, whose nodes are companies and whose links represent the various economic and financial ties connecting them* (Barabasi, & Frangos, 2002) – are now defined by the presence and behavior of businesses as complex adaptive systems. They *are composed by a diversity of agents that interact with each other, mutually affect each other, and in so doing generate novel, emergent behavior for the system as a whole. The system is constantly adapting to the conditions around it, and over time it evolves* (Lewin, 2000, p. 198). In conclusion, the idea of symbiosis and co-evolution with the environment is crucial for businesses to survive because, *in today's fast-changing business environment, companies will survive only if they are able constantly to adapt and evolve through operating optimally as a complex adaptive system* (Lewin, 2000, p. 198).

The Overall Context and the Role of Businesses in Emerging Markets

In addition to the emphasizing on a new, *evolutionary* (economic) *perspective* (Boschma, & Martin, 2007), the *new economic geography* (Krugman, 2011) of globalization literarily *reshapes economic geography* (Rigg, et al., 2009), if considering the dynamics that the global economy has registered during the last few decades and the current trends it develops. *Today we increasingly recognize that nothing happens in isolation. Most events and phenomena are connected, caused by, and interacting with a huge number of other pieces of a complex universal puzzle* (Barabasi and Frangos, 2002, p. 7); then, *we look forward and see a new era emerging. (…) a different kind of environment, in which business flows in every direction. (…) Western business orthodoxy entwines with eastern business philosophy and creates a whole new mind-set that embraces profit and competition as well as sustainability and collaboration* (Sirkin, Hemerling, & Bhattacharya, 2008, pp. 1-2).

Under these circumstances, and because *sustainable development itself is a global vision* (Schmidheiny, 1992, p. xxi), the global challenges to sustainable development – which *have been driven by a broad set of "megatrends", such as changing demographic profiles, changing economic and social dynamics, advancements in technology and trends towards environmental deterioration* (United Nations, 2013) – ask for unanimous concern and concerted actions, able to integrate its economic, social and environmental dimensions. On the other hand, corporate responsibility – which *fundamentally (…) has to do with corporations fulfilling their obligations to society in ways that reflect a social contract between business and society* (Smith, Bhattacharya, Vogel, & Levine, 2010, p. 6) – *has gone global* (Smith, Bhattacharya, Vogel, & Levine, 2010, p. 1), while being *one of the ways that companies and others have used to navigate the new terrain associated with globalization that is not necessarily good or bad, but simply different from preceding eras* (Blowfield, Murray, 2011, pp. 110-111). Therefore, as the world is neither flat (Friedman, 2003) nor curved (Smick, 2008), but rather complex (Porter, & Derry, 2012), CSR strategies – as socially responsible decision making processes and business practices for sustainability – should be characterized by the same logic (in terms of determinants, features, behaviors and impacts) of complexity.

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Within this framework, academia generally acknowledges and proclaims that *the rise of emerging markets – their emergence after more than 200 years of being relatively minor players in the global economy – is causing one of the most significant shifts in the global economic and geopolitical structure since the beginning of the industrial revolution* (Ciravegna, Fitzgerald, & Kundu, 2013, p. 1). Having *firms and states* as *major shapers*, this global shift has led to *a multi-polar, kaleidoscopic global economy* (Dicken, 2003) – defined and dominated by:

- The multiplying of the global centers of power and of their determinants, both diachronically (from states to firms – and especially multinational companies) and synchronically (from 'center' – the old Triad, to 'periphery' – the new emerging markets), within a business environment characterized by multi-polarity (Falk, 2009; Layne, 2012);
- The emergence and development of multinationals from emerging markets (Goldstein, 2009; and the rise of new global giants from emerging markets (Ghemawat, & Hout, 2008);
- New approaches and strategies at firm level (domestic and multinational companies as well, originated and/or hosted in/by emerging markets) – aiming for (global) competitiveness by valorizing the new – internal and external – dynamics and trends (Hoskisson, Eden, Lau, & Wright, 2000; Pillania, 2009).

Although the definition and the content of the term are still subjects to debates – for both researchers (Ciravegna, Fitzgerald, & Kundu, 2013) and international institutions (The World Bank, The International Monetary Fund) – it is generally recognized that the emerging markets possess some *core characteristics* that distinguish them from other countries – *(1). they are dynamic economies; (2). their institutional environments were buffeted in the 1990s by a contagious tidal wave of policy shocks (liberalization, privatization, deregulation); and (3). they suffer from missing or weak market-based institutions, particularly in terms of property rights and legal infrastructure* (Mendoza, & Irmak, 2008, pp. 333-334). By taking a dynamic and evolutionary perspective, Kvint (2010) goes even further, and identifies 45 *major characteristics that all EMCs* (emerging-market countries) *have, had, or will have at some stage during their process of economic maturation and development* (Kvint, 2010, p. 82).

It is also true that the emerging markets category is far from being homogenous, as the literature emphasizes on the fact that they *differ in many manners: size; political, regulatory, and legal regimes; the role of governments; economic reforms and industry structure transformation* (Luo, 2002, pp. 7-8), which leaded to the reality that *the overall improvement in the fundamentals of EMEs masks a great dispersion regarding most of the benchmark indicators (notably GDP growth, inflation, balance of payments, foreign currency reserves and public* finances) (Odonnat, & Rahmouni, 2006).

Given the emerging markets common characteristics, on one hand, and their idiosyncratic features and development paths, on the other hand, academia recommends that *businesses still need to distinguish emerging markets – collectively from developed markets and individually from each other* (Khanna, & Palepu, 2013, p. 3). Therefore, as relatively new – but very vigorous – entrants on the global arena as players that count and decisively contribute to the reshaping of the global economic architecture (Dicken, 2003; Ravenhill, 2014), the emerging market economies are confronted with the transformative realities of nowadays, on one hand, while struggling with particular challenges of their own (common and / or different), on the other hand. As recent studies and reports have revealed, although *after decades of stalled and even regressed convergence, emerging markets* (EMs) *started closing the income gap with*

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advanced economies in the last decade (Cubeddu, et al., 2014), they also *face growing domestic vulnerabilities along with a heightened sensitivity to global conditions* (International Monetary Fund, 2014).

SWOT ANALYSIS, POSSIBLE SOLUTIONS AND CSR STRATEGIES IN EMERGING MARKETS

The increasing pressures towards sustainability and responsibility – coming from myriads of global stakeholders concerned about the impact of the (rather irresponsible as concern CSR) business models and business practices dominating in emerging markets (Rettab, Brik, & Mellahi, 2009; Reimann, Ehrgott, Kaufmann, & Carter, 2012) – force the companies (both domestic or multinational, originated from or hosted by an emerging market) to take the issue of CSR (and especially the CSR strategies) in emerging markets more and more seriously. Therefore, the (generic) SWOT analysis – undertaken prior to proposing and developing a CSR strategy at firm level – might serve as a valuable instrument able to offer significant insights on the internal and external determinants of CSR strategies in emerging markets, as well as possible guidance regarding effective and efficient behaviors.

Although both the emerging markets and their firms are quite different, some general aspects have to be taken into account when considering (both the idea and the formulation of) a CSR strategy:

- It is based on the internal and external audits of the firm – developed in accordance with: the strategic management approach (David, 2011), a combined strategic management approach with a stakeholder approach (Freeman, 2010) and/or a stakeholder approach of CSR (Jamali, 2008);
- These combined internal and external audits lead to specific lists of:
  - Strengths and weaknesses – coming from within the firm (either domestic or multinational – originated from / or hosted by an emerging market) and determining CSR strategies in emerging markets as socially responsible business practices;
  - Opportunities and threats – raised by the external environment (at global level and at national – emerging market – level) – and determining CSR strategies in emerging markets as business practices for sustainability.

Therefore, performing such a SWOT analysis will imply for each company a unique interpretation of the internal and external forces shaping its riverbed of evolution, and will generate a unique integration – looking for the best suited CSR strategy, able to deliver a symbiosis of the stakeholders needs, expectations and interests while maintaining the company on the competitiveness map – of the following:

- The impact of *globalization on different* (internal and external) *stakeholder groups*: *shareholders; consumers; suppliers and competitors; civil society; government and regulation* (Crane, & Matten, 2010, p. 25);
- The *characteristics of emerging markets and the opportunities they create: markets and culture are demanding; there are high rates of emigration to the developed world; markets are fragmented; populations are youthful and growing; there is limited income and space; infrastructure is weak; technology is underdeveloped; distribution channels are weak; markets are changing rapidly* (Mahajan, & Banga, 2005);

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- The *business challenges* – emphasizing on *the importance of good corporate governance and CSR* – determined by *globalization: more demanding consumers, competitive differentiation, emergence of NGOs, complexity of market and environment, government policy and regulation, tightening margins, converge and consolidation, the importance of developing human resources, competition in capability* (Urip, 2010, p. 4);
- The new insights that firm related approaches bring to support the (internal and external) environmental assessment:
  - The resource-based view of the firm – looking for the capitalizing of: *resources, dynamic capabilities and knowledge; corporate governance; management buy-outs and venture capital financing; institutional environment; entrepreneurship*, and, particularly, *a uniquely ethical culture* (Barney, Wright, & Ketchen, 2001), in order to reach a *sustained competitive advantage* (Barney, & Clark, 2007);
  - The value-chain analysis – bringing together *key elements* such as *barriers to entry and rent; governance; and systemic efficiency* – within a process *which includes the whole cycle of the organization, production and delivery of products from inception to use and recycling* in a manner consistent with the idea that *it is not so much a matter of whether to participate in global processes, but how to do so in a way which provides sustainable income growth for poor people and for poor countries* (Kaplinsky, 2000);
  - The CSR view of the firm – which, starting from the hypothesis that *a firm's level of CSR will depend on its size, level of diversification, research and development, advertising, government sales, consumer income, labor market conditions, and stage in the industry life cycle*, emphasizes on the idea that *there is an "ideal" level of CSR, which managers can determine via cost-benefit analysis* (McWilliams, & Siegel, 2001).

The solutions that academia brings to the problem of CSR strategies – aiming to transform the company into a sustainable development agent while operating on the basis of CSR as a sustainable development tool – are quite diverse (some of them more realistic, as opposed to quite idealistic others), and may be divided into general and specific (emerging markets based) ones.

Within the first category, the *sustainable business*, based on the concept and practice of the *triple bottom line* (profit, people, and planet) is one of the most known and referred to. As Elkington (2004) argued, *in the simplest terms, the TBL agenda focuses corporations not just on the economic value that they add, but also on the environmental and social value that they add – or destroy*. Considering their different stages *along the evolutionary path to a chrysalis economy*, the author insists on the fact that *the key to developing environmental policies that facilitate the transition to sustainability is to understand that the roles of government need to be different in relation to the four different types of corporation* (Elkington, 2004).

More than that, Porter and Kramer (2011) claim that *companies must take the lead in bringing business and society back together* (…and …) *the solution lies in the principle of shared value, which involves creating economic value in a way that also creates value for society by addressing its needs and challenges*. This would be possible through: *reconceiving products and markets, redefining productivity in the value chain* (in terms of *energy use and logistics*, *resource use, procurement, distribution, employee productivity, location*), *and building supportive industry clusters at the company's locations* (Porter, & Kramer, 2011), and by being aware and valorizing the fact that each one of these actions has a leverage effect on the others, and on the entire company.

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Yunus (2007), on the other hand, makes a distinction between two types of businesses – based on the CSR approach they embrace: (a). companies promoting a "*weak CSR*" *credo*: *do not harm to people or the planet (unless that means sacrificing profit)* – category which refers to businesses which *avoid selling defective goods, dumping factory wastes into rivers or landfills, or bribing government officials*; (b). companies promoting a *"strong CSR" credo*: *do good for people and the planet (as long as you can do so without sacrificing profit)* – category which refers to businesses which *may work to develop green products and practices, provide educational opportunities and health plans for their employees, and support initiatives to bring transparency and fairness to government regulation of business* (Yunus, 2007, pp. 15-16). But, rather pessimistic about the transformative power of CSR on the entire business landscape, he comes with the solution of *social business* – which is developed *to pursue specific social goals,* as opposed to the *profit-maximizing businesses* (Yunus, 2007).

Taking a broader view, Young (2003) advocates for *reconciling private interest with the public good* – based on the fact that *the enterprise is not self-contained and self-sufficient but, rather, is importantly dependent on inputs controlled by others. It must please others in order to prosper. That service is a moral activity, subordinating self to what is beyond the self* (Young, 2003, p. 3). Therefore, the solution he comes with is the *moral capitalism*, considered to be *the most appropriate means by which our modern, global human civilization can empower people and enrich their lives materially and spiritually* (Young, 2003, p. 1).

When specifically addressing the case of CSR in emerging markets, academia generally insists on: (a). aspects such as *context and consequences dependency* (Halme, Roome, & Dobers, 2009) – arguing that *CSR should be seen as a local, not a universal, concept. The historical and national context of communities, especially their corporate and societal governance frameworks and business-society relations, impact on how CSR may be practiced in these areas.* (Zhang, 2008); (b). the main particular concern such an endeavor should pursue – considering that *a real contribution to the society will happen only when this is enabled to have its own sustainable development. The empowerment of people through providing them the capability of developing their own instruments of income should be the ultimate objective of a responsible corporate* (Pelle, 2007, p. 172).

Regarding the particular case of those positioned at *the bottom of the pyramid* – category that encompasses more than four billion people living on less than two American dollars per day (Prahalad, 2006) – theory insists on a perspective shift, leading to a symbiotic development. Thus, *if we stop thinking of the poor as victims or as a burden and start recognizing them as resilient and creative entrepreneurs and value-conscious consumers, a whole new world of opportunity will open up*, based on *an approach that involves partnering with them to innovate and achieve sustainable win-win scenarios where the poor are actively engaged and, at the same time, the companies providing products and services to them are profitable* (Prahalad, 2006, pp. 1-3).

Given this discussion framework, the CSR strategies that companies embrace in emerging markets are, at theirs turn, quite different. However, some general *aspects related to the formulation of corporate social strategy* could be mentioned: *(a). market opportunities; (b) resources; (c) corporate values; (d) structure of industry; (e) stakeholders; (f) CSR alignment to core business; and (g) the social impact of corporation competitiveness* (Sousa Filho, Wanderley, Gómez, & Farache, 2010); in the same time, some particular business models integrating CSR strategies could be noticed in the case of both multinationals – hosted by / or originated in an emerging market – and local companies.

Thus, as concerns the MNEs hosted by emerging markets and their CSR strategy, studies generally revealed that:

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- *Global MNEs face a clear choice. They can (…) manage local and global CSR issues on a case-by-case analysis of the pressures for integration and responsiveness surrounding each issue: in short, they can become 'transnational' in their CSR strategy. Alternatively, they can ignore local subtleties and nuances in their CSR agenda, with the attendant risks* (Husted, & Allen, 2006);
- More attention should be paid to the *politics, corruption, and corporate social responsibility lenses on the multinational enterprise* and *the potential linkages across* them – because MNEs *operate in multiple countries and institutional environments throughout the world. As local residents, they must respond to local rules and institutions, adapt to diverse socio-economic conditions, and respond to multiple stakeholders* (Rodriguez, Siegel, Hillman, & Eden, 2006);
- *A comprehensive CSR strategic framework must include key components for MNEs (…): (1). to define a CSR mission reflecting corporate values and objectives; (2). to assess existing programs, codes of conducts, guidelines, standards (…) and reflect how they can be included into policy and decision-making; (3). to develop a CSR strategy based on the above; (4). to gather a team of international leaders, reflecting the diversity of the organization in charge of implementing and monitoring the process; (5). to get feedback from employees, governmental and non-governmental institutions about the positive impacts and/or limitations of implemented policies; (6). to review compliance mechanisms and performance requirements.* (Lévy, 2007).

On the other hand, as regards the MNEs originated in emerging markets, they develop particular business models and CSR strategy – by specifically addressing the opportunities and challenges they face in their home countries, while leveraging their idiosyncratic strengths. Regardless of their country of origin, the development paths they pursue, and/or the generic umbrella that covers them – *southern multinationals* (Battat, & Aykut, 2005), *emerging economies' multinationals (*Salehizadeh, 2007), *global latinas* (Casanova, 2009), *global players from India* (Taylor, & Nölke, 2010), *non-triad multinationals* (Nölke, & Taylor, 2010), *Chinese multinationals* (Hobdari, Sinani, Papanastassiou, & Pearce, 2010), *emerging Russian multinational companies* (Filippov, 2012) and so on – the emerging market multinationals are not only sensitive to CSR concerns, but they sometimes take over leadership regarding CSR development within their countries of origin (Torres-Baumgarten, & Yucetepe, 2009).

As Deutsche Gesellschaft für Internationale Zusammenarbeit (2011) argues:

these companies do more than just provide good jobs to many thousands of people in emerging and developing economies. They also: (a). nurture a professional class that commands higher wages and can spur further development in the public, cultural and educational arenas; (b). provide business opportunities for the vendors, small businesses and entrepreneurs from which they source; (c). create innovations that boost productivity and drive sustainable national economic growth; (d). bring profits home and contribute to the tax base so that governments can sponsor development across the socioeconomic spectrum.

More than that, the emerging market multinationals have the vocation of spreading their beneficial influence beyond economic development, towards human development, through:

(a). discovering and serving new markets, potentially growing revenue and profits – and at the same time address unsatisfied needs; (b). creating disruptive innovations in products, processes and business models that are well received not only in their home countries, but also in host markets; (c). improving the business environment so they can operate more effectively – and at the same time addressing de-

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velopment goals such as building infrastructure, combating disease, and educating local populations; (d). engaging in a policy dialogue, and at the same time bolstering their reputation with civic leaders nationally and globally; (e). building their brands in the minds of consumers concerned about social responsibility. (GIZ, 2011)

The analysis of the CSR strategies in the case of domestic (emerging market) companies also indicates practices which respond, through particular actions, to local contexts and expectations, by reconciling businesses and society. But, as the emerging markets are quite different between them, so are their approaches towards CSR – in terms of motivators, actions/behaviors, impacts and reporting/communicating (Vives, 2006; Rivera, 2010; Katamba, Katamba, Zipfel, Haag, & Tushabomwe-Kazooba, 2012; Chahal, Mishra, Raina, & Soni, 2014).

SOLUTIONS AND RECOMMENDATIONS

Due to a variety of reasons – such as solely pursuit of (quick) profits and a myopic interpretation of the CSR paradigm (exclusively in terms of additional costs for business) – and against the background of no serious scrutiny (which favored the lack of businesses' accountability and transparency) – CSR strategies have been rather a peripheral concern for businesses in emerging markets until recently. But, under the auspices that define the new dynamics of both the global (economic) system and the understandings of the CSR paradigm, a series of quite influential determinants – coming from academia, regulatory bodies and different (formal/informal, as well as national/international) pressure groups – has brought the issue into the spotlight of the businesses' core strategy.

Thus, a growing body of (increasingly refined) proofs and evidences has emerged in order to build the case for CSR strategies in emerging markets, emphasizing on both business and country-related effects and positive impacts. So, the arguments on favor of *how corporate social responsibility pays off* in terms of *strategic benefits* for companies (Burke, & Logsdon, 1996), were complimented by those referring to how CSR is *supporting the business case* in terms of *the long-run benefits for companies* – through: *cost savings, enhanced staff loyalty, improved government relations, innovation and learning, enhanced reputation, consumer response* (Luetkenhorst, 2004); and all of the above-mentioned arguments were circumscribed by those related to how *collective corporate social responsibility (CSR) activities amongst various corporations and its stakeholders could contribute to the microeconomic development of a developing country through sustainable benefit to all* (Urip, 2010, p. xiii).

Consequently, despite the fact that, *unfortunately, the majority of companies still see such concepts as sustainability and social responsibility as pursuits that only the rich can afford* (Handy, 2002), the reality reveals that *today, a growing number of creative new business models (..) demonstrate that social and environmental purposes do not have to be sacrificed for profits, and that profits do not have to be sacrificed for social and environmental purposes. Rather than conflicting, the two purposes can mutually reinforce each other. Even better, these innovative, purpose-driven business models can become a source of competitive advantage* (Osterwalder, & Pigneur, 2011). This kind of 'open minded' search for (sustainable) competitive advantage – that only a strategic approach of CSR can provide – would be able to break the vicious circle of unsustainability that surrounds the emerging markets and their businesses, by unleashing the latent potential of contingent creativity and capitalizing on it, for the mutual benefit of all the stakeholders.

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The concept of *strategic corporate social responsibility* should be transposed into business models which reveal a *business strategy that is integrated with core business objectives and core competencies to create business value and positive social/environmental value, and is embedded in day-to-day business culture and operations* (McElhaney, 2007). This kind of simultaneously short and long-term perspective, which equally encompasses daily routines and overall goals, while contributing to the sustainability of both the emerging markets and their businesses, can only be achieved if (long-term) socially responsible decision making processes are operationalized through (short-term) business practices for sustainability.

In this way, strategic corporate social responsibility could serve *as a tool for managing the current situation and helping firms overcome the consequences of the crisis* that was partially caused by *the lack of CSR* itself (Fernández-Feijóo Souto, 2009); more than that, it could help moving businesses forward, towards: (1). higher competitiveness – if considering that *firms who better understand their social responsibilities and who begin to more adequately explore how they can build CSR into strategy are likely to reap the rewards of improved competitive positions in the future, to the benefit of their shareholders, but also to the benefit of society at large* (Galbreath, 2009); (2). expanding and deepening the *CSR boundaries* – if considering that in the case of *emerging or transitional societies, transnational corporations (TNCs) can find themselves the catalyst for legal or conceptual reform* (Mullerat, 2010, p.4). By playing such a role, businesses can contribute to the overall development of the emerging markets, while helping them to climb on the ladder of responsibility and sustainability.

Certainly, such an approach will not be an easy way for businesses in emerging markets, especially if taking into account: (a). the institutional and regulatory voids that still define emerging markets – allowing businesses to act irresponsible without being scrutinized and/or punished for their behaviors; (b). the discretionary dimension that usually characterizes CSR – which makes other than economic values and 'bottom lines' to be easily overlooked and/or ignored; (c). the urge for economic development on the basis of 'no matter' how – which justifies, against the background of no penalties, almost any kind of profit; (d). the lack, until now, of an indubitable proof of a direct causal link between CSR and financial performance – even though different empirical studies have directly, as well as indirectly demonstrated the correlations between those two; (e) the knowledge gap that characterizes both the theory and the practice in the field of strategic CSR – encapsulating all the above.

But it could be the only way for the emerging markets (and their businesses) in order to overcome the sustainability (economic-social-environmental) gaps and to meet the challenges of the complex and networked economy of nowadays. And this is especially true if considering the new age – *of responsibility* – and stage of business responsibility – *systemic CSR* – which is about to emerge, according to Visser (2011). Following *the ages of: greed, philanthropy, marketing and management – characterized by: defensive CSR, charitable CSR, promotional CSR, and strategic CSR* respectively – *systemic CSR* represents a step forward for business (thinking and action) and could become a benchmark for the companies from emerging markets, because it *focuses its activities on identifying and tackling the root causes of our present unsustainability and irresponsibility, typically through innovating business models, revolutionizing their processes, products and services and lobbying for progressive national and international polices* (Visser, 2011).

Therefore, the ideas of co-evolution (with the environment) and symbiosis (between stakeholders' needs and expectations) – considered in terms of both premises and consequences – should accompany any strategic endeavor. They would help businesses to properly asses their (internal and external) environment and to define their most appropriate systemic CSR approach accordingly. As a growing number of businesses will embrace this approach, the interdependencies (between the global stakeholders) will

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multiply and strengthen, while the overall 'sustainability outcome' will (exponentially) be rising. The 'best fitted' businesses will be able to take the lead in terms of competitiveness, while the others will be left behind. Therefore, due to sustainability related reasons will be essential that a critical mass of businesses to make the move towards integrating systemic CSR into their core business. Thus, the challenges of development and sustainability (as moving targets for the emerging markets and their businesses) will get their best answers, enabling emerging markets to catch-up – on one hand, and businesses to be competitive – on the other hand. And the virtuous circle will be continued…

FUTURE RESEARCH DIRECTIONS

The topic of the chapter is at the same time broad and deep, as well as uneven and controversial, therefore it could not be entirely covered. Moreover, it opens new perspectives and research directions in relationship with the generic topic of the book – which deserve to get a closer look and to be thoroughly explored. In this light, some of the future research directions might envisage: firstly, practical case studies for particular contexts – countries and companies – in order to emphasize on the models for good practice in the field of CSR in emerging markets and to extract similarities and differences that define such behaviors; secondly, developing of a flexible strategic model – integrating various inputs and able to generate different CSR strategies, based on particular situations and scenarios and integrating the results of a relevant number of case studies; thirdly, determining of an 'flexible' equilibrium point – in terms of costs versus benefits of different CSR strategies – as result of a comprehensive analysis and serving as decision criterion when developing a CSR strategy; and fourthly, designing, implementing, and evaluating a CSR strategy into an emerging market (Romania) – in accordance with all the above-mentioned, and taking into account the challenges of responsibility and sustainability, on one hand, and of the complex and networked global economy, on the other hand.

CONCLUSION

The chapter brings new insights on the thorny and controversial issue of CSR strategies in emerging markets, insisting on the need for responsibility at firm level, which, in turn, will have the vocation of leading towards sustainability at broader levels (from national to global). Such a view on the relationship between business and society will enable firms in emerging markets to operate as sustainable development agents, while their CSR strategies will act as sustainable development tools, contributing in the same time to a systemic (and long-term) reconciliation of interests between business and society.

The multilevel (firm - country - global), multidisciplinary (management - strategic management - international business) and multifaceted (internal and external global stakeholders) approach of the chapter has revealed the main characteristics that define the challenging (and continuously changing) context of business in emerging markets: the complex and networked global economy of nowadays, the increasing role of the emerging markets on the global arena, the specific internal and external challenges emerging markets and their companies (local and/or multinationals) face, and the growing pressures toward corporate social responsibility coming from different stakeholders. All and each one of the above represent genuine and valuable cues that need to be properly considered and optimally valorized by companies in emerging markets when designing and implementing their best suited CSR strategy.

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Both theory and practice offer recommendations and/or solutions for good practices in the field, but this is not enough – given the great diversity of particular situations. Each business in emerging market has to identify and pursue its own development path while defining and building its own relationships with the society through its CSR strategy. More than that, in search for (global) sustainable competitiveness, it should synergistically integrate the new concepts and practices that have recently emerged – such as *shared value* and *systemic CSR* – into its business core; but this would be a long and difficult process, which asks for a paradigm shift as regards the idea of business itself.

In conclusion, the study has developed a general discussion framework – placed under the auspices of the complex, networked global economy, where each business is a complex adaptive system which has to operate in co-evolution with the environment – on the issue of CSR strategies in emerging markets – by covering from both sides (and through multiple lens) the relationships between (responsible) business and (sustainable) society, while opening new lines of debates and new directions for future research.

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KEY TERMS AND DEFINITIONS

Business Core: The (unique) identity of a company, defined by its most important value / feature.

Business Model: Particular pattern of evolution that is followed by a company in order to succeed.

Business Practice for Sustainability: Activity undertaken by a company in order to have a positive (economic, social and environmental) impact over the long run.

Complex Adaptive System: View on the company, emphasizing on the idea of a multi-component structure, with multiple internal and external links, designed to be able to co-evolve with its environment.

Complex and Networked Global Economy: The world economy as it is today, a global network of networks which permanently evolves according to its own, non-deterministic and subtle rules.

Corporate Social Responsibility: Part of a business model that translate the concept of sustainable (economic, social and environmental) development into a business practice.

Socially Responsible Decision Making Process: Set of activities – part of the business model – pursued by a company in consideration of its (social and environmental) impact.

Stakeholder: Any individual and/or group which have a particular interest into a company or which might be affected by a company's decisions and/or behaviors.

Systemic Corporate Social Responsibility: A new approach on corporate social responsibility aiming at bringing together business and society by considering all the connections between them and their consequences.

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