Handbook of Research on

# Sustainable Development Goals, Climate Change, and Digitalization

Rui Alexandre Castanho

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

# Handbook of Research on Sustainable Development Goals, Climate Change, and Digitalization

Rui Alexandre Castanho
*WSB University, Poland*

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

A volume in the Practice, Progress, and
Proficiency in Sustainability (PPPS) Book Series

Published in the United States of America by
IGI Global
Engineering Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com



Library of Congress Cataloging-in-Publication Data

Names: Castanho, Rui Alexandre, editor.
Title: Handbook of research on sustainable development goals, climate change, and digitalization challenges in planning / Rui Alexandre Castanho, editor.
Description: Hershey, PA : Engineering Science Reference, 2021. | Includes bibliographical references and index. | Summary: "In the last few years, with the world changing considerably, this book looks into the many obstacles, barriers, and opportunities pertaining to the future planning of our territories and cities to achieve the sustainable development goals taking into account climate changes and the shift towards the digitalization"-- Provided by publisher.
Identifiers: LCCN 2021019492 (print) | LCCN 2021019493 (ebook) | ISBN 9781799884828 (hardcover) | ISBN 9781799884842 (ebook)
Subjects: LCSH: Sustainable development--Planning. | Environmental protection--Planning. | Climatic changes--Economic aspects. | Regional planning. | Land use--Planning. | Social planning. | Management--Technological innovations.
Classification: LCC HC79.E5 .S866847 2021 (print) | LCC HC79.E5 (ebook) | DDC 338.9/27--dc23
LC record available at https://lccn.loc.gov/2021019492
LC ebook record available at https://lccn.loc.gov/2021019493

This book is published in the IGI Global book series Practice, Progress, and Proficiency in Sustainability (PPPS) (ISSN: 2330-3271; eISSN: 2330-328X)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

# Practice, Progress, and Proficiency in Sustainability (PPPS) Book Series

Ayman Batisha
International Sustainability Institute, Egypt

ISSN:2330-3271
EISSN:2330-328X

## Mission

In a world where traditional business practices are reconsidered and economic activity is performed in a global context, new areas of economic developments are recognized as the key enablers of wealth and income production. This knowledge of information technologies provides infrastructures, systems, and services towards sustainable development.

The **Practices, Progress, and Proficiency in Sustainability (PPPS) Book Series** focuses on the local and global challenges, business opportunities, and societal needs surrounding international collaboration and sustainable development of technology. This series brings together academics, researchers, entrepreneurs, policy makers and government officers aiming to contribute to the progress and proficiency in sustainability.

## Coverage

- Technological learning
- Knowledge clusters
- Environmental informatics
- Outsourcing
- Intellectual Capital
- Global Business
- Sustainable Development
- Strategic Management of IT
- Global Content and Knowledge Repositories
- ICT and knowledge for development

IGI Global is currently accepting manuscripts for publication within this series. To submit a proposal for a volume in this series, please contact our Acquisition Editors at Acquisitions@igi-global.com or visit: http://www.igi-global.com/publish/.

The Practice, Progress, and Proficiency in Sustainability (PPPS) Book Series (ISSN 2330-3271) is published by IGI Global, 701 E. Chocolate Avenue, Hershey, PA 17033-1240, USA, www.igi-global.com. This series is composed of titles available for purchase individually; each title is edited to be contextually exclusive from any other title within the series. For pricing and ordering information please visit http://www.igi-global.com/book-series/practice-progress-proficiency-sustainability/73810. Postmaster: Send all address changes to above address.

## Titles in this Series

*For a list of additional titles in this series, please visit: www.igi-global.com/book-series*

***Sociological Perspectives on Sustainable Development and Poverty Reduction in Rural Populations***
Ladislaus M. Semali (Pennsylvania State University, USA)
Information Science Reference • © 2022 • 303pp • H/C (ISBN: 9781799846468) • US $195.00

***Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals***
Cristina Raluca Gh. Popescu (University of Bucharest, Romania & The Bucharest University of Economic Studies, Romania & University of Craiova, Romania & The National Institute for Research and Development in Environmental Protection (I.N.C.D.P.M.), Romania & National Research and Development Institute for Gas Turbines COMOTI, Romania)
Engineering Science Reference • © 2021 • 461pp • H/C (ISBN: 9781799884262) • US $295.00

***Advancements in Sustainable Architecture and Energy Efficiency***
Roberto A. González-Lezcano (Universidad CEU San Pablo, Spain)
Engineering Science Reference • © 2021 • 337pp • H/C (ISBN: 9781799870234) • US $195.00

***Management and Conservation of Mediterranean Environments***
Rui Alexandre Castanho (WSB University, Poland) and José Martín Gallardo (Universidad de Extremadura, Spain)
Engineering Science Reference • © 2021 • 336pp • H/C (ISBN: 9781799873914) • US $195.00

***Handbook of Research on Institution Development for Sustainable and Inclusive Economic Growth in Africa***
Evans S. Osabuohien (Covenant University, Nigeria) Emmanuel A. Oduntan (Covenant University, Nigeria) Obindah Gershon (Covenant University, Nigeria) Olaronke Onanuga (Covenant University, Nigeria) and Oluyomi Ola-David (Covenant University, Nigeria)
Business Science Reference • © 2021 • 507pp • H/C (ISBN: 9781799848172) • US $235.00

***Digital Solutions and the Case for Africa's Sustainable Development***
Albert Ong'uti Maake (University of Lay Adventist of Kigali, Rwanda) Benard Magara Maake (Kisii University, Kenya) and Fredrick Mzee Awuor (Kisii University, Kenya)
Information Science Reference • © 2021 • 200pp • H/C (ISBN: 9781799829676) • US $195.00

***Examining Biophilia and Societal Indifference to Environmental Protection***
Mary Ann Markey (Grand Canyon University, USA) and Lonny Douglas Meinecke (King University, USA)
Engineering Science Reference • © 2021 • 279pp • H/C (ISBN: 9781799844082) • US $195.00

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

701 East Chocolate Avenue, Hershey, PA 17033, USA
Tel: 717-533-8845 x100 • Fax: 717-533-8661
E-Mail: cust@igi-global.com • www.igi-global.com

# Editorial Advisory Board

# List of Contributors

# Table of Contents

# Detailed Table of Contents



This research tries to understand the Sustainable Development Goals (SDG) from the perspective of social ecology and environmental law, away from the Darwinian theory of man dominating nature and more focused on rethinking the SDGs from the nature-society co-evaluation in the adaptive sense of society to the new reality of its physical-natural support and to the new legal system of human rights. Development with victims from biologically rich countries like Peru with paradoxical poverty is analyzed, and likewise, the collapse of society in the face of imminent climate change due to human action is analyzed, which requires climate justice for environmentally displaced people in the face of the violation of their human rights, especially of children at risk. Finally, a Latin American academic contribution is presented to rethink the SDGs, generating contributions to the later times of the social confinement of COVID-19, in the so-called new normal.



Many of the most valuable contributions of ecosystems to human wellbeing are ecosystem services and are generally underrepresented in assessments. Indirect and direct factors including biophysical dynamics like soil properties, changing climatic conditions, plant functional structures, and anthropogenic activities

Kyrgyzstan, Kazakhstan, North-West China, and Mongolia, known as the Land of Turks. The water needs of the population within the borders of Central Asia are met by more than 6000 lakes of various sizes and rivers pouring into these lakes. Climate change, which has been heavily felt in the region in the last 50 years, negatively affects water resources and human life in large lake basins. In this study, how the water resources in the large lake basins in Central Asia, especially in the Aral and Balkhash basins, are affected by climate change and how the climate change scenarios will develop were investigated. In addition, conflicts caused by the use and sharing of water between the countries have been identified, and the effects of these conflicts on social life, especially migration, have been discussed.


*Pedro dos Santos Portugal Június, University of South Minas, Brazil*
*Fabricio Pelloso Piurcosky, University of South Minas, Brazil*
*Rodrigo Franklin Frogeri, Centro Universitário do Sul de Minas, Brazil*
*Luiz Carlos Vieira Guedes, University of South Minas, Brazil*
*Sema Ylmaz Yılmaz Genç, Kocaeli University, Turkey*

The present study addresses the issue of mineral waters in Brazil, its institutional problem, and the consequences and conflicts arising from its irrational exploitation. As a solution to these problems and conflicts, it is proposed to integrate these mineral waters and their different types in the management of water resources and the application of guiding economic and ecological principles as in the case of the conception of post-normal science and the precautionary principle. To meet the objective, the authors opted for an exploratory and bibliographical research regarding the adopted procedure. It is concluded that the implementation of an institutional change will allow a participative and polycentric management, mainly at the level of the hydrographic basin committees, which will contribute to the application of the two mentioned principles and a sustainable management of this resource. However, there is a need for improvements in the national water resources policy to more effectively cover groundwater in which mineral waters are embedded.


*Javier Lozano Parra, Universidad Autónoma de Madrid, Spain*
*Jacinto Garrido Velarde, University of Extremadura, Spain*
*Ignacio Aguirre, Centre for Hydrology, University of Saskatchewan, Canada*

This study quantifies the current and future soil water balance in a spatially distributed way for the whole of Chile and establishes what biomes will be the most affected by variations in water resources. The study of water resources reveals that 90% of surface Chile will reduce its soil water resources in the future if greenhouse gas concentration in the atmosphere does not stop. The most disadvantaged biomes are the forests, where soil water availability could decrease an average of 100 mm/year. Desert biomes could not perceive the hydrological imbalances; however, it is expected its surface increases.

Costa Rica is recognized for its efforts in sustainable development. This study analyzes the challenges of environmental sanitation to articulate environmental management in the Canton of Heredia. Currently, the country faces significant challenges regarding access to water and environmental sanitation. This research contributes to the analysis of the challenges of the environmental sanitation system in this territory. The testing techniques and photographic registration in the impact area, along with the interviews with employees and professionals on the subject, and extensive bibliographic consultation support this methodology. The study's conclusions regarding the challenges of environmental sanitation are 1) legal and institutional framework faced by the environmental sanitation project of the Publics Services Company of Heredia (ESPH for its initials in Spanish), 2) strategy for the treatment of sanitary waters in the canton, and 3) improvement in the quality of life of the Heredia's citizens.



Nigeria is one of the world's most vulnerable countries to extreme weather conditions and natural disasters linked to climate change, the impacts of which are exacerbated by rapid population growth, a fragile economy, high dependence on rain-fed agribusiness, and the country's weak adaptive capacity. The lack of or poor application of environmental communication in a strategic approach is critical to all of these. Using a thematic conceptual review of existing literature, this chapter shows that strategic environmental communication can be applied more easily to mitigate the impacts of climate change and environmental degradation through the use of well-established communication strategies and instruments to save the environment for socio-economic development.



The circular economy (CE) is a new paradigm that helps create convergence into a more sustainable society. This chapter shows the main findings of a systematic literature review examining the state of the art of the business concept of sustainability and CE and how scholars have focused on the implementation of circular and sustainable principles in sectors and firms. The main findings show a lack of consensus on definitions related to CE, creating confusion among firms. Final findings also show the challenges that businesses face and the main obstacles that explain why some organisations fail in the transition. Additionally, this review helps to highlight the main research gaps on the topic to encourage sustainability and circularity among firms. Whilst there are an increasing number of papers related to circularity and

The world has realized the fact that the limited resources can't be sustainable for a long time. Sustainable transformation is a key issue to save the current resources and natural environment for the next generation. 2030 Sustainable Development Goals (SDGs) can help governments to focus on main issues to achieve a balance between social, environmental, and economic development. At this point, Goal 6 points out the importance of saving clean and safe freshwater resources. This chapter aims to present the link between municipalities and water security in Turkey. Turkey case was selected according to its risky position in the level of water stress. This study used recent reports and statistical data on environmental indicators related with freshwater resources and the implications of municipalities in Turkey. Environmental Indicators 2020 Report guided the authors to determine water indicators in Turkey. In addition, the available open access data from TURKSTAT is used to determine water supply services of municipalities.

**Section 2**
**The COVID-19 Pandemic, Tourism, and New Technologies**



The COVID-19 pandemic has changed the progress in 2030 Sustainable Development Goals, and policymakers have been challenged with the implications of conventional economic system in the market. At this point, it can be said that the adoption of the best alternative economic and business model for the marketplace is the new phenomenon during the COVID-19 pandemic. Accordingly, alternative economic and business models can reduce the carbon emission, environmental pollution, and global warming, but there is a still dark point in solving social issues globally. This study aims to give a brief framework for alternative economic and business models in the context of sustainability. This study presents the links between 2030 Sustainable Development Goals, digital economy, and de-growth. In other words, this chapter focuses on digital economy (digitalization) and degrowth model (degrowing). Accordingly, it is thought to give an up-to-date work for achieving sustainable development after the COVID-19 pandemic in the long term.



The COVID-19 outbreak and its global spread through human-to-human contact have made it even more important to analyze the environmental effects. The higher the population, the higher the energy usage, the higher amount of carbon emissions, and the faster the environmental degradation. Having a high-quality environment is important for people to protect themselves from infection. During the lockdowns, city residents could benefit from the environment. Shutdowns contributed not only to break the chain of infections but also to the development of the environment and ecosystems. Due to the great cuts in transportation and industrial sectors, air and water pollution levels have come down, and nature has started to reassert itself. In this process, governments have a great role to fight the pandemic and protect the environment. In this chapter, environmental sustainability and the role of governments during

socio-cultural values and public understanding to strengthen the sustaining practices of governance. The method employed is the reflective approach based on an analytical review of the theoretical literature and empirically derived current practices in communities, governments, and organizations. The analysis concludes that the implementation of a sustainable socio-intercultural socioeconomic and environmental development needs to be supported by a well-designed institutional governance. To achieve this, a commitment on the practice of effective community economic growth and socio-environmental sustainable development is required.



The chapter's main objective is to study the city's rising role as a driver for implementing the 2030 SDGs and UNESCO Creative Cities Network's part as UNESCO's mechanism to support cities in the effort. The results show that there is a changing nature of authority in the policy cycle on a more holistic level, where alongside the nation-state, international organizations and cities play a vital role in the problem definition, decision-making, agenda-setting, transfer, and implementation of policies. The increasing importance of cities internationally stretches the municipal policy cycle from the local to regional, national, and international levels. Orchestration complemented with an inter-organizational relations framework is used to study the case of Idanha-a-Nova UNESCO Creative City of Music. The case study shows that Idanha-a-Nova drove the implementation of the SDGs locally with the Portuguese state's support. However, because it lacked expertise and mechanisms of implementing the goals, it reached out to private consultancy and individual experts.



The ultra-peripheral Portuguese region of Azores is considered one of the EU outermost regions. This insular region is widely recognized as a sustainable nature-based destination. Its remoteness and breathtaking landscape attributed the region a label of adventure tourism by global references as Bloomberg, Departures, BBC, Forbes, GeekyExplorer, Lonely Planet, among others. In this regard, this type of tourism incorporated with the digital marketing generated around it is seen as a vital channel for inspiring sustainable regional development. Consequently, it is possible to verify that the digital marketing created around this new typology of tourism along with the Azores' singularity as a destination could significantly influence the local socio-economy base to the sustained development growth of the region. Furthermore, it was identified that the most reasonable opportunities for slow and nature-based tourism were located in rural tourism.

The Azores are an increasingly attractive tourist destination. The excellence of endogenous resources has allowed it to consolidate its position as nature and adventure destination. Consequently, the regional strategy seeks to base this sector's growth on the principles of sustainable development. The potential granted by the new technologies is combined in an excellent opportunity to pursue this objective and convert the Azores into a smart tourist destination. Thus, according to this vision, a conversion plan was elaborated that can guide the performance of the destination management bodies and other stakeholders. In methodological terms, different techniques were applied, including the identification of good local practices and case studies for benchmarking, a self-diagnosis, interviews with stakeholders, and a SWOT analysis. The plan was concluded with the definition of measures, actions, and pilot projects to be implemented in the region following a structure based on the smart destinations development axes proposed in 2015 by Segittur.



This chapter seeks to understand the motivations that lead companies to internationalize and how they do it since this has been a constant challenge for business research. For this purpose, a descriptive research was conducted with a qualitative strategy applied on different companies in the wine sector. International trade is a Portuguese tradition that started and reached its peak in the 16th century with the Portuguese and Spanish discoveries, which justifies this study. The wine industry, particularly in the Douro Region, has also always been closely linked to foreign trade and has even benefited from a historic trade agreement with the United Kingdom. The empirical results show that companies are practically born international. The size of the domestic market was the main justification for the demand for external markets. The constant evolution of markets and industries generates opportunities and potential threats to which companies must be able to respond.

The Sustainable Development Goals (SDGs) represent an innovative strategy to transform the socio-economic and environmental aspects of communities. Sustainable development provides the communities with a set of substantial challenges that are totally geospatial in concept and practice. Most of these challenges can be identified, examined, and visualized within a spatial framework. Despite of noteworthy progress in geospatial information system and science, the lack of comprehensive impressions in planning necessitates the integrative role of geospatial information. This study aims to investigate this role in contributing to SDGs by describing each single goal and following objectives. Furthermore, spatial and non-spatial issues regarding every specific SDG will be accurately discussed to determine the spatial aspects in practice. In this way, the communities will be empowered by unique opportunities to integrate and represent geospatial information into the global agenda in a specific manner, specifically in contributing data resources toward measuring and monitoring the 17 SDGs.



Open, systematic, and global approaches are needed to address the challenges of aeroconservation and pest management. Recent technical progress enables deeper investigation and understanding of aeroecology. Radar plays a central role in flying species monitoring in the global scope. The technology provides various ways of target detection and tracking, working for multiple ranges and different visibility. The existing technology allows deploying global monitoring of avian and insect species. This work discusses the essentials of the technology and the history of its application for bird and insect detection. The author describes the development of the topic according to the main groups of radar approaches: pulsed sets, vertical-looking solutions, harmonic systems, and efficient frequency modulated continuous wave radar. Advances in big data processing, robotics, computation, and communications enable practitioners to combine the discussed radar solutions aiming at global avian and insect biodiversity monitoring and negative human impact systematic estimation.



Cities present multiple opportunities to create a more sustainable future by way of enhancing resource-efficiency and fostering innovation and political and social responsibility. The imperative for biodiversity in cities therefore goes beyond simple conservation to considerations of internalizing provisions of ecosystem services, which would otherwise be sought from outside the city. By presenting a practical approach to biodiversity planning and management, this toolkit seeks to help local governments harness available resources and opportunities to address global biodiversity loss by providing them a baseline of biodiversity, which would further help them to prepare local biodiversity strategy and action plan under the mandate of Biological Diversity Act 2002 providing the scope to municipal corporations to perform all activities relevant to overall biodiversity management. The study proposes a complete framework for formulating LBSAP using the existing tools for biodiversity assessment and how it can be incorporated into the city development plan for effective implementation.



This work analyses energy expenditure in outdoor sport environments with augmented reality technology. Battery efficiency is becoming a relevant topic in the context of the varied outdoor end-user services, among other realms. It is a key to the acceptance and use of mobile technology. In outdoor environments, battery efficiency can be low, especially when information based on close-to-real-time requires internet access and the use of sensors. Such requirement is today evident with the growth of internet dependence and multiple sensors, which perform both actively and passively via fitness gadgets, smartphones, pervasive systems, and other personal mobile gadgets. In this context, it is relevant to understand how energy is spent with the accelerometer, global position system, and internet access (Wi-Fi or mobile data) providing smart data for outdoor sports activities. Through a prototype, an analysis is made based on the current battery autonomy, and an algorithm model for better battery efficiency is proposed.



This chapter assesses the link between climate change and digitisation of archives in South Africa. The study found linkage between flooding, fire, and digitization of archives in the sense that records required long-term preservation to be accessible. The chapter focuses on converting paper-based records into digital platforms as a strategic role to prevent records from damage. Heritage institution such as the National Archives of South Africa is in the forefront of the preservation of archives in South Africa. It is their national mandate to preserve archival materials and make them accessible to various stakeholders. The success of digitization is dependent on the organisation strategy. This means that partnership, privacy, copyright need to be considered. The research found that most of the heritage institutions in South Africa lack digitization strategy, which led to loss of institutional memory.



Currently, working conditions have been evolving continuously, which makes it necessary to incorporate teleworking as a means of support to fulfill the tasks entrusted. However, this type of employment brings with it vulnerabilities within companies that are not prepared for such a situation. For this reason, a teleworking model is proposed to improve the management of information security in organizations in the commercial sector. This research is of a basic type with a non-experimental design and correlational

# Foreword

Humanity is living at a crossroads in its history. On other occasions, the decisions we make together today will be decisive for our future and the next generations. It is in our hands that, when the latter study and judge our choices and behaviors, as far as the conservation of the biosphere is concerned, they must state that we were senseless and short-sighted or wise and long-minded. Compared with other critical moments that humanity faced, today we have a crucial advantage: human beings never had a capacity to access information like the current one. If we receive a conviction, we cannot appeal to ignorance as a mitigating circumstance if we choose the wrong path. A reliable proof is this publication that collects fundamental aspects and analyzes the most current trends of the concept of sustainable development from different perspectives. Together with elements of a theoretical nature, it compiles experiences of a practical nature, and as the conjunction of both inevitably leads both to changes of an economic nature and to the generation of legal bodies aimed at achieving those objectives that are simultaneously related to sustainable development. Therefore, the reader can enjoy a wide range of chapters that delve into such exciting issues as our patterns of use of resources and energy, strategies to strengthen the circular economy, the assessment of environmental impacts as a tool to minimize the degradation of natural resources. Ecosystems and preserve ecosystem services, or the organization of cities as the source and possible solution of environmental problems. It also includes studying the consequences of a hot topic: the effects of the SARS-CoV-2 epidemic that causes COVID-19. In fact, the virus, which has led to the emergence of new scenarios with large-scale social, economic, and environmental effects. The volume that the reader has in his hands will help ´*the wolf not eat the sheep*` since the alarm is real.

*José Martín Gallardo*
*University of Extremadura, Spain*

# Preface

In the last few years, the world was changing considerably. Within the many obstacles, barriers, and opportunities, three significant challenges should be considered for the future planning of our territories and cities are: (i) seeking to achieve the Sustainable Development Goals (SDGs); (ii) facing the Climate Changes; and (iii) performing a shift towards the Digitalization.

If we look back, the concept of 'sustainable development' was firstly introduced in the global policy debate by the World Strategy for Nature. In fact, it was instituted as a new world standard after 'Our Common Future,' - the final report of the Brundtland Commission (Spangenberg, 1995, 2000; Loures, Santos and Panagopoulos, 2007; Castanho, 2017; Castanho *et al*., 2017). Nowadays, this development is often interpreted as the process of meeting the requirements of today without jeopardizing the needs of future generations and, at the same time, do no limits their possibilities to design the territory in their own way (Castanho Couto, and Santos, 2021; Ulucak, Yücel and Koçak, 2019; Castanho, Couto, and Pimentel, 2020). However, by the present moment the sustainable development is no longer a choice, but a necessity of us all. In fact, if we look to prosper as a society, and probably as a specie, there is no alternative instead of opting for a typology based on a sustainable development and growth. Here lays the relevance of the studied topics of the present monography.

Based on several failures over the last few decades, since the utopic concept of sustainability and sustainable planning emerged, the global community finally understood the urgency of this type of development. So, it was necessary to establish the so-called Sustainable Development Goals (SDGs). In fact, several global issues were pivotal to this, being the climate crisis probably one of the most relevant.

Moreover, the pursuit of understanding deeper many fields of science and create more sustainable cities, as is the case of the smart cities, the digital tools become critical for helping us in the pursuit of such goals. Thereby, digital and digitization tools are often seen as solutions to these challenges, and this is the case today and more than ever (the SARS-COV-2 pandemic), as cities and residents look to digital solutions as a way to maintain their lives daily in the context of the sanitary crisis and beyond (ICLEI, 2020). The Digital transaction is inevitable!

Contextually, specific fields within these three main subjects (Sustainable Development Goals, Climate Change, and Digitalization) were studied through this monography. Nevertheless, many other thematic fields within these three major topics should continue to be investigated and analyzed in more detail, such as the Common and Regional Planning and Management, the Migration Fluxes, Public Health Strategies, Land Use Policies, and Spatial Socio-Economic Analysis, among several others. Consequently, it will enable us to identify and define the critical factors for territorial success in the upcoming decades (to be considered) by the Main-Actors, Decision and Policy Makers, Technicians, and Public in General.

Therefore, this publication expects to be a powerful scientific contribution to help us plan our common future.

## ORGANIZATION OF THE BOOK

This book is organized into 33 chapters. A brief description of each of the sections and chapters follows:

### Section1: Ecology, Circular Economy, and Governance

Chapter 1 provides a distinctive viewpoint for the Sustainable Development Goals concept from the perspective of the Environmental Laws inherent to the thematic fields of Social Ecology.

Chapter 2 intends to identify all these critical factors related to Ecosystem Services for Environmental Sustainability. Besides, the authors present suggestions of how to enhance ecosystem services through a long-term program model.

Chapter 3 analyzes the growing problem and awareness of the impacts of Environment Protection Laws on Ecological Degradation. The author explores the case of India. Throughout this chapter, it is possible to learn new insights about this thematic issue.

Chapter 4 addresses the problems related to variations in the landscape caused by transportation infrastructures creation. In this specific case, the authors highlight a Spanish territory situation related to high-speed railways through Geographic Information Systems – GIS tools.

Chapter 5 addresses the hot topic of climate change focusing on Ecological, Political, and Social Impacts. This study shows the climate scenarios for the Large Water Basins of Central Asia.

Chapter 6 approaches the issue of mineral waters in Brazil. Throughout this chapter, an institutional problem and the consequences and conflicts arising from its irrational exploitation are explored. In this regard, the authors propose integrating these mineral waters and their different types in the management of water resources.

Chapter 7 follows the same line of the previous contribution, yet, in this case, the author addresses the issue of Water resources in Chile. This chapter makes it possible to understand the current and future projections and their relationships with biomes.

Chapter 8 investigates the effects of environmental sanitation in a specific region of Costa Rica. The study's conclusions allow us to consider some legal and institutional frameworks faced by the environmental sanitation project of the Publics Services Company of Heredia or strategies for treating sanitary waters.

Chapter 9 centers on the thematic of strategic communication for sustainable environmental development. Contextually, the authors provide us an interesting review of this topic and, in particular, about the situation in the Northern Nigerian Region.

Chapter 10 reviews the thematic field of the sustainable circular economy. Therefore, this review helps to highlight the main research gaps on the topic to encourage sustainability and circularity among firms.

Chapter 11 follows the same issue of the previous contribution. Here, the authors emphasize practical strategies to reduce consumption and promote circularity, specifically in urban centers.

Chapter 12 investigates the barriers that overall hinder the implementation of the Circular Economy (CE) principles within the European manufacturing sector. Based on an in-depth literature review carried out with a systematic approach, this study identifies and describes the external and internal barriers that affect the implementation of CE principles.

Chapter 13 measures the asymmetry effect of research and development (R&D) investments, population growth, energy consumption, and economic growth on carbon emissions in the sample of Turkey for the period 1990-2020. Some of the findings point that economic growth and R&D are efficient in reducing carbon emissions, while energy consumption increases carbon emissions.

Chapter 14 provides an appealing discussion of the redefinition of smart cities, urban energy, and green technologies for sustainable development. In this chapter, framework information for the position of cities in climate change and environmental pollution globally is debated.

Chapter 15 approaches the topic of land use and sustainable resilience. This work highlights the design and use of urban land should consider including a multi-functional green infrastructure to obtain different benefits, from ecosystem services to value creation. Furthermore, it is possible to learn that the urban land use planning system contributes to economic growth, social development, and environmental sustainability.

Chapter 16 deals with problems related to the local perspectives of sustainable urbanism. This study reflects the particular situation occurring in the Spanish legislative model.

Chapter 17 aims to display the connection between municipalities and water security in Turkey. This research used reports and statistical data on environmental indicators related to freshwater resources and the implications of municipalities in Turkey.

## Section 2: The COVID-19 Pandemic, Tourism, and New Technologies

Chapter 18 exposes a review of a different economic approach to reach the so-desired sustainable development. Therefore, the actual scenario of the pandemic crisis of SARS-COV-2 and the links between 2030 sustainable development goals, digital economy, and de-growth are discussed.

Chapter 19 analyzes environmental sustainability and the role of governments during the pandemic of Covid-19. Moreover, this work displays possible solutions for environmental sustainability that governments can provide.

Chapter 20 evaluates the sustainable development goals from a social work viewpoint in the Covid-19 period. Thereby, this chapter discloses the growing problem and awareness of the impacts of environmental protection laws on ecological degradation.

Chapter 21 review on the topics related to tourism, entrepreneurship, and sustainability. So, based on the theoretical framework and the review of relevant global environmental and tourism-specific tendencies, this chapter enables us to understand how young adults perceive entrepreneurship and sustainability in tourism and the contribution of those two for the so-desired sustainable development.

Chapter 22 addresses the problems and tendencies related to sustainable socio-intercultural development. This study assumes that the implementation of a sustainable socio-intercultural socioeconomic and environmental development needs to be established by well-designed institutional governance.

Chapter 23 intends to study cities' rising role as drivers for implementing the 2030 sustainable development goals and UNESCO Creative Cities Networks. This study was used as a case study of the Portuguese city of Idanha-a-Nova.

Chapter 24 centers on digital brand marketing in ultra-peripheral territories. With this chapter, it is possible to verify that the digital marketing created around this new typology of tourism and the Azores' singularity as a destination could significantly influence the local socio-economy base to the sustained development growth of the region.

Chapter 25 follows a similar line of research. Nonetheless, in this case, how to convert a region into a smart tourism destination.

Chapter 26 intends to understand the motivations that lead companies to internationalize a product. In this case, the authors used the Douro Demarcated Region as a case study. Therefore, it is possible to evidence the continuous evolution of markets and industries creates opportunities and potential threats to which companies must be able to react.

Chapter 27 focuses on the pivotal role of the Geographic Information Systems (GIS) in advancing science and, consequently, reaching the desired sustainable development goals.

Chapter 28 discusses the essentials of the technology and the history of its application for bird and insect detection. Besides, the author explains the evolution of the topic according to the main groups of radar approaches.

Chapter 29 presents a practical approach to biodiversity planning and management. Thus, it is presented a toolkit for the conservation of urban biodiversity. Also, the study allows us to learn a complete framework for formulating LBSAP using the existing tools for biodiversity assessment and how it can be incorporated into the city development plan for effective implementation.

Chapter 30 analyses energy expenditure in outdoor sport environments with augmented reality technology. In this regard, the author presents an analysis of the current battery autonomy and an algorithm model for better battery efficiency through a prototype.

Chapter 31 assesses the link between climate change and the digitization of archives in South Africa. Furthermore, the study found that most of the heritage institutions in South Africa lack a digitization strategy which led to a loss of institutional memory.

Chapter 32 studies the changes in the Peruvian Inbound Tour Operators by analyzing Teleworking and Worker Productivity.

Chapter 33 addresses the plastic greenhouses in Valparaiso, Chile. The study shows the relevance of the GIS tools and consequently proposes a new methodology through Landsat 8 and Data Cloud Platform.

*Rui Alexandre Castanho*
*WSB University, Poland*

## REFERENCES

Castanho, R. A. (2017). *Sustainable Urban Planning in Transboundary Areas: Analysis of Critical Factors for Territorial Success* (Doctoral Thesis). University of Extremadura (UEx), Department of Vegetal Biology, Ecology and Earth Sciences.

Castanho, R.A., Cabezas, J., Loures, L., & Fernández-Pozo, L. (2017). Evolution of Urban Planning Process in the Iberian Peninsula and his Footprints in Cityscape. New Challenges. *Monfragüe Resiliente – Scientific Journal, 8*(2).

Castanho, R. A., & Couto, G. (2020). Principles of Sustainable Tourism and Cultural Management in Rural and Ultra-peripheral Territories: Extracting Guidelines for its application in the Azores Archipelago. *Cultural Management: Science and Education (CMSE)*. doi:10.30819/cmse.4-1.01

Castanho, R.A., Couto, G. & Santos, R. (2021). *Introductory Chapter: Rural Tourism as a Catalyst for Sustainable Regional Development of Peripheral Territories*. doi:10.5772/intechopen.96651

ICLEI - Local Governments for Sustainability. (2020). *Digitalização na Era Covid-19: Desafios e Oportunidades para as Cidades.* Available at: https://smart-cities.pt/noticias/iclei-2508digitalizacao/

Loures, L., Santos, R., & Panagopoulos, T. (2007). Urban Parks and Sustainable Development – The Case Study of Portimão City, Portugal. In A. Stamou, T. Panagopoulos, E. Stamatiou, A. Hatzopoulou, & D. Antunes (Eds.), *Energy, Environment, Ecosystems & Sustainable Development* (pp. 127–131). WSEAS Press.

Spangenberg, J. (1995). Towards Sustainable Europe. A Study from the Wuppertal Institute for Friends of the Earth Europe.

Spangenberg, J. (2000). *Sustainable Development – Concepts and Indicators*. Colonia.

Ulucak, R., Yücel, A., & Koçak, E. (2019). *The process of sustainability: From past to present.* EKC. doi:10.1016/B978-0-12-816797-7.00005-9

# Acknowledgment

I would like to acknowledge all the book contributors. The very professional and resilient reviewers, the editorial advisory board, as well as to the incredible IGI Global assistants assigned to me. In fact, without any of the previous-mentioned key persons, this successfully published book project was not more than that...just a project…many thanks to you all!

This book is dedicated to my grandpa for providing me the right tools to achieve my professional objectives. An eternal thanks.

# Section 1

# Ecology, Circular Economy, and Governance

# Chapter 1
# Re-Thinking the Sustainable Development Goals From the Point of View of Social Ecology and Environmental Law

**Edwin Vegas-Gallo**
*Universidad Peruana de Ciencias e Informatica, Peru*

**Wilfredo Vegas-López**
*Liga Mundial Abogados Ambientalistas, Peru*

**Alex Pacheco-Pumaleque**
*Universidad Peruana de Ciencias e Informática, Peru*

## ABSTRACT

*This research tries to understand the Sustainable Development Goals (SDG) from the perspective of social ecology and environmental law, away from the Darwinian theory of man dominating nature and more focused on rethinking the SDGs from the nature-society co-evaluation in the adaptive sense of society to the new reality of its physical-natural support and to the new legal system of human rights. Development with victims from biologically rich countries like Peru with paradoxical poverty is analyzed, and likewise, the collapse of society in the face of imminent climate change due to human action is analyzed, which requires climate justice for environmentally displaced people in the face of the violation of their human rights, especially of children at risk. Finally, a Latin American academic contribution is presented to rethink the SDGs, generating contributions to the later times of the social confinement of COVID-19, in the so-called new normal.*

## INTRODUCTION

The global health crisis that humanity faces, makes us rethink the Sustainable Development Goals (SDG),

DOI: 10.4018/978-1-7998-8482-8.ch001

in the construction of the new paradigm of social ecology, avoiding the tragedy of the common good in its two essential characteristics: that there is no rivalry for them and there are no exclusions of people; so that we can all enjoy those. The SDG action plan made up of 17 goals and 169 targets that the 193 member states of the United Nations system adopted in the 2030 Agenda for Sustainable Development, seek to end poverty, fight inequality and tackle climate change by 2030. To understand these SDGs with the new paradigm of Social Ecology, we must go to the political implications of Darwin's Theory, based on competition and the survival of the fittest and with this "scientific justification" the expansion of the British Empire over the rest of the world. The Darwinian displaced the study of biological interactions, which are collaborative ways of sharing resources in the strict sense of the laws of nature. Darwin was used to impose the idea "the dominating man of nature", in the thought of "the supremacy of the strongest over the weak". Darwin's Theory is the evolutionary biology of the species with reproductive isolation as a real entity, while Ecology emphasizes community relations, including the human one, especially in adaptation. This approach responds to the interactions between human flora and fauna species as one of the engines of evolution.

Like biological interactions that lead to modifications in ecosystems; in human interactions with ecosystems, the same thing happens, they are degraded if they are managed beyond their capacity for recovery and self-purification, with which toxic substances generate risks to human health as a result of human activity itself; above all, in a relationship marked in the linear sequence: ecosystem-merchandise-profit, which leads to an individual and unsupportive linear worldview, producing a Global Unsustainability Crisis (Vegas-Gallo, 2003).

With social ecology and environmental law, we intend to rethink the SDGs based on the coevolution between nature and society, in view of the fact that human societies transform their natural environment by producing changes in social structures, to adapt to the new realities of their natural physical support, with an environmental justice system. We see this positive relationship between society and nature in the first empire of pre-Columbian South America, of the Wari culture, which with an elliptical worldview settled in the heights of the current Moquegua Region, managing the water resource in the rainy and dry seasons to develop agriculture and allow geographic expansion. This means that the relationship is not individual but social community. The link between man and nature should obey a shared and ethical worldview for sustainability, considering that "globalization has fallen into an ethical vacuum." It is evident that it is necessary to promote it politically to move towards a sustainable society.

## DEVELOPMENT WITH VICTIMS: PARADOXAL POVERTY OF BIOLOGICALLY MEGADIVERSE COUNTRIES

Within this list of "mega diverse countries" there are 6 Latin American countries (Mexico, Colombia, Ecuador, Peru, Brazil, Venezuela), which from the beginning of the 21st century to the present show a severe picture of "paradoxical poverty" (Kliksberg, 2004). Peru, with a territory dominated by the Andean mountain, presents a particular biogeography with life zones that go from the coastal desert-marine edge to the Andean ecosystems and the humid mountain ecosystems run along the eastern mountain range. This geography favors the biological richness of species, ecosystems and landscapes; cultural and ethnic. Within its territorial limits a high specific richness of mammals, birds, reptiles, amphibians, marine fish and continental waters has been recorded. In its floristic diversity it registers almost 25 thousand species, being one of the twelve original centers of agricultural cultivars on the planet. Peru with these figures can aspire to a country with high human development, in a modern futuristic vision and taking advantage of its comparative advantages; unfortunately, it is an exporter of natural resources without added value.

These biological figures are paradoxical with their medium to low human development, with 51.3% of Peruvians in poverty and 23.1% in extreme poverty (figures before the COVID-19 pandemic). It ranks 123rd out of 196 countries in literacy rate and 88th in infant mortality (18.4 deaths / 1000 normal births); while life expectancy (79.74 years) is in 36th place globally and third regionally. For (Kliksberg, 2004), the answer goes through the ethical challenge in Latin America mainly in the fight against state corruption (Case of the Transnational Odebrecht of Brazil), drug trafficking, uncontrolled migration, lack of education and health, it also goes through protect infants at risk, families burdened by poverty, provide opportunities for young people and reduce crime. In short, social justice is required.

In the exporting primary development model, dependent on Natural Resources NR, "Western consumerist naturalism" predominates, which considers nature external to humans, without being subject to law; consuming 1% of the world's population 80% of the world's natural resources deepening the ecological footprint (urbanized land, carbon dioxide, farmland, fishing grounds, forest products, grazing lands), in which Western naturalism it demands more from nature than it can produce. In the past 55 years the demand for natural resources in the world has exceeded available biological capacity, leading most countries to live with ecological deficits and the collapse of their societies.

## COLLAPSE OF CURRENT SOCIETY

In his research, (Herrington, 2021), warns that the collapse of society would take place in 2040: "without a drastic change, industrial society is heading for collapse", corroborating a study by the Massachusetts Institute of Technology (MIT) (Meadows et al., 1972), the conclusion of which indicated "the search of humanity by economic growth without taking into account environmental and social costs would lead to the collapse of society in the middle of the 21st century". Herrington using the World3 computing model, concludes "the consumer entrepreneurial mindset puts emphasis on business above all else, will lead to a decline in economic growth in the next decade (2021-2030), followed by total social collapse by 2040. "This terrifying forecast" does not mean that humanity will cease to exist", but rather that "industrial and economic growth will stop and then decline, damaging food production and living standards." Regarding the results of the MIT 1972 model, Jerry Foster, team leader pointed out "around 2020, the condition of the planet becomes very critical… if we don't do about it the quality of life is reduced to zero… pollution becomes so serious that it will begin to kill people, which in turn will cause the population to decline, to a much lower figure than in 1900 ... at this stage, around 2040-2050, civilized life as we know it on this planet will cease to exist". It is remarkable the coincidence of the 2020 turning point indicated by Foster, with the beginning of the year of the C19 pandemic. Although the simulated scenario of MIT 1972 suggests a society doomed to failure, in Herrington's study (2021) it transcends that, with science and technology for sustainability, as well as greater investment in public services (especially in health, education and sustainable infrastructure) could lead us away from collapse. She adds "humanity will have to make a great effort in this decade to change this bleak future. Not all hopes are lost implies a deliberate and global change of trajectory towards other sustainable development goals that is not exclusively excessive economic growth to avoid the worst case scenario".

## ECOLOGICAL RESTORATION FOR DURABLE DEVELOPMENT

The formation of Planet Earth occurred 4.55 billion years ago and the beginning of life 3.55 billion years ago. Homo sapiens sapiens has required 99.99% of the evolutionary process of Life, with Humanity just being born 10 thousand years ago. In the last 70 years, ENVIRONMENTAL DAMAGE has occurred, which causes terrestrial architecture to collapse, destroying the ecological basis of life in the various biomes and terrestrial and marine ecosystems. This global crisis is the crisis of conventional development models. It is a development with victims. For the World Meteorological Organization (WMO) there is a 40% probability that Planet Earth will be closer to warming by 1.5 ° C in the next five years (2021-2025), a figure that would be close to the inflection point of 2 ° C forecast for 2050 (World Meteorological Organization, 2021). The Global Bulletin on Climate Change indicates that there is a 90% probability that the period 2021-2025 will be the warmest year in history. So far the warmest year has been 2016. In that sense, (Vegas-Gallo, 2018); points out "to conserve biodiversity, the factors that threaten it must first be recognized and clearly defined". Among them he cites the loss and fragmentation of habitat, overexploitation, pollution and global climate change.

The Rio 1992 Conference was the starting point that forced countries to turn their attention to the environmental issue. The governments of the south do not fully understand that by destroying the ecological basis of life there will be no social development or economic development in the future. There are no magic recipes for solving the degradation of ecosystems. Basically, it involves modifying our economic system and consumption habits in such a way that the natural foundations of life are preserved. Faced with the possibility that humanity collapse, as Robert Heilbroner called it "ecological Armageddon" (Heilbroner, 1970), the United Nations calls on countries to urgently make peace with nature by promoting the restoration of ecosystems. For this, it has established from 2021 to 2030, the Decade for the recovery of terrestrial ecosystems; in an urgent call to wage a world war for the health of the planet. Likewise, for the strengthening of SDG 14 SUBMARINE LIFE, the United Nations Organization itself recommends that a joint effort be carried out between the States, the business community, fishermen's unions and the university academy (with ocean science and technology), to allow the Oceans to recover their health and provide proteins for human nutrition. In the Peruvian case, fishing and fisheries are managed by four business groups, burning proteins for flour and oil destined for animal feed, regardless of the sustainability of the fishery, only with a mercantile vision with the complicity of the government entities of control, supervision and investigation. marine importing little that many fish that Peruvians commonly consume could disappear as ocean warming increases the pressure on their survival, hampering their ability to survive.

Scientific research is crucial above all so that developing countries in the race against the clock for smarter development must race and prioritize their transition towards digital and ecological societies, designing new political tools to facilitate the transfer of technology with their own research to the industry, avoiding being recipients of foreign scientific knowledge and technology (Schneegans et al., 2021). With the current COVID-19 pandemic and the evolution of the geopolitical panorama, it is necessary to debate on how to safeguard strategic interests in health, education, trade and technology; starting by recognizing the unitary concept of health (human, animal and ecosystem health); understanding that public policies on health must consider both social and environmental determinants.

Given this, it is necessary to recognize that the current pandemic and others to come, prevention measures not only involve confinement or health education, such as hand washing, but also ensure that ecosystems are healthy as natural containment and containment barriers. that we also have an environmental policy with low impact.

## CLIMATE CHANGE, CLIMATE JUSTICE AND HUMAN RIGHTS

In a recent report, the Intergovernmental Panel on Climate Change (IPCC) points out "it is unequivocal that human influence is responsible for the warming of the atmosphere, the ocean and the earth" (IPCC, 2014). Although the results of the IPCC Report are not encouraging in concluding that humans are responsible for the current climate crisis and that we will exacerbate it in the near future; It is also true that the solution to that is in our hands with public policies to adopt reforestation measures and the elimination of the use of fossil fuels to slow down its anticipated progress, overcoming global warming in the 21st century of 1.5 °C and even exceeding 2 ° C.

(Vicedo-Cabrera et al., 2021), using empirical data (1991-2018) from 43 countries, estimated the mortality burden associated with exposure to heat produced by climate change. In all study countries they found that on average 37% of deaths are related to extreme heat. The study considered data from more than 29 million deaths. For Latin America the situation is more worrying. In Ecuador 76.6% of deaths are linked to high temperatures, Colombia 76% and Peru 73.5%.

## CLIMATE DISPLACED

With climate displaced persons or environmental refugees, both nationally and internationally, a true transgression of all human rights occurs, starting with the scarcity of resources for the displaced, the human right to education as seen in the indigenous and rural community, in Africa or even exchange of fish for sex in some African regions; the right to freedom of movement that due to climate change cannot return to the country of origin and even the right to decent housing (Ibarra-Sarlat, 2019).

It is necessary that the Courts of Justice begin to deal with these issues and for which there is a political and legal basis for the administration of environmental justice, referred to in Principle 10 of the Rio Declaration.

(ECLAC, 2020a), based on this Principle, has implemented the Escazú Agreement for Latin America and the Caribbean; whereby citizens can request information from governments regarding environmental conservation and also the duty of those for the protection of environmental defenders. Peru, due to political and business pressure, did not ratify the Escazú Agreement. However, there is the Madre de Dios Pact for Environmental Justice, with 10 commitments; taking into account the Amazon deforestation as a result of illegal gold mining and drug trafficking; that lead to the assassinations of environmental defenders (a dozen in the pandemic confinement) and environmental displaced people to Lima Capital.

Worldwide, there are nearly 30 million climate displaced people who left their homes due to disastrous floods attributable to climate change and whose human rights are precarious. In Piura, Peru, the year 2017; There was a Coastal Child with catastrophic floods, as a sign of global warming, leaving the infrastructure of the Region collapsed materially and without economic growth and with more than 30,000 people displaced to shelters, lacking water, drainage and electricity; with children who, before the pandemic, used to walk for miles among the dunes of the Sechura Desert to reach their Educational Center. Persistent and recurring situation since the sixties of the last century, in evident lack of concerted planning between the different levels of government for a dignified life with well-being. This Peruvian, Latin American and global reality with asymmetry and social inequity, leads us to the issue of violated human rights that collapse as a society. David Boyd High Commissioner of the United Nations (2021) points out “to conserve and protect nature, human rights must be placed as the central axis if we want to guarantee the future of life on our planet” and also expresses “leave human rights on the margins of the process cannot be an option, because conservation centered on them is the most effective, efficient and equitable way to protect the planet”.

In the Report (UNICEF, 2021) called “The climate crisis is a crisis of the rights of the child,” the Children’s Climate Risk Index, IRC, is presented, concluding that 1 billion children (almost half of the total of 2.2 billion that exist in the world) are severely exposed to the effects of the climate crisis, the most vulnerable being children in the Central African Republic, Chad and Nigeria. These children face the lethal combination of being exposed to multiple climatic and environmental shocks and being highly vulnerable due to the precariousness of the essential services they receive, such as water, sanitation, medical care, education and poor nutrition. An emblematic case of climate justice that deserves to be pointed out is the Schell Case, in the Court of Justice of The Hague (Friends of the Earth International, 2021), which obliges the oil company to reduce greenhouse gases by 45%, as it had in 2019. Although It is true this ruling is only applicable in the Netherlands, it will undoubtedly have worldwide repercussions. The positive of the sentence is that the Dutch justice includes the principles of precaution, prevention, environmental damage and non-regression in environmental matters.

## FINAL COMMENT

Last 2020 the Peruvian University of Sciences and Informatics UPCI, the Autonomous University of Guerrero UAGro, Mexico; the World League of Environmental Lawyers LMAA, Mexico and the Center for Research and Development of Education, Culture, Science and Technology CIDECCYT; held a panel in eight sessions rethinking the SDGs, for the Post Covid 19 time, generating contributions to the later times of social confinement to what is called “new normal”, in the vision of Social Ecology and Environmental Law; understanding that the fatal, social and economic consequences of C19 are as dramatic and threatening as are its structural causes (ŽIŽEK, 2020), (WHO, 2020); transmitted through the YOUTUBE channel of CIDECCYT.

The joint work that is proposed is in accordance with the consideration of the “2030 Agenda that in the post-Covid-19 world requires more cooperation and regional integration, greater multilateralism and productive integration”; consistent with the Report (ECLAC, 2020b): The social challenge in times of COVID-19, where an economic, social and welfare proposal is proposed. The Report points out “there is a fragility of the welfare state in the people of Latin America and the Caribbean, because access to health is fragmented by income levels, a problem that is exacerbated by the existence of vulnerable groups that do not have an affiliation to get a retirement pension”.

*The pandemic caused by Covid-19 has made visible the structural problems of the economic model and the shortcomings of social protection systems and welfare regimes. Therefore, a new normal is not the way, we must rethink the development model and consolidate the economic, social and environmental dimensions of sustainable development, leaving no one behind, said Alicia Bárcena (ECLAC, 2021).*

*Figure 1. Online Latin American panels*
*Source: (UAGro, 2020)*


In the area of employment, more than 50% of workers are in the informal sector without social security support. These structural difficulties exacerbated by the pandemic cause poverty to increase by 28.7 million people more than in 2019, this means that there will be approximately 2 147 million poor people. In relation to extreme poverty, it will increase by 15.9 million people more than in 2019, which will generate 83.4 million people in extreme poverty in the region.

We start from the consideration that it is important to take the learning that this pandemic offers us to improve social aspects, human rights, education, science, culture, environment, among others, which allows the elaboration and implementation of an action program to gradually transform the consequences of this coronavirus and its chaos. In such a way, that we obtain responses to future pandemics and other global challenges, of which the most urgent is climate change, which requires a stronger focus on carbon neutrality by 2050 and on caring for biodiversity (Guterres, 2020). These transformations must be added to the end of the climate wars, the wars for natural resources (for example, the war for oil), the water wars (as in the case of the conflict in Darfur, in western Sudan) and the environmental wars. in armed conflicts. Also, it is necessary to ensure that countries do not abandon their environmental responsibilities with the justification of the coronavirus pandemic (Sharma, 2020).

While it is important to respond to the pandemic in the short term, it is inescapable to place the Covid-19 pandemic in the historical context to avoid repetition of past mistakes, think about the unthinkable, plan what to do after the Covid-19 disaster, and give answers to questions such as: what world do we want to live in when all this ends? What education do we need? How will science and technology focus on the poorest and most vulnerable be strengthened? field, male and female peasants? How will public health systems be strengthened?

To offer answers to these and other questions that allow us to be better human beings, it is important to think in the long term in the midst of the Covid-19 crisis, since now is the time to imagine the world to come. to rethink our priorities and needs, becoming the opportune moment to build the future we want.

There are different institutional and academic voices that are in accordance with our proposal to think about the world after the pandemic. Some of these voices are the UN's approaches to human rights.

(In the report: COVID-19 and Human Rights we are all in this together (Guterres, 2020). Likewise, the ECLAC Report, "Latin America and the Caribbean: Measuring the effects of COVID-19 to think about reactivation, is relevant." (ECLAC, 2020a); and furthermore, we find a strong argumentative closeness in the manifesto signed by 170 Dutch intellectuals and scientists entitled: Five proposals for the post-coronavirus: we can make the Netherlands radically more sustainable and fairer (Arsel, 2020).

The inter-institutional alliance between UAGro, UPCI, LIMAA and CIDECCYT; It allows us to tackle the priority task of rethinking how to achieve the proposals of the framework of action of the SDGs, under the gaze of Social Ecology and Environmental Law.

One of the cross-cutting tasks of the international community, in the midst of this health crisis, is to strengthen efforts to guarantee health and well-being in accordance with SDG 3. More work is needed in education, equity, the environment and peace with the achievements of SDGs 4, 10, 13 and 16. Education (SDG 4) is one of the debated topics where the answers to the problems referred to and raised in the report of the Organization of Ibero-American States for Education, Science are deepened and Culture (OEI) (Sanz et al., 2020). In this regard, the following questions were raised: what measures are necessary to reduce the educational and social impacts on education due to the actions taken in the face of the Covid-19 pandemic? What effects are there and what solutions can be carried out by the closures of educational institutions where the alternative of online education had an impact on the digital divide for students and teachers? How are educational indicators (enrollment, dropout, approval, failure and terminal efficiency) impacted? of education in highly marginalized areas and groups such as: rural areas, groups of indigenous peoples and Afro-descendants or disabled people? What should be the actions for the reopening of educational education institutions at all levels? role can popular, alternative, emancipatory pedagogies play? How to implement alternation pedagogy in rural schools? And for what and how to strengthen the training of rural teachers?

Regarding SDG 13 in the environmental case, David Boyd considers that it is necessary to: "accelerate efforts to achieve the 2030 Sustainable Development Goals", since achieving "a healthy environment is an effective way to prevent pandemics and protect human rights" (Sharma, 2020).

For the environmental issue Adhanom Ghebreyesus points out:

*"More than six million deaths annually are due to combined air pollution in homes and in the environment. Air pollution is one of the leading causes of the noncommunicable disease epidemic, accounting for between a quarter and a third of the burden of disease from stroke, coronary heart attack, lung cancer, and chronic obstructive pulmonary disease, as well as more than half of deaths from childhood pneumonia" (World Health Assembly, 2018).*

Regarding economy and society, Michelle Bachelet; According to (Barral, 2020), she points out: "we have to redouble our efforts to build more inclusive and sustainable economies and shape societies that are more resistant and resilient to crises, and for this the SDGs are still our most powerful instrument."

Consequently, the inter-institutional and interdisciplinary articulated work of the UAGro, the UPCI, the LIMMA and the CIDECCYT collectively seeks to contribute in different interpretations of the SARS-CoV-2 pandemic and the times after it, which contribute to forging another vision of the world, different from the one we live in at the moment (Chomsky, 2020); through debates with a high level of rigor and depth, to answer the question of how to achieve the transformation of the SDGs that contributes to changing the economic model that generated this disaster (Klein, 2020) that is hitting the right to health hard and exceeding the other human rights.

We recognize that this is a miniscule world crisis in the face of the great challenges of this civilization in reference to climate change, the approach of a nuclear war, the increase in poverty and famine (there may be more than 135 million people facing level three of insecurity at the end of 2020, there could be 130 million people who are in phase 2), inequities and inequalities and, above all, the arduous task of achieving a culture of peace.

To achieve alternatives on the results of this pandemic, we rigorously address debates about the new role of SDGs 1 to 8, 10, 11, 13, 16 and 17 related to human rights, science, technology, social, the economic, the political, indigenous and Afro-Mexican peoples, young people, women and children, migrants and refugees, the ecological, educational, health, cultural, violence, peace, among other dimensions of analysis that allows recognizing the incidences of inequity and social inequality in different populations and areas affected by the pandemic, such as ours, Table 1, where ECLAC proposes socioeconomic effects due to the exacerbation generated by Covid-19.

*Table 1. Populations affected by the impacts of Covid-19*

**The different socioeconomic impacts reflect the social inequality matrix**

**Populations most affected by the socioeconomic impacts of COVID-19**

| Population | Area affected by the pandemic | |
|---|---|---|
| Women<br>Low- and lower-middle income strata<br>Informal workers<br>Female paid domestic workers<br>Children and adolescents<br>Young people<br>Older persons<br>Rural population<br>Indigenous peoples<br>Afrodescendants<br>Persons with disabilities<br>Migrants<br>Homeless persons | Physical and mental health<br>Nutrition<br>Education<br>Labour income<br>Child labour<br>Access to basic services (water, sanitation, electricity, gas, digital technologies)<br>Unpaid care work<br>Intrafamily violence | ***Inequalities**, which accumulate, enhance and interact, cause discrimination that implies differences in the exercise of rights.<br><br>*In a context of confinement, **unpaid domestic work** and **violence against women, girls and adolescents increases.**<br><br>***The poorest children and adolescents: increase in child labor** |

Source: (ECLAC, 2020a)

Another issue addressed in the panels has been the structural problem of food security, where currently 821 million people go to bed hungry, this figure being able to double with loss of food security sovereignty. In relation to this reality, it is important to guarantee food security and promote the resilience of the agri-food sector so that SDGs 1 and 2 are achieved, in relation to achieving zero hunger, a commitment that is now seen much further than before. Agriculture is analyzed based on its negative environmental impacts, such as the "avocado" in Mexico or viticulture in Piura, Peru.

## REFERENCES

Arsel, M. (2020, April 25). *Werkgroep, nieuws, Manifest Nederland na Corona*. https://www.voetafdruk.eu/nieuws/_20200411manifestnederlandnacorona.html

Barral, B. (2020, April 9). *El coronavirus nos muestra los dañinos efectos de la desigualdad en todo tipo de sociedades*. Naciones Unidas. https://news.un.org/es/story/2020/04/1472682

Chomsky, N. (2020, April 21). *Estamos ante otro fallo masivo y colosal del capitalismo neoliberal | Cultura y entretenimiento | Agencia EFE*. Agencia EFE. https://www.efe.com/efe/espana/cultura/chomsky-estamos-ante-otro-fallo-masivo-y-colosal-del-capitalismo-neoliberal/10005-4226729

ECLAC. (2020a). *The 2030 Agenda for Sustainable Development in the new global and regional context: Scenarios and projections in the current crisis*. https://www.cepal.org/en/publications/45338-2030-agenda-sustainable-development-new-global-and-regional-context-scenarios-and

ECLAC. (2020b). *The social challenge in times of COVID-19*. https://www.cepal.org/en/publications/45544-social-challenge-times-covid-19

ECLAC. (2021, March 18). *Countries of Latin America and the Caribbean Commit to Implementing the 2030 Agenda for Sustainable Development and Building Forward Better*. https://foroalc2030.cepal.org/2021/en/news/countries-latin-america-and-caribbean-commit-implementing-2030-agenda-sustainable-development

Friends of the Earth International. (2021, May). *Historic victory: judge forces Shell to drastically reduce CO2 emissions*. https://www.foei.org/features/historic-victory-judge-forces-shell-to-drastically-reduce-co2-emissions

Guterres, A. (2020, April 23). *We are all in this Together: Human Rights and COVID-19 Response and Recovery*. United Nations. https://www.un.org/en/un-coronavirus-communications-team/we-are-all-together-human-rights-and-covid-19-response-and

Heilbroner, R. (1970). *Ecological Armageddon*. https://www.nybooks.com/articles/1970/04/23/ecological-armageddon/

Herrington, G. (2021). Update to limits to growth: Comparing the World3 model with empirical data. *Journal of Industrial Ecology*, *25*(3), 614–626. doi:10.1111/jiec.13084

Ibarra-Sarlat, R. (2019). *Cambio Climático y Gobernanza. Una Visión Transdisciplinaria*. Instituto de Investigaciones Jurídicas UNAM. https://www.dijuris.com/libro/cambio-climatico-y-gobernanza-una-vision-transdisciplinaria_40648

IPCC. (2014). *Cambio climático 2014*. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full_es.pdf

Klein, N. (2020, March 13). *Coronavirus Is the Perfect Disaster for 'Disaster Capitalism.'* VICE. https://www.vice.com/en/article/5dmqyk/naomi-klein-interview-on-coronavirus-and-disaster-capitalism-shock-doctrine

Kliksberg, B. (2004). *Más ética, más desarrollo*. Temas Grupo Editorial.

Meadows, D., Meadows, D., Randers, J., & Behrens, W. (1972). *The Limits to Growth*. Universe Books. https://www.clubofrome.org/publication/the-limits-to-growth/

Sanz, I., Sainz, J., & Capilla, A. (2020). *Efectos de la Crisis del Coronavirus en la Educación*. https://www.flacsi.net/wp-content/uploads/2020/04/EFECTOS-DE-LA-CRISIS-DEL-CORONAVIRUS-EN-EDUCACIÓN.pdf

Schneegans, S., Lewis, J., & Straza, T. (2021). *UNESCO Science Report: the race against time for smarter development; executive summary*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000377250

Sharma, A. (2020, April 15). *Ningún país ha de escudarse en el coronavirus para revertir sus políticas medioambientales*. Noticias ONU. https://news.un.org/es/story/2020/04/1472912

UAGro. (2020, June). *Ciclo de paneles en línea: Repensar los objetivos de desarrollo sostenible para tiempos PostCovid-19*. http://posgradoderecho.uagro.mx/?page_id=4585

UNICEF. (2021). *The Climate Crisis is a Child Rights Crisis*. https://www.unicef.org/reports/climate-crisis-child-rights-crisis

Vegas-Gallo, E. (2003). *Hacia un Perú Sustentable*. http://biblioteca.unp.edu.pe/cgi-bin/koha/opac-detail.pl?biblionumber=50940

Vegas-Gallo, E. (2018). Biodiversidad de la macroregión norte del Perú: Estado y estrategia para su conservación y uso sustentable. *Repositorio Institucional de UNP*. https://repositorio.unp.edu.pe/handle/UNP/1580

Vicedo-Cabrera, A. M., Scovronick, N., Sera, F., Royé, D., Schneider, R., Tobias, A., Astrom, C., Guo, Y., Honda, Y., Hondula, D. M., Abrutzky, R., Tong, S., Coelho, M. de S. Z. S., Saldiva, P. H. N., Lavigne, E., Correa, P. M., Ortega, N. V., Kan, H., Osorio, S., … Gasparrini, A. (2021). The burden of heat-related mortality attributable to recent human-induced climate change. *Nature Climate Change 2021, 11*(6), 492–500. doi:10.1038/s41558-021-01058-x

WHO. (2020). *Commitment and call to action: Global collaboration to accelerate new COVID-19 health technologies*. https://www.who.int/news/item/24-04-2020-commitment-and-call-to-action-global-collaboration-to-accelerate-new-covid-19-health-technologies

World Health Assembly. (2018). *Health, environment and climate change Road map for an enhanced global response to the adverse health effects of air pollution Report by the Director-General*. https://apps.who.int/iris/handle/10665/276321

World Meteorological Organization. (2021, May 27). *New climate predictions increase likelihood of temporarily reaching 1.5 °C in next 5 years*. https://public.wmo.int/en/media/press-release/new-climate-predictions-increase-likelihood-of-temporarily-reaching-15-c-next-5

Žižek, S. (2020). *Pandemic! COVID-19 Shakes the World*. OR Books. doi:10.2307/j.ctv16t6n4q

# Chapter 2
# Ecosystem Services for Environmental Sustainability

**Bhavya Kavitha Dwarapureddi**
*GITAM University (Deemed), India*

**Swathi Dash**
*GITAM University (Deemed), India*

**Saritha Vara**
https://orcid.org/0000-0003-0473-993X
*GITAM University (Deemed), India*

## ABSTRACT

*Many of the most valuable contributions of ecosystems to human wellbeing are ecosystem services and are generally underrepresented in assessments. Indirect and direct factors including biophysical dynamics like soil properties, changing climatic conditions, plant functional structures, and anthropogenic activities like changes in land use and land degradation reduce ecosystem services. It is challenging and important to identify these factors and also to estimate their relative contributions to the degradation of ecosystem services. The chapter is an attempt to identify all these important factors and also suggest ways to enhance ecosystem services. Furthermore, incorporation of local knowledge would enable quantifying ecosystem services at a greater spatial resolution and also help in identifying chief factors influencing ecosystem service delivery. Furthermore, a long-term program needs to be established for gathering data towards streamlining ecosystem services wherein involvement of stakeholders is necessary for designing payments for these programs.*

## INTRODUCTION

The concept of ecosystem service enables to take into account at a greater level significant ecological services provided by nature towards decision making process along with ensuring sustainable land use for reducing overconsumption and degradation of natural life conditions. Attention towards the concept

DOI: 10.4018/978-1-7998-8482-8.ch002

of ecological service is attributed to its interdisciplinary, integrative and transdisciplinary character including its relation to several socio-economic and environmental factors (Müller and Burkhard 2007). However, the concept of ecological service is not an entirely new concept, movement for ecology dates back with its foundations in history (Westman 1977). The fact that ecosystems deliver free services to mankind has long been recognized (Graf 1984). For defining an integrative notion of ecosystem services, it is vital to create a concept which is equally accepted and understood by ecology, economics, sociology, scientists, policymakers and practitioners.

The framework of ecosystem services has been internationally used for assessing and governing socio-economic values of different biomes and ecosystems, analysing both at local and global scales (TEEB, 2011). The concept of ecosystem services and its applications have endured and progressed after self-reflection methods mostly with reference to utilitarian mounting (Droste et al. 2018), precisely with widespread dialogue over technical and theoretical limitations of indicators and assessment methods for ecosystem services (Cord et al. 2017).

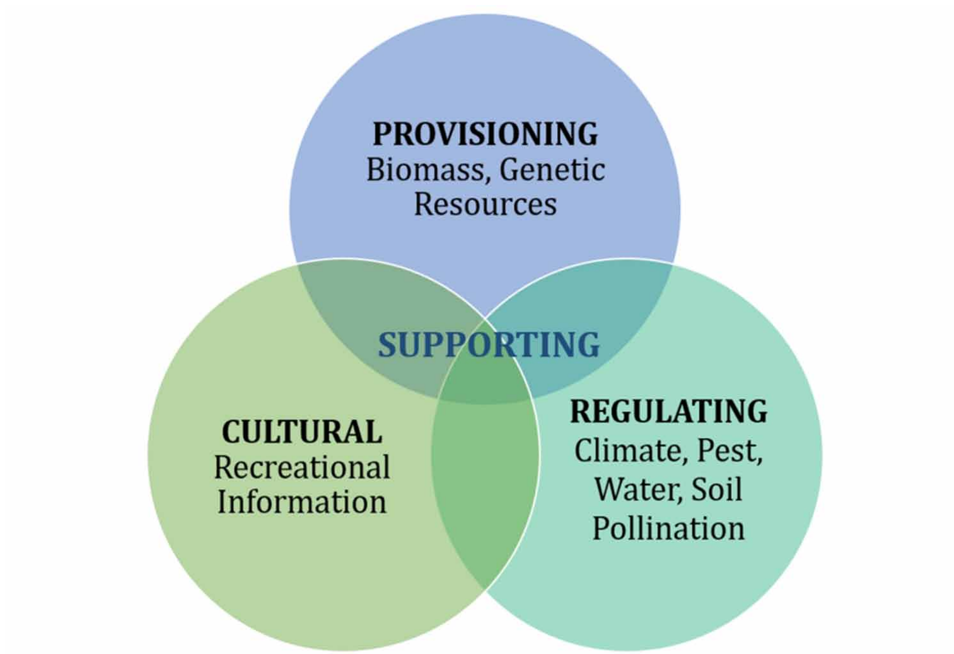
Typically, ecosystem services are mentally visualized as a series of units playing role in association among human wellbeing and nature. Functions and properties of ecosystem are understood to be a web of ecological communications influencing the ecosystems' structure and flow of matter, information and energy. The capacity of ecosystem service is the capability of an ecosystem towards providing services, which is derivative of a set of ecological functions and properties. Value of benefits from ecosystem services differ among various groups of society governed by societal traditions, norms along with preferences, principles and needs of individuals. Interests are articulated leading to mobilization of resources for its management and appropriation when a service is found to have a value, which can trigger both public and private decisions having influence on land use either indirectly or directly via policy tools like regulations and economic tools. All these tools tend to have impact on various kinds of land use and its change.

It is to be noted that provision of ecosystem services is usually resolved by various methods of capital (Spangenberg et al., 2014). Flow of an ecosystem service is the consequence of aggregate of social, institutional and biophysical factors that govern the crusade of ecosystem service capabilities through measures of land management. Additional anthropogenic inputs would be required to use other services like use of knowledge, machines, managing timber and agricultural production through use of fertilizers and towards accommodating recreational visits. Ecosystem services generating benefits are apparent depending on sort of value-articulating establishment. In order to sustainably accomplish ecosystem service delivery, it is important to comprehend preferences of societies to enhance awareness in scenarios wherever services are presently taken for granted leading to non-visibility of trade-offs and synergies. Science of ecosystem services is related to essential societal queries and decision-making procedures on how to conserve, manage, use and re-establish ecosystems towards sustaining delivery of ecosystem services (Díaz et al., 2015). Most of the investigation on ecosystem services focused on designing procedures and standards for assessing and mapping services (Jacobs et al., 2016; Ricketts et al., 2016; Maron et al., 2017; Schröter et al., 2019).

## CLASSIFICATION OF ECOSYSTEM SERVICES

Owing to the complexity and diversity of ecosystems and their services, it is hard to develop classification of ecosystem services that are widely accepted and clear, meeting broad requirements. In this

*Figure 1. Representation of Ecosystem Services*




context, in classification of ecosystem and landscape functions, services and potentials, there exists several proposals, partially divergent opinions and classification systems. All of them exhibit weaknesses and strengths depending on goals of assessment, context of decision making and spatial scales. Niemann, 1977 was first to distinguish four sets of purposes: landscape shaping, production, aesthetic and human-ecological. Later, Van der Maarela dn Dauvellier, 1978 stated that carrier, production, regulation, information and reservoir functions to be societal functions of physical landscape. Later during 1999, Bastian and Schreiber divided landscape functions into three clusters: ecological functions, also known as regulation functions; economic functions, known as production functions and sociocultural functions, also known as habitat functions. Taking into account definition provided by Costanza et al., 1997, MEA i.e Millennium Ecosystem Assessment, 2005 furnished simple typology of amenities which have been widely adopted in international policy and research literature:

- Provisioning Services which include water for consumption, food and timber.
- Regulating Services which include control against air pollution and flood protection
- Cultural Services which include recreation services
- Supporting Services which include processes ensuring essential prerequisites for presence of ecosystems like nutrient cycle.

Bastian et al., 2012 has presented that classifying ecosystem services into regulating (ecological), productive (economic) and societal services will provide an advantage of linking them to categories of both social development and basic concepts of sustainability and risk. Grunewald et al., 2015 has adjusted the supporting services contingent to respective situation to either regulatory or ecological processes. In the end, classification is usually dependent on individual researcher. In general, three to four groups having 15 to 30 services are distinguished, which are specified for useful results. Further, suitable indicators information which describes these ecosystem services is necessary.

An outline of ecosystem services furnished by aquatic and terrestrial ecosystems was given by Grunewald et al., 2015. They have classified 30 ecosystem services under three key categories: regulation, provisioning and sociocultural services, and also provided brief description, definition along with examples.

- **Regulation Services**

Ecosystems and biosphere are chief preconditions for sustenance of human life. Phenomenon and processes such as solar radiation transformation to biomass, mineral material, energy (food chains), mineralisation of organic matter (in soils), bio-geochemical cycles and guideline of climate are vital for life on earth. These processes are affected and facilitated through interactions among abiotic factors and living organisms. It is important to ensure the presence and operative of semi-natural and natural ecosystems towards enabling benefits from these process in future as well. Owing to the sheer ancillary profits of regulation services, these are usually overlooked, without been given sufficient consideration leading to their loss even though they are foundation for life of mankind (De Groot et al., 2002).

- **Provisioning Services**

Among several services and goods provided by ecosystems, oxygen, water, food, energy, medicines, genetic resources and resources for shelter and clothing are renewable biotic resources. It is tough to differentiate among human and natural contributions of material, labour and energy to a service, specifically in ecosystems strongly modified by humans.

- **Sociocultural Services**

Semi-natural and natural ecosystems offer diverse prospects for stimulation, aesthetic delight, knowledge enhancement and recreation. These psychological-social services are equally important along with provisioning and regulation services. Usually these can deliver benefits only via interactions with other services and goods as recreation values consist of both natural conditions and technical tools to explore a specific service (Loft and Lux, 2010). Matzdorf et al., 2010 suggested term environmental services in cases when there is necessity for both ecosystem processes and human impacts are required for providing benefits for humans (Grunewald et al., 2015).

- **Ecosystem Services and the Concept of Sustainability**

The idea of ecosystem services usually relates to robust vision of sustainability, wherein economic and social activities are basically reliant on biophysical arrangement (Folke et al., 2016). Association among human and natural systems is illustrated as closed loop. Ecological processes that are valuable to mankind are defied as ecosystem services which confer to varied human well-being dimensions comprising of basic earthly needs, psychological and physical health, security and social consistency (Pires et al., 2021).

Ecosystem services are dependent on geographical, historical and socio-economic aspects of entities or communities of recipients (Oteros-Rozas et al. 2014) and are hence accomplished rendering to fundamental values of a particular tends to seek. The implied selections abaft different sorts of ecosystem management certainly yield collaborations among multiple ecosystem services and sustainability dimensions (Smith et al., 2017). Thus, implementing a tactical management of ecosystem might affect either positively or negatively different groups or individuals of stakeholders, which may be remote spatially and temporally (Schro¨ter et al., 2018). Thus, dynamics of public-private are vital to these tensions where profits from environment are often privatized and prices are civic (Bartkowski et al., 2018). A part of research on ecosystem services, emphases on emerging and refining socio-economic and biophysical valuation methods and pointers towards measuring complex dynamics (Costanza et al. 2017). It is to be noted that drivers of trade-offs and synergies for ecosystem services are taken into account only rarely by scholars for analysis (Dade et al. 2019). The drivers include management of natural resource, land-use and connected policy changes (Vainio et al. 2019). The potential of ecosystem services to connect biodiversity with human well-being, inform and produce sustainable development has been recognized by practitioners, researchers and policy makers. However, ecosystem reservices being young concept invokes several debates leading to crucial concerns impacting efficient application and implementation (D'Amato et al., 2020).

- **Ecosystem Services and Biodiversity**

Thorough knowledge of ecological principles is essential towards completely understanding concept of ecosystem services which is characterized by interactions among organisms and their environment. These levels of interactions vary from microbe to landscape and global; from milliseconds to millions of years which is further intricated by material fluxes and multiscale energy, resulting in an enormously intricate biological interacting system filling agenda of several researchers across the world, towards search for understanding, determining and characterizing the entanglement of biological processes, organisms and their environment along with the most essential aspect being the importance of natural ecosystems for human survival and well-being.

There exists an apparent link among the concepts of ecosystem services and biodiversity. Owing to complexity of both terms' discussions are generally narrowed to precise components infuriating several debates (Mace et al., 2012). In several theoretical and experimental graphs, magnitude of function levels off with increase of species diversity. Further increase in this aspect can result in making system more resilient without increasing the magnitude. In fact, in a linear relation, individual species matters equally, with increasing functioning with every individual species. Dominant as well as rare species both contribute to ecological functions. More unpredictable relationships are described in reality, with gradient among low and high level of biodiversity in relation to functional magnitude is not well presented. Nevertheless, all relations usually point towards enhanced functioning with higher biodiversity, which can also be found on landscape scale having site patches as biodiversity units. In case of greatly fragmented landscape having low connectivity, loss of small patches results in steady decline of related ecosystem function, presenting linear relationship. While in highly connected networks losses at local level usually are repaired by inputs from linked patches, till a critical level is achieved (Scheffer et al., 2013).

In general ecosystem functions are diversified and stabilized by higher biodiversity (Cardinale et al., 2006). Understanding the inherent dependence on biodiversity is essential to use ecosystem service perspective as tool for management of natural resources. Empirical links among functions of ecosystems and several aspects of biodiversity like resource, trophic and genetic diversity has been presented by several recent studies. Functional structure of communities like diversity and composition of functional traits seem to be good predictor of ecological processes (Bartkowski, 2017). Current challenge is including various facets of biodiversity simultaneously that strongly enhance complexity of studies. Attention towards relationships among traits, genes, biotic and abiotic factors and phylogeny, greater insights into mechanisms underpinning functioning of ecosystems can be studied (Mouillot et al., 2011). Previous studies have presented evidence that biological diversity might boost functioning of ecosystems and thus their capability to deliver society with services and goods required to prosper (Naeem et al., 2012; Cardinale et al., 2012).

Ecosystems in fact deliver manifold services that are delivered by large number of activities which in turn rest on different species, physical conditions and ecological likings. Recent studies suggested that the importance of biodiversity enhances when considering multiple functions, as different species tend to govern different functions and studies that focus on individual processes existing in isolation tend to underestimate various levels of biodiversity required towards maintaining multifunctional ecosystems (Ziter, 2016). A larger suite of structures, processes and species tend to display differential retorts towards a given environmental trepidation and hence, when examined together they generate a steadying purpose that conserves the integrity of a service (Wall et al., 2015). Thus, in order to ensure stable supply of ecosystem services and functions in dynamically changing world, conservation and restoration of biodiversity through determination of biodiversity value is essential (Jacobs et al., 2013; Knapp, 2019).

- **Risk and Uncertainty in Ecosystem Service**

Uncertainty in services and goods provided by ecosystems in future has multiple facets, making specific properties of ecosystems valuable. Bartkowski, 2017 have differentiated among two main types of uncertainty in ecosystem services in future, they are: ecological ambiguity leading to supply ambiguity and socio-economic ambiguity resulting in demand uncertainty. These two uncertainties precisely correspond with two concepts of economic value which are option value and insurance value, both of which are attributed to ecosystem biodiversity. Positive influence of biodiversity is exhibited in terms of ecosystems stability and resilience, even though its impact on provisioning ecosystem services is necessarily not optimistic (Maes et al., 2012). Significant mechanism in this situation is the functional redundancy.

Upon combining this notion with the concept of human risk-aversion and supply uncertainty, concept of economic assurance value of biodiversity is achieved (Pascual et al., 2015). Economical value of biodiversity is attributed as it serves as protection against ambiguity adjacent capability of ecosystems towards reliably providing services and goods in future, responding to supply uncertainty. Biodiversity works against both sources of uncertainty i.e, it has a resilience enhancing and stabilizing consequence on ecosystem functioning that eases supply ambiguity and it is a consortium of choices, that can be drawn upon towards accommodating upcoming preferences and needs (Bartkowski, 2017). In order to estimate the ambiguity related values of biodiversity, it is essential to acclimatize common total economic value (TEV) framework towards better reflecting the fact that we live in an uncertain world (Pascual et al., 2015). And it is also necessary to valuate those suitable methods are used for identifying these values. Thus, these recognized values can then be filled into political decision-making processes towards trade-off benefits of enhancing biodiversity levels against costs of necessary land-use changes (Bartkowski and Hansjürgens, 2019).

- **Land Use Change and Ecosystem Services**

Changes in land use is one among chief factors driving changes in natural environment and human activity and hence, must be quantified accurately towards understanding such changes. Changes in land use comprise of changes in land cover as the term encompasses changes that does not include succeeding human use of property (Ellis, 2013). In terms of sustainable development, changes in land use affects worldwide climate change and subsequent responses of ecosystem (Abd El-Kawy et al., 2011). Studies show that several of world's emerging countries are undergoing rapid changes in land use that is driven by population expansion and changes in lifestyles as a result of growth in income (Yu et al, 2013). It is to be noted that landscapes vary both temporally and spatially (Scholte et al., 2015). As per the report of Millennium Ecosystem Assessment (MEA), fifteen out of 24 ecosystem services have been deteriorated across the world, out of which 60% degradation in the provisioning ecosystem services is due to changes in land use by human interaction (Jew et al., 2019; Yang et al., 2019). Vaezi et al., 2017 have highlighted that degraded ecosystem services can generate numerous problems like desertification, salinization, soil erosion and so on.

As population increases, changes in land use in terms of urbanization would demand more natural resources, food and fibre (Rimal et al., 2019; Balatsky et al., 2015; Tilman et al., 2011) across the world. In view of these scenarios ecosystems is constantly experiencing changes, degradation and conversion, effecting provisioning of ecosystem services (Fu et al., 2017; Tolessa et al., 2016; Buytaert et al., 2014). Several studies have claimed that changes in land use for urbanization hamper sustainability of environment, deteriorate biodiversity and also ecosystem services (Keeler et al., 2019; Rijal et al., 2018; Keshtkar et al., 2017; Tao et al., 2015).

- **Changes in Land Use and its Influence on Lithological and Hydrological Properties**

An essential constituent of a nation's ecological environment is agricultural land as it contributes to one of the principal provisioning services and hence, it must be accomplished sustainably towards protecting environment and also to provide food for humans (Yan et al., 2009). Nearly 40 percent of the land surface is covered with agricultural ecosystems, making it one of the greatest significant land management systems in the world. Nevertheless, these ecosystems face multitude of problems due to human induced changes in land use along with global warming leading to degradation in the overall quantity and quality of agricultural land (Jaradat and Boddy, 2011). This has resulted in reduced food provisioning services that are catered by agricultural ecosystems. Changes in land use resulted in fights among land uses for distribution of water resources. Land use change has reduced both ecosystems' services of regulatory and provisioning including food production, carbon sequestration and water flows.

Furthermore, grasslands and forests face grave pressure due to land use and climate change like reduced water yield that have been influenced by land use changes on evaporation and precipitation patterns. A study conducted by Pudyal et al., 2019 on ecosystems services of Nepal's Phewa watershed impacted by land use change has presented that dense forest area has enhanced by eighty eight percent while areas like sparse forest, cultivated land and grassland has reduced. Enhanced resource consumption, destruction of habitat and biodiversity loss was reported by Lawler et al., 2014 due to land use change in terms of extensive urbanization. Several studies have reported loss of wildlife habitat, poor soil productivity owing to degraded soil chemical, physical and biological properties and direct effect on sustainability due to built up area, effects of fragmented land on functions and services of ecological services (Kindu et al., 2016; Larson et al., 2016; Tolessa et al., 2017).

Negative effects on ecosystem services, agriculture and watershed were reported by Arunyawat and Shrestha, 2016 from Thailand due to increase in built-up land and rubber plantation during 1989 – 2013. In a similar study carried out in northern China during 1980 – 2015 Yang et al., 2019 found that huge number of grasslands were converted to built-up and cultivated areas resulting in loss of ecosystem services of that area. It is reported that changes bought in land use like alteration of natural systems to agricultural lands or settlements hamper sustainable ecosystem expansion and also will interfere with provision of ecosystem services (Fagerholm et al., 2016; Turner et al.,2016). Studies on relation among ecosystem services and soil properties were rarely taken up (Adhikari and Hartemink, 2016), yet have provided useful insights. As changes in land use enhance, this led to reduced soil nutrients, organic matter leading to degradation and erosion of soil and also reduced storage of soil organic carbon (Gamboa and Galicia, 2011; Poeplau and Don, 2013).

Various hydrological ecosystem services include cultural services like aesthetic and spiritual values; regulating services like erosion control and water purification; supporting services like water for plant growth and aquatic organisms and provisioning services like water supply and irrigation (Brauman et al., 2007; Jin et al., 2015). Reduction in the area of surface water to nearly 35 percent was reported by Hasan et al., 2017 in Bangladesh during 2000 – 2010 owing to extreme population growth coupled with changes in land use which has led to reduced annual average rainfall and enhanced temperatures. Impact of land use change and climate change on ecosystem services of water in Kentucky, USA was assessed by Bai et al., 2019 and presented that land use changes in terms of forest land conversion to agricultural, built-up and pasture lands have condensed provision of water-related ecosystem services. While a study conducted by Rimal et al., 2019 presented an increase in soil loss, export of phosphorus and nitrogen due to changes in land use, a decline in carbon storage and food production was observed (Hasan et al., 2020).

- **Future Value of Ecosystem Services**

Evaluating ecosystem services value is key which allows to shape integrated, complete measures for sustainable happiness that can drive development. Kubiszewski et al., 2020 created three current groups of situations towards developing and evaluating upcoming value of worldwide ecosystem services falling under four different land-use administration scenario based on the Great Transition Initiative (GTI) archetypes created by Raskin et al., 2002 (Hunt et al., 2012). These provide a range of reasonable features which integrate various world views, policies and their effects on a variety of concerns comprising of economics, climate change, land and water use management and overall wellbeing. They have estimated consequences of these scenarios along with their land use and management expectations for value of ecosystem services to 2050. These scenarios in brief are:

1. Fortress world, an archetype wherein countries and world become more inequitable, fragmented, heading towards permanent or temporary social collapse;
2. Market Forces, describing population and economic growth archetype which is based on neoliberal free assumptions of market.
3. Great Transition archetype based on assumption regarding limitations to conservative GDP progress, focussing more on social and environmental wellbeing and sustainability.

4. Policy improvement, enduring economic growth archetype with limitation based on expectations regarding necessity for government interference and actual policy.

Over the past several eras, services and properties provided by ecosystems have suggestively tarnished (Sutton et al., 2016). Attention towards ecosystem services at levels of both policy and research is rapidly growing (Braat and de Groot, 2012; Pittock et al., 2012; Balvanera et al., 2012; Costanza and Kubiszewski, 2012). Clear valuation enables the components of all rudiments to be expressed in similar common denominator to enable direct assessment of trade-offs. Usually, this can be most simply and helpfully done using monetary units and other units like land area, energy or time and also likely an integrated, pluralistic approach is preferred for valuation (Pascual et al., 2017; Jacobs et al., 2016).

Estimates made by Kubiszewski et al., 2020 are intended towards helping inform choices through making relation clearer among human wellbeing in future and wellbeing of remaining nature in measurable terms which highlight the trade-offs and decision that are made now. The great transition scenario can also be viewed as exemplifying several of goals that are approved by nations in the UN SDG process (United Nations, 2015). This scenario assumes reduced hunger, inequality, better land and sea ecosystems management, sustainable consumption and production, combating climate change along with several other features that are listed in 17 SDGs. Further, these scenarios can help dealing with uncertainty, design policies for enhancing chances of better futures (Costanza et al., 2015; Schmidt et al., 2016). Further, future work can be carried out in direction of using landscape measure computer simulation representations that can help in creating and evaluating integrated scenarios for ecosystem restoration towards correlation with business as usual (Turner et al., 2016).

## CONCLUSION

There exists an accepted understanding that ecosystems are crucial for human existence yet due to absence of market for most of the services and goods from ecosystems these are not characteristically priced. Several researchers round the world have appreciated the significance of quantification and valuation of ecosystem services. Problems related to quantification and valuation of ecosystem services are exacerbated owing to lack of information. Though several models have been proposed for estimating values of ecosystem services, the appraisal presented above states that an integrated approach would be significant in addressing the issue. Owing to the larger area covered by various ecosystems and huge amount of spatial data generated, using geographic information systems will largely benefit especially when using remote sensing data for large areas. Further, it has been understood that growth of population, expansion economically and infrastructure wise (changes in land use) are the main reasons for reduced ecosystem services. These changes resulted in reduction in food security, soil degradation, biodiversity loss and also climatic changes. As presented above changes have been bought in all four types of ecosystem services and have been hampered due to reasons quoted above and are influenced by several factors. Assessment of all these factors is precisely hampered due to lack of reliable data. Further, other factors like social and policy related are yet to be recognized in order to explain the magnitude of their influence. Two significant issues that are to be addressed in future are, first, it is observed that there is no common approach adopted by researchers across the world towards evaluating ecosystem services and hence, there is a need to develop a framework so that researchers can evaluate with a common ap-

*Table 1. Contemporary research across the world on Ecosystem Services*

| S. No | Author | Place | Objective | Results |
|---|---|---|---|---|
| 1. | Bennett et al., 2021 | Canada | Assessed interactions of recent changes on agro-ecosystem features leading to resilience loss. | Suggested crucial research directions towards harmonizing production and ecosystem function. |
| 2. | Kaiser et al., 2021 | Berlin | Showcased variety of existing payments for ecosystem services. | Suggested that future research should target associations among local, regional and global scales for development of payment for ecosystem services. |
| 3. | Janssen et al., 2021 | Netherland | Identified major shallow lake ecosystem services in association with Sustainable Development Goals (SDGs) and also associated service provisioning between 4 ecosystem conditions and discussed their possible trade-offs. | Presented diverse and different set of ecosystem services provided by stable states in shallow lakes with plentiful relations to majority of SDGs and concluded that reinstating and preserving and ecosystem states would credit for possible trade-offs among preserving natural values of shallow lakes and ecosystem services. |
| 4. | Almenar et al., 2021 | Luxembourg | To systematically identify nexuses among ES, UC, and NBS along with describing reasonable causal relationship. | Their results can be utilized in supporting urban policies aiming at mainstreaming NBS and also as basis to better understand ES-UC-NBS relationships. |
| 5. | Maas et al., 2021 | Austria | Investigated motives for application challenge through steering a trans-disciplinary survey towards identifying variances among insights of ninety-eight scientists in environmental research from Germany and Austria and 208 farmers in understanding ecosystem services, biodiversity. | Their findings demonstrated imperative need for enhanced communiqué platforms and collaboration among scientists and important agricultural shareholders towards establishing open discourses among practice, policy and agricultural research. |
| 6. | Wang et al., 2021 | China | Explored technical literature on ecosystem services and human well-being at a worldwide scale towards investigating scientific collaboration, temporal development and emergent trends during last twenty-seven years using CiteSpace. | Presented that an integrated research on biophysical and socio-cultural dimensions is needed towards enhancing support in policymaking in future. |
| 7. | Deng et al., 2021 | China | Analysed trade-offs among ecological edifice and development via changes in land-use and also assessed its impact on ecosystem services. | Their results indicated that trade-off among ecological edifice and development within reasonable range does not imply that ecosystem services will unavoidably decline. Nevertheless, ecosystem services are to be taken into account for land-use planning and policy making towards preserving natural ecosystems. |
| 8. | Gourevitch et al., 2021 | US | Evaluated equity and distribution of ecosystem service changes and its benefits across socioeconomic and demographic groups. | Presented that the burden of declined ecosystem services is primarily on lower-income, non-white, urban populations, which is greatly driven by wetlands and forests converted to urban and croplands. |
| 9. | Ma et al., 2021 | China | To identify conservation priorities through balancing ecosystem services trade-offs along with analysis of spatiotemporal changes in ecosystem services. | Presented significant results towards environmental protection and regional ecological along with enhancing ecosystem services. |
| 10. | Cavanagh et al., 2021 | UK | Synthesized recent valuations of present position along with expected forthcoming climate-driven changes in Southern Ocean ecosystems. | Developed formal representation with reference to network of interactions among suite of services and suite of potential drivers. |
| 11. | Aziz, 2021 | Pakistan | Valued transfer method for valuating ecosystem services in Pakistan during years 1950, 2000, 2015 and 2050. | Presented that per capita values for services like water and climate show a reduction for years 2000, 2015 and 2050 in comparison to 1950. |
| 12. | Lin et al., 2021 | China | Distinguish influences of changing demand and water supply in Aojiang River watershed, China, which is significant water reserve nearly seven million people. | Presented how ecosystem services' flows and changes in land use can be integrated at regional and local levels towards management of land use, reallocation of water and ecological recompense encouraging sustainability of freshwater ecosystems. |
| 13. | zu Ermgassen et al., 2021 | | Drawn literature towards providing a brief snapshot of contemporary field of ecosystem service valuation from salt marsh and also to focus on significance of stakeholder involvement to mitigate them. | Presented perspective that tackling these issues is possible with rise of big data, a growing understanding, expansion of valuation techniques, and application of environmental justice practices, which play serious role in decision-making round salt marshes. |
| 14. | Li et al., 2021 | China | Evaluated 3 important ecosystem services, counting water yield, carbon seizure and soil preservation in Zhanyge during 1990-2015. | Presented the necessity for strengthening ecological fortification in the Qilian Mountain area. |
| 15. | Castellar et al., 2021 | Spain | Consolidated data from four European plans towards setting track for common considerate of NBS and facilitating their mainstreaming. | Presented that important criterion for practitioners towards identifying particular solution is the 'green factor' along with duplication of non-intensive exercises happening in nature. |
| 16. | Alemu et al., 2021 | Singapore | To propose and test suitability of a multi-functional landscape approach towards assessing ecosystem services. | Their study illustrated a clear heterogeneity in capability of mangroves towards supply of various ecosystem services. |
| 17. | Tamburini et al., 2020 | Sweden | Assessed impact of various diversification practices in agricultural systems both below and above ground. | Illustrated that adopting widespread diversification practices prove to be promising towards contribution to food security and conservation of biodiversity. |
| 18. | Hasan et al., 2020 | Bangladesh | Reviewed effect of changes in land use on various types of ecosystem services, and its outcomes on human well-being. | Presented quantification and valuation of impacts of changes in land use on ecosystem services management, and proposed directions for future research. |
| 19. | Langemeyer et al., 2020 | Spain | Aimed at expansion of analytical foundation for fairness in urban ecosystem provision valuations through model which associates co-production of urban ecosystem services. | Outlined hypothetical entry points and provided real-world examples for intertwining notions of fairness into urban ecosystem service investigation and practice. |
| 20. | Orth et al., 2020 | USA | To report restoration of an unparalleled large-scale seagrass along the mid-western Atlantic that has been maintained annually for over 20 years. | Their study serves as a blueprint towards maintaining and restoring healthy ecosystems to safeguard numerous benefits, comprising of co-benefits which may emerge as management primacies over time. |
| 21. | Zhao et al., 2020 | China | To present concept of sustainable development from perspective of ecosystem services and to analyze few current problems in assessment of ecosystem service. | Outlined eight main principles illustrating general framework towards the study of landsenseology. |
| 22. | Peng et al., 2017 | China | To quantify four ecosystem services along with total ecosystem services, followed by identifying numerous benefits of ecosystem services in the peri-urban area of Beijing City. | Presented that population urbanization and economy should be reinforced through retarding land urbanization in order to achieve sustainability in urban ecology along with less degradation of ecosystem services. |

*continued on following page*

*Table 1. Continued*

| S. No | Author | Place | Objective | Results |
|---|---|---|---|---|
| 23. | Small et al., 2017 | UK | To review briefly problems associated with quantifying and defining cultural ecosystem services. | Suggested necessity to focus on changes in ecosystem service rather than service delivery, along with identifying common boundaries pertinent for ecosystems and people would help in addressing few of the challenges. |
| 24. | Woodhead et al., 2019 | UK | Question regarding meaning of Anthropocene towards delivery of ecosystem services obtained from coral reefs. | Concluded that with existing uncertainty around impending nature of coral reefs in Anthropocene, investigation discovering how profits to people can be of countless significance. |
| 25. | Cortinovis et al., 2018 | Italy | To investigate on what extent ecosystem services are presently included in urban plans. | Presented that defining strategic objectives, range of urban ecosystem services, and identifying demand and recipients could enhance awareness of the values at stake, ensuring commitment in long-term at implementation phase while also strengthening planning arguments against conflicting interests. |

proach. Second, need to incorporate values of ecosystem services in planning of ecosystems towards maximizing benefits for human wellbeing.

## REFERENCES

Abd El-Kawy, O. R., Rød, J. K., Ismail, H. A., & Suliman, A. S. (2011). Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data. *Applied Geography (Sevenoaks, England)*, *31*(2), 483–494. doi:10.1016/j.apgeog.2010.10.012

Adhikari, K., & Hartemink, A. E. (2016). Linking soils to ecosystem services—A global review. *Geoderma*, *262*, 101–111. doi:10.1016/j.geoderma.2015.08.009

Alemu, J. B., Richards, D. R., Gaw, L. Y. F., Masoudi, M., Nathan, Y., & Friess, D. A. (2021). Identifying spatial patterns and interactions among multiple ecosystem services in an urban mangrove landscape. *Ecological Indicators*, *121*, 107042. doi:10.1016/j.ecolind.2020.107042

Almenar, J. B., Elliot, T., Rugani, B., Philippe, B., Gutierrez, T. N., Sonnemann, G., & Geneletti, D. (2021). Nexus between nature-based solutions, ecosystem services and urban challenges. *Land Use Policy*, *100*, 104898. doi:10.1016/j.landusepol.2020.104898

Arunyawat, S., & Shrestha, R. P. (2016). Assessing land use change and its impact on ecosystem services in Northern Thailand. *Sustainability*, *8*(8), 768. doi:10.3390u8080768

Aziz, T. (2021). Changes in land use and ecosystem services values in Pakistan, 1950–2050. *Environmental Development*, *37*, 100576. doi:10.1016/j.envdev.2020.100576

Bai, Y., Ochuodho, T. O., & Yang, J. (2019). Impact of land use and climate change on water-related ecosystem services in Kentucky, USA. *Ecological Indicators*, *102*, 51–64. doi:10.1016/j.ecolind.2019.01.079

Balatsky, A. V., Balatsky, G. I., & Borysov, S. S. (2015). Resource demand growth and sustainability due to increased world consumption. *Sustainability*, *7*(3), 3430–3440. doi:10.3390u7033430

Balvanera, P., Uriarte, M., Almeida-Leñero, L., Altesor, A., DeClerck, F., Gardner, T., Hall, J., Lara, A., Laterra, P., Peña-Claros, M., Silva Matos, D. M., Vogl, A. L., Romero-Duque, L. P., Arreola, L. F., Caro-Borrero, Á. P., Gallego, F., Jain, M., Little, C., de Oliveira Xavier, R., ... Vallejos, M. (2012). Ecosystem services research in Latin America: The state of the art. *Ecosystem Services*, *2*, 56–70. doi:10.1016/j.ecoser.2012.09.006

Bartkowski, B. (2017). *Economic valuation of biodiversity: an interdisciplinary conceptual perspective*. Routledge. doi:10.4324/9781315175911

Bartkowski, B., & Hansjürgens, B. (2019). Risk and uncertainty as sources of economic value of biodiversity and ecosystem services. In Atlas of Ecosystem Services (pp. 21-24). Springer. doi:10.1007/978-3-319-96229-0_5

Bartkowski, B., Hansjürgens, B., Möckel, S., & Bartke, S. (2018). Institutional economics of agricultural soil ecosystem services. *Sustainability*, *10*(7), 2447. doi:10.3390u10072447

Bastian, O., Haase, D., & Grunewald, K. (2012). Ecosystem properties, potentials and services–The EPPS conceptual framework and an urban application example. *Ecological Indicators*, *21*, 7–16. doi:10.1016/j.ecolind.2011.03.014

Bennett, E. M., Baird, J., Baulch, H., Chaplin-Kramer, R., Fraser, E., Loring, P., & Lapen, D. (2021). Ecosystem services and the resilience of agricultural landscapes. In *Advances in ecological research* (pp. 1–43). Academic Press Inc.

Braat, L. C., & De Groot, R. (2012). The ecosystem services agenda: Bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem Services*, *1*(1), 4–15. doi:10.1016/j.ecoser.2012.07.011

Brauman, K. A., Daily, G. C., Duarte, T. K. E., & Mooney, H. A. (2007). The nature and value of ecosystem services: An overview highlighting hydrologic services. *Annual Review of Environment and Resources*, *32*(1), 67–98. doi:10.1146/annurev.energy.32.031306.102758

Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Alemie, T. C., Bastiaensen, J., ... Zhumanova, M. (2014). Citizen science in hydrology and water resources: Opportunities for knowledge generation, ecosystem service management, and sustainable development. *Frontiers of Earth Science*, *2*, 26.

Cardinale, B. J., & Je, D. (2012). gonzalez a, hooper Du. *Perrings C, Venail P, narwani a, mace gm, tilman D, Wardle Da, Kinzig aP, Daily gC, loreau m, grace JB, larigauderie a, srivastava Ds, naeem s*, 59-67.

Cardinale, B. J., Srivastava, D. S., Duffy, J. E., Wright, J. P., Downing, A. L., Sankaran, M., & Jouseau, C. (2006). Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature*, *443*(7114), 989–992. doi:10.1038/nature05202 PMID:17066035

Castellar, J. A. C., Popartan, L. A., Pueyo-Ros, J., Atanasova, N., Langergraber, G., Säumel, I., Corominas, L., Comas, J., & Acuna, V. (2021). Nature-based solutions in the urban context: Terminology, classification and scoring for urban challenges and ecosystem services. *The Science of the Total Environment*, *779*, 146237. doi:10.1016/j.scitotenv.2021.146237 PMID:34030251

Cavanagh, R. D., Melbourne-Thomas, J., Grant, S. M., Barnes, D. K., Hughes, K. A., Halfter, S., Meredith, M. P., Murphy, E. J., Trebilco, R., & Hill, S. L. (2021). Future risk for southern ocean ecosystem services under climate change. *Frontiers in Marine Science*, *7*, 1224. doi:10.3389/fmars.2020.615214

Cord, A. F., Bartkowski, B., Beckmann, M., Dittrich, A., Hermans-Neumann, K., Kaim, A., Lienhoop, N., Locher-Krause, K., Priess, J., Schröter-Schlaack, C., Schwarz, N., Seppelt, R., Strauch, M., Václavík, T., & Volk, M. (2017). Towards systematic analyses of ecosystem service trade-offs and synergies: Main concepts, methods and the road ahead. *Ecosystem Services*, *28*, 264–272. doi:10.1016/j.ecoser.2017.07.012

Cortés-Calderón, S., Mora, F., Arreola-Villa, F., & Balvanera, P. (2021). Ecosystem services supply and interactions along secondary tropical dry forests succession. *Forest Ecology and Management*, *482*, 118858. doi:10.1016/j.foreco.2020.118858

Cortinovis, C., & Geneletti, D. (2018). Ecosystem services in urban plans: What is there, and what is still needed for better decisions. *Land Use Policy*, *70*, 298–312. doi:10.1016/j.landusepol.2017.10.017

Costanza, R. (2020). Valuing natural capital and ecosystem services toward the goals of efficiency, fairness, and sustainability. *Ecosystem Services*, *43*, 101096. doi:10.1016/j.ecoser.2020.101096

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... Van Den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*(6630), 253-260.

Costanza, R., De Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. doi:10.1016/j.ecoser.2017.09.008

Costanza, R., & Kubiszewski, I. (2012). The authorship structure of "ecosystem services" as a transdisciplinary field of scholarship. *Ecosystem Services*, *1*(1), 16–25. doi:10.1016/j.ecoser.2012.06.002

D'Amato, D., Bartkowski, B., & Droste, N. (2020). Reviewing the interface of bioeconomy and ecosystem service research. *Ambio*, *49*(12), 1–19. doi:10.100713280-020-01374-0 PMID:33044700

Dade, M. C., Mitchell, M. G., McAlpine, C. A., & Rhodes, J. R. (2019). Assessing ecosystem service trade-offs and synergies: The need for a more mechanistic approach. *Ambio*, *48*(10), 1116–1128. doi:10.100713280-018-1127-7 PMID:30474830

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, *41*(3), 393–408. doi:10.1016/S0921-8009(02)00089-7

Deng, C., Liu, J., Nie, X., Li, Z., Liu, Y., Xiao, H., Hu, X., Wang, L., Zhang, Y., Zhang, G., Zhu, D., & Xiao, L. (2021). How trade-offs between ecological construction and urbanization expansion affect ecosystem services. *Ecological Indicators*, *122*, 107253. doi:10.1016/j.ecolind.2020.107253

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M. A., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., ... Zlatanova, D. (2015). The IPBES Conceptual Framework—Connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. doi:10.1016/j.cosust.2014.11.002

Droste, N., D'Amato, D., & Goddard, J. J. (2018). Where communities intermingle, diversity grows–The evolution of topics in ecosystem service research. *PLoS One*, *13*(9), e0204749. doi:10.1371/journal.pone.0204749 PMID:30265733

Economics of Ecosystems and Biodiversity (TEEB). (2011). *TEEB manual for cities: Ecosystem services in urban management*. Author.

Fagerholm, N., Oteros-Rozas, E., Raymond, C. M., Torralba, M., Moreno, G., & Plieninger, T. (2016). Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS. *Applied Geography (Sevenoaks, England)*, *74*, 30–46. doi:10.1016/j.apgeog.2016.06.007

Folke, C., Biggs, R., Norström, A. V., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, *21*(3), art41. doi:10.5751/ES-08748-210341

Fu, Q., Li, B., Hou, Y., Bi, X., & Zhang, X. (2017). Effects of land use and climate change on ecosystem services in Central Asia's arid regions: A case study in Altay Prefecture, China. *The Science of the Total Environment*, *607*, 633–646. doi:10.1016/j.scitotenv.2017.06.241 PMID:28709097

Gamboa, A. M., & Galicia, L. (2011). Differential influence of land use/cover change on topsoil carbon and microbial activity in low-latitude temperate forests. *Agriculture, Ecosystems & Environment*, *142*(3-4), 280–290. doi:10.1016/j.agee.2011.05.025

Gourevitch, J. D., Alonso-Rodríguez, A. M., Aristizábal, N., de Wit, L. A., Kinnebrew, E., Littlefield, C. E., Moore, M., Nicholson, C. C., Schwartz, A. J., & Ricketts, T. H. (2021). Projected losses of ecosystem services in the US disproportionately affect non-white and lower-income populations. *Nature Communications*, *12*(1), 1–9. doi:10.103841467-021-23905-3 PMID:34112778

Grunewald, K., & Bastian, O. (2015). Ecosystem Services (ES): More Than Just a Vogue Term? In Ecosystem Services–Concept, Methods and Case Studies (pp. 1-11). Springer.

Hasan, S. S., Deng, X., Li, Z., & Chen, D. (2017). Projections of future land use in Bangladesh under the background of baseline, ecological protection and economic development. *Sustainability*, *9*(4), 505. doi:10.3390u9040505

Hasan, S. S., Zhen, L., Miah, M. G., Ahamed, T., & Samie, A. (2020). Impact of land use change on ecosystem services: A review. *Environmental Development*, *34*, 100527. doi:10.1016/j.envdev.2020.100527

Hunt, D. V., Lombardi, D. R., Atkinson, S., Barber, A. R., Barnes, M., Boyko, C. T., Brown, J., Bryson, J., Butler, D., Caputo, S., Caserio, M., Coles, R., Cooper, R. F. D., Farmani, R., Gaterell, M., Hale, J., Hales, C., Hewitt, C. N., Jankovic, L., ... Rogers, C. D. (2012). Scenario archetypes: Converging rather than diverging themes. *Sustainability*, *4*(4), 740–772. doi:10.3390u4040740

Jacobs, S., Dendoncker, N., Martín-López, B., Barton, D. N., Gomez-Baggethun, E., Boeraeve, F., McGrath, F. L., Vierikko, K., Geneletti, D., Sevecke, K. J., Pipart, N., Primmer, E., Mederly, P., Schmidt, S., Aragão, A., Baral, H., Bark, R. H., Briceno, T., Brogna, D., ... Washbourne, C. L. (2016). A new valuation school: Integrating diverse values of nature in resource and land use decisions. *Ecosystem Services*, *22*, 213–220. doi:10.1016/j.ecoser.2016.11.007

Jacobs, S., Haest, B., de Bie, T., Deliège, G., Schneiders, A., & Turkelboom, F. (2013). Biodiversity and ecosystem services. In *Ecosystem Services* (pp. 29–40). Elsevier. doi:10.1016/B978-0-12-419964-4.00003-2

Janssen, A. B., Hilt, S., Kosten, S., de Klein, J. J., Paerl, H. W., & Van de Waal, D. B. (2021). Shifting states, shifting services: Linking regime shifts to changes in ecosystem services of shallow lakes. *Freshwater Biology*, *66*(1), 1–12. doi:10.1111/fwb.13582

Jaradat, A. A., & Boody, G. (2011). Modeling agroecosystem services under simulated climate and land-use changes. *International Scholarly Research Notices*.

Jew, E. K., Burdekin, O. J., Dougill, A. J., & Sallu, S. M. (2019, February). Rapid land use change threatens provisioning ecosystem services in miombo woodlands. *Natural Resources Forum*, *43*(1), 56–70. doi:10.1111/1477-8947.12167

Jin, G., Wang, P., Zhao, T., Bai, Y., Zhao, C., & Chen, D. (2015). Reviews on land use change induced effects on regional hydrological ecosystem services for integrated water resources management. *Physics and Chemistry of the Earth Parts A/B/C*, *89*, 33–39. doi:10.1016/j.pce.2015.10.011

Kaiser, J., Haase, D., & Krueger, T. (2021). Payments for ecosystem services: A review of definitions, the role of spatial scales, and critique. *Ecology and Society*, *26*(2), art12. doi:10.5751/ES-12307-260212

Keeler, B. L., Hamel, P., McPhearson, T., Hamann, M. H., Donahue, M. L., Prado, K. A. M., ... Wood, S. A. (2019). Social-ecological and technological factors moderate the value of urban nature. *Nature Sustainability*, *2*(1), 29–38. doi:10.103841893-018-0202-1

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2016). Changes of ecosystem service values in response to land use/land cover dynamics in Munessa–Shashemene landscape of the Ethiopian highlands. *The Science of the Total Environment*, *547*, 137–147. doi:10.1016/j.scitotenv.2015.12.127 PMID:26780139

Knapp, S. (2019). The link between diversity, ecosystem functions, and ecosystem services. In *Atlas of Ecosystem Services* (pp. 13–15). Springer. doi:10.1007/978-3-319-96229-0_3

Kubiszewski, I., Costanza, R., Anderson, S., & Sutton, P. (2020). The future value of ecosystem services: Global scenarios and national implications. In *Environmental Assessments*. Edward Elgar Publishing. doi:10.4337/9781788976879.00016

Langemeyer, J., & Connolly, J. J. (2020). Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science & Policy*, *109*, 1–14. doi:10.1016/j.envsci.2020.03.021

Larson, K. L., Nelson, K. C., Samples, S. R., Hall, S. J., Bettez, N., Cavender-Bares, J., Groffman, P. M., Grove, M., Heffernan, J. B., Hobbie, S. E., Learned, J., Morse, J. L., Neill, C., Ogden, L. A., O'Neil-Dunne, J., Pataki, D. E., Polsky, C., Chowdhury, R. R., Steele, M., & Trammell, T. L. E. (2016). Ecosystem services in managing residential landscapes: Priorities, value dimensions, and cross-regional patterns. *Urban Ecosystems*, *19*(1), 95–113. doi:10.100711252-015-0477-1

Lawler, J. J., Lewis, D. J., Nelson, E., Plantinga, A. J., Polasky, S., Withey, J. C., Helmers, D. P., Martinuzzi, S., Pennington, D., & Radeloff, V. C. (2014). Projected land-use change impacts on ecosystem services in the United States. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(20), 7492–7497. doi:10.1073/pnas.1405557111 PMID:24799685

Li, Z., Xia, J., Deng, X., & Yan, H. (2021). Multilevel modelling of impacts of human and natural factors on ecosystem services change in an oasis, Northwest China. *Resources, Conservation and Recycling*, *169*, 105474. doi:10.1016/j.resconrec.2021.105474

Lin, J., Huang, J., Prell, C., & Bryan, B. A. (2021). Changes in supply and demand mediate the effects of land-use change on freshwater ecosystem services flows. *The Science of the Total Environment*, *763*, 143012. doi:10.1016/j.scitotenv.2020.143012 PMID:33162131

Loft, L., & Lux, A. (2010). *Ecosystem Services*. Eine Einführung.

Ma, S., Wang, L. J., Zhu, D., & Zhang, J. (2021). Spatiotemporal changes in ecosystem services in the conservation priorities of the southern hill and mountain belt, China. *Ecological Indicators*, *122*, 107225. doi:10.1016/j.ecolind.2020.107225

Maas, B., Fabian, Y., Kross, S. M., & Richter, A. (2021). Divergent farmer and scientist perceptions of agricultural biodiversity, ecosystem services and decision-making. *Biological Conservation*, *256*, 109065. doi:10.1016/j.biocon.2021.109065

Mace, G. M., Norris, K., & Fitter, A. H. (2012). Biodiversity and ecosystem services: A multilayered relationship. *Trends in Ecology & Evolution*, *27*(1), 19–26. doi:10.1016/j.tree.2011.08.006 PMID:21943703

Maes, J., Paracchini, M. L., Zulian, G., Dunbar, M. B., & Alkemade, R. (2012). Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. *Biological Conservation*, *155*, 1–12. doi:10.1016/j.biocon.2012.06.016

Maron, M., Mitchell, M. G., Runting, R. K., Rhodes, J. R., Mace, G. M., Keith, D. A., & Watson, J. E. (2017). Towards a threat assessment framework for ecosystem services. *Trends in Ecology & Evolution*, *32*(4), 240–248. doi:10.1016/j.tree.2016.12.011 PMID:28190532

Matzdorf, B., Reutter, M., & Hübner, C. (2010). *Gutachten-Vorstudie Bewertung der Ökosystemdienstleistungen von HNV-Grünland (High Nature Value Grassland) Abschlussbericht. Institut für Sozioökonomie Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) eV*. Müncheberg.

Mouillot, D., Villéger, S., Scherer-Lorenzen, M., & Mason, N. W. (2011). Functional structure of biological communities predicts ecosystem multifunctionality. *PLoS One*, *6*(3), e17476. doi:10.1371/journal.pone.0017476 PMID:21423747

Müller, F., & Burkhard, B. (2007). An ecosystem based framework to link landscape structures, functions and services. In *Multifunctional land use* (pp. 37–63). Springer. doi:10.1007/978-3-540-36763-5_3

Naeem, S., Duffy, J. E., & Zavaleta, E. (2012). The functions of biological diversity in an age of extinction. *Science, 336*(6087), 1401-1406.

Nations, U. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations, Department of Economic and Social Affairs.

Niemann, E. (1977). Eine Methode zur Erarbeitung der Funktionsleistungsgrade von Landschaftselementen. *Archiv fur Naturschutz und Landschaftsforschung*.

Orth, R. J., Lefcheck, J. S., McGlathery, K. S., Aoki, L., Luckenbach, M. W., Moore, K. A., Oreska, M. P. J., Snyder, R., Wilcox, D. J., & Lusk, B. (2020). Restoration of seagrass habitat leads to rapid recovery of coastal ecosystem services. *Science Advances*, *6*(41), eabc6434. doi:10.1126ciadv.abc6434 PMID:33028530

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R. T., Başak Dessane, E., Islar, M., Kelemen, E., Maris, V., Quaas, M., Subramanian, S. M., Wittmer, H., Adlan, A., Ahn, S. E., Al-Hafedh, Y. S., Amankwah, E., Asah, S. T., ... Yagi, N. (2017). Valuing nature's contributions to people: The IPBES approach. *Current Opinion in Environmental Sustainability*, *26*, 7–16. doi:10.1016/j.cosust.2016.12.006

Pascual, U., Termansen, M., Hedlund, K., Brussaard, L., Faber, J. H., Foudi, S., Lemanceau, P., & Jørgensen, S. L. (2015). On the value of soil biodiversity and ecosystem services. *Ecosystem Services*, *15*, 11–18. doi:10.1016/j.ecoser.2015.06.002

Paudyal, K., Baral, H., Bhandari, S. P., Bhandari, A., & Keenan, R. J. (2019). Spatial assessment of the impact of land use and land cover change on supply of ecosystem services in Phewa watershed, Nepal. *Ecosystem Services*, *36*, 100895. doi:10.1016/j.ecoser.2019.100895

Peng, J., Tian, L., Liu, Y., Zhao, M., & Wu, J. (2017). Ecosystem services response to urbanization in metropolitan areas: Thresholds identification. *The Science of the Total Environment*, *607*, 706–714. doi:10.1016/j.scitotenv.2017.06.218 PMID:28711000

Pires, A. P., Soto, C. R., & Scarano, F. R. (2021). Strategies to reach global sustainability should take better account of ecosystem services. *Ecosystem Services*, *49*, 101292. doi:10.1016/j.ecoser.2021.101292

Pittock, J., Cork, S., & Maynard, S. (2012). The state of the application of ecosystems services in Australia. *Ecosystem Services*, *1*(1), 111–120. doi:10.1016/j.ecoser.2012.07.010

Poeplau, C., & Don, A. (2013). Sensitivity of soil organic carbon stocks and fractions to different land-use changes across Europe. *Geoderma*, *192*, 189–201. doi:10.1016/j.geoderma.2012.08.003

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R., & Swart, R. (2002). *Great transition: The promise and lure of the times ahead* (Vol. 1). Stockholm Environmental Institute.

Ricketts, T. H., Watson, K. B., Koh, I., Ellis, A. M., Nicholson, C. C., Posner, S., Richardson, L. L., & Sonter, L. J. (2016). Disaggregating the evidence linking biodiversity and ecosystem services. *Nature Communications*, *7*(1), 1–8. doi:10.1038/ncomms13106 PMID:27713429

Rijal, S., Rimal, B., & Sloan, S. (2018). Flood hazard mapping of a rapidly urbanizing city in the foothills (Birendranagar, Surkhet) of Nepal. *Land (Basel)*, *7*(2), 60. doi:10.3390/land7020060

Rimal, B., Keshtkar, H., Sharma, R., Stork, N., Rijal, S., & Kunwar, R. (2019). Simulating urban expansion in a rapidly changing landscape in eastern Tarai, Nepal. *Environmental Monitoring and Assessment*, *191*(4), 1–14. doi:10.100710661-019-7389-0 PMID:30923960

Scheffer, M., Carpenter, S. R., Lenton, T. M., Bascompte, J., Brock, W., Dakos, V., ... & Vandermeer, J. (2012). Anticipating critical transitions. *Science, 338*(6105), 344-348.

Schmidt, S., Manceur, A. M., & Seppelt, R. (2016). Uncertainty of monetary valued ecosystem services–value transfer functions for global mapping. *PLoS One*, *11*(3), e0148524. doi:10.1371/journal.pone.0148524 PMID:26938447

Scholte, S. S., Van Teeffelen, A. J., & Verburg, P. H. (2015). Integrating socio-cultural perspectives into ecosystem service valuation: A review of concepts and methods. *Ecological Economics*, *114*, 67–78. doi:10.1016/j.ecolecon.2015.03.007

Schröter, M., Koellner, T., Alkemade, R., Arnhold, S., Bagstad, K. J., Erb, K. H., Frank, K., Kastner, T., Kissinger, M., Liu, J., López-Hoffman, L., Maes, J., Marques, A., Martín-López, B., Meyer, C., Schulp, C. J. E., Thober, J., Wolff, S., & Bonn, A. (2018). Interregional flows of ecosystem services: Concepts, typology and four cases. *Ecosystem Services*, *31*, 231–241. doi:10.1016/j.ecoser.2018.02.003

Schröter, M., Ring, I., Schröter-Schlaack, C., & Bonn, A. (2019). The Ecosystem Service Concept: Linking Ecosystems and Human Wellbeing. In Atlas of Ecosystem Services (pp. 7-11). Springer.

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. doi:10.1016/j.gloenvcha.2017.03.005

Smith, A. C., Harrison, P. A., Soba, M. P., Archaux, F., Blicharska, M., Egoh, B. N., ... De Echeverria, V. W. (2017). How natural capital delivers ecosystem services: A typology derived from a systematic review. *Ecosystem Services*, *26*, 111–126. doi:10.1016/j.ecoser.2017.06.006

Spangenberg, J. H., Görg, C., Truong, D. T., Tekken, V., Bustamante, J. V., & Settele, J. (2014). Provision of ecosystem services is determined by human agency, not ecosystem functions. Four case studies. *The International Journal of Biodiversity Science, Ecosystem Services & Management*, *10*(1), 40–53. doi:10.1080/21513732.2014.884166

Sutton, P. C., Anderson, S. J., Costanza, R., & Kubiszewski, I. (2016). The ecological economics of land degradation: Impacts on ecosystem service values. *Ecological Economics*, *129*, 182–192. doi:10.1016/j.ecolecon.2016.06.016

Tamburini, G., Bommarco, R., Wanger, T. C., Kremen, C., van der Heijden, M. G., Liebman, M., & Hallin, S. (2020). Agricultural diversification promotes multiple ecosystem services without compromising yield. *Science Advances, 6*(45), eaba1715.

Tao, Y., Li, F., Wang, R., & Zhao, D. (2015). Effects of land use and cover change on terrestrial carbon stocks in urbanized areas: A study from Changzhou, China. *Journal of Cleaner Production*, *103*, 651–657. doi:10.1016/j.jclepro.2014.07.055

Tolessa, T., Senbeta, F., & Abebe, T. (2017). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. *Forests, Trees and Livelihoods*, *26*(2), 111–123. doi:10.1080/14728028.2016.1221780

Tolessa, T., Senbeta, F., & Kidane, M. (2017). The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. *Ecosystem Services*, *23*, 47–54. doi:10.1016/j.ecoser.2016.11.010

Turner, K. G., Anderson, S., Gonzales-Chang, M., Costanza, R., Courville, S., Dalgaard, T., Dominati, E., Kubiszewski, I., Ogilvy, S., Porfirio, L., Ratna, N., Sandhu, H., Sutton, P. C., Svenning, J.-C., Turner, G. M., Varennes, Y.-D., Voinov, A., & Wratten, S. (2016). A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling*, *319*, 190–207. doi:10.1016/j.ecolmodel.2015.07.017

Vaezi, A. R., Ahmadi, M., & Cerda, A. (2017). Contribution of raindrop impact to the change of soil physical properties and water erosion under semi-arid rainfalls. *The Science of the Total Environment*, *583*, 382–392. doi:10.1016/j.scitotenv.2017.01.078 PMID:28119004

Vainio, A., Ovaska, U., & Varho, V. (2019). Not so sustainable? Images of bioeconomy by future environmental professionals and citizens. *Journal of Cleaner Production*, *210*, 1396–1405. doi:10.1016/j.jclepro.2018.10.290

Wall, D. H., Nielsen, U. N., & Six, J. (2015). Soil biodiversity and human health. *Nature*, *528*(7580), 69–76. doi:10.1038/nature15744 PMID:26595276

Wang, B., Zhang, Q., & Cui, F. (2021). Scientific research on ecosystem services and human well-being: A bibliometric analysis. *Ecological Indicators*, *125*, 107449. doi:10.1016/j.ecolind.2021.107449

Westman, W. E. (1977). How much are nature's services worth? *Science*, *197*(4307), 960–964. doi:10.1126cience.197.4307.960 PMID:17784115

Woodhead, A. J., Hicks, C. C., Norström, A. V., Williams, G. J., & Graham, N. A. (2019). Coral reef ecosystem services in the Anthropocene. *Functional Ecology*, *33*(6), 1023–1034. doi:10.1111/1365-2435.13331

Yan, H., Liu, J., Huang, H. Q., Tao, B., & Cao, M. (2009). Assessing the consequence of land use change on agricultural productivity in China. *Global and Planetary Change*, *67*(1-2), 13–19. doi:10.1016/j.gloplacha.2008.12.012

Yang, Y., Wang, K., Liu, D., Zhao, X., & Fan, J. (2020). Effects of land-use conversions on the ecosystem services in the agro-pastoral ecotone of northern China. *Journal of Cleaner Production*, *249*, 119360. doi:10.1016/j.jclepro.2019.119360

Yu, R., Deng, X., Yan, Z., & Shi, C. (2013). Dynamic evaluation of land productivity in China. *Zhongguo Renkou Ziyuan Yu Huanjing*, *11*(3), 253–260. doi:10.1080/10042857.2013.835547

Zhao, J., Yan, Y., Deng, H., Liu, G., Dai, L., Tang, L., Shi, L., & Shao, G. (2020). Remarks about land-senses ecology and ecosystem services. *International Journal of Sustainable Development and World Ecology*, *27*(3), 196–201. doi:10.1080/13504509.2020.1718795

Ziter, C. (2016). The biodiversity–ecosystem service relationship in urban areas: A quantitative review. *Oikos*, *125*(6), 761–768. doi:10.1111/oik.02883

zu Ermgassen, P. S., Baker, R., Beck, M. W., Dodds, K., zu Ermgassen, S. O., Mallick, D., ... Turner, R. E. (2021). Ecosystem services: Delivering decision-making for salt marshes. *Estuaries and Coasts*, 1–8.

# Chapter 3
# The Impact of Awareness Regarding Environmental Protection Laws on Ecological Degradation

**Atul Bamrara**
*Government of Uttarakhand, India*

## ABSTRACT

*Global environmental troubles are gaining significance because of the speedy and antagonistic speed of urbanization. Environmental degradation restricts the flow of environmental services. Dumping of pollutants in excess of its assimilative capacity into air, water, and soil results in deterioration of the quality of these vital resources. The nature of environmental problem depends upon the level of economic development and the geographical condition of the area under consideration. India being a developing economy with a low per capita income, high population density, agriculture-dependent labour force, and high percentage of rural areas, the problems here are different from those in developed countries. The chapter highlights the impact of knowledge regarding environmental protection issues on environmental degradation.*

## INTRODUCTION

During the last few decades, there has been an increasing consciousness and concern that the environment in which we live has deteriorated very fast. The air we breathe and the water we drink is getting polluted, rains are becoming erratic, forests are getting depleted, large number of plant and animal species are becoming extinct. The top soil is being eroded and even the ozone layer is getting damaged. There is also a danger of global warming (Baumol and Oates, 1971). This environmental degradation threatens the very existence of human beings. The tragedy is that these problems are being created by human beings themselves. We receive all the life supporting materials from our environment but in return, we do little for the environment. Basically, what is needed is that we should manage our environment properly. Our

DOI: 10.4018/978-1-7998-8482-8.ch003

interference with environment should be minimal and we should ensure that it does not deteriorate and cause a challenge to our existence (Drummond and Barros-Platiau, 2006).

In India, legislations directly aimed at environmental protection were implemented for the first time in 1974 in the form of the Water (Prevention and Control of Pollution) Act (Agarwal, 2005). Prior to that, however, there were certain legislations enacted which have a bearing on environment indirectly (e.g., Motor Vehicles Act, Factories Act and Insecticides Act). After the Water Act, two notable laws have been introduced-

First one is the 42nd Amendment of the Constitution in 1977 which has two sub divisions: (i) Entry 48A mentions that the state will protect and improve the environment and safeguard forests and wildlife; and (ii) Entry 51A suggests that it is also the duty of the citizens to protect and improve the natural environment including wildlife. The forty-second amendment was followed by the Forest Conservation Act, 1980; and subsequently the Air (Prevention and Control of Pollution) Act, 1981. A comprehensive legislation on environment covering all aspects was enacted in 1986 in the form of the Environment Protection Act, 1986. Two international conferences on environment and development - one at Stockholm in 1972 and the other at Rio de Janeiro in 1992 - have influenced environmental policies in most countries, including India. Many countries and international agencies have accepted the ‘polluter pays principle’, the ‘precautionary principle and the concept of ‘intergenerational equity’ as guidelines for designing environmental policies (Agarwal, 2005; Jha and Sen, 1991).

## BACKGROUND

It is a matter of surprise that even at the International level attention to environment was not being given till the sixties. Very few people attached any importance to the Stockholm Conference which was held in 1972. However, some activities started in the field of environmental sciences, when Stockolm Conference brought the problems of deteriorating environment to the notice of the world leaders. Earlier to this the environmental problems were generally considered to be local problems. The developed and industrialized countries have been facing tremendous environmental problems on account of their unplanned industrialisation and growth in developmental activities (Akella and Cannon; Abessa et al., 2019). Consequently, they started turning their attention to environmental management much earlier: They also had enough resources to support these activities. The developing countries which on the other hand, had just started industrialisation and developmental activities did not face such problem so acutely. The environmental problems of the developing countries were generally related to under development, poverty and lack of resources (Dembach and Mintz, 2011). For them, demands such as drinking water, food, shelter, clothing and health were much more important, and for this reason they could not pay proper attention towards environmental management. Last two decades have witnessed dramatic rise in environmental concerns. Governments in various countries have enacted legislations to prevent pollution of natural resources such as air and water and to conserve and ensure sustainable use of forest resources. In India various Acts have been put in place to protect environmental resources. The United States, for example, preferred ‘tradable emission permits’ presumably because of its reliance on the allocative efficiency of markets while many countries in Europe seem to prefer fiscal approach to solve the pollution problem because of their commitment to the concept of welfare state (Linden et al., 1979).

Environmental degradation restricts the flow of environmental services. Dumping of pollutants in excess of its assimilative capacity into air, water and soil results in deterioration of the quality of these vital resources. The nature of environmental problem depends upon the level of economic development and the geographical condition of the area under consideration. India being a developing economy with a low per capita income, high population density, agriculture-dependent labor force, and high percentage of rural areas, the problems here are different from those in developed countries (Korhonen and Lappalainen, 2004). The tropical climate with scanty rainfall in many areas also brings in a specific set of environmental problems. While acknowledging the fact that it is difficult to describe all the problems and analyze the underlying factors, some important problems are presented below. Poverty, illiteracy and lack of awareness have aggravated environmental problems in many cases. Poverty in rural areas, largely due to unavailability of gainful employment, compels people to go to the nearby forests to collect fuel-wood and minor forest products to supplement their household income (Zaelke et al., 1993).

Agriculture being the backbone of the country and draught animal being the major source of power, animals are reared in large numbers and sent to forests for grazing. Cooking by using fuel-wood not only aggravates destruction of forest but also releases harmful gases into the air (Wemer, 1993). Lack of proper sanitation both in rural areas and urban slums vitiates the local environment. High population density in urban areas without adequate infrastructure such as water and electricity supply, public transport and waste disposal has brought in many environmental problems. For example, lack of public transport and rise in per capita income have led urban households to go for private vehicles which has increased fuel consumption, traffic congestion, and increased emission from vehicles. Tightening of emission standards and use of cleaner fuel has not been able to offset the pollution load. Technological progress has also contributed to environmental problems in India.

## OBJECTIVE AND HYPOTHESIS

To measure the correlation between knowledge and awareness about environment protection laws on environmental degradation. The following hypothesis will be tested -

$H_0$: The level of knowledge and awareness about environment protection laws is not associated with environmental degradation

## RESEARCH METHODOLOGY

The present study has adopted the survey method to collect the relevant data. The primary data was collected on the basis of questionnaires administered to various respondents in the Western India (i.e., Uttarakhand, Uttar Pradesh, Himanchal Pradesh, Delhi/NCR, Haryana, Punjab, Rajsthan etc.). The individuals associated to industry, judiciary/ legal departments, non government organizations, social workers, agencies involved in policy formation and academic organizations have been selected for conducting the survey. The secondary data was collected from various published reports available nationally or internationally. It also includes portals of various environmental regulatory bodies. Necessary statistical tools shave been applied to explore the correlation coefficients as well as chi square values.

## DATA ANALYSIS

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 38% individuals have aware of Water Prevention and Control of Pollution Act 1974, while rest 62% people have no awareness of same. Out of 16% females, 25% have aware of Water Prevention and Control of Pollution Act 1974, while 75% females have no awareness of Water Prevention and Control of Pollution Act.

*Table 1.*

| | | | You are aware of Water Prevention and Control of Pollution Act 1974 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 64 | 104 | 168 |
| | | % | 38.1% | 61.9% | 84.0% |
| | Female | Count | 8 | 24 | 32 |
| | | % | 25.0% | 75.0% | 16.0% |
| Total | | Count | 72 | 128 | 200 |
| | | % | 36.0% | 64.0% | 100.0% |
| Chi Square Value = 5.001 | | | Pearson R = 0.1 | | |

The value of Karl Pearson coefficient of correlation is 0.1 which conclude that there is a positive correlation between gender and awareness of Water Prevention and Control of Pollution Act 1974. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 5.001 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Water Prevention and Control of Pollution Act 1974 differs significantly.

## WATER PREVENTION AND CONTROL OF POLLUTION CESS ACT 1977

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 19% individuals are aware of Water Prevention and Control of Pollution Cess Act 1977, while rest 81% people have no awareness of same. Out of 16% females, no one is aware of Water Prevention and Control of Pollution Act.

The value of Karl Pearson coefficient of correlation is 0.19 which conclude that there is a positive correlation between gender and awareness of Water Prevention and Control of Pollution Cess Act 1977. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 7.26 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Water Prevention and Control of Pollution Cess Act 1977 differs significantly.

*Table 2.*

| | | | You are aware of Water Prevention and Control of Pollution Cess Act 1977 | | Total |
|---|---|---|---|---|---|
| | | | **Yes** | **No** | |
| Gender | Male | Count | 80 | 340 | 420 |
| | | % | 19.0% | 81.0% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 80 | 420 | 500 |
| | | % | 16.0% | 84.0% | 100.0% |
| Chi Square Value = 7.26 | | | Pearson R = 0.19 | | |

## AIR PREVENTION AND CONTROL OF POLLUTION ACT 1981

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 31% individuals are aware of Air Prevention and Control of Pollution Act 1981, while rest 69% people have no awareness of same. Out of 16% females, 25% are aware of Air Prevention and Control of Pollution Act, while 75% females have no awareness of same.

*Table 3.*

| | | | You are aware of Air Prevention and Control of Pollution Act 1981 | | Total |
|---|---|---|---|---|---|
| | | | **Yes** | **No** | |
| Gender | Male | Count | 130 | 290 | 420 |
| | | % | 31.0% | 69.0% | 84.0% |
| | Female | Count | 20 | 60 | 80 |
| | | % | 25.0% | 75.0% | 16.0% |
| Total | | Count | 150 | 350 | 500 |
| | | % | 30.0% | 70.0% | 100.0% |
| Chi Square Value = 6.454 | | | Pearson R = 0.048 | | |

The value of Karl Pearson coefficient of correlation is 0.048 which conclude that there is a positive correlation between gender and awareness of Air Prevention and Control of Pollution Act 1981. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 6.454 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Air Prevention and Control of Pollution Act 1981 differs significantly.

## AIR PREVENTION AND CONTROL OF POLLUTION RULES 1982

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 21% individuals are aware of Air Prevention and Control of Pollution Rules 1982, while rest 79% people have no awareness of same. Out of 16% females, 25% are aware of Air Prevention and Control of Pollution Rules 1982, while 75% females have no awareness of same.

*Table 4.*

| | | | You are aware of Air Prevention and Control of Pollution Rules 1982 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 90 | 330 | 420 |
| | | % | 21.4% | 78.6% | 84.0% |
| | Female | Count | 20 | 60 | 80 |
| | | % | 25.0% | 75.0% | 16.0% |
| Total | | Count | 110 | 390 | 500 |
| | | % | 22.0% | 78.0% | 100.0% |
| Chi Square Value = 0.5 | | | Pearson R = -0.032 | | |

The value of Karl Pearson coefficient of correlation is -0.032 which conclude that there is a negative correlation between gender and awareness of Air Prevention and Control of Pollution Rules 1982. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 0.5 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Air Prevention and Control of Pollution Rules 1982 differs significantly.

## WILDLIFE PROTECTION ACT 1972

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 19% individuals are aware of Wildlife Protection Act 1972, while rest 81% people have no awareness of same. Out of 16% females, 13% are aware of Wildlife Protection Act 1972, while 87% females have no awareness of same.

The value of Karl Pearson coefficient of correlation is 0.062 which conclude that there is a positive correlation between gender and awareness of Wildlife Protection Act 1972. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 8.781 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Wildlife Protection Act 1972 differs significantly.

*Table 5.*

| | | | You are aware of the Wildlife Protection Act 1972 | | Total |
|---|---|---|---|---|---|
| | | | **Yes** | **No** | |
| Gender | Male | Count | 80 | 340 | 420 |
| | | % | 19.0% | 81.0% | 84.0% |
| | Female | Count | 10 | 70 | 80 |
| | | % | 12.5% | 87.5% | 16.0% |
| Total | | Count | 90 | 410 | 500 |
| | | % | 18.0% | 82.0% | 100.0% |
| Chi Square Value = 8.781 | | | Pearson R = 0.062 | | |

## FOREST CONSERVATION ACT 1980

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 17% individuals are aware of Forest Conservation Act 1980, while rest 83% people have no awareness of same. Out of 16% females, nobody is aware of Forest Conservation Act 1980.

*Table 6.*

| | | | You are aware of the Forest Conservation Act 1980 | | Total |
|---|---|---|---|---|---|
| | | | **Yes** | **No** | |
| Gender | Male | Count | 70 | 350 | 420 |
| | | % | 16.7% | 83.3% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 70 | 430 | 500 |
| | | % | 14.0% | 86.0% | 100.0% |
| Chi Square Value = 6.202 | | | Pearson R = 0.204 | | |

The value of Karl Pearson coefficient of correlation is 0.204 which conclude that there is a positive correlation between gender and awareness of Forest Conservation Act 1980. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 6.202 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Forest Conservation Act 1980 differs significantly.

## ENVIRONMENT PROTECTION ACT 1986

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 21% individuals are aware of Environment Protection Act 1986, while rest 79% people have no awareness of same. Out of 16% females, no one is aware of Environment Protection Act 1986.

*Table 7.*

| | | | You are aware of the Environment Protection Act 1986 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 90 | 330 | 420 |
| | | % | 21.4% | 78.6% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 90 | 410 | 500 |
| | | % | 18.0% | 82.0% | 100.0% |
| Chi Square Value = 8.362 | | | Pearson R = 0.204 | | |

The value of Karl Pearson coefficient of correlation is 0.204 which conclude that there is a positive correlation between gender and awareness of Environment Protection Act 1986. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 8.362 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Environment Protection Act 1986 differs significantly.

*Table 8.*

| | | | You are aware of the Power of Central Government to take measures to protect and improve environment | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 20 | 400 | 420 |
| | | % | 4.8% | 95.2% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 20 | 480 | 500 |
| | | % | 4.0% | 96.0% | 100.0% |
| Chi Square Value = 1.589 | | | Pearson R = 0.089 | | |

## POWER OF CENTRAL GOVERNMENT

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 5% individuals are aware of Power of Central Government to take measures to protect and improve environment, while rest 95% people have no awareness of same. Out of 16% females, no one is aware of Power of Central Government to take measures to protect and improve environment.

The value of Karl Pearson coefficient of correlation is 0.089 which conclude that there is a positive correlation between gender and awareness of Power of Central Government to take measures to protect and improve environment. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 1.589 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is less than tabulated value therefore null hypothesis is accepted or it can be concluded that awareness of Power of Central Government to take measures to protect and improve environment does not differ significantly.

## NATIONAL ENVIRONMENT APPELLATE AUTHORITY ACT 1997

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 2% individuals are aware of National Environment Appellate Authority Act 1997, while rest 98% people have no awareness of same. Out of 16% females, no one is aware of National Environment Appellate Authority Act 1997.

*Table 9.*

| | | | You are aware of the National Environment Appellate Authority Act 1997 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 10 | 410 | 420 |
| | | % | 2.4% | 97.6% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 10 | 490 | 500 |
| | | % | 2.0% | 98.0% | 100.0% |
| Chi Square Value = 0.777 | | | Pearson R = 0.062 | | |

The value of Karl Pearson coefficient of correlation is 0.062 which conclude that there is a positive correlation between gender and awareness of National Environment Appellate Authority Act 1997. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 0.777 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is less than tabulated value therefore null hypothesis is accepted or it can be concluded that awareness of National Environment Appellate Authority Act 1997 does not differ significantly.

## FACTORIES ACT 1948

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 5% individuals are aware of Factories Act 1948, while rest 95% people have no awareness of same. Out of 16% females, 25% are aware of Factories Act 1948, while 75% females have no awareness of same.

*Table 10.*

| | | | You are aware of the Factories Act 1948 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 20 | 400 | 420 |
| | | % | 4.8% | 95.2% | 84.0% |
| | Female | Count | 20 | 60 | 80 |
| | | % | 25.0% | 75.0% | 16.0% |
| Total | | Count | 40 | 460 | 500 |
| | | % | 8.0% | 92.0% | 100.0% |
| Chi Square Value = 14.95 | | | Pearson R = -0.273 | | |

The value of Karl Pearson coefficient of correlation is -0.273 which conclude that there is a negative correlation between gender and awareness of Factories Act 1948. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 14.95 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of Factories Act 1948 differs significantly.

*Table 11.*

| | | | You are aware of Public Liability Insurance Act 1991 | | Total |
|---|---|---|---|---|---|
| | | | Yes | No | |
| Gender | Male | Count | 8 | 412 | 420 |
| | | % | 2.4% | 97.6% | 84.0% |
| | Female | Count | 0 | 80 | 80 |
| | | % | 0.0% | 100.0% | 16.0% |
| Total | | Count | 10 | 490 | 500 |
| | | % | 2.0% | 98.0% | 100.0% |
| Chi Square Value = 0.777 | | | Pearson R = 0.062 | | |

## PUBLIC LIABILITY INSURANCE ACT 1991

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 2% individuals are aware of Public Liability Insurance Act 1991, while rest 98% people have no awareness of same. Out of 16% females, no one is aware of Public Liability Insurance Act 1991.

The value of Karl Pearson coefficient of correlation is 0.062 which conclude that there is a positive correlation between gender and awareness of Public Liability Insurance Act 1991. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 0.777 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is less than tabulated value therefore null hypothesis is accepted or it can be concluded that awareness of Public Liability Insurance Act 1991 does not differ significantly.

## NATIONAL ENVIRONMENT TRIBUNAL ACT 1995

Out of the total respondents 84% are males while rest 16% were females. Out of 84% males, 12% individuals are aware of National Environment Tribunal Act 1995, while rest 88% people have no awareness of same. Out of 16% females, 13% are aware of National Environment Tribunal Act 1995, while 87% females have no awareness of same.

*Table 12.*

| | | | You are aware of National Environment Tribunal Act 1995 | | Total |
|---|---|---|---|---|---|
| | | | **Yes** | **No** | |
| Gender | Male | Count | 50 | 370 | 420 |
| | | % | 11.9% | 88.1% | 84.0% |
| | Female | Count | 10 | 70 | 80 |
| | | % | 12.5% | 87.5% | 16.0% |
| Total | | Count | 60 | 440 | 500 |
| | | % | 12.0% | 88.0% | 100.0% |
| Chi Square Value = 6.009 | | | Pearson R = -0.007 | | |

The value of Karl Pearson coefficient of correlation is -0.007 which conclude that there is a negative correlation between gender and awareness of National Environment Tribunal Act 1995. Calculated value of $\chi^2$ for 1 degree of freedom at 5% level of significance is 6.009 and tabulated value of $\chi^2$ is 3.841. Since calculated value of chi-square is greater than tabulated value therefore null hypothesis is rejected or it can be concluded that awareness of National Environment Tribunal Act 1995 differs significantly.

## CONCLUSION

The nine variables “Awareness of Water Prevention and Control of Pollution Act 1974”, “Awareness of Water Prevention and Control of Pollution Cess Act 1977”, “Awareness of Air Prevention and Control of Pollution Act 1981”, “Awareness of Wildlife Protection Act 1972”,

*Table 13.*

| | Proposed Relationship | Results |
|---|---|---|
| 1 | Gender - Awareness of Water Prevention and Control of Pollution Act 1974 | +ve, Rejected |
| 2 | Gender - Awareness of Water Prevention and Control of Pollution Cess Act 1977 | +ve, Rejected |
| 3 | Gender - Awareness of Air Prevention and Control of Pollution Act 1981 | +ve, Rejected |
| 4 | Gender - Awareness of Air Prevention and Control of Pollution Rules 1982 | -ve, Rejected |
| 5 | Gender - Awareness of Wildlife Protection Act 1972 | +ve, Rejected |
| 6 | Gender - Awareness of Forest Conservation Act 1980 | +ve, Rejected |
| 7 | Gender - Awareness of Environment Protection Act 1986 | +ve, Rejected |
| 8 | Gender - Awareness of Power of Central Government to take measures to protect and improve environment | +ve, Accepted |
| 9 | Gender - Awareness of National Environment Appellate Authority Act 1997 | +ve, Accepted |
| 10 | Gender - Awareness of Factories Act 1948 | -ve, Rejected |
| 11 | Gender - Awareness of Public Liability Insurance Act 1991 | +ve, Accepted |
| 12 | Gender - Awareness of National Environment Tribunal Act 1995 | -ve, Rejected |

“Awareness of Forest Conservation Act 1980”, “Awareness of Environment Protection Act 1986”, “Awareness of Power of Central Government to take measures to protect and improve environment”, “Awareness of National Environment Appellate Authority Act 1997” & “Awareness of Public Liability Insurance Act 1991” & “Industry Type” are positively correlated with gender of the respondents. Whereas, the variables “Awareness of Air Prevention and Control of Pollution Rules 1982”, “Awareness of Factories Act 1948” & “Awareness of National Environment Tribunal Act 1995” are negatively correlated with gender of the respondents. On the basis of Chi square results, it can be concluded that in spite of enough limitations, degradation is a continuous process due to lack of knowledge and awareness.

## REFERENCES

Abessa, D., Famá, A., & Buruaem, L. (2019). The systematic dismantling of Brazilian environmental laws risks losses on all fronts. *Nature Ecology & Evolution*, *3*(4), 510–511. doi:10.103841559-019-0855-9 PMID:30886371

Agarwal, V. K. (2005). Environmental laws in India: Challenges for enforcement. *Bulletin of the National Institute of Ecology*, *15*, 227–238.

Akella, A. S., & Cannon, J. B. (2017). *Strengthening the weakest links: strategies for improving the enforcement of environmental laws globally*. Routledge. doi:10.4324/9781315084589-28

Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: Assessment of the current campus environmental management practices. *Journal of Cleaner Production*, *16*(16), 1777–1785. doi:10.1016/j.jclepro.2007.12.002

Baumol, W. J., & Oates, W. E. (1971). The use of standards and prices for protection of the environment. *The Swedish Journal of Economics*, *73*(1), 42–54. doi:10.2307/3439132

Dernbach, J. C., & Mintz, J. A. (2011). *Environmental laws and sustainability: An introduction*. Academic Press.

Drummond, J., & Barros-Platiau, A. F. (2006). Brazilian environmental laws and policies, 1934–2002: A critical overview. *Law & Policy*, *28*(1), 83–108. doi:10.1111/j.1467-9930.2005.00218.x

Korhonen, K., & Lappalainen, A. (2004). Examining the environmental awareness of children and adolescents in the Ranomafana region, Madagascar. *Environmental Education Research*, *10*(2), 195–216. doi:10.1080/13504620242000198177

Jha, L. K., & Sen, P. P. (1991). *Social Forestry*. Himalaya Publishing House.

Sankar, U. (1998). *Laws and Institutions relating to Environmental Protection in India*. Occasional Paper, Madras School of Economics. www.mse.ac.in

Linden, E., Bengtsson, B. E., Svanberg, O., Sundström, G., & Board, N. S. E. P. (1979). The acute toxicity of 78 chemicals and pesticide formulations against two brackish water organisms, the bleak (Alburnus alburnus) and the harpacticoid Nitocra spinipes. *Chemosphere*, *8*(11-12), 843–851. doi:10.1016/0045-6535(79)90015-8

Mei, N. S., Wai, C. W., & Ahamad, R. (2016). Environmental awareness and behaviour index for Malaysia. *Procedia: Social and Behavioral Sciences*, *222*(7), 668–675. doi:10.1016/j.sbspro.2016.05.223

Werner, W. L. (1993). Aspects of ecological problems and environmental awareness in South Asia. *European Conference on Modern South Asian Studies 1990*.

Zaelke, D., Orbuch, P., & Housman, R. (Eds.). (1993). *Trade and the Environment: Law, economics, and policy*. Island Press.

# Chapter 4
# Variations in the Landscape Along the High-Speed Rail Route

**José Cabezas**
https://orcid.org/0000-0002-7209-3731
*University of Extremadura, Spain*

**José Manuel Naranjo**
*University of Extremadura, Spain*

**Francisco Jesús Moral**
*University of Extremadura, Spain*

**Patricia Bratos**
*University of Extremadura, Spain*

## ABSTRACT

*The development carried out in the last decades is degrading the ecosystems, damaging the existing biodiversity. One of the elements that is having the most impact on the deterioration of natural areas is the construction of transport infrastructures, among which are high-speed routes. These linear infrastructures are contributing to the deterioration of biodiversity enclaves, which contribute to providing highly relevant ecosystem services. Among these deteriorations are the processes of fragmentation and alteration of the landscape. This chapter analyses a situation that occurs in Spanish territory related to high-speed railways. This transport system began in Spain on the occasion of the Universal Exhibition of Seville 1992. By this transport activity, the changes suffered in the landscape are calculated and analysed through Corine land cover data since its inception until the last report of 2018.*

## INTRODUCTION

The Seville-Madrid high-speed rail line began to be built in 1989, with the intention of being able to

DOI: 10.4018/978-1-7998-8482-8.ch004

open in 1992, coinciding with the Universal Exhibition of Seville that same year. On April 14, 1992, the line was inaugurated and on April 21, 1992, the service was opened to the public (García, 2006), thus becoming the first high-speed line of international width in Spain.

There is a debate on the socio-economic benefits of high-speed lines in Spain, given that their economic and social impact is very complex to measure, as it affects many sectors and there is little scientific literature on long-term studies, focusing the majority on the first years of opening (Pinos Navarrete, & Mínguez García, (2017). However, Preciado, Arilla, Uribeondo, and Yanci (2006) highlights the success of this line with respect to air travel and social benefits, especially in the cities closest to Madrid.

Independently of the Spanish case, linear infrastructures consisting of roads and railways, and to a lesser extent canal, form artificial corridors, which have direct economic benefits (Bruinsma et al., 2008; Banister, 2011; Hickman, Bonilla, Givoni & Banister, 2015; Vickerman, 2015). But as a counterpart contributes to the environmental deterioration of the territory causing polluting effects (Borrego Tchepel, Barros & Miranda, 2000; Galera Sudnik-Wójcikowska, Wierzbicka & Wiłkomirski, 2011); acting as barriers to the mobility and spread of species (Forman & Alexander, 1998; Tikka, Högmander & Koski, 2001); or increase fragmentation and edge generation (Bohemenhd, 1998; Daniel & Dennis, 2001).

The development of communication infrastructures is marked by the urban centres being connected. These centres create a web of communications that suffocate the natural environment, so in Europe, more than 50% of its territory is less than 1500 meters from a communication route, in the USA that distance is reduced to less than 400 m and finally in the case of Spain is below 900 m (Riitters & Wickham, 2003; Torres, Jaeger & Alonso, 2016). These will suffer the positive or negative impacts that these communication paths entail and that affects in particular the natural environment located between the populations that it connects (Torres, Jaeger & Alonso, 2016; Miao, Yang & Song, 2021).

Rail impacts are linked to multiple factors ranging from the technical characteristics of vehicles (shape, length, weight, number of passengers), type and energy levels used, together with others related to operational factors such as acceleration, braking capacity, maximum speed and distance between stations (Van Wee, Van Den Brink & Nijland, 2003). This last characteristic acquires remarkable importance when analysing the environmental conditions and the level of conservation along the route of the road. Some of these impacts are measurable monetarily, but the effects on natural habitats and the landscape cannot be measured economically, due to the difficulty of assessing them (Heinzerling & Ackerman, 2002; Sen, 2000; Niemeyer & Spash, 2001; Eijgenraam & Ossokina, 2008). But despite this, it should not be forgotten that it also has positive environmental impacts reducing global pollution (Barbosa, 1019; Yang, Lin, Li & He, 2019) and contributing to the reduction of problematic global warming (Dalkic, Balaban, Tuydes-Yaman & Celikkol-Kocak, 2017; Chang et al., 2019).

There is no doubt that among the greatest impacts caused by communication infrastructures are the occupation of the territory and consequently its effects related to alterations of the landscape and natural habitats (Forman, 2003). Although this type of research, as mentioned above, has focused more on roads (Jaeger, 2015; Mahmoud et al., 2017; Valerio et al., 2019) than on the problems generated by the railway (Popp & Boyle, 2017; Barrientos et al., 2019; Clair et al., 2020). This lower attention may be determined by the smaller size of the rail network compared to the road network (Santos, Carvalho & Mira, 2017; Dasoler et al., 2020), but within 30 years it is estimated that roads will increase by only 36% compared to 45% of railways (Dulac, 2013).

Among the problems suffered by the landscapes, fragmentation, which also occurs naturally, is the alteration most frequently related to the increase in transport activity (Borda-de-Água, Barrientos, Beja & Pereira, 2017; Miao, Yang & Song, 2021). This pressure on the landscapes leads to losses in the functionality of the different landscape units caused by the decrease in the size of the patch, disconnection between patches, attention to horizontal flows and consequently effects on the behaviour of the animals that settle in those landscapes (Van der Ree, Smith, Grilo & van der Ree, 2015; Barrientos et al., 2019; Dasoler et al., 2020). One of the methodologies used by this type of study is the use of buffers along the path of the infrastructure, to determine the effects caused along the path in successive years (Zhang, Liu & Zhou, 2018; Mehdipour, Fakheran, Soffianian, & Pourmanafi, 2019; Miao, Yang & Song, 2021).

In 1990, the European Commission launched the CORINE Land Cover programme as a way of monitoring changes in the European landscape (CLC, 2018). It has information covering the European landscape, with a minimum resolution of 25 hectares and inventories corresponding to five periods from 1990 to 2018. For all these reasons, it is a database of information widely used in landscape studies (Shen, Silva & Martínez, 2014; Sallustio et al. 2016; Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021)

This research analyses a situation that is presented in Spanish territory related to high-speed railways, specifically the Madrid-Seville line inaugurated in 1992 and whose construction works coincided with the first CLC of 1990.

## METODOLGY

For the analysis of the studied territory, the first layers of information used are composed of the data obtained from the Corine Land Cover project (CLC), within the framework of the CORINE Environmental Information Coordination program. The territorial information is presented in the form of detailed geodatabases of land use data. Likewise, the graphical representation of these is done by polygons (https://land.copernicus.eu/pan-european/corine-land-cover).

As for the spatial component, the reference scale 1:100,000 has been used, the geodesic reference system is the European Terrestrial Reference System 1989 (ETRS89). The minimum width recorded for linear phenomena 100 m. In polygonal phenomena, the minimum cartographic unit (MCU) is 25 hectares in squares of 5 x 5 mm or in circles of 2.8 mm (https://land.copernicus.eu/pan-european/corine-land-cover).

On the other hand, the thematic component has three hierarchical levels of information. Also, all data is vector formatted and uses polygons to represent land uses/covers. In line with the European Environmental Agency, these uses are organized into three hierarchical levels by 44 classes (Table 1).

Based on the land uses obtained for the years 1990 and 2018, those coverages that are 1 and 5 km from the Madrid-Seville high-speed railway line will be analysed (Figure 1).

In this regard, the study area encompasses several regions belonging to Spain. For this reason, the layer regarding the location of the railway line was obtained from the Download Center of the National Geographic Information Center, belonging to the Ministry of Transport, Mobility and Urban Agenda of the Government of Spain (https://centrodedescargas.cnig.es/CentroDescargas/index.jsp). Specifically, it was acquired at a scale of 1:100,000 of the National Topographic Base.

Later, from the railway line, two buffers were obtained at 1 and 5 km. Thus, four layers of information were available, that is, land uses in 1990 and 2018, and buffer 1 km and buffer 5 km from the high-speed railway line.

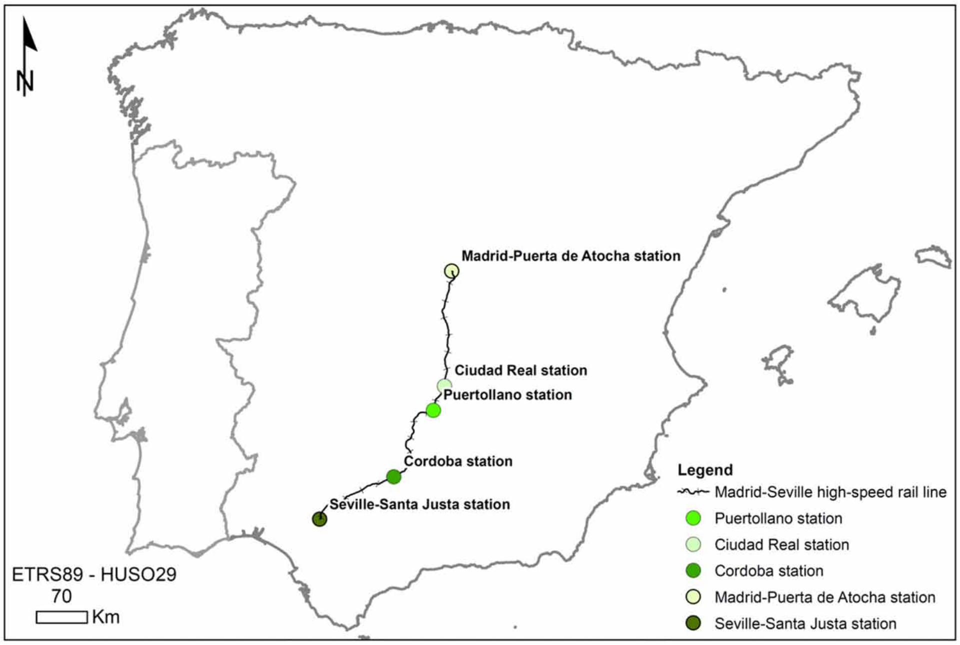
Subsequently, the layers were then laid out in the ArcGIS 10.5 software. In this way, the polygons representative of the land uses were obtained both in 1990 and in 2018 that were within the two aforementioned buffers.

*Table 1. Corine Land Cover nomenclature. (Source: https://land.copernicus.eu/pan-european/corine-land-cover)*

| Level 1 | Level 2 | Level 3 |
|---|---|---|
| 1. Artificial surfaces | 1.1. Urban fabric | 1.1.1. Continuous urban fabric |
| | | 1.1.2. Discontinuous urban fabric |
| | 1.2. Industrial, commercial and transport | 1.2.1.Industrial or commercial units |
| | | 1.2.2.Road and rail networks and associated land |
| | | 1.2.3.Port areas |
| | | 1.2.4. Airports |
| | 1.3. Mine, dump and construction sites | 1.3.1.Mineral extraction sites |
| | | 1.3.2.Dump sites |
| | | 1.3.3.Construction sites |
| | 1.4. Artificial, non-agricultural vegetated areas | 1.4.1.Green urban areas |
| | | 1.4.2.Sport and leisure facilities |
| 2. Agricultural areas | 2.1. Arable land | 2.1.1. Non-irrigated arable land |
| | | 2.1.2. Permanently irrigated land |
| | | 2.1.3. Rice fields |
| | 2.2. Permanent crops | 2.2.1.Vineyards |
| | | 2.2.2.Fruit trees and berry plantations |
| | | 2.2.3.Olive groves |
| | 2.3. Pastures | 2.3.1.Pastures |
| | 2.4. Heterogeneous agricultural areas | 2.4.1.Annual crops associated with permanent crops |
| | | 2.4.2.Complex cultivation |
| | | 2.4.3.Land occupied by agriculture |
| 3. Forests and semi-natural areas | 3.1. Forests | 3.1.1. Broad-leaved forest |
| | | 3.1.2.Coniferous forest |
| | | 3.1.3.Mixed forest |
| | 3.2.Shrub and/or herbaceous vegetation association | 3.2.1. Natural grassland |
| | | 3.2.2.Moors and heathland |
| | | 3.2.3.Sclerophyllous vegetation |
| | | 3.2.4.Transitional woodland shrub |
| | 3.3. Open spaces with little or no vegetation | 3.3.1.Beaches, dunes, and plains |
| | | 3.3.2.Bare rock |
| | | 3.3.3.Sparsely vegetated areas |
| | | 3.3.4.Burnt areas |
| | | 3.3.5.Glaciers and perpetual snow |
| 4.Wetlands | 4.1. Inland wetlands | 4.1.1.Inland marshes |
| | | 4.1.2.Peatbogs |
| | 4.2. Coastal wetlands | 4.2.1.Salt marshes |
| | | 4.2.2.Salines |
| | | 4.2.3.Intertidal flats |
| 5. Water bodies | 5.1. Inland waters | 5.1.1.Water courses |
| | | 5.1.2.Water bodies |
| | 5.2. Marine waters | 5.2.1.Coastal lagoons |
| | | 5.2.2.Estuaries |
| | | 5.2.3.Sea and ocean |

Based on the information obtained, the area in hectares occupied by each of the polygons was mea-

*Figure 1. Location of the Madrid-Seville high-speed train line and the stations*
*Source: authors.*




sured. Subsequently, the land uses according to the CLC nomenclature in Microsoft Access were grouped to obtain the number of hectares and the proportion in percentage that each of the lands uses occupied cumulatively for levels 1 and 3 of the CLC nomenclature. In this respect, the percentage of occupancy of each use was determined for the buffer at 1 km and 5 km in the years 1990 and 2018.

At a later stage, landscape fragmentation metrics were obtained from polygons defined for level 3 of the CLC nomenclature. Initially, the layers obtained from the land use in ArcGIS 10.5. were transformed into four TIFF raster files (.tif) with 30 m of cell size. These files were then exported to four ERDAS Imagine grid (.img) files. Then a text file with the descriptors of the land uses was generated. After the previous steps the FRAGSTATS 4.2. the software was used to perform landscape metrics and class metrics using the eight-cell neighbourhood rule.

As for land metrics, calculations apply to the landscape as a whole to report the degree of heterogeneity or homogeneity of the whole area that has been quantified. In this research, two diversity measures were carried out. Firstly, the Shannon's Diversity Index (SHDI) values landscape diversity, based on fragment diversity. It is useful for comparing different landscapes or the same landscape at different times of time (Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021)

$$SHDI = -\sum_{i=1}^{m} \left( P_i ln P_i \right)$$

Where $P_i$= proportion of the landscape occupied by patch type (class) i.

SHDI equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion. Note, $P_i$ is based on total landscape area (A) excluding any internal background present.

Secondly, the Shannon's Evenness Index (SHEI) was calculated which is a reverse index of the previous one, both at the calculation and interpretation level, based on landscape homogeneity (Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021).

$$SHEI = \frac{-\sum_{i=1}^{m}\left(P_i ln P_i\right)}{lnm}$$

Where:

$P_i$ = proportion of the landscape occupied by patch type (class) i.
*m*= number of patch types (classes) present in the landscape, excluding the landscape border if present.

Regarding class metrics, the calculations apply to each set of fragments of the same class, that is, those that have the same value or represent the same type of land use, in our case. It is the appropriate level for calculating which area occupies a certain soil cover, such as forests, or what is the average extent occupied by forest fragments (Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021).

In this case, shape metrics were performed as the arithmetic mean of the shape index (SHAPE_?) equals patch perimeter (given in the number of cell surfaces) divided by the minimum perimeter (given in the number of cell surfaces) possible for a maximally compact patch (in a square raster format) of the corresponding patch area (Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021).

$$SHAPE = \frac{p_{ij}}{\min p_{ij}}$$

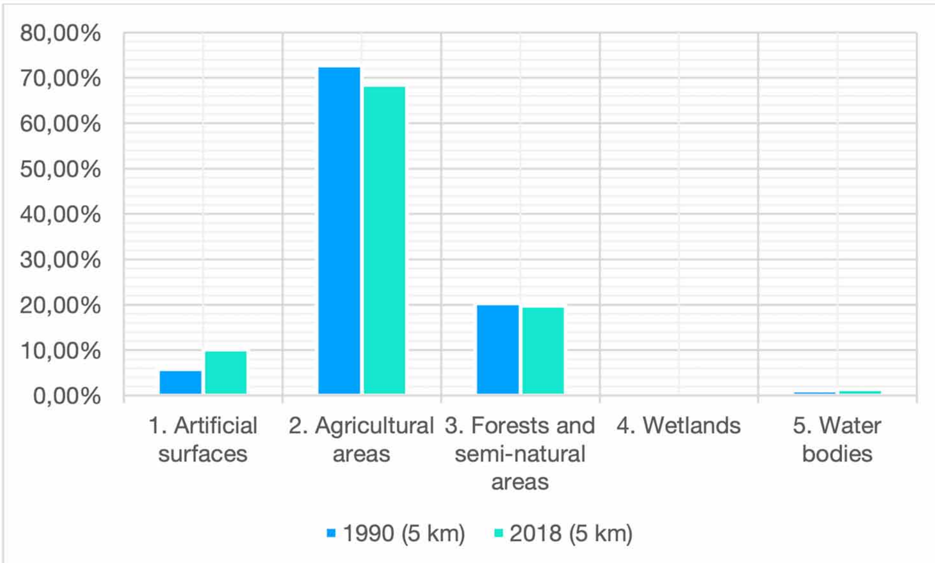
Where:
$p_{ij}$ = perimeter of patch ij in terms of a number of cell surfaces.
$\min p_{ij}$ = minimum perimeter of patch *ij* in terms of number of cell surfaces.

If aij is the area of patch ij (in terms of number of cells) and n is the side of a largest integer square smaller than $a_{ij}$, and m = $a_{ij}$ - $n^2$, then the minimum perimeter of patch ij, min-$p_{ii}$ will take one of the three forms (Milne 1991, Bogaert et al. 2000).

$min - p_{ii} = 4n$ when m = 0, or
$min - p_{ii} = 4n + 2$ when $n^2 < a_{ij} \leq n(1+n)$, or
$min - p_{ii} = 4n + 4$ when $a_{ij} \geq n(1+n)$,

In addition, the calculation of the arithmetic mean of the fractal dimension index (FRAC_?) was executed that calculates the degree of complexity of each fragment from the relationship between area and perimeter (Castanho, Naranjo-Gómez, Vulevic & Gouto, 2021).

*Figure 2. Percentage of land-uses within 1 km of the high-speed rail line, according to level 1 of CLC nomenclature*




$$FRAC = \frac{2\ln\left(25 p_{ij}\right)}{\ln a_{ij}}$$

Where:

$p_{ij}$ = perimeter (m) of patch ij.

$a_{ij}$ = area ($m^2$) of patch ij.

The shape of fragments is of paramount importance and is sometimes even considered more relevant than dimension. The form is conditioned by human activity and natural conditions such as topography. Thus, the mastery of natural conditions favours curvilinear and irregular forms. On the contrary, the mastery of human activity promotes the diversification of forms. Intense human activity implies a simplification of variability (Vila, Linde, Pascual & Palom, 2006).

Finally, the number of patches were calculated, that is, the number of total fragments and the number of fragments of each class since the number of tiles is the simplest metric that can give an idea of the extent to which land use is divided or fragmented.

## RESULTS AND DISCUSSIONS

From the quantification in hectares of each of the land uses/coverages classified according to CLC for level 1, it is possible to establish the percentage of occupancy of each of them in the different years analysed, as well as for the two buffers at 1 and 5 km from the high-speed railway line, and also the difference between the occupation of a certain kind of ground (Figures 2 and 3).

*Figure 3. Percentage of land-uses within 5 km of the high-speed rail line, according to level 1 of CLC nomenclature*

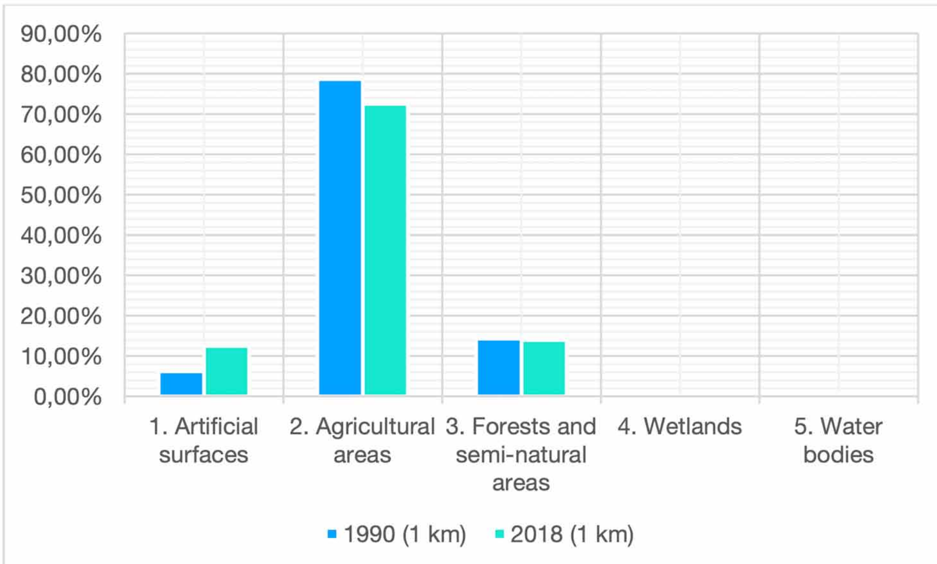



Figure 2 shows, for land uses within 1 km of the railway line, that the largest amount of land corresponds to agricultural areas. It could therefore be said that agricultural uses are the most immediate to the railway line. In contrast, there is hardly any proportion of lands classified as wetlands and water bodies. Also, the difference recorded for each of the lands uses when comparing the two years analysed is not very high. However, it highlights that the greatest difference occurs in artificial surfaces with an increase that seems to come from the decrease of agricultural areas between 1990 and 2018.

Land uses 5 km from the high-speed railway line were also quantified (Figure 3), showing a behaviour very similar to those recorded at 1 km (Figure 2). As a result, despite the greater amount of territory analysed by increasing the distance to 5 km, the occupation has a behaviour very similar to the situation found in areas less than 1 km.

In the same way, as previously for obtaining the percentage of occupancy of land uses classified according to CLC for level 1, the percentages for level 3 were calculated, obtaining more disaggregated information (Table 2).

In Table 2 it can be established that there has been a variation in land uses, it is observed that the minimum values recorded do not always correspond to the same land use. In fact, for the buffer of 1 km in 1990 is 142 (sport and leisure facilities), and in 2018 is 333 (sparsely vegetated areas); and for the buffer of 5 km in 1990 is 332 (bare rock), and 334 (burnt areas) in 2018. Then, there is an alternation of different land uses, along with the non-existence of some of them in certain years. On the contrary, the highest value is always the same in the two years and buffers analysed, corresponding to land use 211 (non-irrigated arable land). In this case, it could be established that there is a prevalence of the land that occupies more area 211 (non-irrigated arable land) being the most predominant and characteristic of the coverage up to 5 km of the high-speed railway line. If we add the above to the fact that the second most abundant is 212 (permanently irrigated land), it reinforces the eminently agricultural character of the territory, which every year occupies more than half of the area.

*Table 2. Percentage of land-uses according to level 3 of CLC nomenclature*

| CODE | 1990 (1 km) | 2018 (1 km) | 2018-1990 (1 km) | 1990 (5 km) | 2018 (5 km) | 2018-1990 (5 km) |
|---|---|---|---|---|---|---|
| 111 | 3.27% | 2.67% | -0.60% | 2.63% | 2.00% | -0.63% |
| 112 | 0.99% | 3.57% | 2.58% | 1.39% | 3.20% | 1.81% |
| 121 | 1.13% | 2.64% | 1.50% | 0.82% | 2.00% | 1.18% |
| 122 | 0.34% | 1.39% | 1.04% | 0.12% | 0.63% | 0.51% |
| 123 | 0.00% | 0.00% | 0.00% | 0.03% | 0.02% | -0.01% |
| 124 | 0.00% | 0.13% | 0.13% | 0.12% | 0.26% | 0.14% |
| 131 | 0.15% | 0.83% | 0.68% | 0.20% | 0.68% | 0.48% |
| 132 | 0.00% | 0.22% | 0.22% | 0.08% | 0.15% | 0.07% |
| 133 | 0.28% | 0.36% | 0.08% | 0.18% | 0.25% | 0.07% |
| 141 | 0.05% | 0.38% | 0.33% | 0.23% | 0.72% | 0.49% |
| 142 | 0.03% | 0.36% | 0.32% | 0.06% | 0.26% | 0.20% |
| 211 | 25.15% | 25.01% | -0.14% | 24.36% | 23.03% | -1.33% |
| 212 | 24.70% | 14.71% | -9.98% | 17.62% | 13.20% | -4.41% |
| 221 | 1.04% | 0.88% | -0.15% | 1.45% | 1.13% | -0.32% |
| 222 | 2.72% | 7.18% | 4.46% | 2.31% | 6.78% | 4.46% |
| 223 | 6.66% | 8.40% | 1.74% | 7.13% | 9.55% | 2.42% |
| 231 | 0.00% | 1.97% | 1.97% | 0.00% | 1.32% | 1.32% |
| 241 | 0.16% | 0.00% | -0.16% | 0.10% | 0.00% | -0.10% |
| 242 | 7.03% | 4.04% | -2.99% | 7.98% | 3.07% | -4.92% |
| 243 | 0.25% | 1.99% | 1.74% | 0.90% | 1.65% | 0.75% |
| 244 | 10.95% | 8.29% | -2.66% | 10.90% | 8.77% | -2.13% |
| 311 | 1.65% | 3.01% | 1.37% | 3.14% | 4.48% | 1.34% |
| 312 | 1.51% | 1.59% | 0.08% | 1.93% | 1.70% | -0.22% |
| 313 | 0.27% | 0.41% | 0.14% | 0.19% | 0.57% | 0.38% |
| 321 | 3.60% | 3.68% | 0.07% | 4.17% | 5.53% | 1.37% |
| 323 | 2.72% | 2.68% | -0.04% | 4.86% | 4.13% | -0.73% |
| 324 | 4.55% | 2.39% | -2.16% | 5.97% | 3.18% | -2.79% |
| 332 | 0.04% | 0.12% | 0.08% | 0.01% | 0.15% | 0.15% |
| 333 | 0.00% | 0.03% | 0.03% | 0.03% | 0.05% | 0.02% |
| 334 | 0.00% | 0.08% | 0.08% | 0.00% | 0.02% | 0.02% |
| 411 | 0.00% | 0.07% | 0.07% | 0.02% | 0.07% | 0.05% |
| 511 | 0.48% | 0.57% | 0.10% | 0.82% | 0.85% | 0.03% |
| 512 | 0.29% | 0.35% | 0.05% | 0.27% | 0.60% | 0.33% |

As for the differences registered, increase or decrease, between 2018 and 1990 for each of the buffers, in all types of CLC there are variations, not remaining constant none. In the 1 km buffer, it can be observed that the greatest difference -9.98% happens due to the loss of land use surface 212 (permanently irrigated land). Nevertheless, in the 5 km buffer, the biggest difference -4.92% occurs due to the loss of type 242 (complex cultivation). Although it is true that in the buffer of the 5 km that loss could be offset with an increase in uses 223 (pastures) and 321 (natural grassland), it can be established that there has been practically alternation of these land uses to 5 km of the railway high-speed rail. The same does not happen in the land closer to 1 km from the railway line, since the increase of land 222 (fruit trees and Berry plantations) is -2.99% approximately half -9.98% of the loss of land 212 (permanently irrigated land). Therefore, land 5 kilometres away loses hegemony in one land in favour of another. However, in lands closer to 1 km and that most directly interact with the terrestrial infrastructure, a land loses hegemony at the expense of a greater presence of other types of use, being able to interpret that the closer to the high-speed rail line there is greater variability in the area occupied by the different land uses.

Subsequently, the results of the landscape fragmentation metrics were obtained.

*Table 3. Landscape metrics for 1-kilometre buffer*

| 1990 | | 2018 | | Difference 2018-1990 | |
|---|---|---|---|---|---|
| SHDI | SHEI | SHDI | SHEI | SHDI | SHEI |
| 0.2055 | 0.0624 | 0.2159 | 0.0623 | 0.0104 | -0.0001 |

Table 3 shows the values obtained for SHDI and SHEI, referring to the diversity of the landscape in 1990 and 2018, which in the case of SHDI are slightly higher than 0, and for SHEI are relatively close to 0. As a consequence, there is little diversity in land use within 1 kilometre of the high-speed railway line, both in 1990 and in 2018.

In addition, the difference in values for these indices between the years analysed (Table 3), increases slightly for the SHDI and decreases the SHEI. Therefore, the number of different polygons grows and the distribution in the analysed buffer becomes less equitable.

*Table 4. Landscape metrics for 5-kilometre buffer*

| 1990 | | 2018 | | Difference 2018-1990 | |
|---|---|---|---|---|---|
| SHDI | SHEI | SHDI | SHEI | SHDI | SHEI |
| 0.7333 | 0.2097 | 0.5920 | 0.1693 | -0.1413 | -0.0404 |

As would be expected, the results obtained for the buffer 5 kilometres from the high-speed railway line (Table 4), show an increase in the SHDI and SHEI indices, both in 1990 and in 2018, as the study area increased. Therefore, the diversity of land uses is greater than previously for the 1-kilometre buffer (Table 3). But, the value of the indices between the years analysed is reduced, reducing as a consequence the diversity in the uses of the land over the years. In addition, in those 28 years, although the territory has become more fragmented, it tends to concentrate more on some types of classes.

The class metrics were then obtained in 1990 and 2018, again for 1 and 5 km buffers around the high-speed rail line (Tables 5 and 6).

*Table 5. Class metrics for 1-kilometre buffer*

| 1990 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|
| TYPE | NP | SHAPE_MN | FRAC_MN | TYPE | NP | SHAPE_MN | FRAC_MN |
| 111 | 28 | 1.7841 | 1.0867 | 111 | 38 | 1.7084 | 1.0746 |
| 112 | 26 | 1.7463 | 1.0809 | 112 | 74 | 1.9119 | 1.0981 |
| 121 | 21 | 1.5874 | 1.0700 | 121 | 58 | 1.7843 | 1.0892 |
| 122 | 3 | 2.5048 | 1.1327 | 122 | 25 | 2.4415 | 1.1278 |
| | | | | 124 | 1 | 1.4737 | 1.0568 |
| 131 | 5 | 1.4455 | 1.0629 | 131 | 22 | 1.6583 | 1.0828 |
| | | | | 132 | 3 | 1.7062 | 1.0944 |
| 133 | 7 | 1.9079 | 1.1085 | 133 | 16 | 1.6534 | 1.0871 |
| 141 | 1 | 1.2979 | 1.0404 | 141 | 13 | 1.6575 | 1.0874 |
| 142 | 1 | 1.3077 | 1.0452 | 142 | 7 | 1.9397 | 1.1065 |
| 211 | 114 | 1.8092 | 1.0830 | 211 | 144 | 1.8781 | 1.0849 |
| 212 | 81 | 1.8979 | 1.0864 | 212 | 124 | 1.8175 | 1.0815 |
| 221 | 16 | 1.6341 | 1.0748 | 221 | 29 | 1.9091 | 1.0961 |
| 222 | 35 | 1.8534 | 1.0939 | 222 | 79 | 1.7976 | 1.0844 |
| 223 | 63 | 1.7350 | 1.0825 | 223 | 119 | 1.9556 | 1.0991 |
| | | | | 231 | 49 | 1.8304 | 1.0949 |
| 241 | 1 | 1.6463 | 1.0713 | | | | |
| 242 | 44 | 1.7587 | 1.0848 | 242 | 97 | 1.7659 | 1.0868 |
| 243 | 11 | 1.6870 | 1.0833 | 243 | 39 | 1.9422 | 1.1044 |
| 244 | 41 | 1.7631 | 1.0884 | 244 | 54 | 1.9270 | 1.0941 |
| 311 | 42 | 1.6605 | 1.0791 | 311 | 80 | 1.9782 | 1.1040 |
| 312 | 11 | 1.8224 | 1.0895 | 312 | 20 | 1.7402 | 1.0769 |
| 313 | 3 | 1.4641 | 1.0559 | 313 | 6 | 1.9382 | 1.0983 |
| 321 | 40 | 1.7800 | 1.0860 | 321 | 72 | 1.8237 | 1.0912 |
| 323 | 53 | 1.6999 | 1.0840 | 323 | 78 | 1.8847 | 1.1019 |
| 324 | 53 | 1.6500 | 1.0796 | 324 | 60 | 1.8749 | 1.0955 |
| 332 | 1 | 1.7073 | 1.0842 | 332 | 3 | 1.7956 | 1.0938 |
| | | | | 333 | 2 | 2.5304 | 1.1586 |
| | | | | 334 | 1 | 1.5345 | 1.0635 |
| | | | | 411 | 1 | 1.2593 | 1.0367 |
| 511 | 13 | 3.0201 | 1.1664 | 511 | 13 | 3.0083 | 1.1712 |
| 512 | 3 | 1.4337 | 1.0500 | 512 | 6 | 1.8198 | 1.0860 |

Each of the lands uses was previously classified according to the CLC nomenclature for level 3 by quantifying in class metrics (Table 5). For the form index SHAPE, the arithmetic means SHAPE_MN was determined. The range of values in this index can be greater than 1 and without limit. Furthermore, if the value is equal to 1, then the polygon is completely compact, tending to the circle, and increases without limit as the shape of the polygon becomes more unpredictable.

In addition, the dimension of the fractal index FRAC reflects the complexity of the form; in this case, the arithmetic means FRAC_MN was also determined. This index can yield values between 1 and 2. Thus, when the value obtained approaches 1, it indicates that polygons have very simple perimeters. However, if the value is close to 2, then the shapes are highly complex.

In addition, the number of polygons for each of the CLC land uses for the two years studied was determined.

In the case of the 1 km buffer (Table 5), the number of classes changes in the two years analysed. In fact, class lands (TYPE) 124 (airport), 132 (dump sites), 231 (pastures), 333 (sparsely vegetated areas), 334 (burnt areas), and 411 (inland marshes) do not appear in 1990, as the values recorded are zero. Similarly, in 2018 there is no land (TYPE) 241 (annual crops associated with permanent crops). Therefore, there has been an increase in the types of use classes from 26 to 31 in 2018. Likewise, SHAPE_MN values in 1990 are between 1.2979 as the most compact form, corresponding to land use 141 (green urban areas) and 3.0201 correspondings to 511 (water courses) as the least compact form. Similarly in 2018, the values range from 1.2593 for 411 (inland marshes), to the more complex with a value of 3.0083 also, as in 1990, for type 511 (water courses).

In addition, the 1990 values for FRAC_MN fluctuate between 1.0404 for 141 (green urban areas) as a form with a very simple perimeter, and 1.1664 for type 511 (water courses) as a form with a slightly more complex perimeter. Similarly, in 2018 for FRAC_MN they range between 1.0367 and 1.1586 for land uses 411 (inland marshes) and 333 (sparsely vegetated areas), producing a change in more and less compact forms. Nevertheless, it can be said that these are shapes with relatively simple perimeters by staying away from value 2.

As regards the number of polygons, in 1990 the minimum values correspond to 1 for land uses 141 (green urban areas), 142 (sport and leisure facilities), 241 (annual crops associated with permanent crops) and 332 (bare rock). These land uses are therefore exclusive to very specific locations less than 1 km from the high-speed rail line. In contrast, the maximum value is 114 polygons for land 211 (non-irrigated arable land), being the most frequently used in different polygons and locations along the high-speed railway line. Besides, in 2018 the minimum value is 1 patch or polygon for land uses 124 (airports), 334 (burnt areas) and 411 (inland marshes), these land uses being exclusive to certain places 1 kilometre away from the high-speed line. The maximum value is 144 patches or polygons for land 211 (non-irrigated arable land), which would be more extended along the 1-kilometre buffer.

In addition, in Table 5 we can see a high variation in the number of patches for certain land uses, highlighting the most significant increase for 223 lands (olive groves), 242 (complex cultivation) and 231 (pastures), the latter of new appearance. Also, considering that the total of patches or polygons in 1990 was 717, in 2018 almost doubled with 1333 patches, so it can be said that the territory has fragmented enormously between those 28 years.

As before (Table 5) land uses are classified according to the CLC nomenclature at level 3 and the same landscape fragmentation indices are used, but for the buffer of 5 kilometres (Table 6). As for the number of classes, it does not change between the two years analysed, since all of them register the same values (32 types) both in 1990 and 28 years later. Therefore, land use variability has remained constant. Likewise, SHAPE_MN values in 1990 are between 1 as the most compact form (circular trend), corresponding to land use 334 (burnt areas) and 6.6620 correspondings to 511 (water courses) as the hugely branched form. Similarly in 2018, the lowest value of SHAPE_MN, is equal to 1.5172 for land

*Table 6. Class metrics for 5-kilometre buffer*

| 1990 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|
| **TYPE** | **NP** | **SHAPE_MN** | **FRAC_MN** | **TYPE** | **NP** | **SHAPE_MN** | **FRAC_MN** |
| 111 | 76 | 1.6571 | 1.0745 | 111 | 82 | 1.9646 | 1.0970 |
| 112 | 65 | 1.7282 | 1.0774 | 112 | 164 | 2.0710 | 1.1044 |
| 121 | 47 | 1.5600 | 1.0655 | 121 | 132 | 1.9503 | 1.0982 |
| 122 | 6 | 3.0008 | 1.1548 | 122 | 40 | 3.1593 | 1.1526 |
| 123 | 2 | 2.1836 | 1.1171 | 123 | 2 | 2.1010 | 1.1117 |
| 124 | 4 | 1.7911 | 1.0848 | 124 | 4 | 1.6899 | 1.0699 |
| 131 | 14 | 1.6500 | 1.0731 | 131 | 48 | 1.8840 | 1.0891 |
| 132 | 7 | 1.7979 | 1.0883 | 132 | 16 | 1.6218 | 1.0743 |
| 133 | 15 | 1.7576 | 1.0820 | 133 | 25 | 1.8346 | 1.0879 |
| 141 | 11 | 1.5594 | 1.0627 | 141 | 47 | 2.1418 | 1.1079 |
| 142 | 5 | 1.3639 | 1.0477 | 142 | 25 | 1.8103 | 1.0885 |
| 211 | 232 | 2.0869 | 1.0962 | 211 | 364 | 2.0058 | 1.0889 |
| 212 | 129 | 2.1081 | 1.0938 | 212 | 199 | 2.1338 | 1.0933 |
| 221 | 40 | 1.7521 | 1.0790 | 221 | 88 | 2.1130 | 1.1080 |
| 222 | 95 | 1.9541 | 1.0931 | 222 | 182 | 2.0538 | 1.0962 |
| 223 | 162 | 1.9084 | 1.0881 | 223 | 319 | 2.0877 | 1.1002 |
| 241 | 3 | 1.6787 | 1.0738 | 231 | 103 | 1.8612 | 1.0910 |
| 242 | 80 | 2.0959 | 1.0964 | 242 | 190 | 2.1959 | 1.1110 |
| 243 | 42 | 1.8801 | 1.0918 | 243 | 143 | 2.1243 | 1.1098 |
| 244 | 117 | 1.9848 | 1.0948 | 244 | 230 | 2.0336 | 1.0923 |
| 311 | 105 | 2.1918 | 1.1097 | 311 | 282 | 2.2719 | 1.1115 |
| 312 | 29 | 2.0024 | 1.0933 | 312 | 76 | 2.0961 | 1.0969 |
| 313 | 11 | 1.8335 | 1.0968 | 313 | 34 | 2.1941 | 1.1151 |
| 321 | 144 | 1.9495 | 1.0942 | 321 | 226 | 2.2512 | 1.1123 |
| 323 | 193 | 1.9889 | 1.0973 | 323 | 272 | 2.1973 | 1.1112 |
| 324 | 165 | 2.0302 | 1.0968 | 324 | 213 | 2.1860 | 1.1104 |
| 332 | 1 | 1.7317 | 1.0858 | 332 | 12 | 2.3435 | 1.1234 |
| 333 | 3 | 1.8119 | 1.0824 | 333 | 6 | 2.5356 | 1.1510 |
| 334 | 1 | 1.0000 | 1.0287 | 334 | 1 | 1.5172 | 1.0619 |
| 411 | 3 | 1.5887 | 1.0715 | 411 | 7 | 1.8009 | 1.0789 |
| 511 | 9 | 6.6620 | 1.2134 | 511 | 14 | 5.2360 | 1.1693 |
| 512 | 12 | 1.8860 | 1.0827 | 512 | 30 | 2.0099 | 1.0883 |

334 (burnt areas), possessing a very compact shape. In contrast, the maximum value is 5.2360 for 511 (water courses), being a very compact form.

With respect to the 1990 values for FRAC_MN they fluctuate between 1.0287 for land 334 (burnt areas) and 1.2134 for land 511 (water courses), suggesting landscape units with a tendency to simple perimeters, as it remains a value close to 1. Likewise, in 2018 for FRAC_MN the values range between 1.0619 and 1.1693 for land uses 334 (burnt areas) and 511 (water courses) respectively, so it can be said that it continues to tend towards simple forms of perimeters.

As for the number of polygons or patches, in 1990 land uses 332 (bare rock) and 334 (burnt areas) are the least representative, with 1 polygon each. In contrast, the maximum value is 232 polygons for land 211 (non-irrigated arable land), being the most frequently used in different polygons and locations along the high-speed line, and 5 kilometres from it. In 2018 the minimum value is 1 patch or polygon for land use 334 (burnt areas). The maximum value is reached with 364 patches or polygons for land 211 (non-irrigated arable land), which would be the most common and extended along the buffer of 5 kilometres.

The number of patches or polygons (Table 6) for certain land uses shows a high variation, highlighting the highest increase for lands 211 (non-irrigated arable land), 223 (olive groves) and 311 (broad-leaved forest). Also, considering that the total number of patches or polygons in 1990 was 1828, in 2018 it increased considerably to 3576, it can be said that land uses have largely fragmented between 1990 and 2018 in the 5-kilometre buffer territory.

The results show that the changes produced by the construction of the railroad are attributable mainly in the buffer of 1 km there is a greater growth of the infrastructures (smaller in that of 5 km), as was to be expected by contributing to the greater economic development of the territory. This lost land comes mainly from agricultural areas, since forests and semi-natural areas hardly change, both at 1 km and 5 km. Despite the low percentages of the CLC types involved, there is a marked dynamism between them (Sallustio et al., 2016), confirming the results of the influence of infrastructures in the areas near the route (Łowicki, 2008).

Although it is explained by the increase in the areas of infrastructure use of the territory, it is not entirely attributable to this type of coverage fragmentation, which occurs with more intensity in agricultural areas and forests-semi-natural, while in other territories it does have a strong involvement, especially urban expansion (Sallustio et al., 2016).

When analysing the landscape metrics, with fragmentation that after 28 years tends to be greater in the vicinity of the railway than in the more remote areas as can be observed by the numbers of fragments, it can be indicated the influence that it has had in this process (Miao, Yang & Song, 2021). This is also confirmed by the changes in that interval of years, by values of SHEI and SHDI, and by those of SHAPE_MN and FRAC_MN, indicating greater complexity and less stability of shape of the stains along the rail and as it gets closer to it (Miao, Yang & Song, 2021).

## CONCLUSION

After analysing the CLC data from 1990 and 2018, the authors have found a greater alteration of the landscape in the areas near the railway line. These changes involve further infrastructure development in the vicinity of the railway and further fragmentation caused by an increase in economic activity. This increase in space occupied by infrastructure has been at the expense of agricultural territories and not of natural land.

The applied landscape metrics show that in that interval of time the diversity and equity of the landscape have shifted to territories with smaller fragments and where there is less equitable distribution. In short, they confirm the fragmentation of the territory as there has been a tendency towards more equally distributed fragments. In addition, seeing its shape index and fractal dimension, the territory in 2018 has evolved towards less stable spots with greater complexity at their edges. All these conditions contribute to less stable landscapes with more problems in their dynamics and flows.

The limitations of the study are marked by the 25 hectares of CLC resolution level which leaves the residual landscape units out of the study. These represent that in areas close to infrastructures they constitute a number and important characteristics, with implications in the environmental impact studies.

## ACKNOWLEDGMENT

The dissemination of this present chapter has been possible thanks to the financial support from the ´European Fund of Regional Development´ (ERDF) and the Government of Extremadura to the research group ARAM through the subsidies with reference GR18054 and to the research group DESOSTE through the subsidies with reference GR18052.

## REFERENCES

Ackerman, F., & Heinzerling, L. (2002). Pricing the Priceless: Cost-Benefit Analysis of Environmental Protection. *University of Pennsylvania Law Review*, *150*(5), 1553. doi:10.2307/3312947

Alberti, M., & Marzluff, J. (2004). Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions. *Urban Ecosystems*, *7*(7), 241–265. doi:10.1023/B:UECO.0000044038.90173.c6

Banister, D. (2011). Railway Development: Interesting Research Lacking Coherence. *Built Environment*, *37*(1), 116-118.

Barbosa, F. C. (2018). High Speed Rail Technology: Increased Mobility With Efficient Capacity Allocation and Improved Environmental Performance. In *ASME/IEEE Joint Rail Conference* (*Vol. 50978*, p. V001T04A002). American Society of Mechanical Engineers. 10.1115/JRC2018-6137

Barrientos, R., Ascensão, F., Beja, P., Pereira, H. M., & Borda-de-Água, L. (2019). Railway ecology vs. road ecology: Similarities and differences. *European Journal of Wildlife Research*, *65*(1), 12. doi:10.100710344-018-1248-0

Berling-Wolff, S., & Wu, J. (2004). Modeling urban landscape dynamics: A case study in Phoenix, USA. *Urban Ecosystems*, *7*(3), 215–240. doi:10.1023/B:UECO.0000044037.23965.45

Bogaert, J., Rousseau, R., Van Hecke, P., & Impens, I. (2000). Alternative perimeter-area ratios for measurement of 2-D shape compactness of habitats. *Applied Mathematics and Computation*, *111*(1), 71–85. doi:10.1016/S0096-3003(99)00075-2

Borda-De-Água, L., Barrientos, R., Beja, P., & Pereira, H. M. (2017). Railway Ecology (English Edition) (1st ed. 2017 ed.). Springer.

Borrego, C., Tchepel, O., Barros, N., & Miranda, A. I. (2000). Impact of road traffic emissions on air quality of the Lisbon region. *Atmospheric Environment*, *34*(27), 4683–4690. doi:10.1016/S1352-2310(00)00301-0

Bruinsma, F., Pels, E., Priemus, H., Rietveld, P., van Wee, B., & van Wee, B. (2007). *Railway Development*. Beltz Verlag.

Castanho, R. A., Naranjo-Gomez, J. M., Vulevic, A., & Couto, G. (2021). The Land-Use Change Dynamics Based on the CORINE Data in the Period 1990–2018 in the European Archipelagos of the Macaronesia Region: Azores, Canary Islands and Madeira. *ISPRS International Journal of Geo-Information*, *10*(5), 342. doi:10.3390/ijgi10050342

Chang, Y., Lei, S., Teng, J., Zhang, J., Zhang, L., & Xu, X. (2019). The energy use and environmental emissions of high-speed rail transportation in China: A bottom-up modeling. *Energy*, *182*, 1193–1201. doi:10.1016/j.energy.2019.06.120

Chen, H., Li, S., & Zhang, Y. (2003). Impact of road construction on vegetation alongside Qinghai-Xizang highway and railway. *Chinese Geographical Science*, *13*(4), 340–346. doi:10.100711769-003-0040-5

Clair, C. C. S., Whittington, J., Forshner, A., Gangadharan, A., & Laskin, D. N. (2020). Railway mortality for several mammal species increases with train speed, proximity to water, and track curvature. *Scientific Reports*, *10*(1), 1–13. doi:10.103841598-020-77321-6 PMID:31913322

CLC. (2020). *Corine Land Cover 2018*. European Environment Agency. https://www.eea.europa.eu/data-and-maps/data/external/corine-land-cover-2018

Dalkic, G., Balaban, O., Tuydes-Yaman, H., & Celikkol-Kocak, T. (2017). An assessment of the CO2 emissions reduction in high speed rail lines: Two case studies from Turkey. *Journal of Cleaner Production*, *165*, 746–761. doi:10.1016/j.jclepro.2017.07.045

Dasoler, B. T., Kindel, A., Beduschi, J., Biasotto, L. D., Dornas, R. A. P., Gonçalves, L. O., Lombardi, P. M., Menger, T., de Oliveira, G. S., & Teixeira, F. Z. (2020). The need to consider searcher efficiency and carcass persistence in railway wildlife fatality studies. *European Journal of Wildlife Research*, *66*(5), 81. doi:10.100710344-020-01417-7

Dulac, J. (2013). *Global land transport infrastructure requirements*. International Energy Agency.

European Commission. (2001). *Joint Research Centre Map Projections for Europe*. Institute for Environment and Sustainability.

Eijgenraam, C., & Ossokina, I. (2008). Cost-benefit analysis of railway station area development: The case of Amsterdam South Axis. In *Railway Development* (pp. 191–211). Physica-Verlag HD. doi:10.1007/978-3-7908-1972-4_10

Forman, R. T., & Alexander, L. E. (1998). Roads and their major ecological effects. *Annual Review of Ecology and Systematics*, *29*(1), 207–231. doi:10.1146/annurev.ecolsys.29.1.207

Forman, R. T. T., Sperling, D., Bissonette, J. A., Clevenger, A. P., Cutshall, C. D., Dale, V. H., Fahrig, L., France, R. L., Goldman, C. R., Heanue, K., Jones, J., Swanson, F., Turrentine, T., & Winter, T. C. (2003). *Road Ecology*. Amsterdam University Press.

Galera, H., Sudnik-Wójcikowska, B., Wierzbicka, M., & Wiłkomirski, B. (2011). Encroachment of forest species into operating and abandoned railway areas in north-eastern Poland. *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology, 145*(1), 23–36.

J. García Raya (Ed.). (2006). *Cronología básica del ferrocarril español de vía ancha. IV Congreso Historia Ferroviaria*, Málaga.

Herold, M., Couclelis, H., & Clarke, K. C. (2005). The role of spatial metrics in the analysis and modeling of urban land use change. *Computers, Environment and Urban Systems*, *29*(4), 369–399. doi:10.1016/j.compenvurbsys.2003.12.001

Herzog, F., & Lausch, A. (2001). Supplementing land-use statistics with landscape metrics: Some methodological considerations. *Environmental Monitoring and Assessment*, *72*(1), 37–50. doi:10.1023/A:1011949704308 PMID:11693553

Hickman, R., Bonilla, D., Givoni, M., & Banister, D. (2015). *International Handbook on Transport and Development*. Edward Elgar Publishing. doi:10.4337/9780857937261

Jaeger, J. A. (2015). Improving environmental impact assessment and road planning at the landscape scale. Handbook of Road Ecology, 32-42.

Łowicki, D. (2008). Land use changes in Poland during transformation: Case study of Wielkopolska region. *Landscape and Urban Planning*, *87*(4), 279–288. doi:10.1016/j.landurbplan.2008.06.010

Mahmoud, M. I., Sloan, S., Campbell, M. J., Alamgir, M., Imong, I., Odigha, O., Chapman, H. M., Dunn, A., & Laurance, W. F. (2017). Alternative Routes for a Proposed Nigerian Superhighway to Limit Damage to Rare Ecosystems and Wildlife. *Tropical Conservation Science*, *10*. doi:10.1177/1940082917709274

Mehdipour, N., Fakheran, S., Soffianian, A., & Pourmanafi, S. (2019). Road-induced fragmentation and the environmental value of roadless areas in a partly protected landscape in Central Iran. *Environmental Monitoring and Assessment*, *191*(7), 1–12. doi:10.100710661-019-7571-4 PMID:31236686

Miao, Y., Dai, T., Yang, X., & Song, J. (2021). Landscape fragmentation associated with the Qingzang Highway and its influencing factors—A comparison study on road sections and buffers. *Geography and Sustainability*, *2*(1), 59–67. doi:10.1016/j.geosus.2021.03.001

Milne, B. T. (1991). Lessons from applying fractal models to landscape patterns. In *Quantitative Methods in Landscape Ecology–Then Analysis and Interpretation of Landscape Heterogeneity* (pp. 199–235). Springer-Verlag. doi:10.1007/978-1-4757-4244-2_9

National Geographic Institute of Spain. (2007). Necesidad de un Nuevo "Datum". ETRS89, Working Group for the Transition to ETRS89; Higher Geographic Council of Spain.

Niemeyer, S., & Spash, C. L. (2001). Environmental valuation analysis, public deliberation, and their pragmatic syntheses: A critical appraisal. *Environment and Planning. C, Government & Policy*, *19*(4), 567–585. doi:10.1068/c9s

Pinos Navarrete, A., & Mínguez García, C. (2017). El conocimiento científico de la Alta Velocidad Española y su relación con el turismo a través del análisis bibliográfico. *Revista de Estudios Andaluces*, *34*(1), 321–349. doi:10.12795/rea.2017.i34.11

Popp, J. N., & Boyle, S. P. (2017). Railway ecology: Underrepresented in science? *Basic and Applied Ecology*, *19*, 84–93. doi:10.1016/j.baae.2016.11.006

Preciado, J. M. S., Arilla, M. J. A., Uribeondo, M. P. B., & Yanci, M. P. G. (2006). La Movilidad Interurbana en la Línea de Alta Velocidad Madrid-Sevilla: Rasgos Definitorios a los 10 Años de su Implantación [The intercity mobility in the high speed line Madrid-Seville: defining features after ten years of its implementation]. In *Anales de geografía de la Universidad Complutense* (Vol. 26, p. 147). Universidad Complutense de Madrid.

Sallustio, L., Munafò, M., Riitano, N., Lasserre, B., Fattorini, L., & Marchetti, M. (2016). Integration of land use and land cover inventories for landscape management and planning in Italy. *Environmental Monitoring and Assessment*, *188*(1), 1–20. doi:10.100710661-015-5056-7 PMID:26687091

Santos, S. M., Carvalho, F., & Mira, A. (2017). Current knowledge on wildlife mortality in railways. In *Railway ecology* (pp. 11–22). Springer. doi:10.1007/978-3-319-57496-7_2

Shen, Y., Silva, J. D. A., & Martínez, L. M. (2014). Assessing High-Speed Rail's impacts on land cover change in large urban areas based on spatial mixed logit methods: A case study of Madrid Atocha railway station from 1990 to 2006. *Journal of Transport Geography*, *41*, 184–196. doi:10.1016/j.jtrangeo.2014.09.007

Tikka, P. M., Högmander, H., & Koski, P. S. (2001). Road and railway verges serve as dispersal corridors for grassland plants. *Landscape Ecology*, *16*(7), 659–666. doi:10.1023/A:1013120529382

Tinker, D. B., & Knight, D. H. (2001). Temporal and spatial dynamics of coarse woody debris in harvested and unharvested lodgepole pine forests. *Ecological Modelling*, *141*(1-3), 125–149. doi:10.1016/S0304-3800(01)00269-1

Torres, A., Jaeger, J. A., & Alonso, J. C. (2016). Assessing large-scale wildlife responses to human infrastructure development. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(30), 8472–8477. doi:10.1073/pnas.1522488113 PMID:27402749

Valerio, F., Carvalho, F., Barbosa, A. M., Mira, A., & Santos, S. M. (2019). Accounting for connectivity uncertainties in predicting roadkills: A comparative approach between path selection functions and habitat suitability models. *Environmental Management*, *64*(3), 329–343. doi:10.100700267-019-01191-6 PMID:31372805

Van Bohemen, H. D. (1998). Habitat fragmentation, infrastructure and ecological engineering. *Ecological Engineering*, *11*(1-4), 199–207. doi:10.1016/S0925-8574(98)00038-X

Van der Ree, R., Smith, D. J., Grilo, C., & van der Ree, R. (2015). *Handbook of Road Ecology*. Wiley. doi:10.1002/9781118568170

Van Wee, B., Van Den Brink, R., & Nijland, H. (2003). Environmental impacts of high-speed rail links in cost–benefit analyses: A case study of the Dutch Zuider Zee line. *Transportation Research Part D, Transport and Environment*, *8*(4), 299–314. doi:10.1016/S1361-9209(03)00017-8

Vickerman, R. (2018). Can high-speed rail have a transformative effect on the economy? *Transport Policy*, *62*, 31–37. doi:10.1016/j.tranpol.2017.03.008

Vila, J. S., & Linde, D. V., Pascual, A. L., & Palom, A. R. (2006). Conceptos y métodos fundamentales en ecología del paisaje (landscape ecology). Una interpretación desde la geografía. *Documents d'Analisi Geografica*, (48), 151–166.

Yang, X., Lin, S., Li, Y., & He, M. (2019). Can high-speed rail reduce environmental pollution? Evidence from China. *Journal of Cleaner Production*, *239*, 118135. doi:10.1016/j.jclepro.2019.118135

Zhang, X., Liu, Y., & Zhou, L. (2018). Correlation analysis between landscape metrics and water quality under multiple scales. *International Journal of Environmental Research and Public Health*, *15*(8), 1606. doi:10.3390/ijerph15081606 PMID:30060594

# Chapter 5
# Ecological, Political, and Social Impacts of Climate Change in the Large Water Basins of Central Asia

**Ahmet Altın**
https://orcid.org/0000-0001-9398-3111
*Zonguldak Bülent Ecevit University, Turkey*

**Süreyya Altın**
*Zonguldak Bülent Ecevit University, Turkey*

## ABSTRACT

*Central Asia is a term that defines a very large region including Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, Kazakhstan, North-West China, and Mongolia, known as the Land of Turks. The water needs of the population within the borders of Central Asia are met by more than 6000 lakes of various sizes and rivers pouring into these lakes. Climate change, which has been heavily felt in the region in the last 50 years, negatively affects water resources and human life in large lake basins. In this study, how the water resources in the large lake basins in Central Asia, especially in the Aral and Balkhash basins, are affected by climate change and how the climate change scenarios will develop were investigated. In addition, conflicts caused by the use and sharing of water between the countries have been identified, and the effects of these conflicts on social life, especially migration, have been discussed.*

## INTRODUCTION

Middle Asia is a term that defines a very large region including Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, Kazakhstan, North-West China, and Mongolia (Cowan, 2007; Lioubimtseva and Henebry, 2009) and is known as the Land of Turks. The water needs of the population within the borders of Central Asia are met by more than 6000 lakes of various sizes and rivers pouring into these lakes. Almost

DOI: 10.4018/978-1-7998-8482-8.ch005

all of these lakes are closed basin lakes, and they are highly affected by the flows of the rivers feeding them. The largest lake basins in Central Asia are the Aral Sea and Lake Balkhash. The main rivers that carry water to these lakes are Amu Darya, Syr Darya and Ili Rivers, and these rivers are transboundary waters. (Figure 1).

Lake ecosystems, one of the most important components of the hydrological cycle, are highly sensitive ecologically. The ecological balance of lakes can easily be disturbed due to the effects of climate change, differentiation of the environment in the lake basin and human activities (Mason et al. 1994). The rivers in the lake basins are mostly fed by the snow and glaciers of high mountains and their flow rates are affected by climate change and human activities (Friedrich and Oberhänsli, 2004).

Before the rivers in Central Asia are poured into lakes, they are mostly used in energy production or in agricultural activities through dams. Expansion of agricultural lands brought more water consumption and caused less water inflow into lake ecosystems. Many Central Asian lakes (such as Aral Sea, Issyk-Kul, Ebinur Lake, Lake Urmia and Bosten) have shrunk and begun to dry since the 1960s, or some (such as Lop Nur and Manas) have dried up (Bai et al., 2011).

*Figure 1. Map showing surface water resources in Central Asia (Sehring and Giese 2011)*


There are social, economic, and ecological influences of climatic extremes on the world (Luo et al., 2020). In Central Asia, climate change and accompanying drought, population increase, and the increasing water need, and unsuccessful water policies brought together ecological, political, and social problems. For example, water supply in Central Asia is mostly provided by the rivers Syr Darya, Amu Darya and Irtysh, which are the main rivers of the region. Because these rivers are transboundary, they have become the biggest political conflict between the states of the region since the collapse of the Soviet Union (Berndtsson and Tussupova, 2020). To take another example, glaciers in Central Asia play an important climatic role in holding water, controlling flows, and regulating the climate. Temperature increases in the region sharply increase the intensity and frequency of floods and mudflows, and subsequently, heavy household migration occurs in the region (Murakami, 2020).

In this study, the effects of climate change on the ecological structure of the major water basins in Central Asia are presented. In addition, the political problems created by the changes in the region on the plane of transboundary water resources were evaluated and their effects on social life, especially the population movements, were discussed in the cause-effect relationship.

## LARGE WATER BASINS IN CENTRAL ASIA AND CLIMATE CHANGE

The lakes in Central Asia are generally evaluated under 3 types. These can be classified as closed, open and alpine lakes. The large lakes in the region and their general characteristics are given in Table 1. Most of the lakes in Central Asia are closed types and are located within the Aral Sea basin, Irtysh and İli River basins (Bai et al., 2011). Alpine lakes are located on Tian Shan and Altai Mountains. The feeding of closed lakes is mostly through the melting of high mountain glaciers and snow, as well as rivers fed by precipitation or groundwater. Therefore, the existence of Central Asian lakes is highly affected by the climate change and drought.

The most obvious effect of climate change is seen in the change of precipitation regimes and the increase of temperature. Average temperature increased by 1-2 $^{o}$C during the 20th century in Central Asia (Lioubimtseva and Henebry, 2009). Especially, since 1998, this increase is 1$^{o}$C greater than the average temperature between 1960 and 1998 (Chen et al., 2018). However, climate forecasts show that global warming in Central Asia will be above the world average. For example, the temperature increases in the summer months between 2071-2099 is estimated to be between 2,5-6 $^{o}$C compared to between 1951-1980 (Reyer et al., 2017). It is thought that annual average temperatures will increase more especially in regions outside the mountainous areas of Central Asia and this increase will be more evident especially in the summer months. However, for mountainous regions (especially in regions with large mountain glaciers such as Tian Shan) feeding all the water resources of Central Asia, all climate scientists agree that the temperatures will increase significantly in the winter months (Reyer et al., 2017). For example, extreme precipitation and temperatures were observed in the mountainous regions of Central Asia from 1982 to 2015, due to large changes in extreme climate indices (Luo et al., 2020). Considering that the increase in temperature in the summer will cause evaporation and the melting of mountain glaciers much faster, and that the temperature increase in the winter will negatively affect the amount of mountain glaciers and snow cover, it is inevitable that the water resources in the region will be negatively affected by climate change.

The average annual precipitation for Central Asia is about 273 mm. Considering the change of average precipitation on country basis, it is seen that it is approximately 160 mm in Turkmenistan, 690mm annually in Tajikistan, 250 mm in Kazakhstan, 265 mm in Uzbekistan and 530 mm in Kyrgyzstan (Bekturganov et al., 2016). The annual precipitation in the desert regions is around 100 mm/year, around 400 mm/year near the Aral Sea and around 1000 mm/year in the mountainous regions (Bai et al. 2011). Potential evaporation in the region can exceed 2250 mm per year in the driest region, while it is less than 500 mm per year in mountainous areas (Bekturganov et al., 2016). Accordingly, it can be said that water sources especially in arid regions are under serious threat due to the increasing evaporation in parallel with the temperature increase. For example, in the 1970s, precipitation has decreased significantly in the Aral, Balkhash and Ebinur basins. Annual evaporation in the region has been in the range of 900-1500 mm/year in the summer months. For this reason, lake surface areas have decreased rapidly in arid basins such as Aral and Balkhash, while lake surface areas in mountainous regions have changed relatively less.

*Table 1. Great lakes in Central Asia and their general characteristics.*

| Lake | Country | Type of Lake | Elevation (m) | Depth(m) | |
|---|---|---|---|---|---|
| | | | | Max. | Average |
| Aral | Kazakhstan and Uzbekistan | Open | 53 | 42 | 8,7 |
| Balkhash | Kazakhstan | Closed | 342 | 25,6 | 5,8 |
| Alakul | Kazakhstan | Closed | 348 | - | 22,1 |
| Sasikul | Kazakhstan | Open | 347 | - | 3,32 |
| Zaysan | Kazakhstan | Open | 386 | - | 7 |
| Ebinur | Xinjiang Uyghur | Closed | 189 | - | 1,4 |
| Ulungur | Xinjiang Uyghur | Closed | 478 | 12,8 | 8 |
| Sayram | Xinjiang Uyghur | Alpine | 2073 | - | 46,1 |
| Bosten | Xinjiang Uyghur | Open | 1048 | - | 8,15 |
| Issyk | Kyrgyzstan | Alpine | 1608 | 668 | 278 |
| Sarygamıysh | Turkmenistan and Uzbekistan | Closed | 5 | 40 | 8 |
| Karakul | Tajikistan | Alpine | 3600 | 230 | - |
| Urmia | Iran | Closed | 1278 | 16 | - |

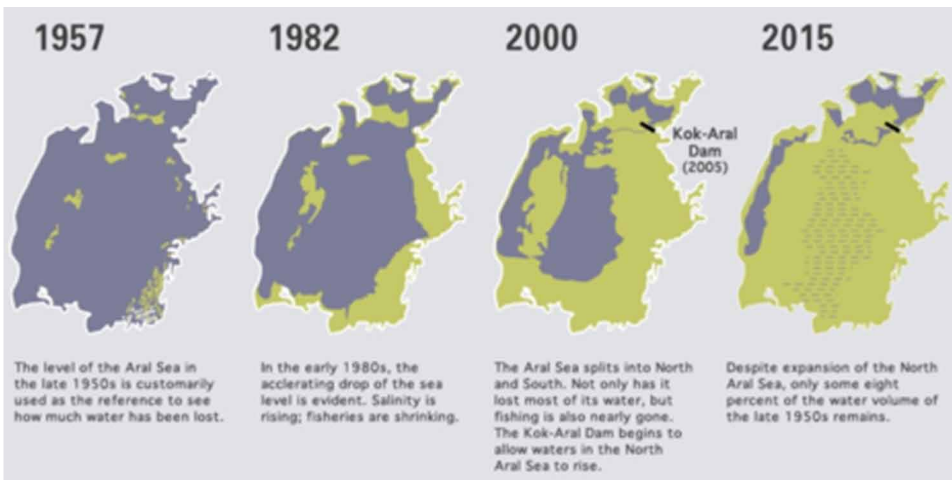
The reduction of water levels in the lakes is the first step in the transition of the lakes to dry and vanish. In this sense, many lakes in Central Asia can be considered as directed towards drying. Especially lakes with low water levels (such as Aral, Ebinur, Urmia) are at risk. Lop Nur Lake, located in the eastern part of the Tarim Basin (Xinjiang Uyghur Autonomous Region) and dried in 1971, stands before us as an example of the seriousness of the situation. Excessive evaporation in the lakes also increases the salinity of the water and the living life in the lake and its immediate surroundings is negatively affected.

## CLIMATE CHANGE IN ARAL AND BALKHASH LAKE BASIN

The Aral Sea, which was previously regarded as the fourth largest fresh water source in the world, is known as the place where the biggest ecological disaster caused by humanity took place (Badescu and Schuiling, 2010). The lake basin where this disaster is observed covers a wide geography encompassing Uzbekistan, Tajikistan, almost all of Turkmenistan, and the southern regions of Kazakhstan and northern Afghanistan. Since they directly affect many activities of related countries, especially agriculture and energy, changes in the Aral Sea basin are shown as the main cause of political and sociological problems in the region.

The Aral Sea basin has been known as an area where agricultural activities have been carried out for centuries. The lake has come near drought as a result of agricultural activities in the Aral basin that started in the 3rd century BC and continue increasingly especially since the beginning of the 20th century (Figure 2). For example, since the 1960s, the lake surface area has shrunk by 79% and the water volume has decreased by 90% (Gaybullaev et al., 2012). Similarly, in 1986, the lake was divided into two in the north and south, and its depth has decreased by about 10 m in the north and 25 m in the south in the last 50 years (Singh et al. 2012). After a decrease in the water level in the lake and excessive evaporation, the amount of salt increased from 1957 10 g/L to 120 g/L in 2009, and it is estimated to reach 200 g/L in 2021 (Gaybullaev et al., 2012). However, in 2005, a new dam called Kok-Aral Dam (Figure 1) was built that separates the north and south of the lake. This dam in Berg Strait was financed by the World Bank using the funds of the GEF (Global Environmental Facility) and the Kazakhstan government to improve the brackish water environment of the Small (North) Aral Sea. Local people call this dam “the dam of life”. Thanks to the Kok-Aral Dam, the lake level in the north rose up to 42 m (Cretaux et al., 2013) and the salinity decreased to 10 g/L. In addition, the fishery in the region has been revived and the lake ecology has improved considerably. Since August 2005, when the accumulation of water in North Aral has increased, the discharge structures in Kok-Aral Dam opens for a period of time, which also provides water entry into the south Aral (Micklin, 2014).

*Figure 2. Changes between 1957-2015 in the surface area of Aral Sea (Luxner, 2015)*




The main reason for this change, which occurred after the 1960s, was previously considered to be just climate change. This assessment makes sense to a certain extent. Especially in the 1960s, the annual precipitation in the basin declined from 9.4 km$^3$ to 3.2 km$^3$ in 2009 is the most basic indicator of drought in the region. Considering that the water entering the lake in 2009 with the Amu Darya and Syr Darya rivers is 5.2 km$^3$ and the annual evaporation is 8.3 km$^3$ (Gaybullaev et al., 2012), it can be seen that the lake water balance is negative. It shows that the possible temperature changes in the Aral Lake basin in 2050 are higher than the values predicted for Central Asia (1-2 $^o$C). According to this, it is thought that the average summer temperature in the region will increase by 3.24-7.36 degrees in the region until 2050 and 1.50-4.95 $^o$C in the winter months (Lioubimtseva, 2014). According to another study conducted by Didovets et al. (2021) about potential climate change impacts on eight river catchments of Central Asia with diverse natural conditions, the climate projections show that the mean annual temperature will increase in all catchments between 3.3 °C and 6.4 °C at the end of the century.

However, the main problem with the drying of the Aral Sea is climate change, as well as long-term overuse of Amu Darya and Syr Darya waters for agricultural purposes. Policies aimed at expanding irrigable areas in these basins, especially after the Russian Empire passed over to Central Asian territories, started to be implemented in 1860s and cotton production was encouraged. For this purpose, projects for the construction of a large number of water channels in the basin lands conducted and some of these projects (for example, in 1895, the 80 km long Tsar Nicholas channel was completed and some of the Sry Darya waters were directed to agricultural use) were completed. The policy was continued uninterruptedly in the period of the Soviet Union and numerous dam and channel constructions were completed and the amount of irrigated areas was increased. With that, the “Davydov Plan (1949)”, which includes the collection of Siberian river waters (Ob and Yenisei rivers) through a mega dam and moving to the Aral basin through a canal reaching 930 km was executed in order to increase the use of Uzbekistan and Turkmenistan steppes for agricultural purposes and to generate energy. (Micklin, 2014). This approach, which was considered as a crazy project, has been cancelled with the concern that it will irreversibly change the ecological structure in the region (Badescu & Schuiling, 2010). These practices were continued by the Turkish states, which declared their independence after the separation of the Soviet Union. Cotton and rice production were started in the dry steppes of Turkmenistan, Kazakhstan, Kyrgyzstan and Tajikistan, especially Uzbekistan through the water structures built on the Amu Darya and Syr Darya rivers. So much so that the region has met 10% of the world cotton production. However, while the agricultural areas in the region increased, the amount of water entering Aral Lake decreased significantly. For example, the irrigation area in Amu Darya basin increased from $227.5 \times 10^4$ ha in 1960 to $481.3 \times 10^4$ ha in 2010. With the rapid expansion of the irrigated land, the water entering the Aral Sea has decreased significantly. As a result, while the water volume of the Aral Sea was around 1.093 $km^3$ in 1960, it decreased to 401 $km^3$ in 1988 and then approached 22.3 $km^3$ in 2014 (Chen et al., 2018).

What happened in the Balkhash lake basin developed a little differently from the Aral Sea. Balkhash lake basin is one of the Central Asian sub-basins and plays an important role in ensuring the water balance of the region and even of Central Asia and balancing the climate (Guo and Xia, 2014). The Ili River is the main water source that extends from Xinjiang-Uyghur region to Kazakhstan and feeds the Balkhash. Karatal, Aksu, Lepsy and Ayaguz are also known as other important water resources in the basin. The north of Balkhash Lake is surrounded by semi-arid Kazakh plateaus, the south by desert and then high mountains (Tian Shan). While the average precipitation in the mountains to the south of the basin is around 633.5mm/year, it decreases to 124.5 mm/year in the city of Balkhash on the lake shore (Guo and Xia, 2014). These values show that there are very different precipitation regimes in the region. All rivers feeding the Lake Baikal are fed both by precipitation and from the snow/glacier melting waters of the Tian Shan. Temperature increases in the region will cause snow/glacier melting and more water to reach the lake through rivers. Increases in precipitation will also bring increase in river flows.

In a study conducted by Guo and Xia (2014), it is observed that the temperature to the annual environment increases by 1-2 $^{o}$C both on the lake and near the Tian Shan, and the precipitation is in an increasing trend. Although this result is considered positive at first sight, the level of Lake Balkhash decreased by 2-3 meters from the 1960s to 1989, with the effect of the Kapchagay Dam built on the upstream of Ili River. This decrease should be considered as a serious problem considering that the minimum water level of the lake is 6m. However, the amount of water entering the lake was increased and the lake level raised by around 1-1.5 m due to the end of the filling of the Kapchagay Dam in the 1990s and the increase of precipitation until the 2005s (Propastin, 2012).

While the agricultural area irrigated from the rivers feeding the Balkhash lake was 3648 $km^2$ in 1965, it increased to 5596 $km^2$ in 1984 (Kezer and Matsuyama, 2006). Accordingly, the use of Kapchagay Dam for irrigation activities in the region prevents the entire water generated by precipitation and snow/glacier melts from reaching the Balkhash lake. Another negative situation is that the glaciers in Tien Shan continue melting each passing day. In a study conducted by Sorg et al. (2012), it was found that the glaciers feeding Balkhash basin in Tien Shan decreased by 20% between 2002 and 2012. In addition, it is thought that the contribution of these glaciers to the total flow of Balkhash basin can be between 40% and 50% (Sorg et al., 2012). Accordingly, the disappearance of mountain glaciers shows that it will negatively affect the water regime in the Balkhash basin in the following years. In addition, pressures such as the transition to irrigated agriculture in the Xinjiang-Uyghur region of China, population movements from other regions of China to this region cause less water to be dropped from the provincial river that feeds Balkhash Lake to the regions of Kazakhstan downstream. Assuming that the population growth rate in the Balkhash lake basin will not change and agricultural activities and economic conditions will continue in the same way, it is thought that the amount of water entering Balkhash lake will decrease from 14.2 $km^3$ to 9.95 $km^3$ annually, and therefore the lake boundaries are given in Figure 3 in 2030 (Spitsyna, 2007).

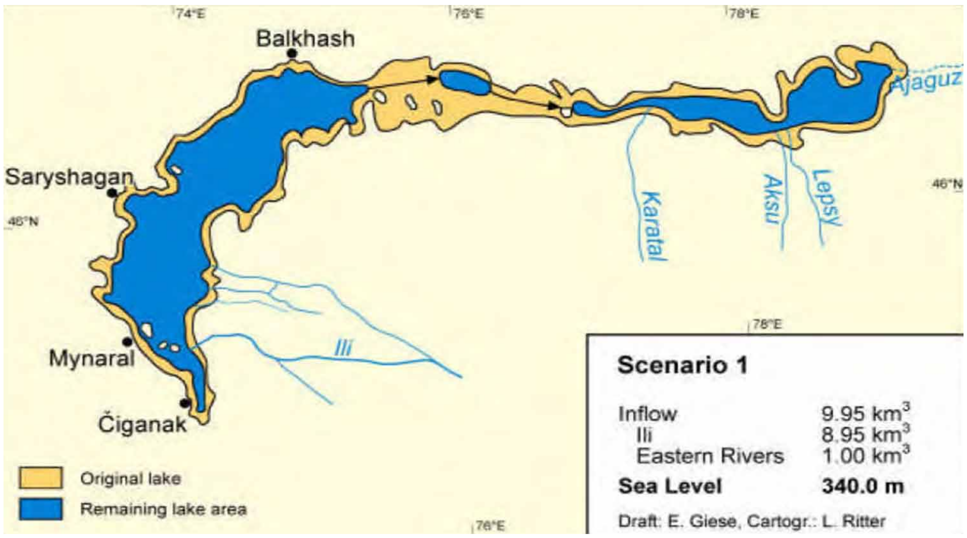
## ECOLOGICAL, SOCIOLOGICAL AND POLITICAL EFFECTS OF CLIMATE CHANGE ON CENTRAL ASIA

In ecosystems where climate change is experienced, it is known that it has long-term economic, sociological, and political effects as well as physical effects (such as temperature increase, decrease or imbalance of precipitation, salinity in water and soil). It can be an example of sociological, economic, and political problems such as unemployment and poverty due to climate change, changes in agricultural product patterns, migrations, and international water disputes. Climate change makes it difficult to reach healthy water in most regions, and since it increases costs, it also creates significant negative effects on public health. For example, according to the World Health Organization (WHO), 39 new infectious disease types have been identified due to climate change (Yayar et al., 2014).

With the use of rivers feeding the Aral Sea in energy production and agriculture, providing less water to the lake, using excessive water and pesticide in agriculture, decreasing precipitation, and increasing drought, there has been salt accumulation in the lakebed (especially the southern Aral Sea). Similar salting problem was experienced in Amu Darya and Syr Darya basins with excessive watering during cotton and rice production. In addition, excessive fertilizer and pesticide use caused pesticide and heavy metal pollution in basin soils, lake waters and drying lakebed. Between 1980 and 1990, it was determined that 72 kg of pesticides (this value is about 54 kg in Uzbekistan, 4 kg in the USSR and 1.6 kg in the USA) were used per hectare per year in Karakalpakstan, located to the south of the Aral Sea (Kuzmits, 2006). These salt and pesticide residues have been moved to the living areas by winds in the dry climate and created health problems in the region. As a result, kidney, and respiratory diseases in Karakalpakstan have increased, death rates have exceeded national and international averages (McLeman, 2011). Moreover, the incidence of asthma, liver/pancreatic diseases and different types of cancer in the region has increased considerably (Lioubimtseva, 2015).

According to United Nations population data, it is estimated that the population will increase by 20 million (30%) in the next 40 years in the Aral basin, in which Uzbekistan is estimated to be 50% and Tajikistan will be 30% effective (Siegfried et al. 2012). The increase in the demand for water will naturally increase the water needs of the countries at least the same rate. That the demand for water will increase further, the drought problem and new water structures (such as dams, irrigation channels) that are planned to be built on the rivers feeding Aral make political conflicts inevitable. 80% of the Amu

*Figure 3. Possible Balkhash lake borders by 2030 (Spitsyna, 2007)*




Darya and Syr Darya rivers come out of the territory of Kyrgyzstan and Tajikistan, but 86% of its water is used by Kazakhstan, Uzbekistan, and Turkmenistan (Allouche, 2007).

During the Soviet Union period there was a win-win relationship between upstream (Kyrgyzstan and Tajikistan) and downstream (Kazakhstan, Uzbekistan, and Turkmenistan) countries. Accordingly, the upstream countries have left enough water for the water needs of the downstream countries in the summer months, and the energy needs in the winter months of the upstream countries were provided by the downstream countries. Thus, by storage of more water upstream countries in the winter months, damages in agricultural lands reduced, and productivity of agricultural lands increased the in downstream countries (Loodin, 2020). Particularly, the countries located on the upstream side of the Amu Darya and Syr Darya rivers want to develop their economies with low water percentages and use them to generate energy. In addition, they do not hesitate to tell the wealthier downstream countries that they can use water resources as a political threat (Akiner, 2000).

Another basin of Central Asia is Balkhash lake basin. The largest of the transboundary waters in the Balkhash basin is the Ili river and is the most important water source that feeds the lake. However, since the dams built on the Ili river (especially Kapchagay dam) are used for agriculture and energy production, they reduce the amount of water entering the lake. Xinjiang-Uyghur region is located upstream of the Ili river. There is an intense water demand in this region, as China's government policy promotes cotton production (40% of the arable land is used for cotton production). Currently, 27% of the Ili river waters are used in the Xinjiang-Uyghur region. The policies put forward by China for the economic development of the Xinjiang-Uyghur region (such as increasing cotton production and energy production) show that water demand will increase further (Spitsyna, 2007). It seems inevitable that this situation will cause political tensions between Kazakhstan and China in the following years. On the Kazakhstan side, agricultural products such as rice, melon and onion are grown. In addition, in the Kazakhstan region (especially in the cities of Almaty and Balkhash) there are approximately 1200 industrial facilities where mineral processing and refinery facilities are concentrated, and the lake ecosystem is constantly polluted through these facilities. For example, significant metal and sulphate pollution is experienced from the copper processing facility in Balkhash city (Spitsyna, 2007). Especially the waters left from the Kapchagay dam after excessive rains have become an important problem. These waters cause erosion in the delta of the province in the south of Balkhash, giving rise to fish deaths and damage to fishing. The loss of soil in agricultural lands due to erosion reduces agricultural productivity. The main reason for excessive precipitation and floods in the region is climate change. Especially the reason of the rapid melting of glaciers in the Tien Shan is due to excessive water flow to Kapchagay dam in spring, excess water is left in the riverbed and floods are experienced.

Over the past century, extreme changes in global warming and precipitation regimes have led to increased evaporation and drought severity in Central Asia. These droughts threaten the livelihoods of societies dependent on climate-sensitive sectors and they adversely affect agricultural production and water utilization (Liu et al., 2020). Therefore, it can be said that there is a positive relationship between climate change and migration. Migration with climate change can generally occur due to environmental changes such as prolonged drought, permanent effects such as the impact on agricultural areas by sudden environmental events such as overflows, floods, landslides, and rising or withdrawing water levels (Otto et al., 2017). These migrations can be either short-term displacements or irreversible migrations. The formation of migration and the return of a migration movement that is already formed, depends on many socio-economic parameters. Here, many measures such as restoring environmental degradation, adapting the society to new climatic conditions, current well-being of the residents in the region and being economically hopeful for the future, strengthening their bonds to the past and culture of my society are among the tools that can be used to reduce, stop or reverse the migration. However, migration observed in Central Asia is thought to have occurred mainly because the population exposed to climate change was forced to move either by its own decision to survive or by the state authority (Blondin, 2019). Therefore, it seems to be quite difficult to be reversible.

The population living in the Aral Sea basin is 57 million as of 2010 and it is estimated that the population will reach 75 million by 2035. The majority of this population lives within the borders of Uzbekistan (27 million as of 2010) (İyikan, 2013). Especially the Karakalpakstan Autonomous Region of Uzbekistan is the region most affected by the Aral Sea problem. While Moynak city of Karakalpakstan used to be known for its coastal tourism, fishing fleet and port, it has become known for cargo ships abandoned on the sand today. From the 1960s to the 1990s, with the disappearance of fisheries and related industries in the Moynak region, 100 thousand people have migrated from the region (the population migrating in Karakalpakstan region is thought to be more than 300 thousand) and still 3-4 thousand people continue to migrate from the region annually (McLeman, 2011). In another study, this number has doubled and reached 6 thousand people a year. The direction of migration was mostly towards the east of Uzbekistan and Kazakhstan (Lioubimtseva, 2014). The fishing profession/culture that the people living in the region have taken from their ancestors and brought to the present day has vanished, people have either migrated or have turned to agriculture activities to which they are not familiar. This population movement, which used to be a migrant activity as a seasonal agricultural worker, caused many infectious diseases to be moved to Karakalpakstan. In addition, as the national income per capita decreased and combined with the deficiencies of malnutrition, insufficient health care and infrastructure facilities, it significantly increased the incidence of diseases such as tuberculosis and malaria. For example, malaria, which disappeared in the 1950s, reappeared in the Aral Sea basin (Reyer et al., 2017). In addition, divided families have increased, and significant increases have occurred in the region in cases of alcoholism, prostitution, and suicide.

A similar situation is valid for the Fergana Valley in the Aral Sea basin. This region is one of the most populated residential areas of Central Asia. An estimated 10.5 million inhabitants live in the region and agriculture is the most important source of income for this region. Migration from the regions where the drought is experienced to this area is increasing day by day. In particular, there is a population and refugee movement from the south of Uzbekistan to the northern regions of Kyrgyzstan due to environmental problems. In addition, population growth in the region is quite high. By 2050, it is thought that the population of the region will increase by 77.2% with internal and external migrations (Reyer et al., 2017). However, the valley is located within the borders of 3 countries (Uzbekistan, Kyrgyzstan, and Tajikistan) and here is an ethnically mixed region. This situation carries cross-country based, especially the sharing of water, food and agriculture areas in the region, and/or ethnic-based tensions.

Environmental migration has also become an important problem in the Balkhash basin. The increasing use of Ili river waters in the Xinjiang-Uyghur region for irrigated agriculture, and the development of industrial production, has led to significant migration in the region. It is known that the Chinese government particularly promotes these migrations in order to change the ethnic structure in the region. For example, while the population of the region was around 3.6 million in 1945, the population reached 23.1 million in 2008. However, while the Uighur population in the region constituted 82.7% and the Han population 6.2% of the total population in 1945, this rate was 46.2% and 39.1% in 2008, respectively (Howell and Fan 2011). This rapid population growth and internal migration in the Xinjiang-Uyghur region naturally means that more water is drawn from China by the Ili and Irtysh rivers. This situation makes the conflict of interest arising from water issues between Kazakhstan and China inevitable. That more and more water is drawn from China by the Ili river and that the glaciers in the Tien Shan feeding Ili and Irtysh are destroyed by climate change may cause environmental disaster and environmental migrations in the Aral basin and in the Balkhash basin (especially in the territory of the basin located in Kazakhstan).

## CONCLUSION

In this study, the negativities caused by climate change in Central Asia, which is known as the Land of Turks, are discussed and the direction, sociological and political effects of climate change in the future are discussed specifically for the Aral and Balkhash basins.

Climate change in Central Asia will manifest itself in the form of rising temperatures and irregular precipitation and/or decreasing in many regions, glacial disappearance in Tien Shan, Altai and Pamir, degradation or destruction of important lake ecosystems such as Aral, Balkhash, Ebinur, and Issyk. Particularly, countries in the Aral basin will be much more affected by climate change. Therefore, societies living in these basins will face sociological problems such as public health problems, migration, poverty, famine, and cultural degeneration. In addition, the sharing of already scarce water resources will bring political tensions among the countries of the region.

The way in which the negativities brought about by climate change can be reduced and the people living in the region can adapt to the new climate is possible through the caring about the problem and implementing common policies of states. In the event that cooperation between countries cannot be achieved and common policies cannot be developed, it is not possible for the well-intentioned programs to be prepared and implemented by countries individually to achieve success in Central Asia. However, the political problems and disagreements between the countries currently in the region, and the regional conflicts and economic problems that the countries are experiencing within themselves prevent this union.

## REFERENCES

Akiner, S. (2000). *Central Asia: A survey of the region and the five republics*. United Nations High Commissioner for Refugees.

Allouche, J. (2007, November). *The governance of Central Asian waters: national interests versus regional cooperation.* Disarmament Forum, Genova, Switzerland.

Badescu, V., & Schuiling, R. D. (2010). Aral Sea; Irretrievable loss or Irtysh imports. *Water Resources Management*, *24*(3), 597–616. doi:10.100711269-009-9461-y

Bai, J., Chen, X., Li, J., Yang, L., & Fang, H. (2011). Changes in the area of inland lakes in arid regions of Central Asia during the past 30 years. *Environmental Monitoring and Assessment*, *178*(1-4), 247–256. doi:10.100710661-010-1686-y PMID:20830516

Bekturganov, Z., Tussupova, K., Berndtsson, R., Sharapatova, N., Aryngazin, K., & Zhanasova, M. (2016). Water related health problems in Central Asia - A review. *Water (Basel)*, *8*(6), 219. doi:10.3390/w8060219

Berndtsson, R., & Tussupova, K. (2020). The Future of Water Management in Central Asia. *Water (Basel)*, *12*(8), 2241. doi:10.3390/w12082241

Blondin, S. (2019). Environmental migrations in Central Asia: A multifaceted approach to the issue. *Central Asian Survey*, *38*(2), 275–292. doi:10.1080/02634937.2018.1519778

Chen, Y., Li, Z., Fang, G., & Li, W. (2018). Large hydrological processes changes in the transboundary rivers of Central Asia. *Journal of Geophysical Research, D, Atmospheres*, *123*(10), 5059–5069. doi:10.1029/2017JD028184

Cowan, P. J. (2007). Geographic usage of the terms Middle Asia and Central Asia. *Journal of Arid Environments*, *69*(2), 359–363. doi:10.1016/j.jaridenv.2006.09.013

Cretaux, J. F., Letolle, R., & Bergé-Nguyen, M. (2013). History of Aral Sea level variability and current scientific debates. *Global and Planetary Change*, *110*(Special Issue), 99–113. doi:10.1016/j.gloplacha.2013.05.006

Didovets, I., Lobanova, A., Krysanova, V., Menz, C., Babagalieva, Z., Nurbatsina, A., Gavrilenko, N., Khamidov, V., Umirbekov, A., Qodirov, S., Muhyyew, D., & Hattermann, F. F. (2021). Central Asian rivers under climate change: Impacts assessment in eight representative catchments. *Journal of Hydrology. Regional Studies*, *34*, 100779. doi:10.1016/j.ejrh.2021.100779

Friedrich, J., & Oberhänsli, H. (2004). Hydrochemical properties of the Aral Sea water in summer 2002. *Journal of Marine Systems*, *47*(1), 77–88. doi:10.1016/j.jmarsys.2003.12.010

Gaybullaev, B., Chen, S. C., & Kuo, Y. M. (2012). Large-scale desiccation of the Aral Sea due to overexploitation after 1960. *Journal of Mountain Science*, *9*(4), 538–546. doi:10.100711629-012-2273-1

Guo, L., & Xia, Z. (2014). Temperature and precipitation long-term trends and variations in the Ili-Balkhash Basin. *Theoretical and Applied Climatology*, *115*(1-2), 219–229. doi:10.100700704-013-0883-3

Howell, A., & Fan, C. C. (2011). Migration and inequality in Xinjiang: A survey of Han and Uyghur migrants in Urumqi. *Eurasian Geography and Economics*, *52*(1), 119–139. doi:10.2747/1539-7216.52.1.119

İyikan, N. (2013). Almanca kaynaklara göre Aral Gölü (Kumu) sorununda Rusya faktörü. *Akademik Bakış*, *6*(12), 223–241.

Kezer, K., & Matsuyama, H. (2006). Decrease of river runoff in the Lake Balkhash basin in Central Asia. *Hydrological Processes*, *20*(6), 1407–1423. doi:10.1002/hyp.6097

Kuzmits, B. (2006). *Cross-bordering water management in Central Asia.* ZEF Working Paper Series, No. 66. University of Bonn, Center for Development Research (ZEF).

Lioubimtseva, E. (2014). Impact of Climate Change on the Aral Sea and Its Basin. In P. Micklin, N. Aladin, & I. Plotnikov (Eds.), *The Aral Sea* (pp. 405–427). Springer. doi:10.1007/978-3-642-02356-9_17

Lioubimtseva, E. (2015). A multi-scale assessment of human vulnerability to climate change in the Aral Sea Basin. *Environmental Earth Sciences*, *73*(2), 719–729. doi:10.100712665-014-3104-1

Lioubimtseva, E., & Henebry, G. M. (2009). Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. *Journal of Arid Environments*, *73*(11), 963–977. doi:10.1016/j.jaridenv.2009.04.022

Liu, W., Liu, L., & Gao, J. (2020). Adapting to climate change: Gaps and strategies for Central Asia. *Mitigation and Adaptation Strategies for Global Change*, *25*(8), 1439–1459. doi:10.100711027-020-09929-y

Loodin, N. (2020). Aral Sea: An environmental disaster in twentieth century in Central Asia. *Modeling Earth Systems and Environment*, *6*(4), 2495–2503. doi:10.100740808-020-00837-3

Luo, M., Sa, C., Meng, F., Duan, Y., Liu, T., & Bao, Y. (2020). Assessing extreme climatic changes on a monthly scale and their implications for vegetation in Central Asia. *Journal of Cleaner Production*, *271*, 122396. doi:10.1016/j.jclepro.2020.122396

Luxner, L. (2015). Reviving the North Aral Sea. *AramcoWorld*, *66*(5), 1–17.

Mason, I. M., Guzkowska, M. A. J., Rapley, C. G., & Street-Perrott, F. A. (1994). The response of lake levels and areas to climatic change. *Climatic Change*, *27*(2), 161–197. doi:10.1007/BF01093590

McLeman, R. A. (2011). Settlement abandonment in the context of global environmental change. *Global Environmental Change*, *21*, 108–120. doi:10.1016/j.gloenvcha.2011.08.004

Micklin, P. (2014). The Siberian Water Transfer Schemes. In P. Micklin, N. Aladin, & I. Plotnikov (Eds.), *The Aral Sea* (pp. 381–404). Springer. doi:10.1007/978-3-642-02356-9_16

Murakami, E. (2020). *Climate Change and International Migration: Evidence from Tajikistan.* https://www.adb.org/publications/climate-change-international-migration-tajikistan

Otto, I. M., Reckien, D., Reyer, C. P., Marcus, R., Le Masson, V., Jones, L., Norton, A., & Serdeczny, O. (2017). Social vulnerability to climate change: A review of concepts and evidence. *Regional Environmental Change*, *17*(6), 1651–1662. doi:10.100710113-017-1105-9

Propastin, P. (2012). Problems of Water Resources Management in the Drainage Basin of Lake Balkhash with Respect to Political Development. In W. Leal Filho (Ed.), *Climate Change and the Sustainable Use of Water Resources*. Springer. doi:10.1007/978-3-642-22266-5_28

Reyer, C. P., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., ... Mengel, M. (2017). Climate change impacts in Central Asia and their implications for development. *Regional Environmental Change*, *17*(6), 1639–1650. doi:10.100710113-015-0893-z

Sehring, J., & Giese, E. (2011). Global Environmental Change and Conflict Potential in Central Asia. In *Coping with Global Environmental Change, Disasters and Security* (pp. 525–534). Springer. doi:10.1007/978-3-642-17776-7_27

Siegfried, T., Bernauer, T., Guiennet, R., Sellars, S., Robertson, A. W., Mankin, J., Bauer-Gottwein, P., & Yakovlev, A. (2012). Will climate change exacerbate water stress in Central Asia? *Climatic Change*, *112*(3-4), 881–899. doi:10.100710584-011-0253-z

Singh, A., Seitz, F., & Schwatke, C. (2012). Inter-annual water storage changes in the Aral Sea from multi-mission satellite altimetry, optical remote sensing, and GRACE satellite gravimetry. *Remote Sensing of Environment*, *123*, 187–195. doi:10.1016/j.rse.2012.01.001

Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). *Nature Climate Change*, *2*(10), 725–731. doi:10.1038/nclimate1592

Spitsyna, A. T. (2007). *Preliminary sustainability assessment of water resources management in the Ili-Balkhash Basin of Central Asia* [Unpublished doctoral dissertation]. Royal Institute of Technology, Stockholm, Sweden.

Yayar, R., Kaplan, Ç., & Simsek, Ü. (2014). Awareness on Economic, Social, and Environmental Effects of the Global Warming: Experimental Findings from Turkey. *Business and Economics Research Journal*, *5*(3), 81–95.

# Chapter 6
# Economic-Ecological Principles and the Question of Mineral Waters in Brazil:
## A Propositional Analysis

**Pedro dos Santos Portugal Júnior**
*University of South Minas, Brazil*

**Fabricio Pelloso Piurcosky**
*University of South Minas, Brazil*

**Rodrigo Franklin Frogeri**
https://orcid.org/0000-0002-7545-7529
*Centro Universitário do Sul de Minas, Brazil*

**Luiz Carlos Vieira Guedes**
https://orcid.org/0000-0002-8066-627X
*University of South Minas, Brazil*

**Sema Ylmaz Yılmaz Genç**
*Kocaeli University, Turkey*

## ABSTRACT

*The present study addresses the issue of mineral waters in Brazil, its institutional problem, and the consequences and conflicts arising from its irrational exploitation. As a solution to these problems and conflicts, it is proposed to integrate these mineral waters and their different types in the management of water resources and the application of guiding economic and ecological principles as in the case of the conception of post-normal science and the precautionary principle. To meet the objective, the authors opted for an exploratory and bibliographical research regarding the adopted procedure. It is concluded that the implementation of an institutional change will allow a participative and polycentric management, mainly at the level of the hydrographic basin committees, which will contribute to the application of the two mentioned principles and a sustainable management of this resource. However, there is a need for improvements in the national water resources policy to more effectively cover groundwater in which mineral waters are embedded.*

DOI: 10.4018/978-1-7998-8482-8.ch006

## INTRODUCTION

At the scope of the discussions on the impacts generated by the anthropic action on nature, it is important to highlight the degradation of water resources and their use in an unsustainable manner.

Therefore, this paper aims to analyze in details the issue of mineral waters in Brazil and the importance of incorporating economic-ecological principles into its management and institutions. This study justifies itself by taking into account the fact that mineral waters in Brazil are considered to be a mineral, which results in a series of conflicts and indiscriminate usage of this resource. Moreover, Romeiro's (2003) view indicates that the decisions with regard to the use of water resources undergo a public choice, where society should take a decision based on a number of moral and ethical questions, which is something that does not occur in the case of mineral waters due to above-mentioned institutional problem.

The impact of the exploration above the renewal capacity of the resource (via hydrogeological cycle) is more and more evident, and it is expected that such exploration will increase even more due to the recent increase in the consumption of bottled underground waters. Gesicki and Sindico (2013) stated that the production of bottled waters consists of the industrial segment in the non-alcoholic beverages line that has the greatest expansion worldwide, since its consumption overcomes that of similar products like soft drinks, teas and milk. Such fact, in addition to retrogressive institutions, contributes in a direct manner for serious consequences and conflicts related to the use of mineral waters in Brazil.

Specifically, this study seeks to propose that the precautionary principle and the post-normal science are applied in an effective manner in a new institutional arrangements of mineral waters that would consider them as water resource, managed with broad participation of the involved social actors.

In order to reach such intention, the study uses an exploratory and bibliographic research in order to provide grounds for this discussion and proposition of ideas.

This paper is divided into five parts, including this introduction. The second part approaches two contents: the problem of mineral waters in Brazil, emphasizing its outdated institutions, and certain principles that the Ecological Economy holds dear, which can be applied to the object of this research such as the precautionary principle and the post-normal science. Next, we explain the methodology used in this research. The fourth part analyzes the process of application of these principles in the case of mineral waters, emphasizing the need for an institutional change. Eventually, the final considerations are presented.

## THEORETICAL REFERENCES

This item seeks to the climate changes, the institutional problems related to mineral waters in Brazil and the emergence of conflicts in this field. Next, we explain some economic-ecological principles, which we believe that can be applied to the case under study.

### The Context of Water in the Context of Climate Change

Before addressing the issue of mineral water and its institutional problems in Brazil, it is necessary to address climate change and its interface with the issue of water in general.

It is of great importance to deal with climate change, considering that its impacts are felt by society in general, but more deeply by the poorest populations (Bruna & Pisani, 2010).

Although this problem is to some extent well known, actions to minimize the impacts are still very disconnected even in municipal spheres, with reactive decisions as the main scope to the detriment of proactive ones (Giulio et al., 2019). Added to this is the fact that empirical research on climate change in Brazil is still scarce due to the absence of long-term, reliable, and low-fault climatological series (Sanches; Fialho & Quina, 2017).

Water, as a natural resource of primary necessity for human and animal consumption and for use in production processes, is not immune to the impacts of climate change.Although Brazil has a large availability of water, its distribution among regions is very uneven (Marengo, Tomasella & Nobre, 2017), and can be considered a resource of random occurrence due to the incipient knowledge about the phenomena that make up the hydrological cycle (Alves Júnior, 2009).

Also for Marengo, Tomasella, and Nobre (2017) water resources management must consider climate change projections and uncertainties in the implementation of water policies and regulations. Kundzewicz (2018) reports that uncertainty plays a prominent role in global climate change research with emphasis on hydrology and water resources research.

To break through water issues and minimize uncertainty in this context of climate change, Tundisi (2008) states that a broad governance scheme with integrated and comprehensive management, properly decentralized and with participation of actors such as users, public and private sector is needed. However, a scheme like this in Brazil does not allow the inclusion of mineral waters, in view of the institutional arrangement that such a resource fits into, as is discussed in the following item.

It is also worth highlighting the role of water and its management within the scope of the UN Sustainable Development Goals. According to Silva (2018), this UN document has 17 objectives, among which objective 6 stands out, which aims to ensure the availability and sustainable management of water, and basic sanitation for the entire population (urban and rural). It should also be noted that to achieve this objective, it is necessary to apply principles such as social participation, shared management, institutional strengthening, efficient use of water, regional and environmental development, as well as the responsibility of the State (Silva, 2018).

## The Problem of Mineral Waters in Brazil

The analysis of the mineral waters issue in Brazil requires an approach on the institutional arrangements that prevails in this segment, and how it influences the involved actors and contributes for the onset of conflicts. These facts justify a proposition for the use of economic-ecological principles in order to promote the sustainable use of this resource.

Queiroz (2011), Souza (2011), Esteves (2012) and Portugal Júnior (2016) mention some cases of conflict in the segment of mineral waters in Brazil that illustrate the problems involved in this matter, such as:

- the Nestlé case in São Lourenço - Minas Gerais, perhaps the most emblematic of all, where the exploration above the replenishment capacity of the aquifer at the Water Park resulted in a reduction of water flow in some fountains, decline in the level of mineralization of certain waters, subsidence[1] of the terrain close to one of the fountains and its collapse;

- the Danone case in Jacutinga, Minas Gerais, where mineral water was explored in water sources without permits and licensing from the authorities, plus infrastructure problems at the city due to the increase in the traffic of trucks derived from the expansion in the production;

- in Caldas Novas, Goiás, the indiscriminate use of thermal waters that caused an impact in their quality and availability;

- in Paraná, there has been the case of a company that obtained two different permits for a single water source, one as water resource (under the responsibility and authorization of the state department), and other as mineral water (granted by the National Department of Mineral Production, DNPM, by its acronym in Portuguese[2]);

- the occurrence of lawsuits initiated by the Department of Public Prosecution of some states, with the charge that companies are making 'misleading advertising' by having their labels stating as mineral water a resource that does not have the minimum requirements for being considered as such.

The reason that permeates most of these conflicts is on the existing regressive institutional arrangements in Brazil that considers mineral, thermal, carbonated and potable table waters to be a mineral, and not as water resource. This is something that triggers a series of controversies, culminating in the improper use and irrational exploration of these waters, which may result in their depletion.

Such institutional arrangements results in the existence of two legal prerogatives on a single groundwater resource. Therefore, according to Portugal Júnior (2016), the water, due to its intrinsic characteristics, may receive a differentiated legal treatment based on its source and usage.

Obata, Cabral Júnior and Sintoni (2005) go further in this discussion by explaining the existing controversy. When it is considered as a mineral resource, water is a product under the control of the Federal Government, and its usage is ruled by the Mineral Waters Code, originated from the Decree-Law 7.841 08-08-1945 in conjunction with the Mining Code, established in the Decree-Law 227, 02-27-1967[3] and corresponding legislation. In this case, the application, regulation and inspection are under the responsibility of the National Agency of Mining (ANM). On the other hand, when water is considered as water resource, it becomes a public product of the Federal Government or the States, and its granting and inspection are based on the National Plan of Water Resources, which is based on the Law 9.433/1997 of the Department of Water Resources and Urban Environment of the Ministry of the Environment, whose management is performed by the National System of Water Resources Management.

Specifically, with regard to mineral waters, Martins et. al. (2006) explain that these legal guidelines took place in Brazil in a moment in which the development, mainly the institutional, was incipient and the public power had a nationalist bias, in addition to the fact that the social participation was limited or even inexistent. Therefore, the effective protection of mineral wealth had a prominent position, and mineral water became a component of this set of assets, since it was a resource originated in the subsoil.

Due to these questions, it is clear in Brazil that mineral water is not a mineral in conceptual terms according to mineralogy studies, but is considered to be a mineral only from the legal point of view (Gesicki & Sindico, 2013).

Table 1 presents a comparative summary of the institutionalities on mineral waters applied in Brazil and some other countries. In this context, it is addressed how the resource is fundamentally considered (ore, water and / or food), what are the main legal bases that regulate its use and the main competent body in granting its use.

It is possible to verify that most of the related countries consider mineral waters under the institutionality of an environmental water resource, and their use and exploitation are granted under the aegis of the same bodies that regulate all other water resources. We also emphasize its consideration as food, which is totally understandable, in view of being a resource for general consumption of the population (Serra 2009; Martins et. Al. 2006; Esteves, 2012).

*Table 1. Comparison of institutionalism between selected countries*

| COUNTRY | RESOURCE FUNDAMENTAL CONSIDERATION | MAIN LEGAL BASIS | HOME GRANT AUTHORITY |
|---|---|---|---|
| Brazil | Mineral Resource and Food Mineral | Water Code (1945) and Mining Code (1967) | National Department of Mineral Production DNPM. |
| United States | Food and Water Resources | Federal Code of Regulations. | *Food and Drug Administration* Federal(FDA) and any state agencies. |
| France | Food and Water Resources | Decree 89-369 of 1989 and the Public Health Code | Ministry of Health, with the opinion of the Regional Directorate for Industry, Research and the Environment; Departmental Directorate for Sanitary and Social Relations and the Departmental Council for the Environment and Sanitary and Technological Risks. |
| Germany | Water Resource | Mineral and Table Regulation; Federal Water Management Law. | Regional Councils. |
| Spain | Mineral Resource | Lei de Minas (1973); General Regulation of the Mineiro Regime (1978); Royal Decree (2002). | Organ of the Autonomous Community with the opinion of the Geological and Mining Institute of Spain and the General Directorate of Health. |
| Portugal | Mineral Resource and Food | Decree-Law 86/1990; 90/1990; and 156/1998. | Ministry of Economy and Innovation, on the proposal of the General Directorate of Geology and Energy and opinion of the General Directorate of Health. |
| Argentine | Food and Water Resources | Code (CAA) | General Irrigation Department (DGI). |
| Colombia | Water Resource | National Code of Renewable Natural Resources and Protection of the Environment. | Regional Environmental Authorities. |

Source: Serra (2009); Martins *et. al.* (2006); Esteves (2012); adapted by the authors.

It is noteworthy the fact that only Brazil, Portugal and Spain consider mineral water as an ore, and its granting and inspection processes are in charge of bodies other than those that regulate other types of water. However, it should be noted that in Brazil and Spain there is an intense debate around this institutionality, with researchers, environmental agencies and a number of other institutions categorically defending the institutional change of this resource, starting to be considered as a water resource, passing its grant and inspection to the responsibility of the same bodies that regulate the other water resources (Portugal Júnior, 2016).

According to Portugal Júnior (2016) and Gesicki and Sindico (2013) plans and proposals for an integration of mineral waters into water resources in Brazil have been at the core of discussions and debates since the end of the 1990's, and beginning of this century, involving bodies and institutions such as ABINAM (Brazilian Association of Mineral Water Industry), CNI (National Confederation of Industry), DNPM (ANM), CNRH (National Council of Water Resources), National Agency of Waters, State Departments of Water Resources, Hydrographic Basin Committees, and even NGO's and associations of residents of cities with parks and spa towns of mineral waters; however, without a definitive solution and mutual agreement. Thus, it was not possible to reach a consensus on the resolution of this dispute due to the resistance by representatives of the DNPM (ANM), ABINAM and CNI, which consider this integration an 'invasion' to the federal competence.

At the scope of this institutional framework described herein, it emerges the risk of exploration of mineral waters above their renewal capacity, since the lack of knowledge on the dynamics of the hydrogeological cycle of the aquifers, and the absence of integration with the management of further groundwaters and surface waters, very often integrated to the mineral water itself.

However, it is important to highlight that, based on Alves Júnior (2009) statement PNRH itself fails, because it mainly covers surface waters to the detriment of groundwaters. This fact can be explained by the difficulty to determine hydrogeological parameters, and to apply management instruments for these waters. In this author's opinion, it is necessary to understand that it is not possible to separate the hydrographic basin from the hydrogeological basin because the hydrological cycle does not allow a dissociation of one from the other.

That said, the management of mineral waters requires an institutional change in order to integrate it into the scope of water resources management and, at the same time, the PNRH should be reconsidered by adopting key principles of the Ecological Economy that will be presented below.

## Applicable Economic-Ecological Principles

Two principles are approached in this item: the post-normal science and the precautionary principle.

## Post-Normal Science

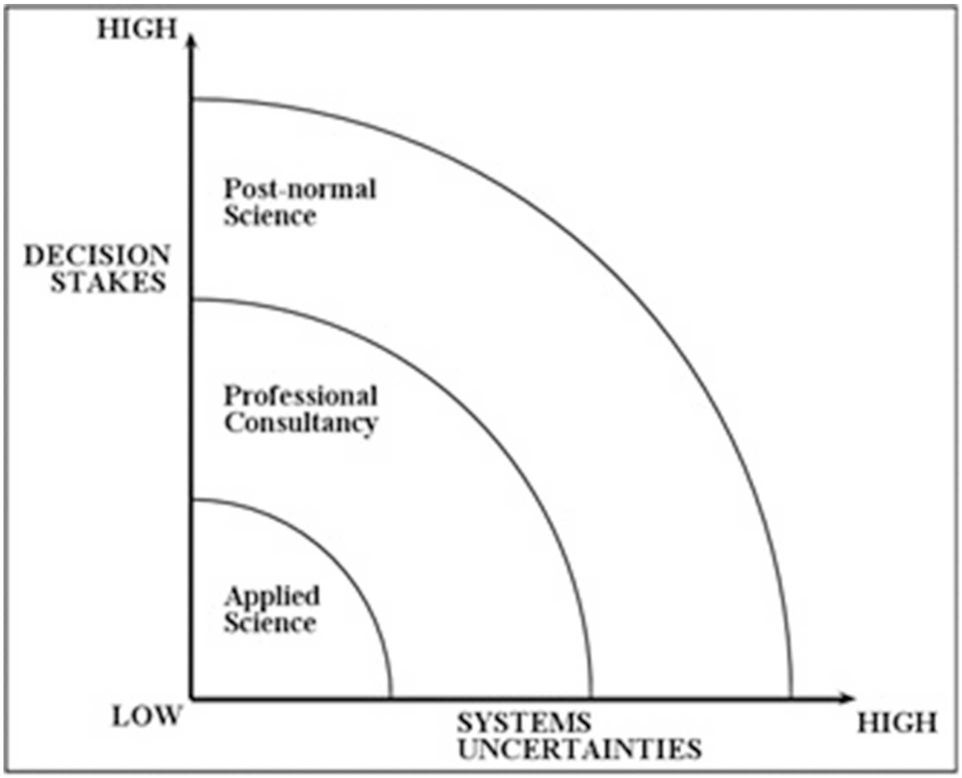
As demonstrated in the work of Funtowicz and Ravetz (1997) part of the notion that the problems related to our environment present specific characteristics such as: i) the facts are uncertain; ii) the values involved are controversial; iii) the stakes are high; e iv) the decisions involve a matter of urgency. Due to these characteristics, the solutions for these problems are far beyond the capacity of the science and its methodology as it is currently known and applied. That said, the need for application of the post-normal science emerges.

The post-normal expression means the passage from a scientific system of simple resolutions to a broader approach of methodological, social and ethical nature, leaving aside the Cartesian and impersonal rationalism, and going towards a 'value judgment' (Funtowicz & Ravetz, 1997).

Figure 1 illustrates the dynamics of application of the post-normal science approach. When the uncertainties are low and the impact of the decisions at stake are also low, the resolution involves the science applied in a Kuhnian approach. On the other hand, when these questions are at a medium level the solution involves the professional advisory of *experts*. However, when the problem involves a high impact of decisions and uncertainties are also high, the solutions include the post-normal science. These solutions occur through the participation of the several involved agents, using the most diverse knowledge (including popular), and not only the traditional applied science.

Even when the uncertainties of the system are low, the decisions present a wide range of impact, or vice-versa, the decision should be submitted to the post-normal science scrutiny. Yet, it is possible to state that this approach is more than interdisplinarity, but a multidisciplinarity, being complimentary to the applied science and professional advisory (Funtowicz & Ravetz, 1997).

*Figure 1. Diagram of the Post-Normal Science*
*Source: adapted of Palma and Mattos (2001).*




Still for the same authors, the post-normal science is recommended in order to escape from the ruling reductionism in the "restricted communities of peers" by taking the decision making to the scope of the "extended communities of peers", through the broad debate with the actors involved in the problems to be analyzed.

By collaborating with this discussion, Mota (2006) emphasizes that there isn't that 'something' that is considered as absolute scientific certainty, but only paradigms, provisional scientific responses originated from a certain historic age. Therefore, the scientific knowledge is not given, but dynamic.

For Abramovay (2007), the Lautorian relativism emphasizes the fact that the scientific results are not objective expressions that clairvoyance allowed to reach, and not even are great solutions already inserted in the natural world. In fact, these results should be understood as legitimate human products such as literary and artistic production. Thus, the purely scientific solution cannot be given as an unchangeable law, mainly when it involves environmental matters.

## Precautionary Principle

Concomitant to the post-normal science analysis it becomes necessary to include the precautionary principle for a broader economic-ecological approach.

This principle came up at the scope of the German Law at the beginning of the decade of 1970, with its effective implementation from the Air Pollution Act of 1974, starting to be widely used, later, in politics and world programs of preservation of the environment (César & Abrantes, 2003).

However, according to the same authors, it was after the principle 15 of the 1992 Rio Declaration — at the United Nations Conference on the Environment and Development — that it was established the most representative formulation of the Precautionary Principle in international law.

For Common and Stagl (2005), the precautionary principle is extremely necessary when problems arise, such as: i) the environmental cost of the economic activity is strongly uncertain and ambiguous; ii) the activity poses a high catastrophic potential; iii) there is a possibility of irreversibility; and iv) the future generations can be widely harmed.

In general terms, the application of this principle occurs when there are impacts over human health and in the environment, and the relationships of cause and effect are not scientifically established. Its application involves a cooperative approach between the involved social actors in order to solve common problems through integrated political measures that would boost the environment, competition and employment. In this case, it is necessary to have a methodological approach of the post-normal science.

Abramovay (2007) corroborates with this view by stating that the precautionary principle puts uncertainty at the center of the decision-making, public and private processes. It is important to highlight that such principle does not have the intention to freeze innovation and the technological progress but seeks to present ways to deal with them.

The need for the precautionary principle comes up after the paradigm of security, in which occurs the inversion in the belief of science's capacity for solving all problems (Ewald, 1996).

However, it is important to highlight that, according to Common and Stagl (2005) and Foster (2003) the possibility of improper usage of the precautionary principle as a way of only political tool and of application of a higher protectionism. Moreover, critics state that this principle should be considered as an environmental extremism, since its calculations only consider risks, but despise the possibility of new technologies to make life safer. In order to break up with this bias, it is necessary to avoid its usage in an arbitrary manner, by privileging an approach that would be as politically transparent as possible.

## METHODS AND MATERIAL

In order to meet the goals that were established for this study, we opted for using the exploratory research that, in accordance with Gil (2008), aims to provide greater familiarity with the problem, in order to make it more explicit or to build hypothesis. This type of research has the major goal to enhance ideas or discover insights. With a more flexible planning, it is possible to take into consideration the most varied aspects in relation to the studied fact.

As a technique of research, we opted for the bibliographic. This research is developed based on a material already prepared, mainly constituted of books and scientific articles. Though in almost all studies some kind of work of this nature is required, there are studies exclusively developed from bibliographic sources. Studies on ideologies — as well as those that propose the analysis of the several positions on a problem — also use to be developed nearly exclusively by means of bibliographic sources (Gil, 2008).

Therefore, this study seeks to propose the inclusion of principles of the Ecological Economy in the resolution of the problems related to the management of mineral waters in Brazil, in a scope of integration of these waters with the management of water resources.

## PROPOSITIONS AND ANALYSIS

The problems related to mineral waters may be approached in the context of market failures that, according to Opschoor (1992), can be defined as the incapacity of the market in performing the economic process for the social optimum. Therefore, it is evident the incapacity of the market, in an isolated manner, to internalize the externalities in the costs and prices, mainly in sectors that explore water.

Based on the view of Abramovay (2007), that the precautionary principle recognizes the incapacity of the science to emit in a peremptory manner the judgment that is able to conduct the controversial situations, the exploration of the mineral waters should follow this principle, considering the uncertainties that permeate the knowledge of the hydrogeological cycle, and the dynamics of the aquifers, deepened in the current environment of climatic changes.

By getting back to the notions proposed by Foster (2003), Mota (2006) e Kundzewicz (2018) the application of the precautionary principle — in the case of mineral waters — should be performed in the most transparent possible manner in political and legal terms. And, companies and regulation bodies should act in a moderate way by means of a provisional course of action, and reviewing it as soon as new facts come to light that would minimize the uncertainties. Thus, the grounds proposed here are that the precautionary principle is not of permanent applicability, but only while uncertainties last.

Therefore, it is important to propose, by considering the bases of action suggested by Daly and Farley (2004), the following stages:

1º) to establish a sustainable scale of use of mineral waters in Brazil, based on the knowledges that already exist on the dynamics of the hydrogeological cycle and the aquifers, by applying the precautionary principle and involving the social actors in the context of a post-normal science;

2°) to promote a fair distribution of this sustainable scale, not only among companies, but considering the different uses and purposes of this resource: bottling, production inputs, “in natura” consumption in the water sources, parks and spas, crenotherapy, living in the natural space, environmental education among others, according to the tradition of the locations and regions where such mineral waters are found;

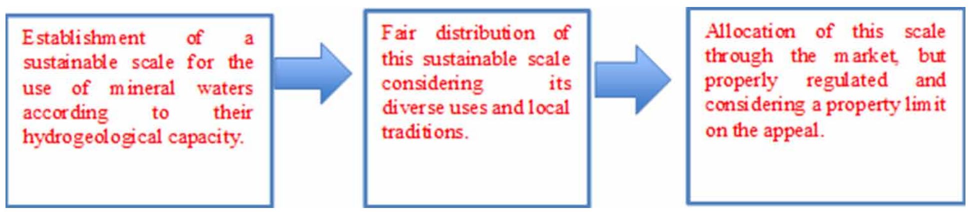
3°) efficient allocation of the productive exploration via market, though regulated by bodies of water resources management, mainly with regard to the determination of limit of ownership of the mineral waters sources by bottling companies, and of usage as production input, avoiding thus an ‘oligopoly’ and the dominance of this market by a small number of business groups.

Figure 2 below shows a flow diagram for this more sustainable use of mineral waters.

In order to have such stages applied effectively, there is a clear need for changing institutional arrangements of the mineral waters in Brazil, starting to treat them as water resources in a context of integrated and polycentric management in the sense of Elinor Ostrom.

Ostrom (2010) informs that the application of empirical studies allowed the verification of the importance of institutional rules that would be more suitable for each specific social and ecological environment. The idea that a single general and centralized policy (as it is the case of the Mining Code and the Mineral Waters Code) would be enough to be a solution for all environmental cases became ineffective when applied in complex economic systems as it is the case of surface and groundwater waters management.

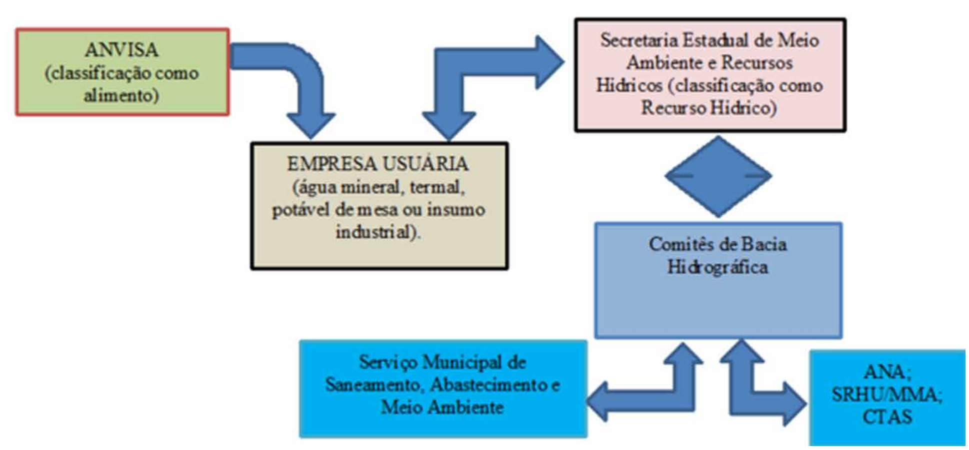
*Figure 2. Scheme for sustainable use of mineral waters*
*Source: the authors.*




For Ostrom (2002; 2010), the success in the governance of common access resources rely on the adaptation of the management system to the specific realities of each region and the active participation of local users.

In the case of water resources (and mineral waters included), this polycentric management would be possible at the scope of the state environment and water resources departments and mainly of the Hydrographic Basins Committees, which is a deliberative and participative environment that aggregates all social actors involved in the various usages of water.

*Figure 3. New institutional arrangement of mineral waters*
*Source: Portugal Júnior (2016).*




Also, according to Portugal Júnior (2016) the double direction arrows used in the scope of consideration as a water resource allow to illustrate a systemic and polycentric management model where the organs are interrelated in the management of this resource of common use so that its multiple uses obey a logic of sustainability, mainly regarding the social (public access to the resource) and environmental (preservation) issue, reducing the impacts of climate change on this resource. This would also allow for a more effective relationship for the fulfillment of objective 6 that composes the UN Sustainable Development Goals (SDG's) since it refers to water and basic sanitation.

Regarding ANVISA, when considering food, sanitary inspection and regulation of procedures for the practices of production, packaging and distribution of bottled water would be under its responsibility, as it is already done today. It is worth highlighting the importance of assistance from the municipal and state health departments and local health surveillance bodies with regard to inspection support.

In addition to that, there is the possibility of constituting the Basin Committees as spaces of action of the post-normal science, considering the possibility of participation of these actors, as well as the possibility of political and social articulation so that the precautionary principle is applied. It collaborates with this fact the claim of Nunes, Almeida and Targa (2019) that the Hydrographic Basin Committees are fundamental elements in the decentralized structure of water management in Brazil.

Still in this field, it is important to highlight a new understanding that begins to arise in studies on the right "to water" and "of water", which is: "*in dubio, pro aqua*"[4]. This understanding is based on the precautionary principle itself; however, with a quite effective orientation to the case under study. In other words, in case of uncertainties on the use of water resources, it is better to be cautious with regard to deeper impacts of its improper use, by strongly reducing and regulating its exploration until information that would more reliable is found, which would reduce the uncertainties on the dynamics of this resource.

## CONCLUSION

In this study, we sought to approach the question of the mineral waters in Brazil, its outdated institutional arrangements and the problems derived from this situation. Using this problem as a starting point, we presented and discussed some fundamental principles of the Ecological Economy that could be applied to mineral waters from its necessary integration with water resources management.

The study sought to contribute for this discussion in the Brazilian context of the institutional treatment of this important resource, which had a direct participation in the emergence and in the historical, anthropological, social and economic structuring of important regions of the country.

Thus, we would like to stress the need for an institutional change of mineral waters in Brazil and the application of precautionary and post-normal science principles for a sustainable usage of this resource, mainly through a greater reinforcement in the protagonism of Hydrographic Basins Committees.

However, it is important to highlight the need for restructuring and adequacy of the National Policy of Water Resources, in order to approach in a more systemic and integrated manner the groundwaters.

As a limitation to this study, we highlight the fact of working with only those two afore-mentioned principles, as well as the bases of action of Daly and Farley. Therefore, for future studies we recommend a deeper investigation on the required steps for the application of these principles, as well as the integration of other principles such as the dynamic of systems and assessment of multiple criteria for the case of mineral waters in Brazil.

## REFERENCES

Abramovay, R. (2007). Bem-vindo ao mundo da controvérsia. In J. E. Veiga (Ed.), *Trangênicos sementes da discórdia*. SENAC.

Alves Júnior, W. J. F. (2009). *Modelo de gestão compartilhada de bacias hidrográficas e hidrogeológicas: estudo de caso – Aquífero Guarani*. Tese de Doutorado, Universidade Estadual de Campinas.

Bruna, G., & Pisani, M. A. (2010). Mudanças climáticas e pobreza: reflexões. *Revista Brasileira De Ciências Ambientais*, *18*, 49-57. Recuperado de http://rbciamb.com.br/index.php/Publicacoes_RBCIAMB/article/view/370

Cezar, F. G., & Abrantes, P. C. C. (2003). Princípio da precaução: Considerações epistemológicas sobre o princípio e sua relação com o processo de análise de risco. *Cadernos de Ciência & Tecnologia*, *20*(2), 225–262.

Common, M., & Stagl, S. (2005). *Ecological economics: an introduction. Cambrigde*. Cambridge University Press. doi:10.1017/CBO9780511805547

Dalla Corte, T. (2018). O direito (des)humano à água: o tratamento jurídico da água no século XXI. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Daly, H., & Farley, J. (2004). *Economia ecológica: princípios e aplicações*. Instituto Piaget.

Decreto-Lei 227/1967 de 28 de fev - *Código de Mineração.* (1967). Retrieved from http://www.planalto.gov.br/ccivil_03/Decreto-Lei/Del0227.htm

Decreto-Lei 7.841 de 8 de ago - *Código de Águas Minerais.* (1945). Retrieved from http://www.planalto.gov.br/ccivil_03/decreto-lei/1937-1946/Del7841.htm

Esteves, C. C. (2012). *O regime jurídico das águas minerais na constituição de 1988*. Tese de Doutorado, Universidade Estadual de Campinas.

Ewald, F. (1996). Philosophie de la précaution. *L'Annee Sociologique*, *46*(2), 402.

Feichas, R. V. (2018). Insights de compliance e efeitos disruptivos sobre os meios de proteção das águas minerais no perímetro das estâncias hidrominerais. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Foster, K. R. (2003, Winter). O princípio da precaução: bom senso ou extremismo ambiental? *IEEE Technology and Society Magazine*.

Funtowicz, S., & Ravetz, J. (1997). Ciência pós-normal e comunidades ampliadas de pares face aos desafios ambientais. *Historia, Ciencias, Saude—Manguinhos*, *4*(2), 219–230. doi:10.1590/S0104-59701997000200002

Gesicki, A. L. D., & Sindico, F. (2013). Gestão das águas minerais no Brasil – panorama legal atual e perspectivas futuras. *Revista do Instituto Geológico*, *34*(2), 69–88. doi:10.5935/0100-929X.20130010

Gil, A. C. (2008). *Como elaborar projetos de pesquisa*. Atlas.

Giulio, G. M. D., Torres, R. R., Vasconcellos, M. P., Braga, D. R. G. C., Mancini, R. M., & Lemos, M. C. (2019). Eventos extremos, mudanças climáticas e adaptação no Estado de São Paulo. *Ambiente & Sociedade*, *22*. Advance online publication. doi:10.1590/1809-4422asoc0277r1vu19l4ao

Kundzewicz, Z. W., Krysanova, V., Benestad, R. E., Hov, Ø., Piniewski, M., & Otto, I. M. (2018). Uncertainty in climate change impacts on water resources. *Environmental Science & Policy*, *79*, 1–8. doi:10.1016/j.envsci.2017.10.008

Marengo, J. A., Tomasella, J., & Nobre, C. A. (2017) Climate Change and Water Resources. In Waters of Brazil. Springer. Recuperado de doi:10.1007/978-3-319-41372-3_12

Martins, A. M. (2006). *Águas minerais do estado do Rio de Janeiro*. Departamento de Recursos Minerais do Governo do Estado do Rio de Janeiro.

Mota, M. (2006). Princípio da precaução no direito ambiental: uma construção a partir da razoabilidade e da proporcionalidade. *Revista brasileira de direito do petróleo, gás e energia, 2*, 1 – 42.

Nunes, L. G. P., Almeida, A. A. S., & Targa, M. S. (2020). Gestão da água para a efetividade dos Objetivos do Desenvolvimento Sustentável. *Revista Técnica Ciências Ambientais, 1*(2), 1-6. Recuperado de http://agro.unitau.br/repositorio/index.php/rca/article/view/53

Obata, O. R., Cabral Júnior, M., & Sintoni, A. (2005). *Águas minerais orientação para regularização e implantação de empreendimentos*. Instituto de Pesquisas Tecnológicas.

Opschoor, J. B. (1992). Institutional change and development towards sustainability. In R. Costanza & O. Segura (Eds.), *ISEE getting down to earth: Practical applications of ecological economics*. Island Press.

Ostrom, E. (2002). Reformulating the commons. *Ambiente & Sociedade*, *5*(10), 1–22.

Ostrom, E. (2010). Beyond Markets and States: Polycentric governance of complex economic systems. *The American Economic Review*, *100*(3), 641–672. doi:10.1257/aer.100.3.641

Palma, A., & Mattos, U. A. O. (2001). Contribuições da ciência pós-normal à saúde pública e a questão da vulnerabilidade social. *Historia, Ciencias, Saude—Manguinhos*, *8*(3), 567–590. doi:10.1590/S0104-59702001000400004 PMID:11949695

Portugal Júnior, P. S. (2016). *A controvérsia sobre as águas: uma proposta de integração institucional e de políticas públicas para o segmento de águas minerais no âmbito da gestão de recursos hídricos*. Tese de Doutorado, Universidade Estadual de Campinas.

Portugal Júnior, P. S. (2018). Rompendo a controvérsia das águas: uma proposta de novo arranjo institucional para as águas minerais no Brasil. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Queiroz, J. T. M. (2011). *O campo das águas envasadas: determinantes, políticas públicas, consequências socioambientais, qualidade das águas e percepções*. Tese de Doutorado, Universidade Federal de Minas Gerais.

Romeiro, A. R. (2003). Economia ou economia política da sustentabilidade. In P. H. May, M. C. Lustosa, & V. Vinha (Eds.), *Economia do meio ambiente*. Campus.

Sanches, F. O., Fialho, E. S., & Quina, R. R. (2017). Evidências de Mudanças Climáticas em Viçosa (MG). *Revista Do Departamento De Geografia*, *34*, 122–136. doi:10.11606/rdg.v34i0.138581

Serra, S. H. (2009). *Águas minerais do Brasil: uma nova perspectiva jurídica*. Millennium.

Silva, E. R. A. (2018). *ODS – metas nacionais dos objetivos de desenvolvimento sustentável*. Brasília: IPEA.

Sousa, S. P. (2011). *Caldas Novas (GO): o uso das águas termais pela atividade turística – das aparências à realidade*. Dissertação de Mestrado, Universidade Federal da Goiás, Catalão, GO.

Tundisi, J. G. (2008). Recursos hídricos no futuro: Problemas e soluções. *Estudos Avançados*, *22*(63), 7–16. doi:10.1590/S0103-40142008000200002

## ENDNOTES

[1] In geologic terms, subsidence consists of lowering of the terrain in relation to its previous level, caused by exploration above the replenishment capacity of an aquifer.

[2] With the effectiveness of the Law 13.575/2017, the DNPM ceased to exist, and was replaced by the National Agency of Mining (ANM, by its acronym in Portuguese).

[3] The current mining code, Law 9.406/2018 did not bring any changes in the approach on mineral waters.

[4] In the same sense of the "*in dubio pro reo*" from civil law, according to Seichas (2018) and Dalla Corte (2018).

# Chapter 7
# Water Resources in Chile:
## Current and Future Projections and Their Relationships With Biomes

**Javier Lozano Parra**
*Universidad Autónoma de Madrid, Spain*

**Jacinto Garrido Velarde**
*University of Extremadura, Spain*

**Ignacio Aguirre**
https://orcid.org/0000-0002-7722-9677
*Centre for Hydrology, University of Saskatchewan, Canada*

## ABSTRACT

*This study quantifies the current and future soil water balance in a spatially distributed way for the whole of Chile and establishes what biomes will be the most affected by variations in water resources. The study of water resources reveals that 90% of surface Chile will reduce its soil water resources in the future if greenhouse gas concentration in the atmosphere does not stop. The most disadvantaged biomes are the forests, where soil water availability could decrease an average of 100 mm/year. Desert biomes could not perceive the hydrological imbalances; however, it is expected its surface increases.*

## Introduction

Chile is one of the countries with greater water resources per person in the world and with greater biomes surface and biodiversity (World Bank, 2011). However, due to the increasing pressure on water resources, it is necessary to face water-related issues from approaches that allow solving problems and efficiently managing resources. One of these approaches is one that addresses hydrological and ecological processes from a combined perspective (ecohydrological approach) or, in other words, one that addresses the interactions between water and vegetation. A primary task for ecohydrology is to understand the

DOI: 10.4018/978-1-7998-8482-8.ch007

responses that arise in different ecosystems in the face of a changing environment, since this will improve the management of spaces and predict their dynamics (Porporato et al., 2002, Rodríguez-Iturbe, 2000).

Ecohydrology is established as an independent scientific discipline from the beginning of XXI century (Rodríguez-Iturbe, 2000) when it focuses on the study of water-plant relationships, i.e., to understand the interactions between water and plants at different spatiotemporal scales. Despite this, scientific studies developed under this approach are still very scarce in Chile, so that Chilean ecohydrology of the present century faces important challenges, such as increased pressure on water, decreased resources or climate change, aspects that have been highlighted by researchers such as Blöschl et al. (2019). Ecohydrological studies have shown that the presence of vegetation is the cause and consequence of the presence of water, and vice versa. For example, the spatial distribution of the vegetation has a strong control over the spatio-temporal variability of soil water content and on soil hydrological processes, such as infiltration or redistribution of water (Lozano-Parra and Schnabel, 2015, Lozano-Parra et al., 2016), while the availability of water in the soil determines the growth and development of vegetation and its productivity (Lozano-Parra et al., 2018a, Lozano-Parra et al., 2018c).

Ecohydrological processes are becoming better understood due to the use of advanced methods and tools, such as models or specialized sensors. However, feedback processes at different spatio-temporal scales are still not well understood because the multiscale relationships originated between ecohydrological processes are non-linear (Goodwell et al., 2018, Yaseef et al., 2010). This leads to the existence of a non-unidirectional behavior for the same variable, that is to say, that said variable can present different stable states whose behaviors can be based on exceeding certain thresholds (Scheffer et al., 2001). This would mean that, for example, areas that have been humid and that are currently experiencing significant variations in their hydric conditions could modify their environmental characteristics towards drier states in which they would persist for a long time in a stable manner.

The study of ecohydrological processes at different scales is therefore necessary to understand the dynamics of ecosystems and the variations that natural resources may have (Zemp et al., 2017). Analysis over large areas can help to identify the mechanisms that induce spatial heterogeneity, which are particularly important in ecosystems where water stress limits plant growth, such as those found in central and northern Chile (Goodwell et al., 2018). These areas, being the most populated, are very sensitive to the variation of water resources (Hirschi et al., 2011, Wu et al., 2013).

Due to the importance of water resources for the maintenance and development of vegetation, this work aims to define the amount of water resources that Chile has at present and that it will have in the future, and establish which biomes could be most affected by the variation of said resources. Thus, the objectives of this study are the following: I) determine the current water balance in a distributed manner for the entire territory of Chile; II) define the future water balance for Chile based on different climatic scenarios and III) determine what biomes in Chile will be the most affected by future variations in soil water resources.

## Study area

Chile's surface is greater than 755000 km$^2$ and, from north to south, reaches a greater length than 4200 km (Fig. 1). It has a population close to 18 million inhabitants, mainly concentrated in the central area of the country, between the Valparaiso and the Metropolitan regions.

The Chilean geology is especially conditioned by its location next to the western edge of the South American tectonic plate, which has allowed it to interact with the subducting plates located to the west, resulting in very heterogeneous and tangled geological features. Thus, its geomorphology can be considered extraordinarily varied and complex. The current reliefs have their origin in the erosion processes of material in higher areas and its subsequent accumulation and sedimentation in valley bottom and depressions. Likewise, the glacier, volcanic or fluvial processes have finally outlined the current reliefs throughout the country. The predominant reliefs are the Andes Mountain, the Coastal Mountain, the Intermediate Depression, and the Transverse Valleys.

The climate is conditioned by latitudinal and altitudinal gradients, and by the maritime influence of the Pacific Ocean. Thus, the most important climatic variations are produced by the influence of latitude and elevation, ranging almost all climatic types except for a few, such as the tropical rainy (Fig. 1).

The soil types are very varied due to their different factors which influence on their formation, such as geomorphology, latitude, vegetation and climate variations. The main types of soils are Cambisols, Andosols, Regosols, and Leptosols.

The Chilean vegetation is also conditioned by latitudinal and altitudinal gradients. Consequently, it presents a great diversity of biomes characterized by strong endemism (it is estimated that there are approximately more than 6,300 endemic species). Despite this, the plant diversity is less than those found in neighboring countries such as Brazil.

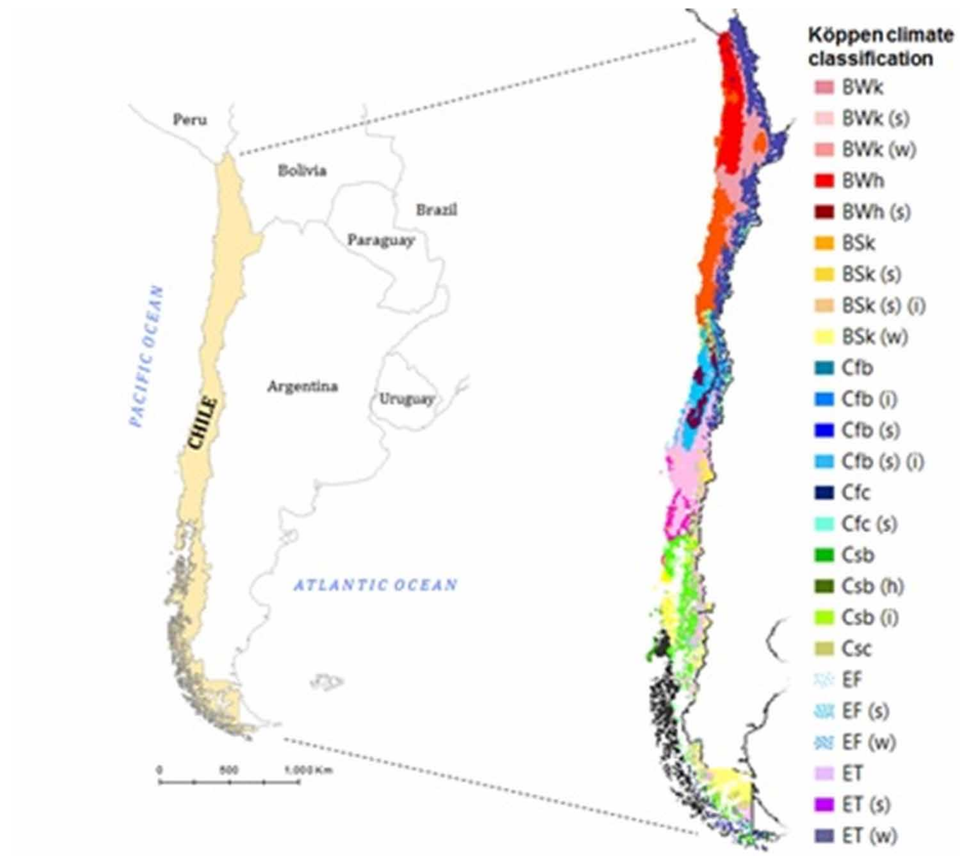
## MATERIAL AND METHODS

### Obtaining Current and Future Climate Data

The spatially-distributed climate data were obtained from Fick and Hijmans (2017). For this, observed data of monthly precipitation, monthly mean temperature and minimum and maximum temperatures were used. Later, these data were interpolated in order to generate a spatially continuous grid on a world scale with a resolution of 1 km2. The interpolation method is based on smoothed splines that operate considering the analysis of covariance and spatial distributions of the standard error. This method can be seen as a generalization of the standard multivariate regression, in which the parametric model is replaced by a smoothed non-parametric function (Wahba, 1990). This interpolation algorithm uses climatic variables, latitude, longitude, and elevation as independent input components. This last variable was obtained from NASA's Shuttle Radar Topography Mission (SRTM). The observed climate data were obtained from meteorological stations distributed on a global scale and belonging to the Global Historical Climatology Network (GHCN). In order to increase the climate observations, improve the databases and lengthened them, meteorological stations from other sources were also used, such as the Food and Agriculture Organization (FAO), the World Meteorological Organization (WMO), the International Center for Tropical Agriculture (CIAT) or the R-HydroNET.

In order to determine the current water balance and to estimate the impact of future climate variations on water resources and biomes at Chile scale, two time periods were used. The first one refers to the lapse 1970-2000 (base period); while the second one refers to a representative scenario of greenhouse gas concentration for the year 2050, which corresponds with RCP8.5 and assumes a situation with a very high level of emissions and gas concentration. The projections used were generated by BCCCSM11,

*Figure 1. Chile in the South America region and its main climates according to the Köppen climate classification (based on Rubel and Kottek (2010))*




one of the global climate models (GCMs) that are part of the fifth phase of the coupled model inter-comparison project (CMIP5).

## Determining the Soil Water Balance

The spatially-distributed water resources were obtained by determining the soil water reserve for the whole Chile. For this, the water balance was calculated at the pixel scale by the following expression:

$$\beta = P - E$$

where, β is the soil water reserve or availability of water resources (mm) at annual timescale, P is the water input by precipitation (mm) and E is the water output by evapotranspiration (mm).

Evapotranspiration was calculated using the Turc (1961) method, which allows obtaining annually the actual evapotranspiration from the following expression:

$$E = \frac{P}{\sqrt{C + \frac{P^2}{L^2}}}$$

where, E is the actual evapotranspiration at annual scale (mm year-1), P is the annual precipitation (mm year-1) and C is a constant value. Finally, L is a coeffient which depends of annual mean temperature (T, in °C) and it is obtained as follows:

$$L = 300 + 25T + 0.05T^3$$

## Obtaining the Biomes of Chile

The spatial distribution of the main biomes of Chile was obtained from Pliscoff and Luebert (2006). These authors presented a classification for vegetation that proposes the existence of macro-bioclimates (Fig. 2) throughout the country and 125 basic units called vegetation floors. Each floor constitutes a spatial unit characterized by a set of plant communities with uniform structure and physiognomy, located under homogeneous meso-climates conditions that occupy a specific position along an altitudinal gradient and on a specific spatial-time scale. Subsequently, a vegetation floor can be characterized by its floristic composition, its dynamics and its internal heterogeneity (Pliscoff and Luebert, 2006). The macro-bioclimate regions used in this study were forests, scrubs, deserts, grasslands, and peat bogs (Fig. 2), which in turn, are constituted by other minor biomes.

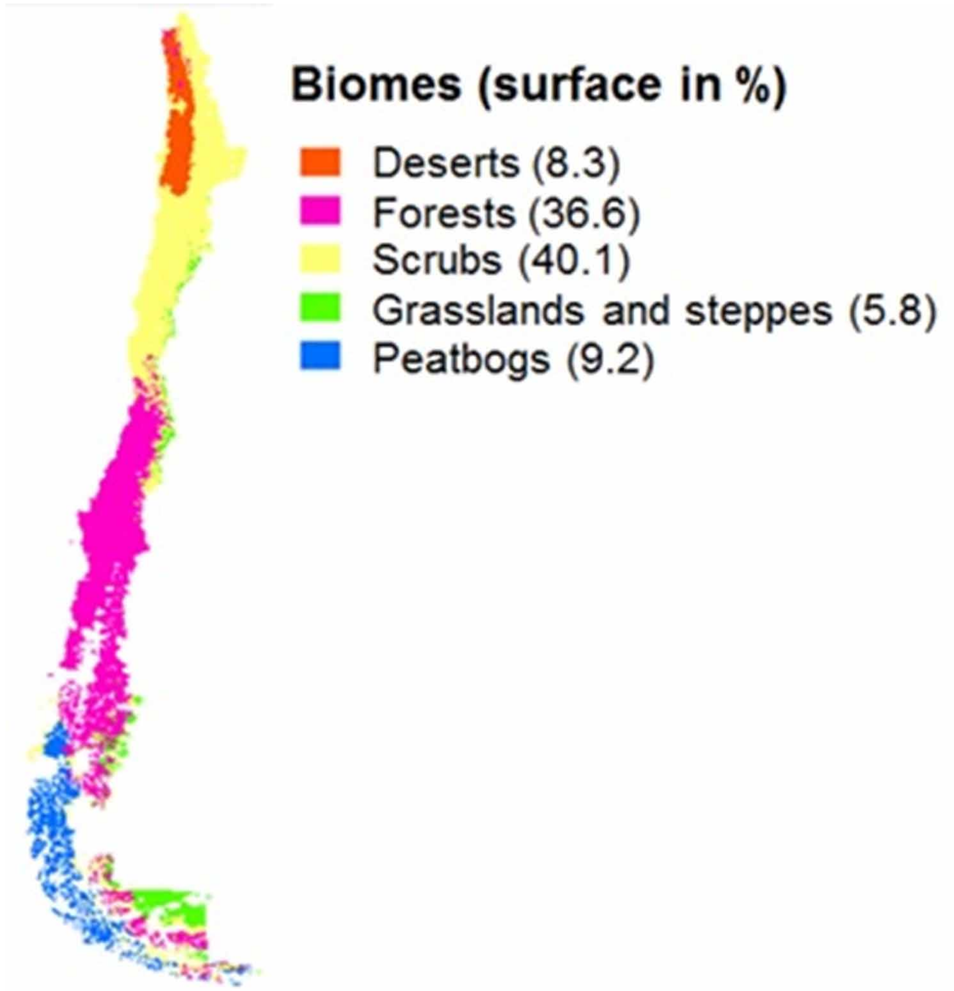
# RESULTS AND DISCUSSION

## Current and Future Soil Water Resources

The annual precipitation in Chile ranged approximately between 0 - 7000 mm for the base period, its annual average was close to 1000 mm and its standard deviation also ranged similarly between ±1000 mm year-1. The actual evapotranspiration ranged between 0 – 677 mm year-1, it was averaged on 312.3 mm year-1 and its standard deviation was of ± 212 mm/year. This given rise to average soil water resources of 684.5 mm year-1. However and despite this water abundance, the spatial distribution of water resources was not homogeneous in Chile and soil water availability varied throughout the country. Southern regions showed greater water resources than northern or central regions. This last one, where the population density is higher and economic activities have greater density, water resources are not as high as in the humid areas of southern regions.

Despite their abundance, the water resources of Chile could be decreasing due to the variations in the hydrometeorological processes caused by climate change, according to the IPCC (2018) forecasts. The projections carried out by BCCCSM11 for the year 2050 with the RCP8.5 scenario, showed that precipitation will reach an average of 949 mm year-1 (Fig. 3. A), which represents a reduction of 6.7% in the rainfall regarding the base period and could suppose a decreasing of more than 43 km3 of water. Similarly, actual evapotranspiration will reach values 6.7% greater than the ones of the base period, i.e.,

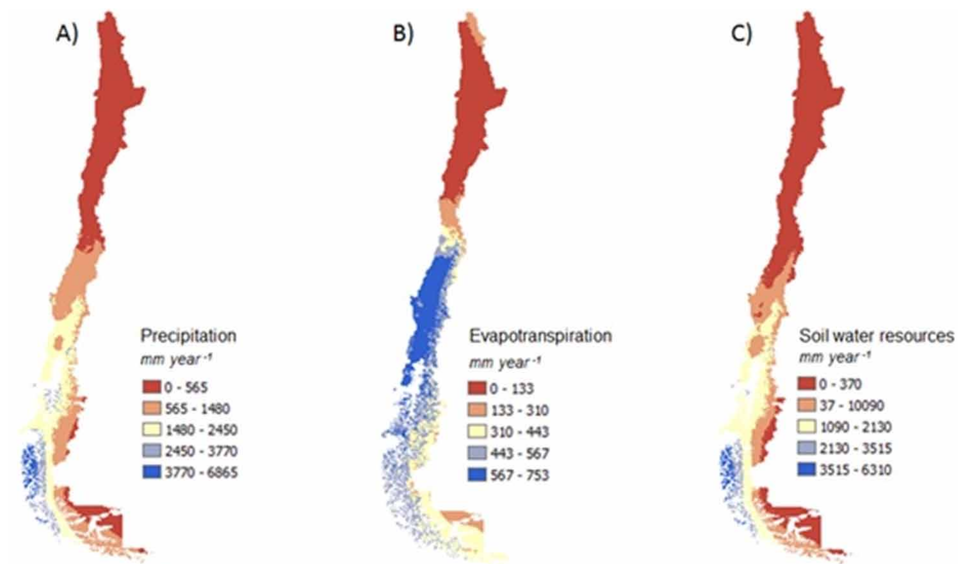
*Figure 2. Main biomes of Chile and their surface expressed in %, according to Pliscoff and Luebert (2006)*




its value will be 333 mm year-1 as an average for the whole of Chile (Fig. 3. B), which could suppose an increasing of 8 km3 of water that will be returned to the atmosphere. Finally, the soil water resources generated by the Chilean territory will reach an average of 619 mm year-1 (Fig. 3. C), which means they could be reduced by 9.5% regarding the base period, and represents an annual decrease in soil water resources of approximately 49 km3

Despite the possible effects of climate change, demand for water is increasing. For example, the Dirección General de Aguas of Chile is granting new water rights for aquifers exploitation in northern regions, although water extraction is close to exceeding the natural recharge thresholds of the aquifers (Hearne and Donoso, 2014). Also in northern regions, the water demand by mining companies is related to an increase in copper prices (Rivera et al., 2016). Strategic sectors such as energy are also intensifying the pressure on water resources, for example, hydroelectric companies sustain a growing demand to supply industrial expansion (Larraín and Poo, 2010). Water demand by agriculture is growing, on one hand, due to the population is also increasing and, on the other hand, because agricultural products

*Figure 3. Precipitation (A), Evapotranspiration (B), and soil water resources (C) in Chile, projected by the BCCCSM11 global climate model for the year 2050 with the scenario RCP 8.5*



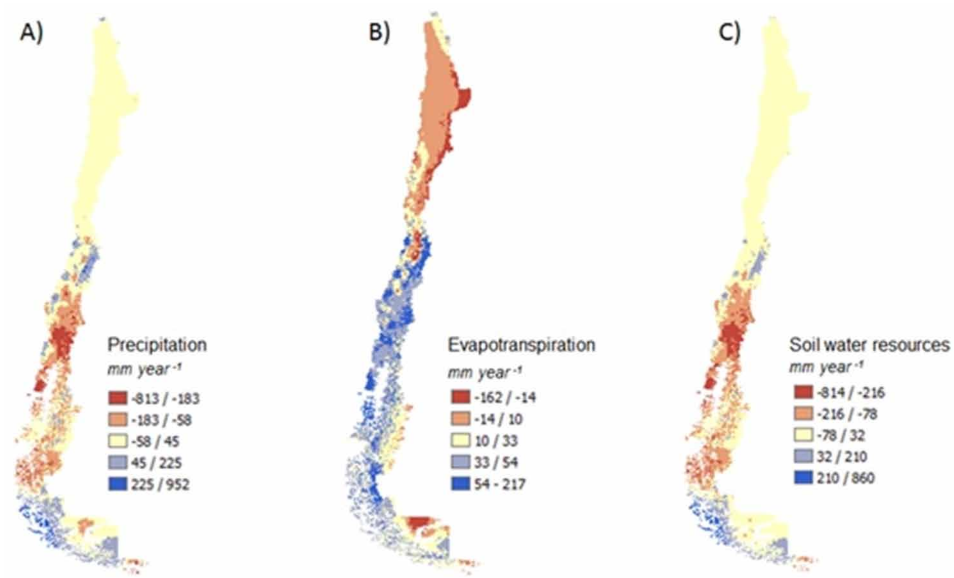

must compete in global markets (Rodell et al., 2018). Thus, both scarcity and competition for water resources are increasing throughout the country and the spatial disparity in water resources distribution is reflected in the increase of water conflicts (Larraín and Poo, 2010). The concentration of disputes is located in the central and northern areas of Chile, where water resources are more variable and demand is more intense (Rivera et al., 2016).

## Variations of Soil Water Resources and Availability for the Biomes of Chile

The forecasts carried out by BCCCSM11 GCM for the year 2050 with the RCP8.5 scenario show that, when these projections were compared with the base period, precipitations tend to decrease in central Chile and in the southern regions, while they tend to be positive in the central-south and in high areas of central Andes (Fig. 4 A). Oppositely, evapotranspiration processes tend to increase in central Chile and in the south areas (Fig. 4 B). Consequently, the impact of climate change on Chile's water resources could be more negative in the south-central zone (Fig. 4 C), since the decrease of water resources was greater in this zone. Only zones of southern Chile and very specific locations of the central Andes of high-altitude would experience increases in their water reserves. The greatest decrease in water resources will occur in territories in the central-south, where the decrease in soil water reserve could be greater than 200 mm year$^{-1}$.

According to projections, all biomes of Chile will tend to reduce their soil water resources except desert biomes (Table 1), which means that 90% of the Chile surface will have to cope with much drier environments than those existing currently. The greatest decline will be experienced by forests biomes, since they will register an average decrease in precipitation around 56 mm year-1, an increase in evapotranspiration close to 40 mm year-1, so the soil water resources will reduce around 100 mm year-1. Grasslands and steppes biomes will also reduce their soil water resources (Table 1) in a significant way,

*Figure 4. Changes in hydrological processes of Chile. calculated as the difference between the RCP8.5 scenario for the year 2050 and the base period (1970-2000). Map A shows differences in precipitation, B in evapotranspiration, and C in soil water resources.*




with the consequent impact on biomass productivity and economic activities depending on livestock. On the opposite side, deserts biomes will tend to be in a similar situation to the current one from the hydrological standpoint, although it is expected its surface increases (Reynolds et al., 2007).

*Table 1. Changes in hydrological processes of Chile. calculated as the difference between the RCP8.5 scenario for the year 2050 and the base period (1970-2000). The unit values are mm/year. Avg. = Average; SD = Standard deviation.*

| | Precipitation | | Evapotranspiration | | Soil water reserve | |
|---|---|---|---|---|---|---|
| | Avg. | SD | Avg. | SD | Avg. | SD |
| Desert | 0.5 | 3.2 | 0.6 | 3.4 | 0.0 | 0.0 |
| Forest | -56.4 | 107.8 | 39.8 | 22.3 | -96.2 | 110.7 |
| Scrubs | 2.0 | 40.1 | 7.1 | 22.0 | -4.9 | 35.4 |
| Grasslands | -11.7 | 53.2 | 8.3 | 28.7 | -19.9 | 38.1 |
| Peatbogs | 30.6 | 188.6 | 39.5 | 13.8 | -8.9 | 187.7 |

The decrease of water resources in central Chile has the particularity of occurring between the most populated urban areas, Santiago and Valparaíso. This implies a significant reduction in water resources where there is a higher concentration of population and where the Mediterranean climate, characterized by its unpredictable variability, is predominant. Studies such as those carried out by Lozano-Parra et al. (2018c), assert that water is the main factor controlling biomass growth in water-limited environments and when water conditions become dry, biomass production could reduce up to 50%, compromising the environmental and economic functions of ecosystems. Likewise, when long and intense soil moisture deficits occur, sensible heat fluxes dominate over latent heat fluxes, which can lead to a warmer atmosphere that inhibits convection cloud formation, creating a positive feedback loop (Lozano-Parra et al., 2018b, Scheffer and Carpenter, 2003). This fact could directly affect extreme heat episodes on a local scale, as already described by Fischer et al. (2007) in Europe. Therefore, it is necessary to continue analyzing the ecohydrological processes in order to evaluate the possible impact of water deficits on ecosystems (Seneviratne et al., 2010).

## CONCLUSION

Chile is a very water-rich country with very high biodiversity, although its water resources are unequally distributed in space and time. So far, Chile's biomes have had water availability to its maintenance; however, future variations give rise to a very unbalanced availability. The study of water resources reveals that 90% of surface Chile will reduce its soil water resources in the future if gases greenhouses concentration in the atmosphere does not stop. The most disadvantaged biomes are the forests, where soil water availability could decrease an average of 100 mm/year. Desert biomes could not perceive the hydrological imbalances, however, it is expected its surface increases. Deciphering the ecohydrological mechanisms and processes that control ecosystems and determining their sensitivity to environmental disturbances constitutes one of the most important challenges of ecohydrology, in order to understand spaces and manage their resources.

## ACKOWLEDGMENT

Authors thanks to Fick, S. and Hijmans, R for doing available their methos and information.

## REFERENCES

Blöschl, G., Bierkens, M. F. P., Chambel, A., Cudennec, C., Destouni, G., Fiori, A., Kirchner, J. W., McDonnell, J. J., Savenije, H. H. G., Sivapalan, M., Stumpp, C., Toth, E., Volpi, E., Carr, G., Lupton, C., Salinas, J., Széles, B., Viglione, A., Aksoy, H., ... Zhang, Y. (2019). Twenty-three unsolved problems in hydrology (UPH) – a community perspective. *Hydrological Sciences Journal*, *64*(10), 1141–1158. doi:10.1080/02626667.2019.1620507

Fick, S. & Hijmans, R. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology, 37*(12), 4302-4315.

Fischer, E., Seneviratne, S., Lüthi, D., & Schär, C. (2007). Contribution of land-atmosphere coupling to recent European summer heat waves. *Geophysical Research Letters*, *34*(6), 1–6. doi:10.1029/2006GL029068

Goodwell, A., Kumar, P., Fellows, A., & Flerchinger, G. (2018). Dynamic process connectivity explains ecohydrologic responses to rainfall pulses and drought. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(37), 1–10. doi:10.1073/pnas.1800236115 PMID:30150371

Hearne, R., & Donoso, G. (2014). Water markets in Chile: Are they meeting needs? In Water markets for the 21st Century. What have we learned? Global Issues in Water Policy. Springer.

Hirschi, M., Seneviratne, S. I., Alexandrov, V., Boberg, F., Boroneant, C., Christensen, O. B., Formayer, H., Orlowsky, B., & Stepanek, P. (2011). Observational evidence for soil-moisture impact on hot extremes in southeastern Europe. *Nature Geoscience*, *4*(1), 17–21. doi:10.1038/ngeo1032

IPCC. (2018). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. World Meteorological Organization.

Larraín, S., & Poo, P. (2010). *Conf lictos por el Agua en Chile. Entre los derechos humanos y las reglas del mercado*. Embajada de Holanda y Fundación Heinrich Böll.

Lozano-Parra, J., Lozano-Fondón, C., Pulido, M., & García-Marín, R. (2018a). El papel del agua sobre la biomasa vegetal en la zona semiárida con clima mediterráneo de Chile. *Revista de Geografía Norte Grande*, (71), 71. doi:10.4067/S0718-34022018000300091

Lozano-Parra, J., Pulido, M., Lozano-Fondón, C., & Schnabel, S. (2018b). How do soil moisture and vegetation covers influence soil temperature in drylands of Mediterranean regions? *Water (Basel)*, *10*(12), 1747. doi:10.3390/w10121747

Lozano-Parra, J., & Schnabel, S. (2015). Respuesta de la vegetación herbácea a las variaciones hídricas del suelo. In Estudios de la Zona No Saturada. Universidad de Alcalá de Henares.

Lozano-Parra, J., Schnabel, S., Pulido, M., Gómez-Gutiérrez, Á. & Lavado-Contador, F. (2018c). Effects of soil moisture and vegetation cover on biomass growth in water-limited environments. *Land Degradation and Development, 29*(12), 4405-4414.

Lozano-Parra, J., Van Schaik, L., Schnabel, S. & Gómez-Gutiérrez, Á. (2016). Soil moisture dynamics at high temporal resolution in a mediterranean watershed with scattered tree cover. *Hydrological Processes, 30*(8), 1155-1170.

Pliscoff, P. & Luebert, F. (2006). *Sinopsis Bioclimatica y Vegetacional de Chile*. Editorial Universitaria.

Porporato, A., D'Odorico, P., Laio, F., Ridolfi, L., & Rodríguez-Iturbe, I. (2002). Ecohydrolgy of water-controlled ecosystems. *Advances in Water Resources*, *25*(8-12), 1335–1348. doi:10.1016/S0309-1708(02)00058-1

Reynolds, J. F. (2007). Global Desertification: Building a Science for Dryland Development. *Science, 316*(5826), 847-851.

Rivera, D., Godoy-Faúndez, A., Lillo, M., Alvez, A., Delgado, V., Gonzalo-Martín, C., Menasalvas, E., Costumero, R., & García-Pedrero, Á. (2016). Legal disputes as a proxy for regional conflicts over water rights in Chile. *Journal of Hydrology (Amsterdam)*, *535*, 36–45. doi:10.1016/j.jhydrol.2016.01.057

Rodell, M., Famiglietti, J. S., Wiese, D. N., Reager, J. T., Beaudoing, H. K., Landerer, F. W., & Lo, M.-H. (2018). Emerging trends in global freshwater availability. *Nature*, *557*(7707), 651–659. doi:10.103841586-018-0123-1 PMID:29769728

Rodríguez-Iturbe, I. (2000). Ecohydrology: A hydrologic perspective of climate-soil-vegetation dynamics. *Water Resources Research, 36*(1), 3-9.

Rubel, F. & Kottek, M. (2010). Observed and projected climate shifts 1901–2100 depicted by world maps of the Koppen-Geiger climate classification. *Meteorologische Zeitschrift, 19*(2), 135-141.

Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature*, *413*(6856), 591–596. doi:10.1038/35098000 PMID:11595939

Scheffer, M. & Carpenter, S. R. (2003). Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in Ecology and Evolution, 18*(12), 648-656.

Seneviratne, S. (2010). Investigating soil moisture–climate interactions in a changing climate: A review. *Earth-Science Reviews, 99*(3-4), 125-161.

Turc, L. (1961). Estimation of irrigation water requirements, potential evapotranspiration: A simple climatic formula evolved up to date. *Annales Agronomiques*, *12*, 13–49.

Wahba, G. (1990). *Spline Models for Observational Data. University of Wisconsin*. University of Wisconsin. doi:10.1137/1.9781611970128

World Bank. (2011). *Chile: Diagnóstico de la gestión de los recursos hídricos 88*. Author.

Wu, P., Christidis, N., & Stott, P. (2013). Anthropogenic impact on Earth's hydrological cycle. *Nature Climate Change*, *3*(9), 807–810. doi:10.1038/nclimate1932

Yaseef, N. R., Yakir, D., Rotenberg, E., Schiller, G. & Shabtai, C. (2010). Ecohydrology of a semi-arid forest: partitioning among water balance components and its implications for predicted precipitation changes. *Ecohydrology, 3*(2), 143–154.

Zemp, D. C. (2017). Self-amplified Amazon forest loss due to vegetation-atmosphere feedbacks. *Nature Communications, 8*(14681), 1-10.

# Chapter 8
# Environmental Sanitation in Heredia:
## A Relevant Challenge in Costa Rica


**Roxana Yasmín Durán Sosa**
*Universidad Nacional, Costa Rica*

**Iliana Araya Ramírez**
*Universidad Nacional, Costa Rica*

**Rui Alexandre Castanho**
https://orcid.org/0000-0003-1882-4801
*WSB University, Portugal*



## ABSTRACT

*Costa Rica is recognized for its efforts in sustainable development. This study analyzes the challenges of environmental sanitation to articulate environmental management in the Canton of Heredia. Currently, the country faces significant challenges regarding access to water and environmental sanitation. This research contributes to the analysis of the challenges of the environmental sanitation system in this territory. The testing techniques and photographic registration in the impact area, along with the interviews with employees and professionals on the subject, and extensive bibliographic consultation support this methodology. The study's conclusions regarding the challenges of environmental sanitation are 1) legal and institutional framework faced by the environmental sanitation project of the Publics Services Company of Heredia (ESPH for its initials in Spanish), 2) strategy for the treatment of sanitary waters in the canton, and 3) improvement in the quality of life of the Heredia's citizens.*


## INTRODUCTION

The Sustainable Development Goals report mentions that the "*proportion of the world's population using safely managed drinking water services increased from 61% in 2000 to 71% in 2017*" (United Nations,

DOI: 10.4018/978-1-7998-8482-8.ch008

2020, p. 36). However, 4.2 billion people report not having water, despite the increase in the number of people who use the drinking water service was 17% in the same period (United Nations, 2020).

Regarding renewable internal freshwater resources, Costa Rica registers a decrease in 2017 of 56,008 cubic meters per capita in a period of 55 years, which represents 1,018 $m^3$ per person per year (World Bank, 2021). For its part, the distribution of the annual extraction of freshwater for industrial use has increased by 3.83% from 2012 to 2017. Regarding domestic use, it decreases 4.37% in the same period, and for agricultural use, it barely grew 0.55% in that period—quinquennium (World Bank, 2021).

Since the last decades of the 20th century, starting with the decline in coffee activity in the 1980s, the Metropolitan Area of Heredia's urban expansion, where the canton of Heredia is located, in Costa Rica, has shown a substantial transformation in land use. In particular, the change from coffee use to residential and commercial use linked to the production processes that have boosted the Greater Metropolitan Area's economy. The accelerated conurbation process experienced exceeds the territory's capacity to absorb environmental repercussions sustainably. Hence, this urbanization generates negative externalities, such as insufficient planning of environmental sanitation.

Durán (2020) affirms that: from the declaration of Pandemic in the country, the right to drinking water stipulated in article 50 of the Political Constitution of the Republic is ratified, which contributes to the health of citizens. On the contrary, the economic instrument of collection for the discharges has not reached the goal of reducing and supervising the amounts collected:

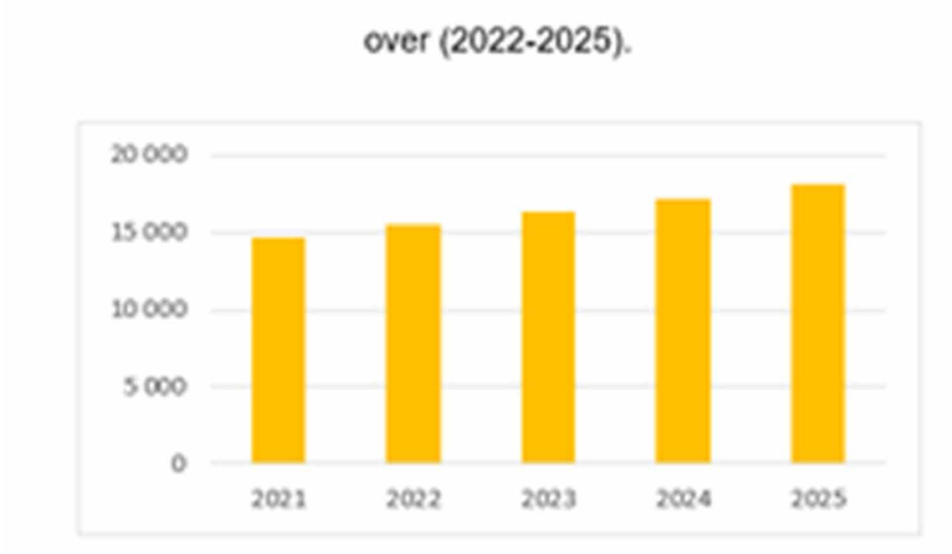
*"from those who use the environmental service of the bodies of water, well of public domain, for transportation, and elimination of liquid waste originated in punctual dumping, which can generate harmful effects on the water resource, related ecosystems, human health and activities productive" (Astorga, s.f. p. 7).*

This makes it clear that the lack of planning and the "who polluter pays" approach opens up spaces to increase discharge to the detriment of water resources.

In Costa Rica, like other Latin American countries, real estate capital has exacerbated real estate speculation and the construction of residential and commercial complexes without anticipating infrastructure and service needs (Janoschka, 2002). More specifically, sanitation infrastructure is not integrated into cities' territorial organization, hence the deficiencies in environmental sanitation planning. Until 2012, the country lacked a regulatory framework for land use planning, and currently, the canton of Heredia does not have a regulatory plan. However, some progress has been made regarding the hydrogeological map's approval, the land use map, and the environmental variable is 80% advanced (Soto, Personal communication, 2020). These efforts affect the environmental policy that began in 2019.

In 2011 Heredia had a total population of 123 616, whose percentage of urban population is 99.70, with a density of 437.4 / km2 and 7.4% over 65 years (INEC, 2011) incremental trend to 2025 for a total of 149 930 people. Regarding the population over 65 years of age, a rise is observed, with an average of 11.06% by 2025 (INEC, 2011-2050) (Figure 1).

*Figure 1. Costa Rica, Canton of Heredia - Projection of the total population aged 65 and over (2022-2025)*
*Source: Developed based on the national projections of the INEC 2011-2050.*




Regarding the human development index, the canton of Heredia is in the very high category, in position ten, with 0.88 preceding the canton of Belén (0.90), with place four at the national level in 2018 (PNUD, 2000). The Human Development index trajectory oscillates between 0.86 and 0.88 at the most in the period from 2010 to 2018 (figure 2)

*Figure 2. Costa Rica, Canton of Heredia - Human Development Index (2010-2018)*
*Source: Cantonal Human Development Atlas (PNUD, 2000).*

This study aims to analyze environmental sanitation challenges to articulate environmental management in the canton of Heredia. Hence the question is: *What is environmental sanitation?* According to Morel, Schertenleib, and Zurbruegg (2003), conventional approaches to environmental sanitation have failed to improve problems in sanitation services in developing countries, understood as access, distribution, and drainage of water for human consumption, residual and pluvial. From this perspective, the groups with the greatest social exclusion are disadvantaged since equity and access are not guaranteed.

Therefore, in the traditional conception of environmental sanitation, the people who inhabit human settlements are users of the services of the different operators or providers of the water service managed by public administrators mediated by market conditions. Although such suppliers are responsible for the supply, health and environmental aspects intervene in the distribution that generates conflicts over water (Chamizo, 2011, 2006). These objectives do not necessarily meet the expectations and needs of sustainable local development and probably end up leaving the needs of the inhabitants unsatisfied.

Thus, the notion of environmental sanitation refers us to populations' ability to give back to nature the precious liquid through the water sanitation system used by people, companies, and institutions established in a specific territory. The management of environmental sanitation occurs and involves elements of material, ideological, and subjective order established following the social actors' norms.

On and other hand, the possibility of controlling river pollution lies in the political, economic, and social capacity established in the territory. These capacities must enhance the well-being of the inhabitants. Chamizo (2010, 2011) proposes a conceptual change on environmental sanitation committed to sustainable development and human needs satisfaction. Likewise, it points out that it is not enough to conceptualize environmental sanitation from the sewage cleaning service perception. On the contrary, it argues that satisfying the basic needs of the population should be incorporated, where living conditions are considered that ensure the right of people to integrated and sustainable development management nurtured by the principles of equity, sustainability, and efficiency.

The lack of an environmental sanitation plan induces untreated water dumping practices, which causes health problems for people (Murillo, 2017). For this reason, it is worthwhile to develop and carry out a sanitation system, both in urban and rural areas. To this definition Chamizo (2010) adds the importance of a local sanitation strategy integrated by institutions, companies, residents, community organizations, and local governments. All this to conceive a model of public management articulated to the development style of the countries.

Since the end of the 20th century, economic, social, environmental, cultural, and technological transformations have compromised Latin American countries' development styles. In this direction, Costa Rica has adopted the National Climate Change Strategy through the joint action of the different sectors and actors, whose goal is to achieve carbon neutrality by 2021, the Central American bicentennial year. Although in the current conditions, the goal will not be reached, the canton of Heredia published its public policy on climate change in 2019, which constitutes "(…) *a pioneering action at the national level and seeks to address and reduce the causes of climate damage that are generated in the canton*" (CINPE, 2019, p. 2). This policy has some technical tools that allow it to be carried out, such as the National Standard for the Declaration of Carbon-Neutrality, Institutional Environmental Management Plans, and Ecological Blue Flag Programs.

According to the International Center for Economic Policy for Sustainable Development CINPE (2019), the strategic pillars of this policy are: 1) management for the management and conservation of ecosystems and environmental services, 2) growth management and habitat improvement urban, 3) management of growth and improvement of rural habitat and 4) management and promotion of low-carbon infrastructure.

The first pillar includes five subtopics. Namely, 1) Water, made up of coverage and efficiency in the water supply service and availability of water resources; 2) Sanitation and drainage, covers the issue of sanitation, wastewater treatment and effectiveness of drainage; 3) Solid waste management, includes the coverage of solid waste collection, disposal and adequate treatment in solid waste management and incentives and fines; 4) Air quality, includes regulations on air quality and pollution control that reviews and controls potential sources of emissions and 5) Ecosystems, considers the conservation and sustainable use of ecosystems and coordination for the development of urban arboriculture as subtopics. This document will focus on the subtopics of water and sanitation, and drainage.

## MATERIALS AND METHODS

The methodology is based on testing techniques and photographic registration in the impact zone, interviews with officials and experts on the subject, and, finally, an extensive bibliographic consultation. The systematization and analysis of the information are carried out based on the strategic pillar of the climate change policy: 1) management for the management and conservation of ecosystems and environmental services (CINPE, 2019), including the issue of sanitation and drainage. The analysis method starts from the description and comparison of core aspects: a) Infrastructure: public sewerage and wastewater treatment; b) Economic activity and building conditions c) Quality of life of the population.

The relational analysis shows that the sanitation and drainage of wastewater form a cycle of the permanent impact that intervenes in economic activity areas, infrastructure, building conditions, and the quality of life. Each of these spheres has its characteristics and values focused on the content of public policies and reflected in the competent institutions' work and the different community actors' actions. For example, the quality of life is conditioned by the families' level of income and the territorial conditions of where they reside. Regarding the economic activity and state of the infrastructure, the determined geographical area is taken up and the size and productive activity to which the business conglomerates are engaged in the canton of Heredia. Regarding infrastructure, it refers to the public health system and its relationship with the inhabitants and construction companies. The type of situations that generate damages to the public service and the forms of approach exercised by the institutions present are identified in the zone.

In order to carry out the photographic portfolios and record evidence, tours were carried out in different areas of the canton and its villages during April and May 2020. These tours were conducted at different times of the day and night, during weekends and weekdays. Some sites were visited more than twice to make comparisons in the residences, in the pipes, the facades of the residences, and the observation of flows on days with and without rain. The recording of the videos and photographs are ordered in the fieldwork reports. After that, they are used in the professional team's analysis sessions, resulting in an objective vision of the environmental sanitation problem in the study area. The criteria and findings obtained in the field trips contrast with the criteria of the municipal staff, thus subtracting the subjectivity in the analyses.

## RESULTS

The definition of the term environmental sanitation is crucial to determine the technical and social scope contained in all the actions carried out by the ESPH and the Municipality of Heredia (MH). In this regard, the MH conceives environmental sanitation as an action that seeks to contribute to the improvement of the Human Development Index (HDI) of the residents of the canton (R. Araya, personal communication, October 20, 2020), which suggests that the possibility of optimizing environmental sanitation lies in a political, economic and social capacity.

In short, environmental sanitation must be established in a way that ranges from the areas with the greatest social exclusion to those that generate the most wealth. The treatment of wastewater must express socio-territorial equity for reasons of sanitary security. Also, through the sanitation system, the strategic lines of any cantonal and regional development plan should be established, contributing to the cooperation intentions for the conservation of hydrographic basins and omitting the political-administrative limits of the cantons and districts.

On the other hand, the treatment of wastewater establishes the highest standards of operational and functional efficiency of the people in charge of the design and operation works, in order to accurately measure the impacts of urban growth and especially of the that produce a greater amount of waste, both liquid and solid. All this supposes the prevention of the problems linked to the saturation of the current system. In this sense, it is necessary for wastewater engineering to play a central role in planning urban areas in the metropolitan area of Heredia. In addition to acting as a facilitator of the opening processes for the regional design of any development plan and cantonal regulator, considering as a priority the vision of the hydrographic basin. This is how all municipal efforts, in terms of development, also incorporate social principles and values.

### Legal Framework and Institutional Competence

ESPH and MH are partners in the leadership in environmental sanitation in the canton. The former is in charge of public projects' entire technical and operational area, such as wastewater treatment plants. The second institution is in charge of arranging the land to construct treatment plants and public sewerage for rainwater. In Costa Rica, the Costa Rican Institute of Aqueducts and Sewerage (ICAA) is the governing body of the system for the collection and evacuation of sewage and liquid industrial waste, the storm sewer system in urban areas, the modification or construction of sewerage works, and promoting the conservation of hydrographic basins through ecological protection and pollution control for the entire national territory stipulated in Articles 1 and 2 of Law No. 5915 (Asamblea Legislativa, 1976).

In practice, the sustainability of the national wastewater treatment system is made up of autonomous institutions, companies, and municipalities in charge of construction projects for aqueduct and sewer works (Table 1) - which must assume the commitment of conservation of the hydrographic basins, directed by the ICAA mentioned in article 2 of Law No. 5915 (Asamblea Legislativa, 1976).

The treatment of wastewater is part of the national Carbon-Neutrality 2021 policy, which began in 2007 with former President Óscar Arias Sánchez. In 2004, Executive Decree No. 32133-S was issued declaring the collection, treatment, and final disposal of ordinary wastewater generated in urban centers of "public interest and social need" (CIECO, 2015).

*Table 1. Qualified entities in environmental sanitation in the Central Canton, Heredia - Costa Rica*

| Entities | Function |
|---|---|
| *Instituto Costarricense de Acueductos y Alcantarillado (ICAA)* | The governing body at the national level. Every project must be endorsed by it, in charge of the national water treatment and sanitation system. Manages the national wastewater and excreta system. |
| *Empresa de Servicios Públicos de Heredia (ESPH)* | In charge of drinking water treatment projects. It supplies 73,000 subscribers, of which 32% have sanitary sewer service, and only 7% have wastewater treatment (ESPH, 2020, p.1). |
| Private companies in free zones, commercial, industrial, residential, condominiums, among others. | Responsible for the design, construction, and operation of wastewater treatment plants in private areas. The citizen has civil liability for any damage and pressure caused to the public service network, including the impact on the roads. |
| Municipality of Heredia (MH) | In charge of the construction and maintenance of the storm sewer network in the canton. |

Source: Prepared based on: Asamblea Legislativa, 1976; ESPH, 2020, p.1; Interviews with neighbors and professionals.

The canton of Heredia is located in the Virilla River basin, one of the main tributaries of the Tárcoles River. According to the Environmental Analysis Laboratory of the National University in 2010, this river presented moderate to severe pollution levels in 60% of the waters (Semanario Universidad, 2017). The discontent on the part of the residents of the cantons where the Tárcoles River empties led to the filing of an appeal for protection, known as Voto Garabito. Thus "resolution No. 2007-05894 of the Constitutional Chamber orders the heads of MINAE, A and A, CCSS, Ministry of Health, Minister of the Presidency and the 34 municipalities of the Central Valley, to adopt the necessary actions to eliminate in a way integrates the sources of contamination that exist along the Grande de Tárcoles river basin, and the necessary measures are taken for which they must carry out the coordination that the case warrants "(MINAE, 2020, p. 19).

This action led to the Comprehensive Management Commission of the Río Grande de Tárcoles Basin through Decree No. 38071-MINAE, "to generate a managing body in coordination, planning, protection, and rehabilitation. Through the collaborative design and construction of viable technical solutions that promote sustainable development, the quality of life of the population, the protection of natural resources, and the biodiversity of the territories included in the said basin" (Gaceta, 2014, p.4).

## Strategy for Sanitary Treatment

### Critical Aspects

The strategy arises from the need to address communication problems between the competent entities and the lack of a broad healthcare network that meets the demands of residential real estate growth, shopping centers, and industrial conglomerates, all with defined growth characteristics. The construction system's aggravating factor lies in the type of housing construction, characterized mainly by the type of horizontal construction with a septic tank. Few residential areas have a water treatment plant, such as the La Aurora residential complex case.

On the other hand, those of fuel service stations are a very mild case since. However, their operation depends on fulfilling the requirements of institutions such as the Fire Department, the National

Technical Secretariat for the Environment (SETENA), the College of Engineers, among others. Some incidents have occurred due to fuel spills, such as the Servicentro Total station (Angulo, 2007). This type of risk increases in urbanizations with high population density, given the probability of occurrence and associated with the lack of training (Hernández, 2016). Besides, the frequency with which institutional controls are carried out for monitoring, as found in interviews with officials and residents of the affected communities in the Central Canton of Heredia.

Parallel to this, the construction of homes in high areas has increased, putting pressure on the capacity of the sewerage system of the Central canton of Heredia. Such is the case of the districts of San Josecito in the canton of San Rafael, where it is common to observe the discharges of sewage run through the cords of the pipe and evacuate to the Central canton of Heredia. This shows the constant challenge of coordination between the neighboring municipalities since each municipality's priorities limit the comprehensive care of the water treatment system and the lack of controls in the supervision of the activities carried out by each resident. In the canton tours, it is observed that the absence of environmental and social commitment puts pressure on the affectation of public infrastructure.

Frequently houses with more than 30 years of building that still drain the rainwater in the cord of the pipe or its effect on the sewage system are observed. In the first case, people break the sidewalks and pipes to ensure that the rainwater from their homes reaches the municipal sewer system. In some cases, it was observed that the waters for washing clothes and food are connected to the rainwater system.

The lack of adequate infrastructure means that the discharges of soapy water and food waste, along with rainwater, are deposited directly into water bodies. In the second case, the sidewalks and sewers are damaged to connect the pluvial and soapy water pipes to the sewer system located on the highway. They often break the asphalt to build the pipes; damage to public property is assumed mainly by the municipality. These damages shorten the roads' useful life in such a way that budgets and maintenance plans for public roads are altered. The forecasts of road damage, for this reason, are almost unpredictable since they depend not only on the construction time of the house but also on the material used and the maintenance given to it.

The observation in the field coincides with the information generated in the Executive Summary of the Heredia Environmental Sanitation Project (ESPH, 2020), where it points out the problems of antiquity and poor condition of the sanitary network, as well as the absence of pipes, wear, deformation and blockages coupled with illicit connections to the sanitary network. Thus, for example, the Wastewater Treatment Plants (WWTP) of the City of Heredia was built in 1943 and is currently out of operation (CIECO, 2015, p.14).

On the contrary, in residential and recent commercial and industrial buildings, this type of damage to public service facilities does not occur, according to what is extracted from the field reports, except the fuel service stations that have already presented problems in terms of accident risks as a result of the operation. It is worth highlighting the planning and land use planning efforts carried out in the municipality.

The cornerstone of the Heredia Environmental Sanitation Project corresponds to ESPH as part of its social and environmental responsibility policies that include "studies, design, financing, execution, operation, and maintenance of the works required for the collection, treatment and disposal end of ordinary wastewater generated in some of the urban centers of the province of Heredia" (ESPH, 2020, p.2). Likewise, through Executive Decree DM-FP-4385-2015, a Project of Public and National Interest is declared.

In summary, the damages caused in a canton irremediably impact the neighboring cantons, since water pollution takes the course that the basin marks, in other words, the treated waters or are not discharged return to the river basin Tárcoles.

## Local Government Policy

The canton has five districts irrigated by the Virilla river that are part of the Grande de Tárcoles river basin, contributing most of the water discharge to this (37%), concerning the rest of the cantons of the province (El Gaucho Periódico, 2017). According to ESPH (2020), 70% of homes use a septic tank with inadequate construction and maintenance, which causes pollution and wastewater problems (p.1). This makes it necessary to design a comprehensive environmental sanitation policy. For this, it requires the participation of the different social sectors, both public and private, whose participation is defined both by laws, regulations, policies; as well as for the "infrastructure, people and goods related to the provision of drinking water and sanitation services" (ICAA, 2002, p. 86).

Three entities related to environmental sanitation were found in the Canton: ICAA, ESPH, and the Municipality defined as the Environmental Sanitation Sector (SSA), which deals with wastewater management. In the Canton, the ICAA is in charge of sewage and the MH of rainwater. For its part, ESPH directs the environmental sanitation project with the construction of a wastewater treatment plant as part of its Corporate Social Responsibility (CSR) policy and in compliance with Executive Decree (DE) No. 32133 (ESPH, Sanitation Project, 2020). 85% sanitary sewer coverage is expected, covering the cantons of Heredia, San Rafael, San Isidro, and in the Canton of Barva, the district of Santa Lucía, thus expanding the six water treatment systems in Heredia (ESPH, 2020).

## Life Quality Standard´s

Costa Rica presents a very high Human Development Index (HDI), for 2019, it is located in position 62 of 0.810 and concerning the rest of the planet's countries (Eustat, 2020). The behavior of the HDI has been increasing since 1990 (0.656) (Expansión, 2020). For its part, Heredia presents an HDI in 2018 of 0.878, and the lowest was in 2016 with 0.857 (PNUD, 2020) (Figure 3).

According to the Cantonal Human Development Atlas of Costa Rica, in 2018, the life expectancy index (IEV) is 0.939, the material well-being index (IBM) is 0.900, the knowledge index (CI) is 0.801, which positions the canton in 10$^{th}$ place in the HDI at the national level, as mentioned above.

Another essential aspect to consider is the Gender Development Index (GDI), which corresponds to 1,021, located in the high category (Figure 4), which indicates that work has been done to achieve these levels of development.

## Economic Dynamics

Heredia is part of the provinces where employment is generated in small and medium-sized companies. "*In total terms for the year 2017 the provinces where the greatest employment is generated are: San José (49.4%), Alajuela (14.3%) and Heredia (13.5%), which concentrate 77.2% of the country's labor force*" (Arce, 2019, p. 6).

The presence of small and medium-sized companies (SMEs) from Heredia has had a behavior with a slight growth trend; however, for the period from 2013 to 2015, it stagnated (Figure 5) (Arce, 2019, p. 20).

*Figure 3. Trend of the Human Development Index (HDI) in the Canton of Heredia (2010-2018)*
*Source: Costa Rica Cantonal Human Development Atlas (PNUD, 2020).*

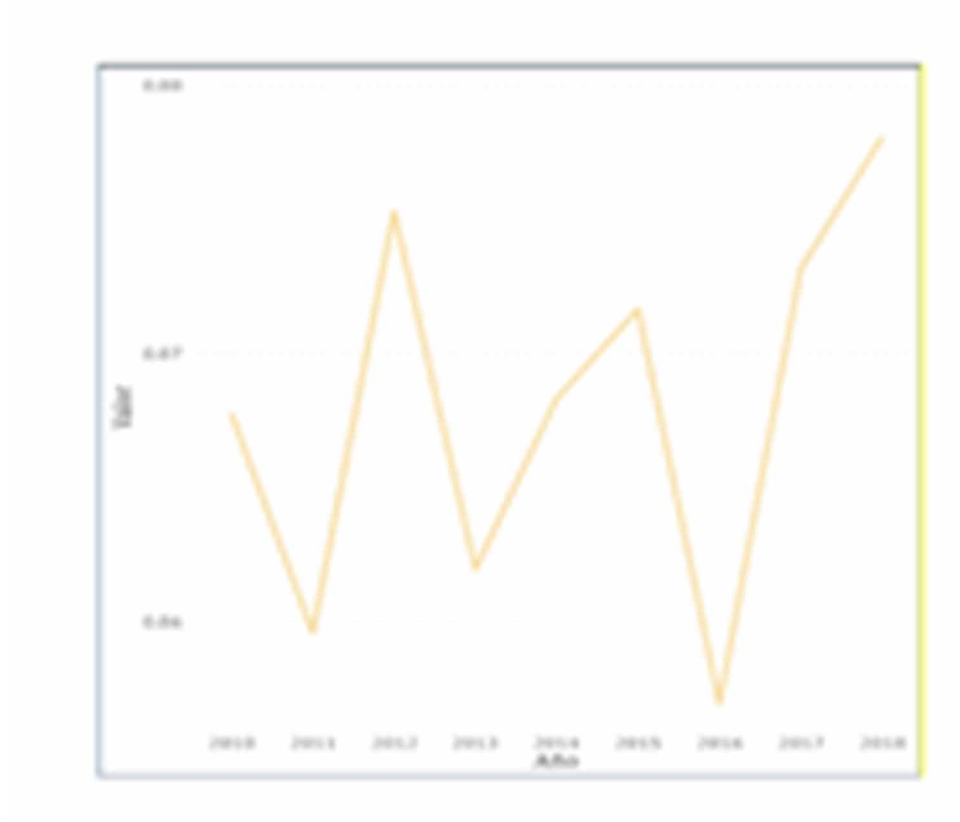


*Figure 4. Trend of the Gender Development Index (GDI) in the Canton of Heredia (2010-2018)*
*Source: Costa Rica Cantonal Human Development Atlas (PNUD, 2020).*

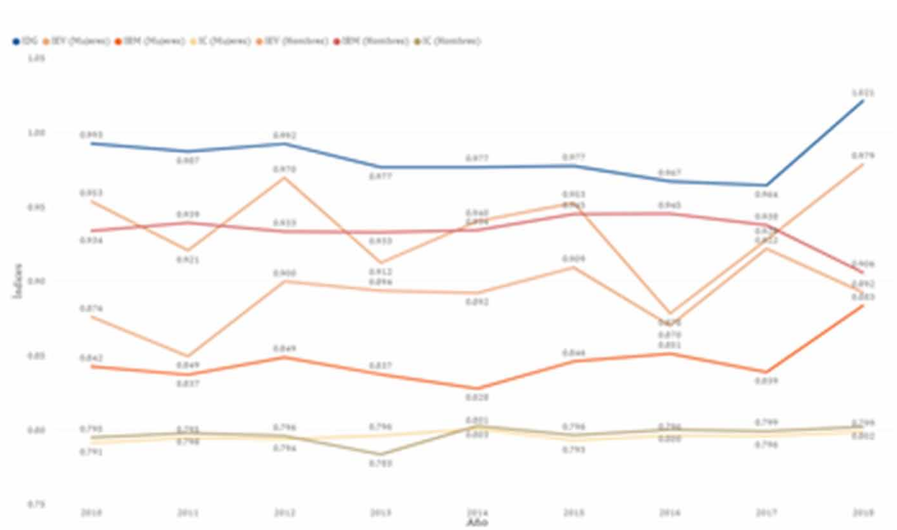
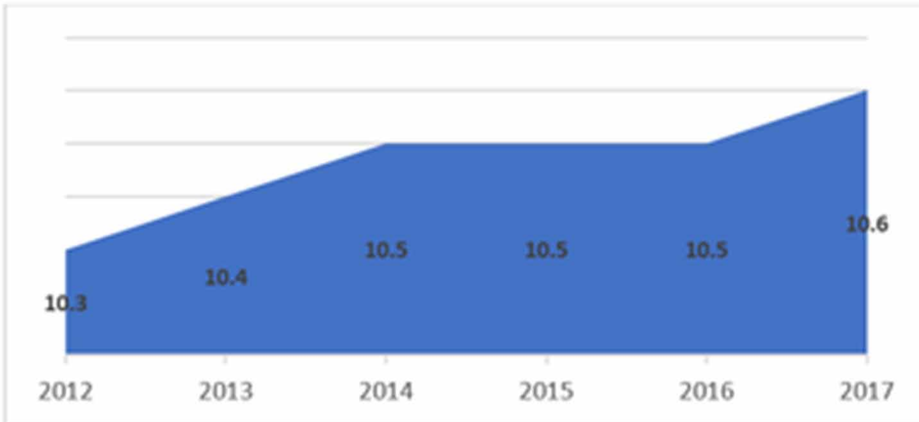


*Figure 5. Percentage growth of small and medium enterprises, Heredia (2012-2017)*
*Source: Adapted from Arce Brenes (2019, p. 20).*




## DISCUSSION

The methodology for the analysis of the environmental sanitation issue promoted by CINPE (2019) mentions that the concatenation between infrastructure, economic activity, and the conditions of buildings, as well as the quality of life of the population, are crucial for the proper management of the System of Environmental Sanitation (SES).

The SES's challenge lies in the buildings that use excreta and sewage treatment systems through septic tanks, given the abrupt increase in residential, commercial, and industrial areas. Water sanitation is complicated since the discharges from the residences drain into the bodies of water. The lack of infrastructure for the sanitation of wastewater significantly damages the rivers that run through the canton.

The EPSH and MH environmental sanitation projects have demonstrated the capacity for joint coordination and planning to address the issue. However, it is essential to think of a comprehensive plan that involves a hydrographic basin concept - it is essential that there is political and social will to achieve it. It requires a change in the design of cantonal policies focused on the environment, in which the basin becomes the crucial element in the planning and management of water resources.

Public participation is the key so that the efforts made in environmental sanitation have a definitive impact on the hydrographic basins. The impact generated by the private company established in the territory cannot be ignored. Both actors intervene in the management of hydrographic basins and can build a protection system. However, it has been detected that companies (despite promoting corporate responsibility activities) require monitoring and control to comply with the Ministry of Health's sanitation laws and the Municipality. This monitoring must also occur through the control exercised by the various social sectors that inhabit the territory. The above is part of the chain of monitoring networks in the management of hydrographic basins.

Watersheds are impacted by deficient sanitation services, the absence of an environmental sanitation system, and the economic limitations of facing the problem. These elements cause the Tárcoles River basin to have high levels of pollutants, and these waters reach the Gulf of Nicoya, whose environmental, social, and economic impact is essential. In the evidence collected, solid waste banks are detected on the beach in Costa de Pájaros. Another challenge is the coordination between the municipalities and institutions of the basin.

## CONCLUSION

The research highlights three significant challenges for establishing the environmental sanitation system in the Canton of Heredia. The legal and institutional framework faced by the Environmental Sanitation Project of the ESPH represents a significant challenge; since the governing body is the ICAA, it lacks resources to face the needs of the construction of the water treatment plant that promotes the municipality and ESPH.

This limitation directly affects the inhabitants' quality of life and the deterioration of the basin and its ecosystems. Likewise, the little interference on the municipality's part to control the proper functioning of private treatment plants located in residential areas, condominiums, and business parks feeds the risk of contamination of water bodies in the canton - in addition to the lack of regulatory and cantonal development plans.

The most significant challenge to solve sanitary water treatment is the coordination between the different social sectors. One of the pending tasks is the synchronization of the various national institutions' activities with influence in the territory. Regarding the problems in the programming and coordination of activities, the institutional control gap to reduce pollution in rivers stands out. According to the interviews results, the ESPH project, although it is of public and national interest, faces difficulties in coordinating with municipalities and other institutions. Some municipalities have even presented obstacles to progress. Although the National Wastewater Sanitation Policy, published in 2017, does not include the Heredia Environmental Sanitation Project developed by ESPH (Personal communication, October 2020).

Also, the lack of a hydrographic basin vision hinders the decontamination of water bodies by institutions and local governments and, even more, the deterioration or lack of infrastructure to treat sanitary waters. Parallel to this, the disrespect for health regulations by the inhabitants of the neighboring cantons.

Companies' existence in the territory has undoubtedly contributed to the increase in the development index, as has an investment in urban infrastructure; not so, the Canton's environmental sanitation system.

## REFERENCES

Angulo, F. (2007). Emergencia por derrame de combustible en gasolinera. *Periódico La Nación*. Recuperado de https://www.nacion.com/sucesos/emergencia-por-derrame-de-combustible-en-gasolinera/HRSIYSGWPNFL3DEPMORMPFWYME/story/

Arce, J. (2019). Estudio Situacional de la PYME en Costa Rica, Serie 2012-2017. [Informe] Dirección General de Apoyo a la Pequeña y Mediana Empresa. Costa Rica: Ministerio de Economía, Industria y Comercio.

Asamblea Legislativa. (1976). Ley 5915. Ley Constitutiva Instituto Costarricense Acueductos y Alcantarillados. San José: Gobierno de la República de Costa Rica.

Astorga, Y. (n.d.). *Situación del Recurso Hídrico.* [Informe]. Decimocuarto informe Estado de la Nación en desarrollo humano sostenible. Informe Preliminar. Estado de la Nación en Desarrollo Humano Sostenible. Consejo Nacional de Rectores. La Defensoría de los Habitantes.

Centro de Integración de Economía y Ecología (CIECO). (2015). *Estudio socioeconómico requerido por MINAE mediante el Oficio VAMCH 227-2014*. Proyecto Alcantarillado Sanitario y Tratamiento de Aguas Residuales para los Cantones de Heredia, San Rafael y San Isidro, y Diseño de la Primera Etapa de Construcción.

Centro Internacional de Política Económica para el Desarrollo Sostenible. (2019). Política para el cambio climático del Cantón de Heredia, Costa Rica: proyecto: formulación e implementación de una política de cambio climático para la municipalidad del Cantón de Heredia: diseño, programación y presupuesto. Heredia, Costa Rica: Author.

Chamizo, H. G. (2011). Territorio y gestión de las políticas de saneamiento ambiental en asentamientos humanos en Costa Rica. *Revista Geográfica de América Central*, *2*, 1–16.

Chamizo García, H. (2010, December). La gestión del saneamiento ambiental en asentamientos humanos en Costa Rica: Los casos de dos comunidades urbanas y una rural. *Cuadernos de Investigación UNED*, *2*(2), 123–131. doi:10.22458/urj.v2i2.153

Chamizo García, H. A. (2006). La información y el conocimiento en la gestión de políticas públicas de saneamiento ambiental en Costa Rica. *Revista de Ciencias Administrativas y Financieras de la Seguridad Social*, *14*(1), 71–82.

Durán Sosa, R. (2020). El establecimiento del agua como recurso fundamental en temporada del Covid-19: Caso de la Empresa de Servicios Públicos de Heredia, Costa Rica. *Revista Científica Monfragüe Resiliente*, *XIII*, 278–288.

El Gaucho Periódico (Redacción). (2017). Factores políticos limitan manejo integrado de la quebrada seca. *El Gaucho Periódico. El periódico de Belén*. Recuperado de https://periodicoelguacho.com/factores-politicos-limitan-manejo-integrado-del-quebrada-seca/

ESPH. (2020). *Resumen ejecutivo proyecto de Saneamiento Ambiental de Heredia* [Informe]. Empresa de Servicios Públicos de Heredia.

Eustat. (2020). *Indice de Desarrollo Humano por indicadores según países. 2020.* https://www.eustat.eus/elementos/ele0013500/indice-de-desarrollo-humano-por-indicadores-segun-paises/tbl0013566_c.html

Expansión. (2020). *Datosmacro.com*. https://datosmacro.expansion.com/paises/costa-rica

Gaceta. (2014). *Decreto Ejecutivo 38071-MINAE, 2014*. Crea Comisión de Gestión Integral de la Cuenca del Río Grande de Tárcoles. Sistema Costarricense de Información Jurídica. Imprenta Nacional.

Hernández, F. (2016). *Plan local de primera respuesta a emergencias en el Poliducto de Recope, Poblado de Colorado de Turrialba, Provincia de Cartago. In Proyecto de Grado para el título de Licenciatura en Geografía con énfasis en Ordenamiento Territorial*. Universidad Nacional, Costa Rica.

ICAA. (2002). Análisis Sectorial de agua potable y saneamiento en Costa Rica. San José, Costa Rica: Instituto Costarricense de Acueductos y Alcantarillado.

INEC. (2011). *Censo 2011*. Instituto Nacional de Estadísticas y Censos. República de Costa Rica. https://www.inec.cr/

INEC. (2020). *Estadísticas demográficas 2011-2050. Proyecciones nacionales.* Instituto Nacional de Estadísticas y Censos. República de Costa Rica. https://www.inec.cr/

Janoschka, M. (2002). El nuevo modelo de la ciudad latinoamericana: Fragmentación y privatización. *EURE. Revista Latinoamericana de Estudios Urbano Regionales*, *28*(85), 11–29. doi:10.4067/S0250-71612002008500002

Ministerio de Ambiente y energía (MINAE). (2020). *Ríos limpios. Estrategia nacional para la recuperación de cuencas urbanas 2020-2030*. http://www.da.go.cr

Morel, A., Schertenleib, R., & Zurbruegg, C. (2003). *Conceptos Alternativos de Saneamiento Ambiental para Países en Desarrollo.* Instituto Federal Suizo de Ciencias del ambiente y Tecnología.

Murillo, A. (2017). Análisis Comparativo de tecnologías para el tratamiento colectivo de las aguas residuales en poblaciones menores a 5000 habitantes equivalentes en Costa Rica. Trabajo de Graduación., Escuela de Ingeniería civil. Facultad de Ingeniería. Universidad de Costa Rica.

PNUD. (2020). *Atlas de Desarrollo Humano Cantonal de Costa Rica.* https://www.cr.undp.org/content/costarica/es/home/atlas-de-desarrollo-humano-cantonal.html

Semanario Universidad. (2017). *Tárcoles: a la espera de un milagro*. Disponible en https://semanariouniversidad.com/pais/httpsemanariouniversidad-ucr-crtarcoles/

United Nations. (2020). *Informe de los Objetivos de Desarrollo Sostenible.* Report.

World Bank. (2021). *Banco Mundial Datos*. Obtenido de https://datos.bancomundial.org/indicator/ER.H2O.INTR.PC?end=2017&locations=CR&start=1962&view=chart

# Chapter 9
# Strategic Communication for Sustainable Environmental Development in the Northern Nigerian Arid Zone:
## Toward Mitigating the Impact of Climate Change

**Adamkolo Mohammed Ibrahim**
https://orcid.org/0000-0003-1662-7054
*University of Maiduguri, Nigeria*

**Nassir Mohammed Abba-Aji**
*University of Maiduguri, Nigeria*

**Phuong Thi Vi**
https://orcid.org/0000-0002-5914-3626
*TNU - Thai Nguyen University of Science, Vietnam*

## ABSTRACT

*Nigeria is one of the world's most vulnerable countries to extreme weather conditions and natural disasters linked to climate change, the impacts of which are exacerbated by rapid population growth, a fragile economy, high dependence on rain-fed agribusiness, and the country's weak adaptive capacity. The lack of or poor application of environmental communication in a strategic approach is critical to all of these. Using a thematic conceptual review of existing literature, this chapter shows that strategic environmental communication can be applied more easily to mitigate the impacts of climate change and environmental degradation through the use of well-established communication strategies and instruments to save the environment for socio-economic development.*

DOI: 10.4018/978-1-7998-8482-8.ch009

## INTRODUCTION

The Centre for Democracy and Development (CDD) reported that the Intergovernmental Panel on Climate in October 2018 warned policymakers of the global need for change to reduce greenhouse gas emissions by 45% before 2030 to limit global warming to 1.5°C. Although an increase above 1.5°C is the point at which the effects of global warming are expected to become more severe and more difficult and costly to mitigate, catastrophic natural disasters such as record high temperatures, severe wildfires, melting glaciers, floods and droughts are already being experienced in the world (CDD, 2020 September 30 cited in Abdullah, 2020 October 3).

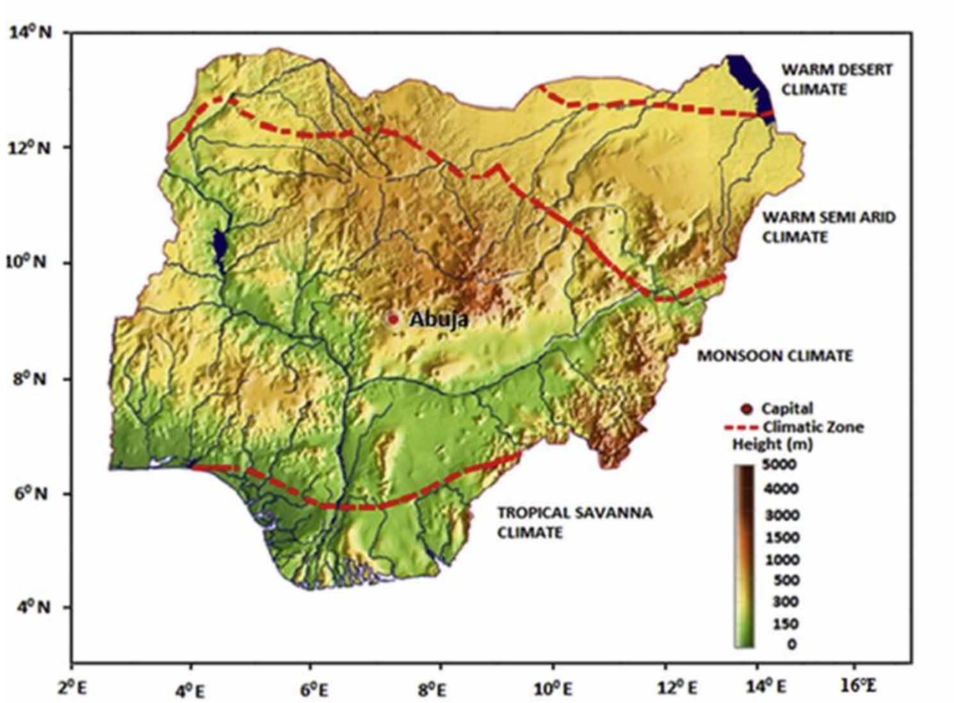
Despite Nigeria's low contribution to greenhouse gas emissions and global warming, it is one of the world's most vulnerable countries to extreme weather and climate-change-related natural disasters. The effects of rapid population growth, a fragile economy, a high level of dependence on rain-fed agricultural businesses and a weak adaptive capacity of the country are exacerbated. Socio-economic pressures are linked to non-seasonal and high temperatures, precipitation, severe floods, and desertification to further degrade the agribusiness environment which consequently affects livelihoods, economic opportunities and increase competition for natural and environmental resources; these, in turn, amplify social tension and a vicious cycle of conflict in different parts of the country (Abdullah, 2020 October 3; Fontaine, Roucou, Gaetani, & Marteau, 2020).

Northern Nigerian rural livestock business has a tradition of migration through fertile grasslands and savannahs by mostly Fulani cattle herders. However, with increasingly violent conflicts between pastoralists and farming communities, this movement of people and livestock business has taken a deadly turn in the past decade. Much has been written about the violence inflicted on the Central Belt, Middle Belt or North-Central farming communities and herders, but not much has been written about the North-West situation (Aude, 2013; Nwankwo, Arduino, Ali & Made, 2020).

The International Crisis Group (ICG) says that "conflict between Hausa farmers and Fulani herders in the region has killed at least 8,000 people since 2011 and displaced more than 200,000 to the neighboring Republic of Niger." The Federal Ministry of Environment was reported to have said that desertification, exacerbated by the dual impact of climate change and unsustainable human activities such as overgrazing and logging for fuel and agriculture, threatens 35% of the country's business environment in 11 states that are on the front line of desertification or (see Figure 1), namely Bauchi, Borno, Gombe, Jigawa Kano, Kebbi, Kaduna, Sokoto, Yobe, Adamawa and Zamfara (CDD, 2020 September 30; ICG, 2020 May 18; World Bank, 2019).

Poor governance and an overburdened justice system also led to violence with the contributing effects of migration and conflict on dwindling resources. The region is littered with small, undocumented weapons that are used not only by criminals, but also by various militias and vigilante groups operating in an environment where law enforcement is weak or non-existent. There are regular crimes such as kidnappings, looting, rape and arson; and so, do revenge killings. For example, on 6 June 2020, farmers cultivating their farmland were allegedly attacked by a group of allied nomadic herders on motorbikes in Yar Gamji Village, Batsari Local Government Area, Katsina State. The accident killed at least 30 people. The efforts for peace have been undermined by these violent crimes. However, due to a lack of "alternative livelihood opportunities for young herders and farmers due to educational deficits and the increasing impact of climate change," violent clashes also persist (CDD, 2020 September 30, p. 13). In the Lake Chad region, climate change, poverty and conflict are intertwined (Abdullah, October 3, 2020). Although Borno State, the epicentre of the decade-long Boko Haram insurgency, has been excluded

*Figure 1. Map of Nigeria showing the climatic zones, with the desertification frontline zone, in brown colours, lying in the Northern half of the map bordering Abuja*
*Source: Shiru, Shahid, Chung and Alias (2018, p. 3)*




from the 2019 poverty and living standards report of the National Bureau of Statistics due to security concerns that have rendered data collection useless, Adamawa and Yobe states are ranked in the report among the poorest states. The region also bears the brunt of high temperatures that affect agriculture and erratic rainfall.

The local economy has also been negatively influenced by desertification and the historical decline of Lake Chad and the wetlands. Although the lake itself has grown to 1,400 square kilometres over the past two decades and is still relatively stable in the southern pool, when it shrank from 25,000 square kilometres to a mere 2,000, it is still recovering from a severe drought in the 1970s and 1980s. Enhancement of economic vulnerability. These communities will make young people more likely to be recruited from the Islamic State in West Africa into Boko Haram and its splinter group (Oepen & Hamacher, 2000; Pham-Duc, Sylvestre, Papa, Frappart, Bouchez & Crétaux, 2020).

Providing sustainable development has proven difficult. After the Rio Summit in 1992, the early days of environmental communication and education were a series of ambitious expectations, misconceptions, and ineffectiveness. Neither conservationists, resource managers, nor sustainable development planners have been well versed in issues of a social, cultural, or political nature that are not technical. As GTZ puts it (2006). Reactive "fire-brigade" operations were often the rule, not pro-active process orientation up-front once problems emerged. Instead of relying on two-way communication to "shared meaning" and "win-win" situations, conflicts of interest were fought by "stakeholders", not negotiated by "shareholders", leading to one-way dissemination of information disregarding understanding (p. 18).

In addition, many decision-makers have not understood how to incorporate communication strategy into their policies or project life cycles, so they are not willing to invest in it. The result was, therefore that the lack of strategic communication resulted in a significant loss of efficiency, sustainability, and financial resources. Unfortunately, conventional, poorly defined approaches to communication in sustainable development (see Table 1) are alive and well but are being gradually replaced by more efficient strategic approaches to communication (Oepen & Hamacher, 2000, also, cited in GTZ, 2006, p. 19).

*Table 1. Communication approach in sustainable development*

| Traditional Communication Approach | Strategic Communication Approach |
| --- | --- |
| ● Managers focus on media and messages, and come up with exciting ideas that capture the imagination | ● Managers analyse the wider system and plan desired outcomes strategically |
| ● Focus on convincing people individually while their social sphere is not analysed | ● Interventions focus on goals, audiences and messages determine media |
| ● Communication is an end-of-pipe activity, isolated from the rest of a project | ● Communication is fully integrated in a project from the start |
| ● Content and message are secondary and cannot answer "why" or "what" questions | ● Target audiences are involved in planning, interventions are based on their values, i.e. their "why" or "what" |

Strategic communication means that a manager can see a problem in a broader context than for example, a tree planting campaign or the conservation of nature. For example, this approach often requires a paradigm shift in one's perception and analysis, shifting from the enforcement of conservation regulations to a more people-oriented perspective, such as relationship management. In other cases, an innovation such as crisis management, customer orientation and so on can be a paradigm shift. External consultants can play a role in capacity improvement through advice, coaching and training if maintenance managers lack the knowledge and skills needed for strategic communication. Their support is often essential for success and sustainability in the long term. Communicating with stakeholders and opinion leaders who may act as change agents by interacting with their audiences is also helpful. Agents of change are individuals within a social group who have an extensive network. They are often already engaged in the kind of sustainable practise that would like to be launched on a larger scale by communication intervention. Others value the views of agents of change so that they act as knowledge and power mediators (Oepen & Hamacher, 2000).

## BACKGROUND

The Nigerian Federal Government has announced plans to build a climate-friendly future and has committed Nigeria to fulfilling its nationally determined contributions to reducing national emissions under the Paris Agreement. President Muhammadu Buhari made the public aware of this in September 2019. The plan further indicates that the development of a green wall protection belt, the introduction of climate-smart agribusinesses and a commitment to the ecological restoration of Lake Chad are key aspects of the resilient future plan of the country (Pham-Duc et al., 2020; Vivekananda, Wall, Nagarajan, Sylvestre & Brown, 2019 May 15). The so-called green wall, 1500 km from Arewa Dandy LGA, Kebbi

State to Abadam LGA, Borno State, is intended to restore degraded agribusiness lands, improve the availability of business environmental resources, and contribute to and store the carbon of the country. Conditions that enhance opportunities for agribusiness and livelihoods can go a long way in addressing the continuing violence between nomadic pastoralists and farming communities. This was also part of the concept behind the unveiling, in June 2019, of plans to create rural grazing areas (RUGA) by the Federal Ministry of Agriculture and Rural Development (CDD, 2020 September 30, p. 13; Abdullah, 2020 October 3) to boost agribusiness.

The Miyetti Allah Cattle Breeders Association of Nigeria, which is the most organized and influential herder advocacy group in the country, has endorsed a plan to settle pastoralists and their flocks in an organized environment with appropriate basic amenities in an effort to do away with the negative impacts of climate change on the environment. In the long run, the settlements are expected to provide schools, veterinary clinics, small ruminant feed factories, water points, grazing lands, and production entities that will process and add value to by-products. Despite the suspension of the RUGA plan by the Federal Government in July 2019, two states (Niger and Zamfara) have pioneered their own plans for RUGA after resistance from many states and a public backlash over fears that its real motive was a land grab by influential politicians in favor of the Fulani ethnic group (ICG, 2020 May 18). The Niger State Government has allocated approximately 30 thousand hectares of land in the Bobi Grazing Reserve to this effect, while the State Government in Zamfara State has chosen Maradun LGA to invest in the settlement of RUGA as part of its soft approach to ending violence. However, it is too early to determine whether there is any noticeable impact of this approach (CDD, 2020 September 30, p. 13; Abdullah, 2020 October 3).

For farmers, access to timely weather information will improve crop production under the pressure of unforeseen weather conditions and is part of the government's efforts to introduce climate-smart farming practises. Diversification of crops, including the use of more drought-resistant crops and the redesign of agricultural land in order to increase productivity and protect soils in the face of increasingly frequent and severe droughts, is also supported. In North-East Nigeria, in partnership with the Federal Government, the United Nations Food and Agriculture Organization (UNFAO) is promoting the adoption of climate-smart farming techniques in the conflict-affected states of Adamawa, Borno and Yobe to make the livelihoods of farmers more sustainable in the face of climate change. In order to improve access to modern agricultural innovations, however, greater investments from the private sector and government are required (Allen, 2016; Heide, von Platen, Simons son & Alzheimer, 2018).

Meanwhile, it is expected that an ambitious inter-basin water transfer proposal to direct water from the Ubangi river in the Democratic Republic of Congo to the Chari river system feeding Lake Chad, i.e., the Lake Chad Replenishment Project, will protect against some climate change impacts. This in turn, is expected to keep local industries thriving and address some of the regional conflict's wider social and economic factors. However, contrary to recent hydrological findings that indicated that the lake is not actually shrinking, the replenishment project has been shown to run (Pham-Duc et al., 2020, n.p.). It also fails to concentrate sufficiently on addressing decades of problems of mismanagement and access to resources around the source of water (Not Haft, 2016).

Overall, the negative impacts of climate change, environmental degradation, weak governance, and poor communication are likely to continue to increase the risk of conflicts while exacerbating the current conflicts. An important means to solve this problem of climate change and ensuing resource-based conflicts is that strategic communication techniques if effectively harnessed can be employed to achieve "more sustainable and climate-sensitive environmental development and management" as well as the preservation of the limited natural resources, which are the drivers of the various conflicts and most of the conflicts effectively managed (Abdullah, 3 October 2020, n.p.). This forms the objective of this review of literature. This chapter will argue that the use of strategic communication techniques to achieve more sustainable and climate-sensitive environmental development and management will provide fertile ground for building peace and security in society.

## REVIEW OF LITERATURE

### The Theory of Communication

The term communication theory was defined by scholars such as Littlejohn (1983) and Glare (1968), cited in Ruler (2018), as the body of theories that constitute our understanding of the communication process. Theories represent different ways in which observers see their environment, and every theory is partial, as Littlejohn claims (1983, p. 12), because theories are abstractions (Ruler, 2018). Each theory delineates a way of looking and therefore only in terms of how well it is constructed can its true value be measured. This is the reason why there is a great deal of disagreement about what constitutes an appropriate communication theory. To paraphrase Laswell (1948), the search for who does what in a communication process and with what consequences is the fundamental question of every communication theory, although it could be studied from different angles or by looking at different facets.

Glare (1968) notes that what "communication" or "to communicate" means has never been agreed on. In Greek, *Communicare* meant "to share with", "to share out", "to make generally accessible", or "to discuss together" even in classical Latin (p. 369). Rosengren (2000) suggests that the process of meaning creation is mainly concerned with communication: questions about how people generate meaning psychologically, socially, and culturally; how messages are intellectually understood; and how ambiguity arises and is resolved. For Littlejohn, "communication does not occur without meaning, and in interpreting events, people create and use meaning" (Littlejohn, 1992, p. 378; Ruler, 2018).

The key question therefore concerns our understanding of "meaning" and how the process of creating meaning works (see Littlejohn, 1983, pp. 95-113). In communication theory, according to Ruler (2018), there are at least three distinct lenses with which to view how this process works: 1) communication as a one-way construction of meaning process in which the sender attempts to construct or reconstruct the meaning developed by the receiver; 2) communication as a two-way construction of meaning process in which two or more people construct new meanings; and 3) communication as a omnidirectional diachronic process of meaning construction, in which the focus is on the continuous development of meaning itself.

### The Process of Two-Way Communication

As a vital factor, the two-way communication perspective has interaction. However, in this context, there are distinct interpretations of what "interaction" means. The term comes from Latin and means not only "direct reciprocal dialogue", but also "acting on each other and influencing each other" (Neumann, 2008, p. 2307). The term can therefore refer to feedback processes as well as direct interaction between individuals, but it can also refer to a more abstract concept of interaction concerning how individuals relate in developing their own meanings to other meanings (Ruler, 2018).

Interaction is usually seen from the perspective of interpersonal communication theory from the angle of person-to-person interaction or group interaction, as in the analysis of Bales' interaction process or Fishers' interaction analysis (see Littlejohn, 1983, pp. 227-240), in which individuals respond to each other. This concept can also be found in the theory of relational communication as constructed by Bateson, who concluded that every interpersonal exchange bears a message containing the communication's substance or content, as well as a statement about the relationship itself (Ruler, 2018).

Watzlawick, Beavin and Jackson (1967, pp. 48-51) termed this latter part of the message "metacommunication". They also claimed that relationships emerge from people's interaction, with many kinds of rules of interaction that govern their communicative behaviours being set. The participants sanction the defined relationship by obeying the rules. Interaction in these models focuses on how individuals engage in conversations with each other and converge literally to create meaning. Thus, the focus is on interpersonal conversations whether mediated or not from this perspective of interaction. In some instances, in this respect, the notion of dialogue is used to mean: to concentrate on the acts of turning to each other and to listen to each other in terms of differences to improve the quality of communication (Broome, 2009, p. 305; Ruler, 2018).

The Communicative Constitution of Organizations (CCO) approach is becoming increasingly important in the context of the theory of strategic communication as a lens through which communication can be examined. CCO thinking begins with the premise, according to Ashcraft, Kuhn and Cooren (2009), that communication is not only a peripheral epiphenomenon of human actions, but the primary model of social reality explanation (also see Schoeneyzn & Blaschke, 2014, p. 302). This interpretation is based on the Chicago School of Urban Sociology (see Rogers, 1997, pp. 137-202) and was popularized in their explanation of reality by Berger and Luckmann (1966) not as "something out there", but as something that human beings are constructing themselves. The idea that this construction is achieved through interactive conversations between individuals is typical of CCO and related approaches (Ruler, 2018).

Taylor and Van Every (2000) constructed the Montreal CCO model based on speech theory and looked at communication from a co-orientation perspective. They concentrated on daily interpersonal human exchanges, by which, they argue, organization arises "endlessly renegotiated through the laminated sense-making activities of members" (Taylor & Van Every, 2000, p. 33). They suggest that individuals are oriented towards each other, leading to moments of consensus, but this consensus is renegotiated endlessly (Ruler, 2018). For Taylor and Every, the co-orientation of these interactions is an ongoing, emerging process.

As explained in a written conversation on various approaches to CCO, Seidl describes his own approach based on Luhmann's theory of social systems (Schoeneborn & Blaschke, 2014), arguing that

*what matters is not how a specific person understands a communication, but how a subsequent communication interprets the previous communication to which it is linked; only the specific way in which the immediately preceding communicative event is understood can be determined by a communicative event. (In Schoeneborn & Blaschke, 2014, Seidl cited, p. 290)*

Co-orientation is also considered as an ongoing, emerging process in this context. Examining the CCO approach as a whole it is clear that emergence is an important concept: the people within and around an organizational order communicate and build the organization by negotiating their meanings repeatedly. Interaction is not so much a matter of how meanings converge, but how meanings are created and developed continuously in this way in this ongoing conversation process (Ruler, 2018). The question to be asked is whether this two-way communication lens depends on the question of what actually strategic communication is.

## Understanding the Strategic Communication Concept

The idea of "strategic communication" suggests that it is not possible to see all communication as strategic. According to Hallahan, Holtzhausen, van Ruler, Verčič, and Sriramesh (2007), communication is strategic when it is fully compatible with the mission, vision, values of the organization and when it is able to improve the strategic positioning and competitiveness among its competitors. In this case, when it has a certain quality, communication is only strategic. According to Ruler (2018), this is problematic when attempting to define a field.

Ruler (2018) pointed out that most known strategic communication authors quote the seminal article by Hallahan et al.' That is, Halahan et al. (2007), who argued that the essence of strategic communication is intended to advance the mission of an organization through communication (Hallahan et al., 2007, p. 3). We can talk about strategic communication if communication helps to move the mission of the organization forward in a purposeful manner. For these scholars, it is not the quality that makes communication strategic, but its purpose of enhancing the mission of the organization (Ruler, 2018). Therefore, only communication that has the intention of advancing the mission of an organization can be defined as strategic. This definition is echoed by many other authors.

The next question to ask is which elements of all organizational communication originating in and transmitted by organizations belong to strategic communication. Hallahan (2004) wrote about the various fields of communication in organizations, such as communication management, marketing communication, public relations, technical communication, political communication, and campaigns for information/ social marketing, sometimes covered by the umbrella term "integrated communications." He suggested that "strategic communication" could be all these forms. Hallahan et al., however, states that: "Strategic communication examines organizational communication from an integrated, multidisciplinary perspective by expanding ideas and problems based on different traditional disciplines of communication" (Hallahan et al., 2007, p. 4; Ruler, 2018). Even though this suggests that strategic communication from a specific perspective is about organizational communication, the authors add that,

*The focus is on the strategic application of communication and how an organization functions to advance its mission as a social actor. While the various processes involved in how people interact in complex organizations are widely examined by academic research on organizational communication, strategic communication focuses on how the organization itself presents and promotes itself through the intentional activities of its leaders, staff, and communication practitioners. (Hallahan et al.,2007, p. 7)*

The authors therefore concentrate on how an organization functions as a social actor, which suggests that only the integration of external communication fields is a matter of strategic communication. In explaining this often-used definition, we can learn that as Ruler (2018) noted, what distinguishes strategic communication is the fact that it concerns the intended communication that presents and promotes the organization in all its expressions to the outside world. Furthermore, Thorson (2013) provides another rationale, "The strength of the approach [of strategic communication] is its emphasis on strategy rather than specific tactics, as well as its holistically understood focus on communications." Furthermore, Johnson and Scholes (1999, p. 17) referred to this as the difference between "strategic" and "operational".

Likewise, Thorson states that the growing complexity of a global digital society has challenged organizations' ability to engage in long-term strategic planning. She claims that therefore, as part of strategy formulation, organizations need strategic communication and its practitioners. This would indicate that not only is strategic communication a matter of presenting and promoting organizational strategy, but also of creating it. Within the field, this idea has already resonated. Argenti, Howel and Beck (2005) interviewed CEOs, SFOs, and CCOs and showed that strategic communication is actually seen by the respondents as making a difference to a company and thus driving the development of strategy. The conclusion of Argenti et al. (2005) is that although the issue of whether communication professionals are part of the formulation of strategy may remain open, it is apparent that strategic communication is part of the formulation of strategies (Ruler, 2018).

This chapter concisely argues that strategic communication is seen as strategic when as explained in Ruler (2018), it integrates all those communications that are associated with organizational goals and strategies. However, for some, strategic communication focuses on the presentation and promotion of goals and strategies; for others it focuses on driving its growth as well. In other words, strategy for some precedes strategic communication; strategic communication for others also constitutes strategy. Surprisingly, these differences are not much debated. This could be due to the relative absence of a communication perspective as a pillar on which strategic communication rests.

## Strategic Communication for the Environment

Environmental communication has been described as the missing link between the subject of environmental issues and the related socio-political processes of policy making and public participation, according to GTZ (2000). It bridges "'hard' technical know-how and 'soft' action-oriented behavioural change" (cited in GTZ, 2006, p. 10).

Communication plays an important role at all stages in the life cycle of a policy or project. As such, environmental-related concepts, techniques, and skills need to be imparted to policy makers, opinion leaders, strategic groups or the public at large. A prerequisite for building consensus and change in any civil society is the splitting of complex information into understandable elements and putting it on the agenda (GTZ, 2000). According to GTZ and OECD (2002), the Operational Communications Unit for Sustainable Development of the World Bank defines environmental communication as "a planned and strategic use of communication processes and media products to promote effective environmental sustainability policy making, public participation and project implementation" (cited in GTZ, 2006, p. 10).

Strategic communication for sustainable development of the environment certainly draws on best practises and lessons learned from communication with the environment. Current challenges, however, extend beyond existing approaches, especially in the following fields:

1. *Level of intervention - project to be processed*: Focus has so far been placed on section-based and regionally limited projects with clearly defined objectives and expected results. Nowadays, development assistance often addresses complicated processes of national change. This requires local, national, and regional level interventions.
2. *Topics - from concrete to complex*: Sustainable development relates not only to environmental issues, but also to social and economic problems. Sustainable development as a term is also difficult to communicate; compared to concrete environmental objectives, it remains abstract. Communication

should, however, make individuals understand sustainable development. If not, then individuals may change their attitudes but do not take action.

3. *Actors - from project partners to strategic alliances*: A few selected project partners will not work on strategic operations. Instead, a range of networks in politics, the private sector, civil society, academia, and so on often rely on fluid strategic alliances. In addition, with ever-decreasing budgets, development aid is expected to have an increasing impact.

With this trend, an ever-growing role will be played by impact assessment. Therefore, new solutions must be explored considering these challenges. On the one hand, to cover a wide range of potential applications based on some basic principles, there is a tendency to perceive communication in more general terms. On the other hand, there is a tendency to use well-established methods and step-by-step procedures to view communication as specific to a particular issue or issue as possible (GTZ, 2006).

Moreover, the importance of sustainable development cannot be separated from such environmental issues and research. Development is simply defined as a complex task that places people at the centre of attention is the strategic processes for sustainable development. Their analysis, dialogue, imagery, skills, planning, investment, and action are intended to define the common economic, social and environmental objectives of society. For example, many developing countries such as Nigeria use conceptual umbrellas such as Poverty Reduction Strategies (PRS) (Evans, 2010; GTZ, 2006; UNECE, 2018), such as the National Program for the Eradication of Poverty (NAPEP), N-power and Sure-P, or national sustainable development strategies (NSSD) such as the National Strategy for Economic and Empowerment and Development (NEEDS).

## Main Divisions of Strategic Communication for Sustainable Environmental Development

Strategic communication for sustainable development has been shown in the literature (see Mefalopulos, Anyaegbunam & Moetsabi, 2005; Oepen & Hamacher, 2000; Padua & Jacobson, 1993) to be broadly borrowed from long-term contact experience in sectors such as rural extension, health, family planning or HIV/AIDS. More recently, curricula have been added to this spectrum, including participation and ownership, such as social marketing, non-formal, recreational, and environmental education, conflict management and negotiation, and civil society mobilization. The problems of unsustainable and non-developmental development have been diagnosed in two fundamentally different ways. While one position argued that the problem was largely due to a lack of population information, the other position suggested that the primary problem was power inequality. The approaches to intervention as outlined in GTZ (2006, p. 26) are as follows:

1. Development's cultural versus environmental definitions
2. Theories and interventions of psychological versus social and political
3. Models of attitude and conduct versus structural and social models
4. Interventions of individual versus community shopping
5. Models of hierarchic and sender-oriented communication versus participatory models of communication
6. The masses and the population's active versus passive perceptions
7. Participation as a means, as a final approach, versus participation

In the current debate on environmentally sustainable development, communication and education as drivers of change and learning processes, GTZ (2006, p. 26), OECD (2002) and CDD (2020 September 30) state that they have an impact on at least two levels, namely: (i) cultural contexts, insights, lifestyles and value judgments define social, political or environmental awareness; all are learned through communication; and (ii) the criteria and choices for sustainable practice decisions are the result of public discourse and transparent communication of alternatives.

Sustainable development cannot be based on behavioral manipulation, but it depends on thinking and pluralism to help civil society develop adequate skills to overcome social, political, or environmental crises (see Han, 1997). While attempting to avoid ideological pitfalls, in what it calls the five branches of strategic communication for sustainable development, GTZ (2006, p. 26) combines structural, social and political interventions with practical and experimental social research methods. The three pillars of sustainable development should best accommodate these five branches of strategic communication interventions: environmental, economic, and social issues. The following are the five branches.

1. Communication with the environment and development
2. Social advertisement
3. Education in informal and environmental terms
4. Mobilizing Civil Society
5. Management and negotiating conflicts

Given that the strategic communication principles, methods, and tools for sustainable environmental development are derived from a combination of domains and approaches (Oepen & Hamacher, 2000), four of the branches of strategic communication interventions used in this chapter need to be clarified (see Figure 2).

## Communication Plan and Communication Problems as a Concept

In this context, communication should be a precondition and instrument for effective policy making and public participation, from the formulation of visions, negotiation and decision-making to the development and implementation of impact monitoring plans. Communication serves to exchange information to build consensus among divergent views and interests, and to facilitate the development of knowledge, decision-making and work capacity at the heart of delicate cooperation between government, civil society, and private sector groups. Accordingly, the United Nations Development Program (UNDP) considers communication and awareness-raising as one of the nine key mechanisms for supporting the strategic processes of sustainable environmental development. In a sense, the "lifeblood" of any strategy is two-way communication. Without it, because cooperation and collaboration between key stakeholders depends on it, the strategy will not succeed (Evans, 2010; GTZ, 2006; Oepen & Hamacher, 2000; UNECE, 2018).

### Communication for Development

Development communication was developed in the early 1960s as a field of study and was applied for the first time to rural development, agricultural extension, health and sanitation and family planning for "nation building". Communication processes and media products are planned to be used to promote effective policymaking, public participation and project implementation aimed at social, economic, political, and

*Figure 2. The five branches of strategic communication for sustainable development*


environmental development. It is a two-way process of social interaction that allows concerned individuals to understand key factors and their interrelationships and to expertly respond to issues. Development communication does not focus on "dissemination of information" as it does on a "shared" vision for a sustainable future and on building social group capacity to solve or prevent emerging problems (Allen, 2016; GTZ, 2006; Oepen & Hamacher, 2000).

## Environmental Communication and Education

As a result of the Rio Conference, the concept of environmental communication emerged in the mid-1990s. In policymaking and project management, it is a management tool. The link between environmental issues and related socio-political processes is missing. In effect, it acts as a bridge between the transformation of "hard" technical know-how and "soft" action-oriented practise. Environmental communication uses established methods, instruments and techniques in communication development, adult education, social marketing, agricultural extension, public relations, informal training, and so on, as an integral part of a well-defined communication strategy (Heide et al., 2018; Not haft, 2016; Oepen & Hamacher, 2000).

Environmental education is the process of developing a global population that has the knowledge, abilities, attitudes, motivations, and commitment to work individually and collectively to solve current problems and to prevent new ones and is aware of and concerned with the macro environment and its associated problems. When they consider options and the implications of those choices for the future, social groups learn from each other. Learning to access and influence systems for public participation in decision-making is crucial to education for sustainable development (Day, 2000; GTZ, 2006).

### Social Marketing and Conflict Management

Social marketing is regarded as an element of communication for growth. The concept of diffusion of innovation and behaviour-change models is based on social marketing. Agricultural extension studies first discovered in the 1960s that social change always goes through different phases: awareness, interest, assessment, trial, acceptance, or rejection. To increase the effectiveness of interventions, social marketing also focuses on marketing techniques such as market segmentation and formative research (GTZ, 2006; Oepen & Hamacher,

In open conflict situations and conflicting decision-making processes, conflict management is designed as an alternative policy tool to provide ways of building consensus and convergence. Social communication processes, such as the promotion of dialogue, reflection, participatory situation analysis, consensus building, decision-making and action planning for change and development among individuals and institutions at different levels, are often required for specific aspects of strategic communication (GTZ, 2006; Oepen & Hamacher, 2000).

## Sustainable Environmental Development Strategies

It is not surprising that the UNDP and even the OECD are recommending them because of the importance of communication and awareness-raising as some of the nine essential mechanisms for supporting strategic processes for sustainable development. Basically, participation, negotiation and conflict management are the relevant mechanisms "that are analytically inseparable" from communication (UNDP/OCHA, 2018).

As cited in GTZ (2006, p. 14), the OECD (2002) defined sustainable development strategies as a "coordinated set of participatory and continuously improving analysis, debate, capacity-building planning, and investment processes that integrate society's economic, social, and environmental goals, seeking trade-offs where this is not feasible. The principles emphasise local ownership of the strategy process, active involvement at all levels and commitment at high levels. The processes also show the importance of convergence and coherence between the various planning frameworks, integrated analysis, and capacity development.

An effective Sustainable Environmental Development Strategy combines the aspirations and capabilities of government, civil society, and the private sector to create a vision for the future and work towards achieving it in a tactical and gradual way. It defines and builds on what works, improves curriculum integration, and provides a framework for decisions when integration is not feasible. An efficient strategy will benefit from thorough understanding by focusing on what can be realistically achieved; however, it will not be paralyzed by simultaneously planning highly comprehensive actions on many fronts. The strategy is likely to concentrate on a few priority goals as a practical organizational change process aimed primarily at mainstreaming environmental sustainability concerns. A sustainable development strategy, however, rarely means initiating an entirely new or standalone strategic planning project. Alternatively, the definition and principles can be met by a series of initiatives, taken together. A broad umbrella, that is, a vision and a set of coordinated mechanisms and processes to improve their integration, mitigate contradictions and bridge gaps when necessary, can be complemented by bringing current initiatives closer to an effective sustainable environmental development strategy (GTZ, 2006).

Nigeria can take a practical approach, building on any strategic models that have been found helpful, such as national green plans, development plans, strategies or action plans for poverty reduction, decentralized planning and consultation processes, or other national practises that have proliferated over the past two decades linked to international agreements to consolidate its sustainable e-commerce Alternative approaches have been developed by civil society organizations in some countries for example. This Directive confirms, in recognition of this wide range of starting points, that nomenclature does not matter. The consistent application of the basic principles referred to above is what is important. A sustainable environmental development strategy can be seen as a system consisting of the following components, depending on the circumstances (GTZ, 2006).

1. Regular multi-stakeholder forums and means of negotiation, with links between them at national and decentralized levels.
2. A shared vision and a wide set of strategic objectives.
3. A set of mechanisms to pursue these objectives in ways that can adapt to change (such as an information system, communication capabilities, and coordinated means of policy integration, budgeting, control, and accountability).
4. Principles and standards that sectors and stakeholders must adopt through legislation, voluntary work, market-based instruments, etc.
5. Experiential activities to generate ownership and learning.
6. A secretariat or other facility with the authority to coordinate the mechanisms referred to above.
7. Delegating all the above from a high-level central authority, such as the Office of the President, and to the extent possible, from organizations of citizens and businesses.

## Strategy for Media and Sustainable Environmental Development

The concept of sustainable development, moreover, does not provide a clear vision of where to go and how to get there, nor does it address the economic, social, and environmental dimensions of the inequality of power and interests behind it. The political and economic systems of most developing countries around the world, such as Nigeria, Ghana, etc., operate based on short-term impulses, while being defined in terms of “long-term”. Journalists such as Geoffrey Lean, famous British journalists, and public relations experts such as the director of the WWF-UK campaign have described the term sustainable development as a problem of communication. Sustainable[environmental] development means absolutely nothing to most people and never will. For them, “Sustainable[environmental] development means absolutely nothing to most people and never will.” Many people tend to associate the term sustainable environmental development once it is associated with the personal affairs of people, such as “my life”, “my job”, “my future”, “my investment “. Therefore, the critical question is how can strategic processes for sustainable environmental development be effectively assimilated to the general Nigerian public and, to Nigerians in the desertification zone? (GTZ, 2006, 2019, p. 9; Vivekananda et al; Vivekananda et al., 2017).

The different categories of the media will play a key role here to achieve this lofty objective. The Environmental Sustainability Strategy Papers (ESSPs), an analysis of the media treatment of one of the most important Millennium Development Goals (MDGs), revealed a very low or poor level of coverage. This analysis has to do with the extent to which the media reported the MDGs, or with the extent to which the media provided a public debate forum. The analysis generally suggested a very low level of media awareness of ESSP processes; a lack of technical skills in journalism to report on economic development and sector-specific issues such as health, education, or agriculture; a weakness in the relationship between government and journalists, which impedes investigation and robust coverage of poverty reduction issues.

The literature further shows that because of the lack of ownership exacerbated by the lack of effective strategic communication, ESSP failed. The media is critical to the type of public debate that can enhance ownership of the programmes of the MDGs, but they have not effectively played this role. This demonstrates the importance of the media in achieving only one of the MDGs. Similar claims can be made with respect to the other MDGs: reducing poverty, reducing child and maternal mortality, education, food security, etc. (Deane, 2005). In addition, Nigerian authorities need to change this behaviour through education and communication that "makes people experience how the environment is affected by their individual behaviour." Even the proverb shows that high knowledge, positive attitudes, and ceremonial concerns are not sufficient to drive environmental suitability. There are no shortcuts to success. The changes in the actual practise of the people involved are what matters (GTZ, 2006; Oepen & Hamacher, 2000).

## Stages of Strategic Communication for Sustainable Environmental Development

A 10-step communication strategy was developed by a working group comprising the OECD, the World Bank and FAO, led by GTZ in the 1990s, following a cycle of analysis, planning, production, and reflection as outlined in GTZ (2006, p. 10) and FAO (2005, 2003). According to them in rational appeals and the cognitive dimension of messages, isolated ad-hoc initiatives that are not integrated into a comprehensive communication strategy may cause inflated expectations. Therefore, a project should define what information is meant for and for whom, and how beneficiaries are meant to translate it into communication and action. This is best accomplished as shown below in a systematic and comprehensive strategic communication approach that is always an integral part of a larger project or programme and uses strategic planning step-by-step as part of a project or programme life cycle as listed below:

- Stage A: Assessment
    1. Situation and problem analysis
    2. Audience's knowledge, attitude, and practice (KAP) analysis
    3. Communication objectives
- Stage B: Planning
    1. Communication strategy formulation
    2. Involvement of strategic groups
    3. Media selection and mix
- Stage C: Production
    1. Message design
    2. Media pre-testing and production
- Stage D: Action and Reflection

1. Media performance and field implementation
2. Process documentation and monitoring and evaluation (M&E) or impact assessment

Also see GTZ (2006, pp. 36-43) as well as Adhikarya (194, 1987), GTZ (2000), OECD (2002), SPAN (1993) and Rice (1989) for details on these steps.

## Practical Application of Strategic Communication for Sustainable Environmental Development

Since the 1992 Rio Conference, communication issues have been ongoing in relation to sustainable environmental development. Environmental communication has become an established field in its own right today and can thus be more easily linked to decades of experience, lessons learned, methods and tools developed for communication strategies in other fields, such as agricultural extension, health and sanitation, poverty alleviation or the social marketing of condoms in the HIV/AIDS campaign. A set of general principles and steps that have been set out in communication with development are what they all have in common. The trend is imposed by concentrating on "sustainable environmental development" with a social, economic, and environmental dimension, also contextualizing "environment" (GTZ, 2006; Not haft, 2016; Oepen & Hamacher, 2000)

In this context, strategic communication should be a precondition and tool for effective policy-making and public participation: from the formulation of visions, negotiation and decision-making to the development and implementation of plans, to impact monitoring. Communication serves to exchange information to build consensus among divergent views and interests, and to facilitate the development of knowledge, decision-making and work capacity at the heart of delicate cooperation between government, civil society, and private sector groups. The Organization for Economic Cooperation and Development (OECD) and the United Nations Development Programme (UNDP) therefore consider communication and awareness-raising to be one of the nine key mechanisms in support of sustainable development strategic processes. In a sense, the "lifeblood" of any strategy is two-way communication. The strategy will not succeed without it, because it is dependent on cooperation and collaboration between key stakeholders (GTZ, 2006; OECD, 2002). Despite its recognized influence, however, communication as a strategic tool in Nigeria is rarely incorporated into development cooperation programmes. The Interest Group on Strategic Communications on Sustainable Development was therefore established (CDD, 2020 September 30; Oepen & Hamacher, 2000).

In the context of this chapter, strategic communication is understood based on the GTZ's (2006) Rioplus-Environmental Policy and Sustainable Development Strategy Promotion as

*a dynamic process, integrated in a large-scale initiative that comprises multi-disciplinary and social marketing, non-formal education and public participation, thrives on acting people, aims at the innovative and sustainable change of practices, behaviors and lifestyles, guides communication processes and media interventions within and among social groups, and is a pre-requisite and a tool for change at the same time. (p. 7)*

A model developed for sustainable environmental development sees it as a process of change guided by several values or branches. Through IUCN, UNEP, and WWF, nurturing the Earth and developing a strategic plan for a sustainable future is defined as: "a type of development that provides real improvements to the quality of human life while preserving the vitality and diversity of the earth" (IUCN, UNEP & WWF, 1991, cited in GTZ, 2006, p. 8).

Sustainable living depends on the obligation to seek harmony with others and with nature. The guiding rules are that individuals must share and care for the sake of the environment with each other and that humanity must not take more from nature than nature can replenish. This, in effect, means "adopting lifestyles and development paths that respect and operate within the limits of nature." This can be done without rejecting the many advantages that modern technology has brought, provided that the technology operates within these limits as well (IUCN, UNEP & WWF, 1991, cited in GTZ, 2006, p. 8). Table 2 shows the six steps of the ABC Model below are often combined with key elements of social strategic communication from a social marketing approach. it has been proven effective in environmental conservation, family planning, health care and other fields (see Waisbord, 2001 cited in GTZ, 2006).

*Table 2. Six steps to apply behavioural-change based strategic communication using the ABC model*

| | | |
|---|---|---|
| 1 | Observe Behaviour | Identify what people like and do not like about a certain behaviour that should be changed. D not just ask questions. Look, count, record behaviour. Arrange for a few people to do what you would like the whole community to do. Watch their problems. |
| 2 | Listen to People | Ask what matters to them, talk about how your target behaviour fits their daily life. Look for what they get out of behaviour as a benefit and who matters to them. |
| 3 | Decide what Matters | Compare people who show the desired behaviour with people who do not. What are they like, where do they live, how do they act out the behaviour you care about? Segmentize your audiences because they will have to be communicated with differently. |
| 4 | Generalize Facts | Summarize critical environmental practices, key facts influencing behaviour and other points like benefits people care about, messages preferred, opinion leaders people trust in. Test your assumptions with a representative survey. |
| 5 | Deliver Benefits | Deliver benefits people want, not just information. Solve barriers the people face, do not just "educate" 66them. This means that service delivery and communication inputs must be synchronized. |
| 6 | Monitor Effects | Find and fix mistakes. Selectively monitor crucial program elements by means of simple and manageable indicators for the behaviour you wish to change (see Day & Smith, 1996). |

Table 3 shows how the World Bank Development Communications Unit describes communication media audiences along a behaviour-change continuum and how potential communication interventions could look like (see World Bank, 2003 cited in GTZ, 2006, p. 30).

## FUTURE RESEARCH DIRECTIONS

Climate change is increasingly exacerbating threats to sustainable environmental development in Nigeria in general and in the desertification frontline region in particular. Climate change has been described as the defining issue of our time, and Northern Nigeria is at a defining moment, as is Nigeria and the whole world. The impacts of climate change are real in the desertification frontline of Northern Nigeria on an unprecedented scale, from shifting weather patterns that threaten food production to increasing precipitation that increase the risk of catastrophic floods (Vivekananda, Fetzek, Mobjorrk, Sawas & Wolfmaier, 2017). According to the United Nations (UN), "Adapting to these impacts in the future will be more difficult and costly without drastic action today" (cited in CDD, 2020 September 30, p.

*Table 3. Communication media audience behaviour-change continuum*

| People are… | | Potential Communication Intervention |
|---|---|---|
| 1 | unaware | • raise awareness<br>• recommend a solution |
| 2 | aware, concerned, knowledgeable | • identify perceived barriers and<br>• benefits to behaviour change |
| 3 | motivated to change | • provide logistical information<br>• use community groups to counsel and motivate |
| 4 | try new behaviour | • provide information on correct use<br>• encourage continued use by emphasizing benefits<br>• reduce barriers through problem solving<br>• build skills through behaviour trials<br>• social support |
| 5 | sustain new behaviour | • recall benefits of new behaviour<br>• assure ability to sustain behaviour<br>• social support |

4). So, future research should focus on providing an understanding of "meaning" and how the process of creating meaning works regarding the conceptual definition of communication considering the argument forwarded by Glare (1968) who contends that "communication" or "to communicate" means has never been agreed on. Also, future research should focus on providing empirical data on the three distinct lenses with which communication is viewed (regarding the context of this chapter) as Ruler (2018) argues namely: (i) communication as a one-way construction of meaning process in which the sender attempts to construct or reconstruct the meaning developed by the receiver; (ii) communication as a two-way construction of meaning process in which two or more people construct new meanings; and (iii) communication as a omnidirectional diachronic process of meaning construction, in which the focus is on the continuous development of meaning itself.

## CONCLUSION

Based on the thematic review of the theories and concepts in strategic communication for sustainable development, this chapter identifies the lack of the adoption and application of the principles, techniques and guidelines of strategic communication by the Federal Government, State Governments and other stakeholders as some of the critical factors militating against controlling and managing the negative impacts of climate change in the desert-prone states (Bauchi, Borno, Gombe, Jigawa, Kano, Kebbi, Kaduna, Sokoto, Yobe, Adamawa and Zamfara) of Northern Nigeria. Consequently, this coupled with the lack of implementable strategic environmental policy framework as well as the lack of long-term environmental development plan could further exacerbate the situation thus leading to enormous environmental crises – some of which are already unfolding – for example, increasing annual flooding, drought, soil leaching or poor soil quality, rampant deforestation, fast desert encroachment, sheet and gully erosions, recession of natural water bodies such as Lake Chad, high temperatures (reportedly temperatures of between +1.5 to 2.0°C have been recorded in the last 60 years in West Africa. According to USAID's Climate Risk Profile of Africa, temperatures are projected to increase a further 2.9°C by 2050 [see CDD, 2020 September 30; Pham-Duc et al., 2020; Vivekananda et al, 2019 May 15]), poor harvest, overpopulation, air pollution, the lack of proper and hygienic sewage disposal system and policy, epidemics such as cholera, Ebola, Lassa Fever and even Coronavirus (COVID-19) pandemic, and so on.

Consequently, all these give rise to over-competition over meagre resources, which ultimately, bring about conflict that claim lives and annihilate properties worth billions of Naira as manifested in the various crises occurring not only in the desertification frontline states but across Nigeria as a whole; for example, the conflict between farmers and herdsmen, cattle rustling and in extreme cases even the Boko Haram insurgency and the agitation by the Niger Delta youth. Poverty and hunger are also critical factors that can be given rise to by those factors outlined earlier. With all these factors impacting the Northern states in the desertification frontline, peace and prosperity would spontaneously vanish, and where there is no prosperity, development of any type will be an alien (Aude, 2013; Nwankwo et al., 2020).

This chapter, therefore, argues that although the media and communication may not spontaneously eliminate those negative elements harming the environment and threatening its sustainability and bring about development that caters for both the present and future generations, the literature (as reviewed in the preceding sections) has consistently demonstrated that strategic communication create an atmosphere that is conducive for and facilitate effective exchange of concrete ideas and thought on how to practically address those challenges with near-precision, cutting-edge tools, techniques and guidelines to realise the dream for a sustainable environment cost-effectively. Also, this chapter argues that strategic communication techniques can be used to achieve more sustainable and climate-sensitive environmental development and management that will provide fertile ground for building peace and security in society. Given the reliance of the people in the desertification frontline states on the sale of raw agricultural commodities for income, and the risks these climatic conditions pose to farming, this could have major macroeconomic ramifications for Nigeria and the West African sub-region. Hence, the imperative to adopt strategic communication approach to address this issue (Allen, 2016; Heide et al., 2018).

## REFERENCES

Abdullah, M. (2020 October 3). *How climate change is undermining peace and security in Nigeria.* HumAngle Media. https://humangle.ng/how-climate-change-is-undermining-peace-and-security-in-nigeria/#

Allen, M. (2016). *Strategic communication for sustainable organisations: Theory and practice*. Springer. doi:10.1007/978-3-319-18005-2

Argenti, P. A., Howel, R. A., & Beck, K. A. (2005). The strategic communication imperative. *MIT Sloan Management Review*, *46*(3), 83–89.

Ashcraft, K., Kuhn, T., & Cooren, F. (2009). Constitutional amendments: "Materialising" organisational communication. *The Academy of Management Annals*, *3*(1), 1–64. doi:10.5465/19416520903047186

Aude, S. A. (2013). Conflicts among farmers and pastoralists in Northern Nigeria induced by freshwater scarcity. *Developing Country Studies*, *3*(12), 25–32.

Berger, P., & Luckmann, T. (1966). *The social construction of reality. A treatise in the sociology of knowledge*. Penguin Books.

Broome, B. J. (2009). Dialogue theories. In S. W. Littlejohn & K. A. Foss (Eds.), *Encyclopedia of communication theory* (pp. 301–305). SAGE. doi:10.4135/9781412959384.n111

CDD. (2020). *Climate change: Recognising the impacts on West Africa*. https://cddelibrary.org/2020/09/30/climate-change-recognising-the-impacts-n-west-africa/

Deane, J., Dixit, K., Mue, N., Banda, F., & Waisbord, S. (2003). The other information revolution: Media and empowerment in developing countries. In E. B. Girard & S. O'Siochru (Eds.), *Communicating in the information society* (pp. 65–100). UNRISD.

Deane. (2005). *Why the media matters*. Paper prepared by Communication for Social Change Consortium for the Global Forum for Media Development.

Environmental education and communication for a sustainable world. (2000). InDay, B. (Ed.), *Handbook for international practitioners*. AED.

Evans, A. (2010). *Resource scarcity, climate change and the risk of violent conflict*. World Development Report 2011 Background Paper.

FAO. (2003). *Communication and natural resource management*. FAO.

FAO. (2005). *Communication for development roundtable report. Focus on sustainable development*. Report of the 9th UN Roundtable on Communication for Development. Rome: FAO.

Fontaine, B., Roucou, P., Gaetani, M., & Marteau, R. (2011). Recent changes in precipitation, ITCZ convection and northern tropical circulation over North Africa (1979-2007). *International Journal of Climatology*, *31*(5), 633–648. doi:10.1002/joc.2108

Glare, P. G. W. (Ed.). (1968). *Oxford Latin dictionary*. Oxford University Press.

Green, C. O. M. (2002). *Heating up society to take environmental action*. AED.

GTZ. (2006). *'Strategic communication for sustainable development: A conceptual overview'. A report by GTZ Rioplus Environmental Policy and Promotion of Strategies for Sustainable Development*. Eschborn.

Hallahan, K. (2004). Communication management. In R. L. Heath (Ed.), *Encyclopedia of public relations* (Vol. 1, pp. 161–164). SAGE.

Hallahan, K., Holtzhausen, D. R., van Ruler, B., Verčič, D., & Sriramesh, K. (2007). Defining strategic communication. *International Journal of Strategic Communication*, *1*(1), 3–35. doi:10.1080/15531180701285244

Heide, M., von Platen, S., Simonsson, C., & Falkheimer, J. (2018). Expanding the scope of strategic communication: Towards a holistic understanding of organisational complexity. *International Journal of Strategic Communication*, *12*(4), 452–468. doi:10.1080/1553118X.2018.1456434

ICG. (2020 May 18). *Violence in Nigeria's North West: Rolling back the mayhem*. https://www.crisisgroup.org/africa/west-africa/nigeria/288-violence-nigerias-north-west-rolling-back-mayhem

Johnson, G., & Scholes, K. (1999). *Exploring corporate strategy* (5th ed.). Prentice Hall Europe.

Lasswell, H. (1948). *The structure and function of communication and society: The communication of idea*. Institute for Religious and Social Studies.

Littlejohn, S. W. (1983). *Theories of human communication* (2nd ed.). Wadsworth.

Neumann, W. R. (2008). Interaction. In W. Donsbach (Ed.), *The international encyclopedia of communication* (Vol. 5, pp. 2305–2309). Blackwell. doi:10.1002/9781405186407.wbieci040

Not haft, H. (2016). A framework for strategic communication research: A call for synthesis and consilience. *International Journal of Strategic Communication, 10*(2), 69-86. doi:10.1080/1553118X.2015.1124277

Nwankwo, C. F., Arduino, R., Ali, A., & Made, I. A. (2020). Farmer-herder conflict: The politics of media discourse in Nigeria. *II Ponte*, *76*(1), 191–221. doi:10.21506/j.ponte.2020.1.13

OECD. (2002). *Sustainable development strategies: A resource book*. Earthscan Publications Ltd.

Oepen, M., & Hamacher, W. (Eds.). (2000). *Communicating the environment*. Peter Lang.

Pham-Duc, B., Sylvestre, F., Papa, F., Frappart, F., Bouchez, C., & Crétaux, J.-F. (2020). The Lake Chad hydrology under current climate change. *Scientific Reports*, *10*(1), 5498. doi:10.103841598-020-62417-w PMID:32218517

Rogers, E. M. (1997). *A history of communication study, a biographical approach*. The Free Press.

Rosengren, K. E. (2000). *Communication, an introduction*. SAGE.

Schoeneborn, D., Blaschke, S., Cooren, F., McPhee, R. D., Seidl, D., & Taylor, J. R. (2014). The three schools of CCO thinking: Interactive dialogue and systematic comparison. *Management Communication Quarterly*, *28*(2), 285–316. doi:10.1177/0893318914527000

Shiru, M. S., Shahid, S., Chung, E.-S., & Alias, N. (2018). Changing characteristics of meteorological droughts in Nigeria during 1901-2010. *Atmospheric Research*. doi:10.1016/j.atmosres.2019.03.010

Taylor, J. R., & Van Every, E. J. (2000). *The emergent organization: Communication as its site and surface*. Erlbaum.

Thorson, K. (2013). *Strategic communication*. Retrieved from https://www.oxfordbibliographies.com/view/document/obo-9780199756841/obo-9780199756841-0007.xml

UNDP/OCHA. (2018). *Resilience for sustainable development in the Lake Chad basin*. Retrieved 8 April 2019 from https://www.undp.org/content/dam/rba/docs/UNDP-OCHA-Lake-Chad-%20Resilience_spreads-EN.pdf

UNECE. (2018). *Strategic communications framework. The United Nations Economic Commission for Europe (UNECE)* Secretariat.

Van Ruler, B. (2018). Communication theory: An underrated pillar on which strategic communication rests. *International Journal of Strategic Communication*, *12*(4), 367–381. doi:10.1080/1553118X.2018.1452240

Vivekananda, J., Fetzek, S., Mobjorrk, M., Sawas, A., & Wolfmaier, S. (2017). Action on climate and security risks: Review of progress 2017. Amsterdam: The Centre for Climate and Security (SIPRI).

Vivekananda, J., Wall, M., Nagarajan, C., Sylvestre, F. & Brown, O. (2019). *Shoring up stability: Addressing climate and fragility risks in the Lake Chad region*. Berlin: Adelphi.

Watzlawick, P., Beavin, J., & Jackson, D. (1967). *Pragmatics of human communication: A study of interactional patterns, pathologies, and paradoxes*. Norton.

World Bank. (2019). *Data for Nigeria, Niger, Chad, Cameroon*. Retrieved 8 April 2019 from https://data.worldbank.org/?locations=NG-NE-CM-TD

## ADDITIONAL READING

Ackerly, B., & True, J. (2010). *Doing feminist research in political and social science*. Palgrave Macmillan. doi:10.1007/978-1-137-05442-5

Anatsui, T. C., & Adekanye, E. A. (2015). Environmental sustainability for national development in Nigeria: The role of mass media. *European Journal of Educational and Development Psychology*, *3*(1), 31–43.

Genç, R. (2017). The importance of communication in sustainability & sustainable strategies. *Procedia Manufacturing*, *8*, 511–516. doi:10.1016/j.promfg.2017.02.065

Hallahan, K., Holtzhausen, D., Van Ruler, B., Verčič, D., & Sriramesh, K. (2007). Defining strategic communication. *International Journal of Strategic Communication*, *1*(1), 3–35. doi:10.1080/15531180701285244

Harwell, M. C., Molleda, J. L., Jackson, C. A., & Sharpe, L. (2020). Establishing a common framework for strategic communications in ecosystem-based management and the natural sciences. In T. G. O'Higgins (Ed.), *Ecosystem-based management, ecosystem services and aquatic biodiversity* (pp. 165–188). Springer. doi:10.1007/978-3-030-45843-0_9

Lenshie, N. E., Okengwu, K., Ogbonna, C. N., & Ezeibe, C. (2020). Desertification, migration, and herder-farmer conflicts in Nigeria: Rethinking the ungoverned spaces thesis. *Small Wars & Insurgencies*, 1-31.

Okwumba, E. O., & Onyiaji, J. (2018). Awareness and use of strategic communication in managing herdsmen-farmers crises in selected media houses in Nigeria. *University of Nigeria Interdisciplinary Journal of communication*. *Studies*, *23*(2), 12–22.

Omijeh, J. (2008). Strategies for the control of desertification in northern Nigeria. *FUTY Journal of the Environment*, *3*(1), 72–83.

Oyero, O., Oyesomi, K., Abioye, T., Ajiboye, E., & Kayode-Adedeji, T. (2018). Strategic communication for climate change awareness and behavioral change in Ota Local Government of Ogun State. *African Population Studies*, *32*(1), 4057–4067.

## KEY TERMS AND DEFINITIONS

**Communication:** This refers to the practical process of the exchange of ideas, thoughts, guidelines, standards and so on between management/stakeholders and beneficiaries on the best practices available that can be applied toward mitigating/preventing problems and challenges associated with the environment in a given society. It also involves community mobilization and dialogue as well as the use media of communication to disseminate information associated with environmental development for long-term benefits to people.

**Desert:** This refers to a vast geographical area that is characterized with a significant degree of drought, desiccation, loose soil, extremely scanty vegetation, wastelands/barren lands, extremely high temperatures and sparse population density.

**Desertification Frontline:** This is a geographical area that shares some of the characteristics of desert because of its proximity and being prone to desert lands.

**Development:** This term simply refers to advancement, progress, and positive changes in the overall condition of a given phenomenon resulting in observable shifts from a previous state of being to a better one.

**Environment:** This refers to the ecosystem or the general physical surrounding in which people live especially in relation to land, water, air, vegetation and wildlife.

**Environmental Development:** Tangible positive changes, advancements and transformations in the overall conditions of the ecosystem especially regarding lesser land, water and air pollution as well as lesser destruction of vegetation and risk to wildlife. Environmental development also involves all positive changes brought about in a particular geographical area through people-centered political, economic, social, cultural and even diplomatic efforts for a better place for all live.

**Strategic Communication:** This term refers to a specialized communication type which involves the utilization of planned, tactical, and calculated deliberations and methodologies to conceive, develop and execute a given communication-related plan to realize a set of desired objectives in an unusual way using existing communication media and forums.

**Sustainable (Environmental) Development:** This term refers to the type of environmental development that can withstand the test of time yielding benefits to people and society.

# Chapter 10
# Towards a Sustainable Circular Economy:
## A Systematic Literature Review of Its Implementation in Business

**Soraya M. Ruiz-Peñalver**
*Universidad de Granada, Spain*

**José M. Rodríguez-Antón**
https://orcid.org/0000-0002-4608-8082
*Universidad Autónoma de Madrid, Spain*

## ABSTRACT

*The circular economy (CE) is a new paradigm that helps create convergence into a more sustainable society. This chapter shows the main findings of a systematic literature review examining the state of the art of the business concept of sustainability and CE and how scholars have focused on the implementation of circular and sustainable principles in sectors and firms. The main findings show a lack of consensus on definitions related to CE, creating confusion among firms. Final findings also show the challenges that businesses face and the main obstacles that explain why some organisations fail in the transition. Additionally, this review helps to highlight the main research gaps on the topic to encourage sustainability and circularity among firms. Whilst there are an increasing number of papers related to circularity and supply chains, few papers concern with dematerialising products and services. Another gap is the lack of quantitative studies measuring the impact of transitioning to sustainable and circular economies.*

## INTRODUCTION

The circular economy (CE) is a relevant and innovative concept in sustainable development (Murray et al., 2017). In fact, some authors consider the CE paradigm as a tool to get sustainability (Ghisellini & Ulgiati, 2020; Geissdoerfer et al., 2017). The concept was first introduced by Pearce and Turner in the 1990s (Sacchi et al., 2018; Merli et al., 2018), but its current definition contains a set of principles and

DOI: 10.4018/978-1-7998-8482-8.ch010

proposals developed after that time, and the concept of CE remains dynamic and changeable (Geissdoerfer et al., 2017). China was the first country to implement this paradigm that addresses to establish an economic system in which goods and services have a closed life cycle. A CE is characterised as an economy that is restorative and regenerative (Ghisellini et al., 2016), which expects products to retain as much value as possible – that is, it is a system in which products have a longer life and that features greater reuse, refurbishment, remanufacturing and recycling of goods and resources (Ellen MacArthur Foundation, 2015).

The importance and novelty of the CE implies great challenges for socioeconomic stakeholders, especially for firms. Transitioning from a traditional linear economy to a sustainable circular one implies huge risks, but if these risks are successfully surmounted, firms can become even more competitive than before (Jørgensen & Remmen, 2018).

Because of the stakes involved, scholars have focused on researching the business concept of sustainability and CE principles for their implementation in firms. Great differences of opinion remain, however, creating confusion and decreasing opportunities for international cooperation (Merli et al., 2018), although this lack of consensus may be due to the of CE being in its infancy with roots in sustainability and several disciplines (Weissbrod & Bocken, 2017; Murray et al., 2017).

To avoid this confusion, previous concepts are required. As noticed, CE paradigm is a tool to get sustainability. For the moment, we must distinguish between sustainable business models (SBMs) and circular business models (CBMs). Whilst SBMs are those businesses whose innovations reduce negative impacts or create positive ones for the triple bottom line (economy, society and environment) (Prendeville & Bocken, 2017), CBMs are a type of SBMs with the same goals, but focused on slowing material loops, that is, a way to preserve resources by reusing, repairing or remarketing (Nußholz, 2017; Bocken et al., 2018); or closing loops, which is based on reducing waste generation by recycling or re-manufacturing (Oghazi & Mostaghel, 2018).

This paper presents a complete systematic literature review of the academic research on the business concept of a CE and CE implementation in firms. However, the link between sustainability and CE implies the consideration of SBMs and CBMs. The analysis addresses the main research question: How do scholars approach the new business model concept of and firms transition to a more circular and sustainable economy?

## METHODS

As noted, this paper proposes a systematic literature review on the subject of CE is implemented in business models (BMs). According to Fetscherin and Heinrich (2015, pp. 381), a literature review *'is based on the assumption that researchers publish their most important findings in scholarly journals and predominantly base their research on articles previously published in similar journals'*. However, a systematic literature review goes further because it *'differs from traditional narrative reviews by adopting a replicable and transparent process, in other words a detailed technology, that aims to minimize bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewers decisions, procedures and conclusions'* (Denyer & Tranfield, 2009, pp. 209). Because this type of analysis compares published papers measuring text and other information (e.g., citations, keywords and authors), its results are generally useful for establishing relationships among articles based on a specific research topic and monitoring the trajectory followed by a discipline or a given researcher through analysis of, for example, co-citing, the impact of the publications and their authors (Fetscherin & Heinrich, 2015; Geissdoerfer et al., 2017). Systematic literature reviews therefore accomplish two main goals: first, they summarise existing research by identifying patterns, themes and issues; second, such reviews help identify the conceptual content of the field and assist theory development (Seuring & Müller, 2008; Wang, Li, & Li, 2009). There is, however, a significant drawback to such methods, as it is impossible to read everything (Seuring & Müller, 2008).

In terms of methodology, systematic literature reviews require both qualitative and quantitative analysis (Seuring & Müller, 2008). To reproduce a suitable systematic literature review, several authors such as Merli et al. (2018), Seuring and Müller (2008) or Shukla and Jharkharia (2013) based their reviews on previous frameworks proposed by Mayring (2002), whose methodological framework includes the following stages:

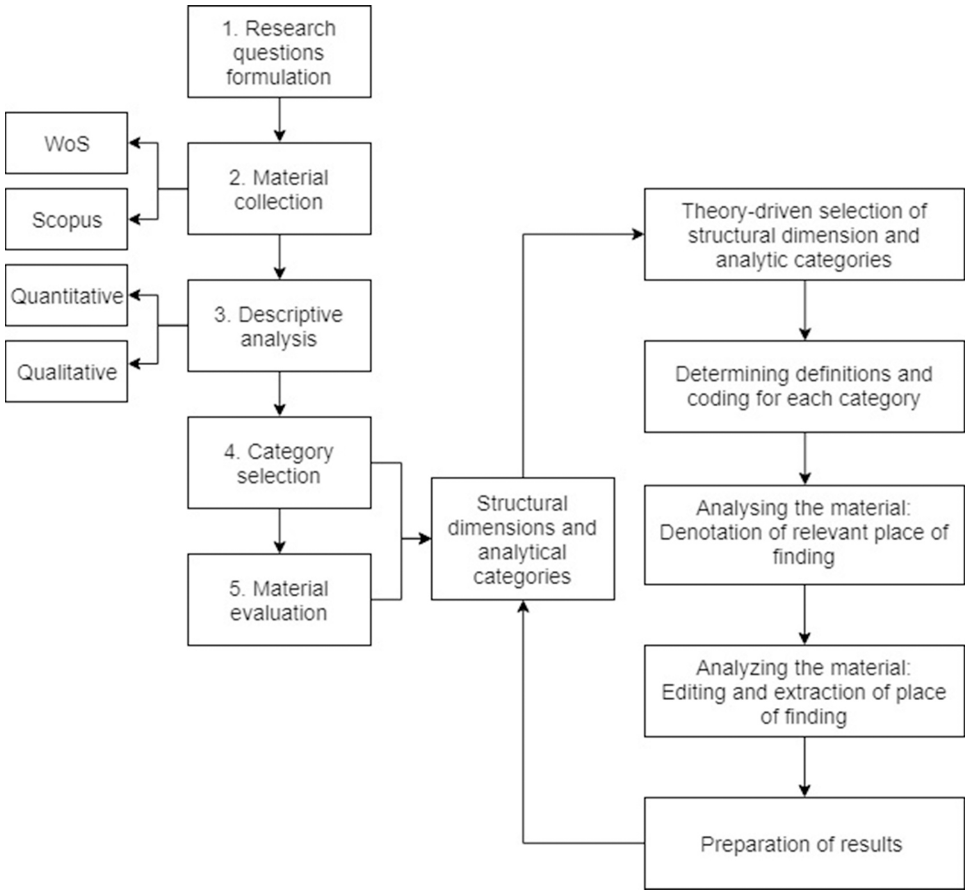
1. Research questions formulation (section 1).
2. Material collection (section 3.1.). This step implies defining and selecting materials and criteria to delimit the search and unit of analysis.
3. Descriptive analysis (section 3.2.). A descriptive analysis is carried out to analyse formal aspects of selected material applying qualitative and quantitative methods (see sections 3.2.1. and 3.2.2. respectively).
4. Category selection (section 3.2.3). Structural dimensions and their related analytic categories are chosen to classify the different publications.
5. Material evaluation (section 3.2.3 and 4). Then all the material is analysed, taking into account the structural dimensions and analytical categories from the previous step. This stage may allow the interpretation and identification of the main results.

Figure 1 shows a schematic description of this process. Stages 4 and 5 require an iterative process starting with the selected structural dimensions and their analytic categories, and ending with the preparation of results. This iterative process might nevertheless be extended to the overall framework due when developing a systematic literature review, as it is better to apply both a deductive and inductive approach (Seuring & Müller, 2008; Shukla & Jharkharia, 2013). This study began with a deductive process, defining structural and analytical attributes identified in previous literature; then, an initial review of collected material was carried out and an inductive approach was applied through which some of the previous dimensions and categories were rejected and new ones were considered to categorise all of the obtained material.

## Material Collection

The bibliography was compiled from Web of Science (WoS) and Scopus. Both databases are considered as the most exhaustive scientific databases supporting researchers in their work (Merli et al., 2018). Several authors recommend WoS for being the oldest database, possessing the most complete records of citation indexes and including a powerful analysis tool (Ellegaard & Wallin, 2015). WoS does not, however, index as many publications as Scopus does, although it is commonly accepted that it includes a great quantity of high-quality interdisciplinary literature in different fields (Ellegaard & Wallin, 2015). Santa and Herrero-Solana (2010) conclude that WoS coverage is worse in subjects related to business management. Beyond these discrepancies, most researchers find a high correlation between both databases

*Figure 1. Methodological scheme*
*Source: (Adapted from Seuring and Müller, 2008, pp. 1700).*




because of the large amount of indexed material (Durán et al., 2017). This paper therefore considers both databases to compare the contained material.

The references were obtained in May 2021 by searching the WoS Core Collection and Scopus. To get a general view of the topic, the following keywords were entered into both databases: 'circular economy business models' (CBMs) and 'sustainable business models' (SBMs). These terms were entered into the most generic fields in the respective databases; for WoS this was 'Topic', while for Scopus this was 'Article Title, Abstract, Keywords, Author'. The search was just circumscribed in both databases by the document type 'articles' and the language 'English', which is globally considered the international academic language (Merli et al., 2018). Because of the high number of related publications, we only considered articles published in journals to exclude grey literature, that may contain relevant support to the topic. Finally, no time filter was selected, so all articles published between 1900 and May 2021 were taking into consideration.

Because of the novelty of the CE concept and its implications for the transition from a linear economy, there are many articles related to the topic. Most relevant articles were published within the last 20 years, so, after filtering out irrelevant articles, we focused our interest on the period 2000–2021. From this search, 1,566 records were found, from them 778 references belonged to WoS and 788 to Scopus.

The 1,566 references obtained from the two databases were then cross-checked, and 559 were found to overlap, leaving a total of 1,007 articles. WoS yielded 219 unique articles while Scopus had 229 unique ones; due to the large number of references it was necessary to synthesise, not all of these references can be cited. Following a simple random sampling with 95% confidence level and 10% margin of error, a sample of 88 articles were selected for this research.

## RESULTS

### Descriptive Quantitative and Qualitative Analysis

#### Monitoring, Coverage and Overlap in Bibliographic Databases

This section develops a descriptive-quantitative analysis to explain how both databases deal with the topic. Three indexes were applied to compare the capacity of each database to cover a particular topic and the overlap between WoS and Scopus. Following the quantitative method for systematic literature reviews given by Durán et al. (2017), we have applied the three proposed indexes.

First, Meyer's Index (MI) examines databases monitoring a specific topic. The obtained results show how the database covers the topic. Meyer's Index distinguishes between primary and secondary sources. The primary ones cover all the unique material, weighting more than secondary sources; primary sources are weighted 1, whilst secondary sources that involve duplicated material are weighted 0.5, as they are contained in both databases (triplicates, when comparing three databases, are weight 0.3 and so on). Higher values indicate greater uniqueness of the database (Durán et al., 2017). The obtained results show a lower percentage for WoS (MI=49.50%) than Scopus (MI=50.50%), which means that Scopus presents a higher singularity; that is, Scopus possesses 50.50% of the unique articles (not duplicate ones), while 49.50% of WoS references are unique.

Second, traditional overlap (TO) indicates that there is a 55.51% of affinity between the databases. This result implies that a single database (WoS or Scopus) covers 44.49% of unique articles.

Third, the obtained relative overlap (RO) reveals that Scopus includes 71.85% of WoS articles while WoS covers 70.94% of Scopus references.

Overall, Scopus is the database that best covers the topic, although the difference between Scopus and WoS is relatively small.

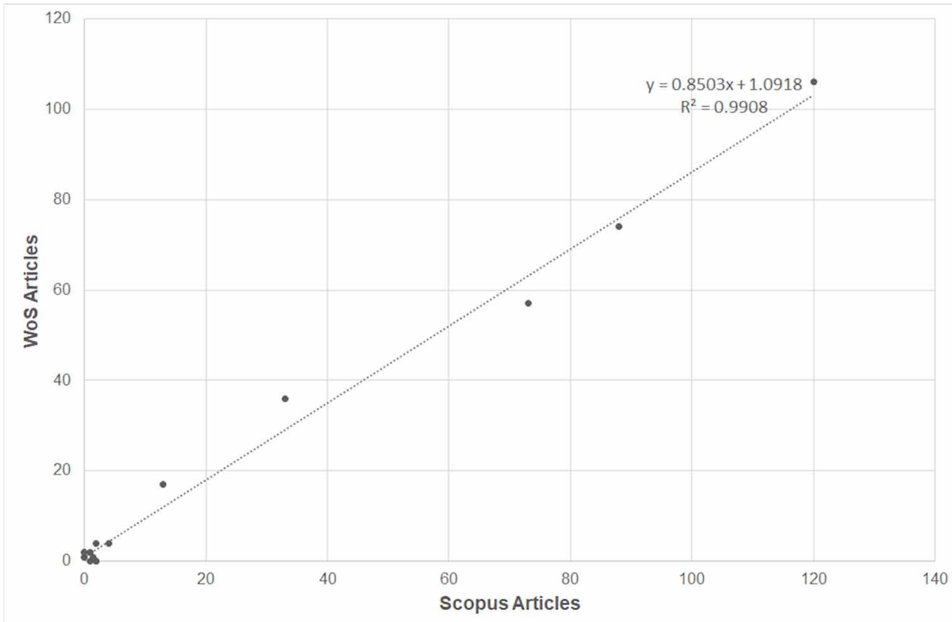
Finally, we obtained the correlation between WoS and Scopus for this topic (Durán et al., 2017). As already noted, there is a strong correlation ($R^2$=0.99) between them in terms of the number of indexed articles in both. Figure 2 shows these results.

#### Trends and Distribution of Articles across Time, Sources and Authors

This section develops a descriptive-qualitative analysis based on the trend and distribution of the collected material.

Although no temporal restrictions were applied to the material collection, the most relevant articles belonged to the period 2000-May 2021, and especially from 2016 to the present, when 96.62% of the articles were published (see Figure 3). The current environmental awareness, the transition from a linear economy to a circular one, demand pressure and other reasons explain the increasing interest in this topic.

*Figure 2. Correlation between papers from WoS and Scopus*




Taking into account that the 2030 Agenda was signed in 2015 to reinforce the sustainability principles (United Nations, 2015), and the CE strategy came into force in Europe the same year (European Commission, 2015), it is reasonable that the number of research articles increased thereafter (see Figure 3).

All of the considered journals have publications related to this subject, but the *Journal of Cleaner Production* leads the ranking with 19.96% of the published articles (see Figure 4), followed by *Sustainability* (13.90%), *Resources, Conservation and Recycling* (5.96%), *Business Strategy and The Environment* (3.57%) and the *Sustainable Production and Consumption* (1.99%). The five journals with the highest number of published articles accounted for 45.38% of records.

Figure 5 illustrates that *Journal of Cleaner Production* has maintained its leadership on the topic of CE since 2014, publishing more articles on this topic than the other sources. In fact, in 2020, when the most articles on the topic were published (336 papers), this journal accounted 15.18% of the total. The obtained results show that although CE is a paradigm whose final aim is to redefine the socioeconomic system, scholars tend to approach CE from the productive and consumption perspective, focusing on production transition and waste generation.

Table 1 presents the most prolific authors on the topic. The most representative author is N. M. P. Bocken from the Netherlands with 20 research papers on SBMs and CBMs, followed by L. Fraccascia from Netherlands (10 articles) and D. C. A. Pigosso from Denmark (8 articles). The analysis reveals a substantial predominance of European authors (especially from Netherlands), although most of them tend to cooperate with other European colleagues, and to a lesser extent with scholars from other continents. These results suggest that the European CE strategy and its related policies are being widely studied by European universities from a business transition perspective.

*Figure 3. Number of papers published per year*

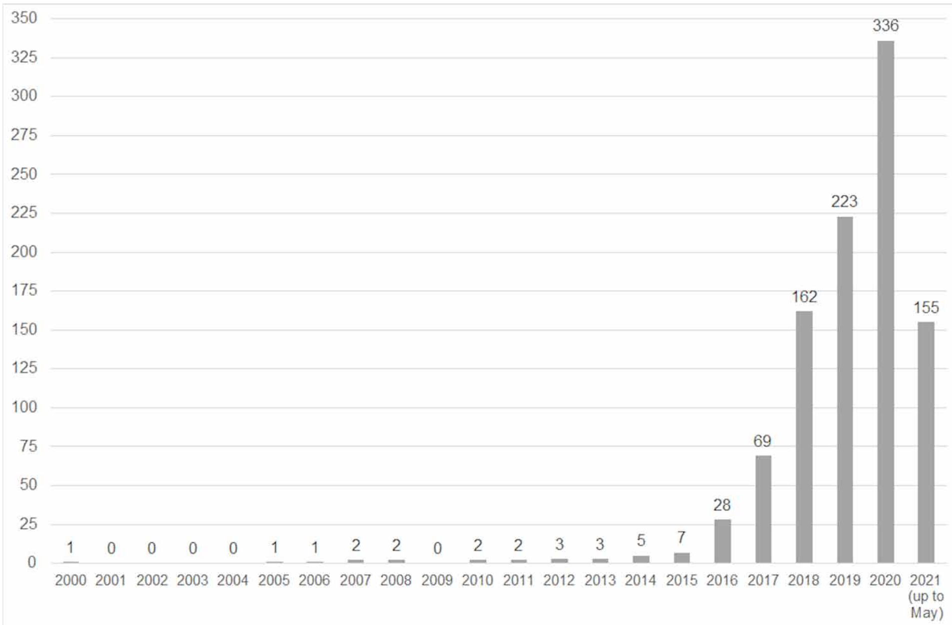



*Figure 4. Number of articles per source*

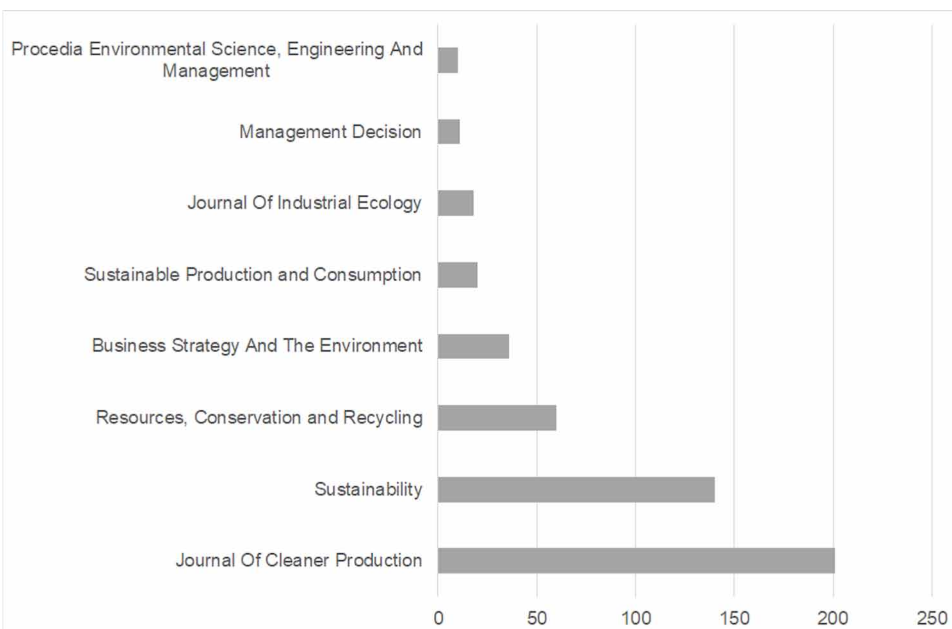


*Figure 5. The top journals with the highest number of issues*

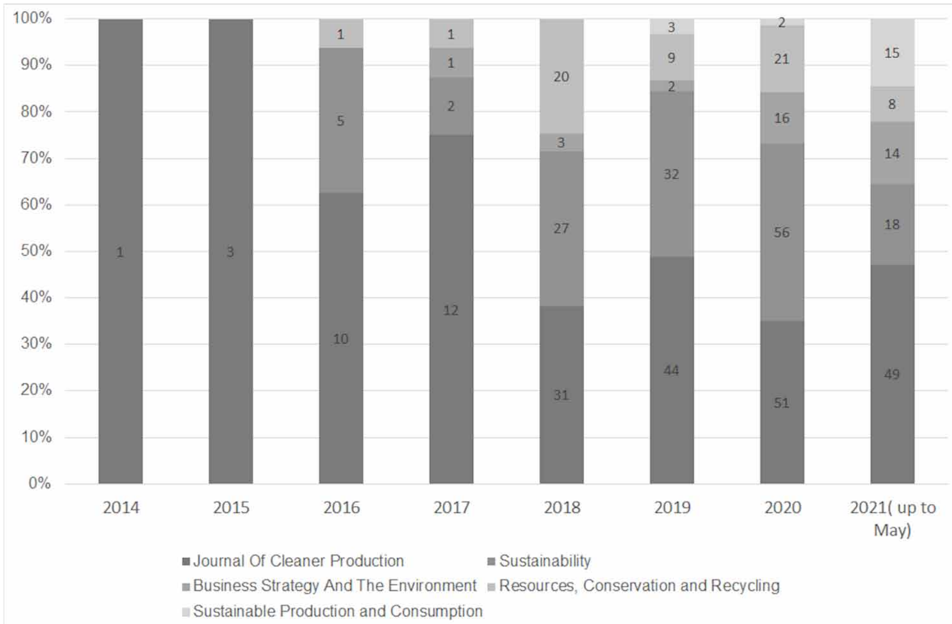



*Table 1. Authors with at least 5 publications, number of published papers and country of affiliation*

| Authors | Number of papers | Affiliation |
|---|---|---|
| Bocken, N. | 20 | Netherlands |
| Fraccascia, L. | 10 | Netherlands |
| Pigosso, D.C.A. | 8 | Denmark |
| McAloone, T.C. | 7 | Denmark |
| Yazan, D. M. | 7 | Netherlands |
| Balkenende, R. | 7 | Netherlands |
| Mugge, R. | 6 | Netherlands |
| Moreno, M. | 6 | United Kingdom |
| Bakker, C. | 5 | Netherlands |
| De Angelis, R. | 5 | United Kingdom |
| Fogarassy, C. | 5 | Hungary |
| Nußholz, J. L. K. | 5 | Sweden |
| Scarpellini, S. | 5 | Spain |

## Category Selection and Material Classification

To study the topic and make categorisation of the collected materials easier for the reader, this section presents six structural attributes and their analytical categories to classify the selected material. One of the main drawbacks related to systematic literature reviews is that each article may simultaneously be part of more than one category, and some of the articles may not belong to any category (Merli et al., 2018). Thus, a different number of related articles may appear in each structural attribute. Some structural and analytical attributes were included in the analysis of studies concerning SBM and CBM (i.e., research methodology, level of analysis, keyword families, industries and geographical focus). After an initial analysis, the dimension 'circular business models' was included due to the large number of papers related to the topic.

### *Research Methodology*

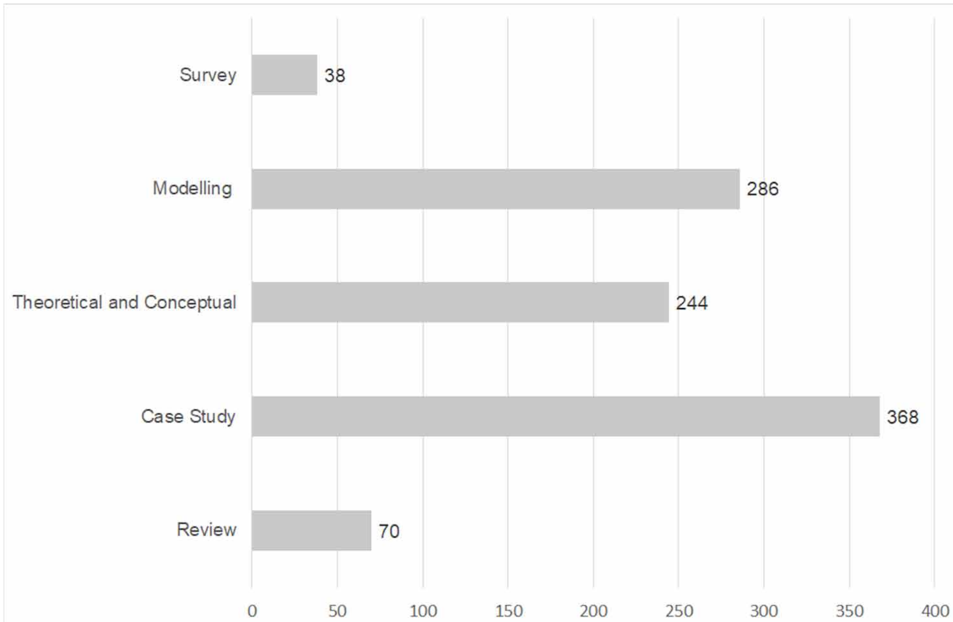
This structural dimension was proposed by Seuring and Müller (2008) who included five analytical categories for a preliminary classification of the research methodologies and treatment of CBMs: 'theoretical and conceptual papers', 'case studies', 'modelling papers', 'surveys' and 'literature reviews' (Seuring & Müller, 2008). Figure 6 illustrates the paper assignments for these research methodologies. The most abundant are 'case study' documents (36.58%), which presents a lot of papers related to business experiences with sustainability and CE (e.g., Pesce et al., 2020; Bocken et al., 2018), especially dealing with specific eco-industrial parks, industrial symbiosis or industrial clusters (e.g., Chen et al., 2021; Ramakrishna et al., 2020; Dong et al., 2016; Baldassarre et al., 2019), or a specific industry or product (e.g., Zufall et al., 2020; Hahladakis & Iacovidou, 2018). This dimension is followed by 'modelling papers' (28.43%) and 'theoretical and conceptual' (24.25%). 'Modelling papers' involve proposals to introduce innovations in product design (e.g., Evrard et al., 2021; Cong et al., 2019; Ungerman & Dedková, 2019), eco-efficiency (e.g., López et al., 2019) or waste depletion from production (e.g., Chen et al., 2021; Zucchella & Previtali, 2019). 'Theoretical and conceptual' includes a significant number of papers dealt with CE implementation in businesses (e.g., Ferasso et al., 2020; Unal & Shao, 2019; Fraccascia et al., 2019b; Geissdoerfer et al., 2018a); consumers and behaviour (e.g., Borrello et al., 2020; Mugge et al., 2017); resource efficiency (e.g., Schult, 2013); and supply chains (e.g., Kalverkamp & Young, 2019; Zhu et al., 2010). The 'review' and 'survey' categories included 6.96% and 3.78% of the papers, respectively.

### *Level of Analysis*

According to Ghisellini et al. (2016), it is important to categorise the collected material at the following three systematic levels. The macro level implies all the articles based on activities developed at the city, province, regional, national and international levels, and includes activities that have repercussions on society. The meso level includes the inter-firm level within a geographic proximity (e.g., eco-industrial parks, industrial symbiosis, business clusters or networks; Merli et al., 2018). The micro level focuses its interest in consumers and firms. The importance of this dimension established the need to identify the levels most studied by scholars when they refer to sustainability and CE applied to businesses. Indeed, the sustainability principles and CE need to transform the traditional patterns at all levels of society, so although the macro level covers the public policies that will implement the CE at a territorial level, the micro and meso levels cover specific requirements for business and consumers (Merli et al., 2018).

The macro level is the most common among scholars, with 46.82% of the studied papers. This level includes articles focused on policy and public decisions (e.g., Nußholz et al., 2019; Nußholz, 2017) or territorial analysis targeting cities, provinces, countries or international contexts (e.g., Fassio & Minotti, 2019; Girard & Nocca, 2019; Antikainen & Valkokari, 2016). The micro level represents 34.79% of published articles and includes cases study papers focused on specific business strategies to reach either

*Figure 6. Research methodology*




sustainable and CE principles (e.g., Koksharov et al., 2019; Jensen et al., 2019) or consumer behaviour (e.g., Borrello et al., 2020; van Weelden et al., 2016). Finally, the meso level (18.39%) includes papers about industrial symbiosis and clusters (e. g. Baldassarre et al., 2019; Yazan & Fraccascia, 2019; Fraccascia et al., 2019a).

## *Keyword Families*

The following section develops a cluster analysis for the keywords in both databases. It is suitable to visualise the relationships and strength links among the keywords through the papers. Only keywords with a minimum number of three occurrences were considered. Figure 7 shows these relationships among the keywords. The different colours distinguish the keywords clusters. The stronger the link between two items, the thicker the line that is employed to display the link. The thickest lines belonged to the following words: 'circular economy', 'circular business models', 'sustainability' and 'business models'. The main keyword was 'circular economy' which contained a far higher occurrence than the other keywords and presents a strength link of 238. 'Circular Business models' was the second main keyword with 59 occurrences and a strength link of 81. 'Sustainability' was the other generic keyword, found in 38 papers with a strength link of 78. These three keywords were followed by: 'business models' (27 articles), 'business models innovation' (18), 'sustainable business models' (18), 'remanufacturing' (14). Figure 8 illustrates the trends across time of all these keywords. The newest keywords (light colours) are 'eco-innovation', 'built environment', 'recycling', 'bio-economy' and 'business ethics and sustainability', which have been used more often since 2019 up to May 2021. The dark colours show the 'oldest' keywords (note, however, that all these keywords have been used since 2017): 'business model innovation', 'circular business model', 'sustainable business models', 'manufacturing', 'supply chain', 'circular design' and 'closed loop'.

*Figure 7. Keyword families*

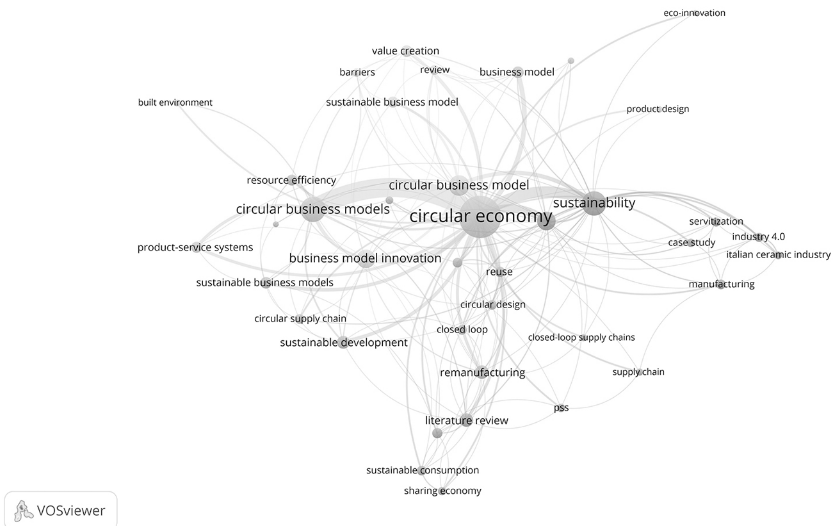
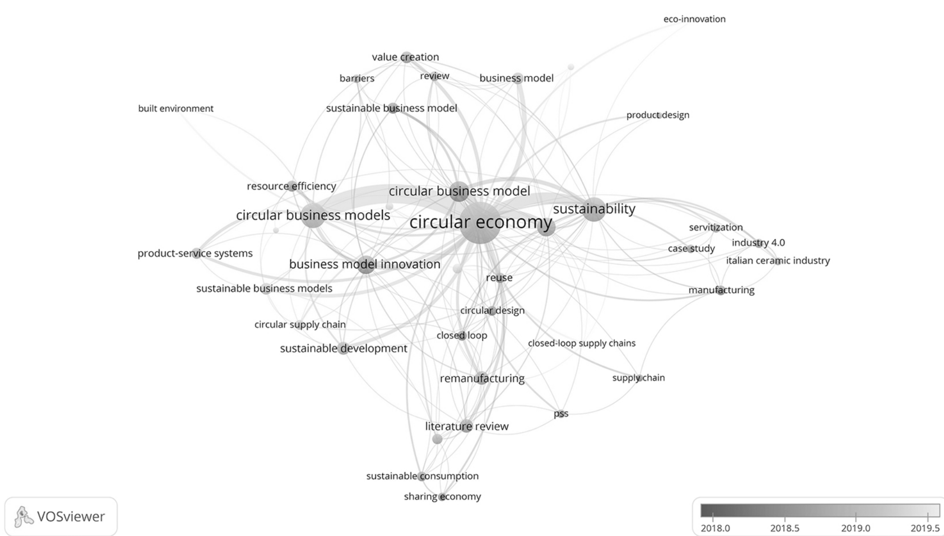


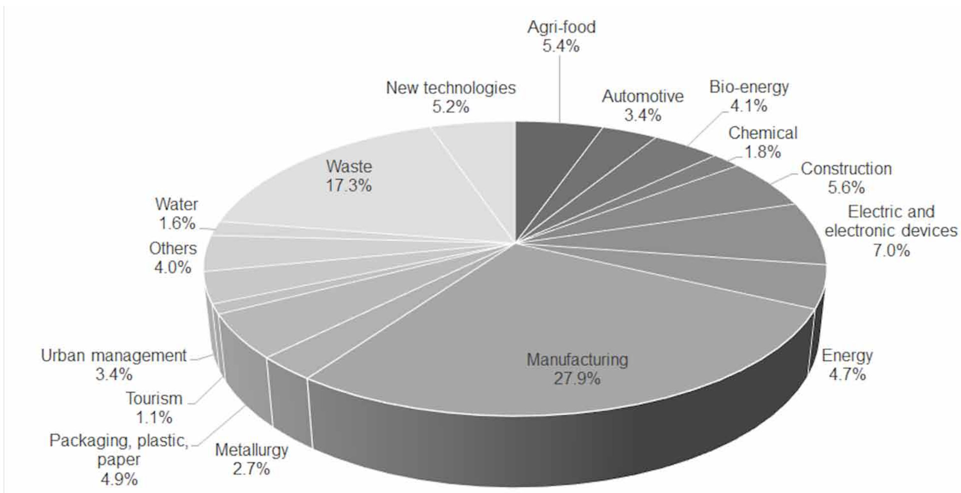

*Figure 8. Keyword families across time.*




## Industries

To identify the sector to which the collected material relates, the articles were classified according to the focus industry (Merli et al., 2018). Figure 9 shows that manufacturing is by far the most common sector with 27.9% of papers (e.g., Moktadir et al., 2020; Todeschini et al., 2020; Baldassarre et al., 2019), followed by waste (17.3%; e.g., Gunarathne et al., 2020; Zucchella & Previtali, 2019; Perey et al., 2018) and electric and electronic devices (7.0%; e.g., Bressanelli et al., 2021; et al., 2017). Considering that manufacturing is the sector that requires the highest investment to become greener, it is obvious that most research has focused there. In the case of waste, the CE aims to reduce and manage the volume of waste so much of the research concerns the implementation of SBMs and CBMs to minimise the volume of waste. Finally, as electric and electronic device usage has increased (e.g., mobile phones, tablets, laptops, smart watches), production has been increasing and so has waste.

*Figure 9. Industries studied by the papers.*




## *Geographical Focus*

This dimension was proposed by Merli et al. (2018) and analyses, when possible, the geographical focus of the papers. Only 62.31% of papers focused on a specific territory. Of these, 79.93% focused on Europe, 28.87% on Asia, 7.39% on North America, 5.99% on South America, 2.46% on Oceania and 3.52% on Africa. By country, China is the most studied (16.88%), perhaps because it was one of the first countries to implement CE in 2009 with the Circular Economy Promotion Law of the People's Republic of China, following Germany (1996, by the Closed Substance Cycle and Waste Management Act) and Japan (2002, with The Basic Law for Establishing a Recycling-Based Society) (Lieder & Rashid, 2016; Geissdoerfer et al., 2017). China is followed by Italy (13.55%), United Kingdom (10.55%), Netherlands (7.17%), Sweden and Brazil (6.33% and 6.25% respectively) and Spain (5.06%).

## *Circular Business Models*

As commented, due to the large number of papers about CBMs, this dimension was established. Business models that tend most towards a CE can be classified in different ways, including through the following six categories: 'short cycle', 'long cycle', 'cascading', 'pure cycle', 'digitisation' and 'produce on demand' (Manninen et al., 2018). Nevertheless, the most used classifications are given by the Ellen

MacArthur Foundation (2015) and Bocken et al. (2016), so the 88% out of the 642 papers were catalogued following both proposals.

According to the Ellen MacArthur Foundation (2015), we included a 'ReSOLVE framework' and its six analytical categories that describe operational actions needed for business and governments to implement CE principles (Table 1).

Following this framework, 43.24% of articles belong to 'loop', and in particular to recycling secondary products, discarded materials or waste to close loops (e.g., Bressanelli et al., 2021; Dong et al., 2016; Hahladakis & Iacovidou, 2018), obtaining energy from waste (e.g., Hussain et al., 2020; Gontard et al., 2018) and other recovery practices (e.g., Perey et al., 2018). Papers catalogued as 'optimise' are oriented towards resources and energy efficiency, waste depletion and engineering processes (e.g., Schulte, 2013; López et al., 2019) and represent 29.95% of papers published. The 'exchange' category (12.73%) includes articles based on innovations and new technologies to implement in business models and product design (e.g., Karman, 2020; de los Ríos & Charnley 2017; Weissbrod & Bocken 2017; den Hollander et al., 2017). The 'share' (8.22%), 'virtualise' (3.27%) and 'regenerate' (2.59%) categories are the least studied from the ReSOLVE framework dimension. These figures indicate that the least explored areas are related to dematerialising productive processes, redirecting consumer behaviour (e.g., sharing or using second-hand products) and restoring the environment.

*Table 2. ReSOLVE framework*

| ReSolve Framework | Meaning |
|---|---|
| REgenerate | • Shift to renewable energy and materials<br>• Reclaim, retain and restore ecosystem health of ecosystems<br>• Return recovered biological resources to the biosphere |
| Share | • Share assets<br>• Reuse/Second-hand<br>• Prolong life through maintenance, design for durability, upgradability, etc. |
| Optimise | • Increase performance/efficiency of product<br>• Remove waste in production and supply chain<br>• Leverage big data, automation, remote sensing and steering |
| Loop | • Remanufacture products or components<br>• Recycle materials<br>• Digest anaerobically<br>• Extract biochemicals from organic waste |
| Virtualise | • Dematerialise directly and indirectly |
| Exchange | • Replace old with advanced non-renewable materials<br>• Apply new technologies<br>• Choose new product /service |

Source: (Ellen MacArthur Foundation, 2015, pp. 21)

Basing on their environmental strategies, Bocken et al. (2016) proposed a framework with three pillars: 'slowing resource loops', 'closing resource loops' and 'resource efficiency or narrowing resource flows'. The first refers to designing long-life products, lengthening its durability at the user level and the application of product reuse. The second concerns waste valorisation through the production process. The last one implies the use of fewer resources in production. According to this CBM categorisation, 55.46% of obtained papers were classified. Of these, 52.94% were categorised as 'slowing the loops' (e.g., Casper & Sunding 2018; Dominish et al., 2018); 26.92% belong to 'closing the loop' (e.g., Baldassarre et al., 2019; Fraccascia et al., 2019a), and 20.12% fall into the 'narrowing the loop' category.

Summarising, the topic is going to be studied by scholars due to the high number of publications up to May 2021, which indicates that 2021 will surpass the number of published papers in previous years. The database that best covers the topic is Scopus, although the difference with WoS is small. Among the journals that publish the majority of papers, *Journal of Cleaner Production'* leaders the ranking. According to the bibliographic information, European scholars are by far the authors that publish the most of papers, especially Italians, although the most studied country is China, which is the first country that implemented circular strategies. As commented, the 1,007 papers were grouped in different categories to make easier the content analysis. The most of papers are 'cases study', followed by far by 'theoretical and conceptual' and also 'modelling' papers. The most prolific types of research are related to 'tools, models framework, methods for decision making' and also 'process engineering' and 'business models and management'. It is important to underline the importance of the knowledge transfer in these aspects due to firm's requirements to make possible the transition towards a CE. The most of papers study at macro level, proposing plans and strategies for public policies to implement the CE, territorial analysis at different levels (cities, provinces, countries or international context). As noticed, the keywords families are a category that groups the documents according to the most employed keywords between papers. The keywords analysis shed light about the current and future research trend. Keywords such as 'eco-innovation', 'built environment', 'recycling', 'bio-economy' or 'business ethics and sustainability' have been used more often since 2019 up to May 2021, which suggest that these keywords will be present in future research. Additionally, manufacturing is by far the most studied sector due to it requires the highest investment to become greener, it is obvious that most research has focused there. Waste is the second topic most studied because the CE aims to reduce and manage the volume of waste. Finally, there are a great variety of business' strategies that firms can implemented. The most recurrent model is 'loop' which includes strategies such as closing and slowing the loops (e.g., industrial symbiosis, extending the resource value, extending product value, remanufacturing or refurbishment practices); 'optimise', a CE strategy that tries to increase the product efficiency removing waste from the supply chain, automation or remote sensing and steering; 'exchange' practices are focused on replacing old materials with advanced renewable ones, choosing new products and services or applying new technologies. 'Share' practices try to lengthen the product life (e.g., satisfying needs without the ownership of product, encouraging reuse or second hand). 'Virtualise' implies dematerialise the product process and 'regenerate' pretends to reclaim, retain, recovery or regenerate the damaged ecosystems.

## DISCUSSION

This part contains the most significant findings of the analysis, discusses the content of the studied papers and identifies the main trends.

### There is a Lack of Consensus on Definitions Related to CE

Several authors (Karman, 2020; Linder & Williander 2017; Sacchi et al., 2018) have highlighted that CE has become a familiar concept but there remains a lack of convergence and consensus in the available definitions. Karman (2020) underlines the heterogeneity of the CE concept and how it hinds the implementation of circular strategies in firms. Murray et al. (2017) suggested that the CE term is highly confused due to the pre-existence of the concepts ‘linear economy’ and ‘circular economy’ applied in different economic contexts. Bartl (2020) also indicates that CE is based on theoretical basis that emerged four decades ago. Sacchi et al. (2018) gathered a sample of 25 different definitions of CE, each of which is related to different CE principles. Their findings suggest that definitions associated with ‘management’ and ‘strategies’ pay more attention to CE due to the increased number of papers related to business models. ‘Close the loops’ is another of the most cited aspects in CE concepts, while ‘biological loops’ are found in CE concepts linked with biological and even environmental studies and ‘technical closed loops’ are mentioned in economic and industrial backgrounds (Sacchi et al., 2018). Their results confirm that some dimensions of CE and even the legislative, institutional and cultural issues are practically missing from literature. Murray et al. (2017) consider that CE is in its early stages of development and is a new school of thought in sustainable development. However, they are critical of CE acceptation and emphasise that it does not include the social dimension that is essential to achieve sustainability. The social dimension of CE needs strengthening through the creation of jobs, due to the acknowledge of the role citizens as producers and consumers (Hobson & Lynch 2016; Pla-Julián & Guevara, 2019). The CE approach is also critiqued for its unplanned consequences and its over-simplistic goals based on weak foundations, which may have ominous consequences (e.g., biodiesel is considered less of a pollutant than fossil fuels, but its extraction is destroying rainforests to plant oil palm; Murray et al., 2017). To maintain the new CE framework and correct its current limitations, Murray et al. (2017, pp. 377) suggest a new concept: *‘The CE is an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximise ecosystem functioning and human well-being*’.

## Lack of Consensus on the Concept of CE is Extendible to its Semantic Field and Related Terms such as SBMs and CBMs and Closed-Loop BMs

A similar problem occurs with related terms like SBMs, CBMs and closed-loops BMs, which implies a problem for practitioners who want to be more sustainable or require to implement CE principles to move from a linear economy to circular one. The novelty of the CE paradigm suggests that definitions have not yet been delimited, which requires that these terms be defined to aid companies in transitioning towards a CE (Bartl, 2020). In truth, each business needs to understand its current BMs, embrace the concepts of innovative business models (IBMs), SBMs, CBMs and closed-loops BMs, identify which one is best suited to the company and adapt its business model or even develop a new one (Karman, 2020; Evans et al., 2017). In this sense, BM is ‘*the conceptual and architectural implementation of a business strategy and the foundation for the implementation of business processes*’ (Oghazi & Mostaghel, 2018, pp. 741), and it includes the following value dimensions: value creation (concerns partners and stakeholders, processes, development and technologies, and even resources and capabilities such as materials, value chain, procedures and structures); value proposition (includes the offering of goods and services); value capture (defines the revenue streams and cost structures); and value delivery (deals with distribution channels and customer segmentation and relationships; Nußholz 2017; Lüdeke-Freund, Gold, & Bocken, 2018; Oghazi & Mostaghel 2018).

Innovation plays an important role as a vehicle for achieving sustainable or circular practices and includes the introduction of innovative goods and technologies to the market, as well as new methods of production, procedures and even organisation structure. IBMs can therefore be defined as ‘*a recon-*

*figuration in the business model elements, including innovating: the content (adding new activities); the structure (linkages and sequencing of activities); or the governance (the control/responsibility over an activity) of the activity system between the company and its network*' (Nußholz, 2017, pp. 1815). It can be considered an iterative process of experimenting, analysing and learning (Boons & Lüdeke-Freund, 2013). IBMs include SBMs, CBMs and closed-loop BMs (Oghazi & Mostaghel, 2018).

SBMs are those businesses whose innovations reduce negative impacts or create positive ones for the triple bottom line (economy, society and environment) through changes ways of thinking about or doing business (including changes to the organisation, and even to the value proposition, value delivery, value creation or value capture; Prendeville & Bocken, 2017). CBMs are a type of SBMs that have the same goals (Oghazi & Mostaghel, 2018) and can be defined as the way a company develops its value dimensions to slow material loops (Nußholz, 2017; Bocken et al., 2018); that is, a CBM is oriented to preserve resources by reusing, repairing and remarketing. Karman (2020) indicates that CBM are based on old sustainable principles and there is a lack of models focused on CE. Additionally, Karman (2020) suggest that SBM do not include CE principles, a problem to consolidate the knowledge in this topic. Closed-loop BMs are a type of CBM and SBM that focus on reducing waste through recycling and remanufacturing (Oghazi & Mostaghel, 2018).

## Previous Findings Showed Current Increase in Publications on CE and BMs with New Trends

The yearly evolution of articles, especially on CE and BMs, implies new research opportunities, such as researching the development of new strategies for BMs to solve the uncertainty of transitioning from traditional to circular approaches. The literature review also shows a high link between supply chains and CE with new focus. Although supply chain research is an extremely active field, current studies have transformed it to join supply chains to CE principles (Zhu et al., 2010). Circular supply chains (e.g., Yang et al., 2018), open-loop supply chains (e.g., Kalverkamp & Young, 2019) or closed-loop supply chain (Gaur & Mani, 2018) applied to specific case studies are examples of these emergent trends. This bridge between CE and supply chains is established because of the need to consider the sustainable aspects (social, economic and environmental) and impacts that manufacturing and product supply chains exert on the CE framework. Product design is gaining more importance among scholars as a part of the supply chain studies due to the new roles and competences required or the marketing and communications challenges (Evrard et al., 2021; Ferasso et al., 2020). Future studies may examine how eco-design and eco-innovations could be implemented in different sectors and firms, the requirements to implement them or the productive process challenges. Additionally, there exist a growing interest on the sub-processes of value chains, especially those analysis based on value propositions (a mix of product and services that cover the final consumer needs) (Karman, 2020), whilst the value transition is less studied. As a result, strategies aimed at minimise environment impacts and dematerialising productive processes or changing the product design are well-studied by academia However, there is still a lack of research on reformulating the value transition by using new radical innovations. Bressanelli et al. (2020) indicate that radical changes are rarely taken by firms, and also underline that radical innovations are based on '*disruptive practices based on reuse, remanufacture and sharing, where digital 4.0 technologies have a strong enabling role*' (Bressanelli et al., 2020, pp. 148). Another gap for future research is the lack of quantitative studies measuring the impact of transitioning, especially in small and medium firms. Despite the high number of businesses that fail when implementing CE strategies, there are few articles that study this problem. Markov and Font (2018) are one of the pioneers in this field, quantifying the magnitude of the effects from smartphone reuse. Bassi and Dias (2020) grouped the European small and medium enterprises' according to their involvement in CE activities. Their results suggest that firms' dimension (both in terms of employees and incomes) and the economic sector are factors closely linked to the higher involvement, existing high differences between Europe. Italy concentrates the highest prevalence of firms that are willing to implement CE strategies, followed by the East of Europe, Spain and Malta, and finally by Northern and Western countries plus Portugal and Cyprus. There also seem to be few studies on the challenges associated with IBMs and the importance of innovation to get more sustainable and circular firms. Few studies aim at sustainability and circularity as a source of competitive advantage which encourages managerial competences to develop SBMs and CBMs (Ferasso et al., 2020).

## Business Challenges for Transitioning to a More Sustainable and Circular Economy

The first challenge for an organisation that wants to transition is to assume '*the co-creation of profits, social and environmental benefits and the balance among them […] for moving towards SBMs*' (Evans et al., 2017, pp. 599). The sustainability and CE principles imply potential benefits and competitive advantages for any type of organisation (Jørgensen & Remmen, 2018; Ungerman & Dedková, 2019). These benefits include cost savings in manufacturing of products and low-cost competition in markets, enhanced profits, brand differentiation and protection, new customers and stronger customer relations, lower environmental impacts or new social responsibility.

The barriers do, of course, represent a huge challenge for businesses and especially for small and medium organisations with limited resources (Heyes et al., 2018; Álvarez et al., 2019). A great challenge is choosing which strategy is best for each business, taking into account that there is a great variety of strategies available. Indeed, Lüdeke-Freund et al. (2018) identified 26 different CBMs, although CE implementation remains open to suggestion. Before applying sustainable measures or circular principles, Jørgensen and Remmen (2018) recommend create a map of organisational and material links of businesses to supply a base for developing new ideas for the transition. Previous experimentation is also required before implementing a strategy to reduce risk and uncertainties (Weissbrod & Bocken, 2017; Antikainen & Valkokari, 2016). Bocken et al. (2018) have created an emergent process to help a sustainable transition in businesses based on the following steps: (1) defining the strategy and purpose, where the organisation describes what outcomes it wants to achieve in terms of social, environmental and economic issues; (2) business model experimentation, which is related to experiments or tests of the different BM dimensions (e.g., value proposition, value creation, value delivery, value capture and value transformation); and (3) field test experiments, in which real customers try the new products to check them.

The literature review suggests that many businesses fail during the transition. Despite the interest in the issue, there are still few studies that have explored the reasons for such failures. Evans et al. (2017) and Geissdoerfer et al. (2018b) have emphasised that most implemented BMs tend to fail, especially in start-ups, probably due to lack of experience as well as the large financial requirements and costs. Other authors affirm that strategies tend to fail because innovating processes do not take place as businesses choose an unsuitable BM for implementing new technologies, solutions or innovations (Chesbrough, 2010; Ungerman & Dedková, 2019). Geissdoerfer et al. (2018b) remark that some organisations identify the correct strategy, but encounter problems during implementation when changes in the current BM are required. Sometimes these implementation problems are related to the application of new technological innovations (Yu & Hang, 2010), especially given the inherent risk of radical innovations (Heyes et al., 2018).

The transition sometimes fails because of the inherent aspects of innovation connected to organisational issues. On the one hand, lack of entrepreneurial spirit, insufficient management, low knowledge of the product, sourcing and manufacturing capabilities, failure to allocate resources and reconfigure processes are critical internal barriers for converting into a more SBM, because this conversion implies new actions and ideas (Chesbrough, 2010; Hughes, 2011; Álvarez et al., 2019). On the other hand, external relationships fail because the transition needs greater interaction with stakeholders and stronger customer relationships (Boons & Lüdeke-Freund, 2013). In any case, the business transition must be compatible with the providers, retailers and service partner organisations to control the value chain. Regarding customer relations, studies analysing the demands of current customers and potential ones are necessary, because consumer preferences are not static and very few customers are willing to purchase refurbished or remanufactured products or even accepting strategies focused on pay-per-use services which question the product ownership (Ferrasso et al., 2020; Linder & Williander, 2017). Other external barriers are connected to the lack of reinforcement of existing laws or even lack of laws that regulate the transition to a more sustainable scenario (Álvarez et al., 2019), and these gaps mean that during the great effort within the firm to convert to a BM within the CE framework, firms sometimes feel unprotected by the authorities.

## Most of the Firms Offer Incremental Innovations Instead of Radical Ones to Transition

Historically, previous industrial revolutions have been associated with radical innovations that made changes though new products and processes. According to Bocken et al. (2016, pp. 312) *'the move to a circular economy model is an example of a radical change, which will require a new way of thinking and doing business'.* Following these authors, radical innovations will permit greater changes in traditional businesses. If slight improvements are applied to processes, technologies or products, the transition to SBMs, CBMs or closed-loop BMs will slow down. The lack of governmental support and destruction of businesses during the period of crisis has decreased investment in radical innovations. Geissdoerfer et al. (2018a) highlight the important role of technical innovations – but also for social innovations. Their results show, independently of the type and size of business, that all of businesses rely on a change in consumer and provider behaviour due to SBMs and, by extension, CBMs and closed-loop BMs, require a systematic paradigm shift.

Table 3 shows a summary of the main trends. As notices, all these trends are connected and justify why many businesses do not or cannot implement the CE principles to transition towards sustainability. A lot of scholars underline the lack of accuracy of the European CE definition and even the Strategy is criticised by its simplicity and weak basis. As a consequence, all the related business models based on the CE suffer from this problem and a lot of organizations find obstacles to implement certain business strategies to leave the linear economy. Despite research provides business advice, new alternatives and proposals, firms undoubtedly require public support in terms of reinforcement laws, regulation to guide the process and financial resources to foster the transition process. These are the pillars for the suitable transition. In this sense, the lack of public support justifies the shortcomings that researchers highlight of the CE strategy. Bressanelli et al. (2021) also support this argument, underlining the requirement of mandatory regulations to enhance CE strategies and to clearly lay out role of each stakeholder throughout

*Table 3. Summary of the main trends*

| Trends | Explanation |
|---|---|
| There is a lack of consensus on definitions related to CE. | • The CE term is confused due to the pre-existence of the concepts applied in diverse economic contexts. Great variety of CE definitions related to different principles.<br>• Some dimensions of CE and even the legislative, institutional and cultural issues are practically missing from literature. The social dimension of CE needs strengthening through the creation of jobs, due to the acknowledge of the role citizens as producers and consumers.<br>• The CE approach is also critiqued for its unplanned consequences and its over-simplistic goals based on weak foundations, which may have ominous consequences.<br>• Homogeneity in the CE definition is required to develop proper strategies to get sustainability. |
| Lack of consensus on the concept of CE is extendible to its semantic field and related terms. | • A similar problem occurs with terms like SBMs, CBMs and closed-loops BMs. The novelty of the CE paradigm suggests that definitions have not yet been delimited, which requires that these terms be defined to aid companies in transitioning towards a CE.<br>• Firms need to understand its current BMs, embrace the concepts of innovative business models (IBMs), SBMs, CBMs and closed-loops BMs, and identify which one is best suited to the company. Not all the business models are suitable to all the firms. |
| Previous findings showed current increase in publications on CE and BMs with new trends. | • New research trends:<br>• The development of new strategies for BMs to solve the uncertainty of transitioning from traditional to circular approaches.<br>• Link between supply chains and CE with new focus: Circular supply chains, open-loop supply chains or closed-loop supply chains, applied to specific cases of study.<br>• Research gaps related to:<br>• Dematerialising (or virtualising) products and services and their processes.<br>• Lack of quantitative studies measuring the impact of transitioning.<br>• Lack of studies exploring the reasons for which many firms fail in the transition. |
| Business challenges for transitioning to a more sustainable and circular economy. | • The first challenge for a firm is to assume its willingness to change. The transition implies potential benefits and competitive advantages but it is difficult to get it.<br>• The barriers represent a huge challenge for businesses, especially for small and medium firms with limited resources. Main reasons:<br>• Great variety of strategies available, so it is important to analyse the business' requirements and stablish and study different scenarios before implementing the best one for each firm.<br>• Many businesses fail during the transition:<br>• Start-ups fail due to the lack of experience and the large financial needs and costs.<br>• Many strategies fail because innovating processes do not take place as businesses choose an unsuitable BM for implementing new technologies, solutions or innovations (Chesbrough, 2010; Ungerman & Dedková, 2019).<br>• Other organisations identify the correct strategy, but encounter problems during implementation.<br>• Innovation *versus* organisational issues: lack of entrepreneurial spirit, insufficient management, low knowledge of the product, failure to allocate resources and reconfigure processes.<br>• External relationships fail because the transition needs greater interaction with stakeholders (customer, provider and retailer relationships).<br>• Lack of reinforcement of existing laws or even lack of laws that regulate the transition to a more sustainable scenario (Álvarez et al., 2019). |
| Most of the firms offer incremental innovations instead of radical ones to transition. | • Radical innovations will permit greater changes in traditional businesses whilst incremental ones imply slight modifications. The lack of governmental support and destruction of businesses during the crisis has decreased investment. |

supply chains. Converging towards a CE require great investments for changing industrial processes, materials, recycling, dematerialising, among other alternatives to abandon the traditional productive patterns. All these changes need innovative proposals that differs from being cheap and hence, the availability of financial resources should be facilitated by public policies. Additionally, not all the IBMs neither the SBMs are suitable for all the business hence, support from public administrations, universities and other research organizations is crucial to give advice to all the business committed with the transition. That is, an industrial symbiosis, especially with universities, *'that should play a pivotal role in engendering CE transitions'* (Ramakrishna, 2020, pp. 505).

## CONCLUSION

This study has shown the main results of a systematic literature review to answer the research question: How do scholars approach the new business model concept of and firms transition to a more circular and sustainable economy? We found 642 related papers from WoS and Scopus, which have been classified according to six structural dimensions and their analytical categories. Quantitative findings show that Scopus presents a higher number of unique papers than WoS, although both are relevant for studying this topic. Qualitative analysis found that the business transition to a more sustainable economy and, by extension, to a CE is an ongoing research area, especially since 2016, supported by public decision makers, firms and scholars. Most articles have focused on China and Europe, probably because of the growing number of public policies in these regions to implement CE and sustainable principles. The most studied sector is manufacturing, followed by waste and then electronic and electric devices; this is perhaps because manufacturing requires the greatest effort to transition, while waste includes the huge volume of generated residues, and consumer demand for electronics and electronic devices has considerably increased, creating interest in this area.

This review emphasises that the sustainable and CE practices and their implementation among firms are in their early stages and, as a consequence, there is no unanimity among scholars about the meaning of CE, which creates confusion among organisations, decreasing opportunities for interindustry collaboration. Other concepts like the supply chain or business models are also re-directing the research trend to re-adapt to the CE paradigm. New concepts like the circular supply chain, open-loop supply chain or closed-loop supply chain, and IBM, SBM, CBM and closed-loop BM are examples of this change. Transitioning supposes a challenge for businesses, although if this challenge is overcome, firms gain competitive advantages. There remain many internal and external barriers to implementing CE, and these have been emphasised by scholars. Internal barriers include, among others, lack of resources and the implied costs of transition, choice of suitable BM, lack of experience, new technologies, lack of entrepreneurial spirit and insufficient management. External challenges include market obstacles, consumer preferences and fashion trends, relationships with stakeholders and lack of supporting legislation to help the transition process, and so forth. There remains a research gap in articles about dematerialising products and services, as well as quantifying the impact of transitioning. These gaps remain, of course, important lines for future research.

## FUNDING SOURCES

This research received no specific grant form any funding agency in the public, commercial, or not-for-profit sectors.

## ACKNOWLEDGMENT

The authors deeply appreciate the comments from the anonymous reviewers and the associate editor of IGI Global.

## REFERENCES

Álvarez, J., Zartha, J. W., & Orozco, G. L. (2019). Barriers to sustainability for small and medium enterprises in the framework of sustainable development- Literature Review. *Business Strategy and the Environment*, *28*(4), 512–524.

Antikainen, M., & Valkokari, K. (2016). A framework for sustainable circular business model innovation. *Technology Innovation Management Review*, *6*(7), 5–12. doi:10.22215/timreview/1000

Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., & Calabretta, G. (2019). Industrial Symbiosis: Towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives. *Journal of Cleaner Production*, *69*, 10–16. doi:10.1016/j.jclepro.2019.01.091

Bartl, A. (2021). The circular economy package of the European Union: Are new paths being taken or is it an old story? *Detritus*, *12*, 12–17.

Bassi, F., & Dias, J. G. (2020). Sustainable development of small-and medium-sized enterprises in the European union: A taxonomy of circular economy practices. *Business Strategy and the Environment*, *29*(6), 2528–2541. doi:10.1002/bse.2518

Bocken, N., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. doi:10.1080/21681015.2016.1172124

Bocken, N., Schuit, C. S. C., & Kraaijenhagen, C. (2018). Experimenting with a circular business model: Lessons from eight cases. *Environmental Innovation and Societal Transitions*, *28*, 79–95. doi:10.1016/j.eist.2018.02.001

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: State-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9–19. doi:10.1016/j.jclepro.2012.07.007

Borrello, M. P., Pacucci, S., Caracciolo, F., Lombardi, A., & Cembalo, L. (2020). Consumers are willing to participate in circular business models: A practice theory perspective to food provisioning. *Journal of Cleaner Production*, *259*, 121013. doi:10.1016/j.jclepro.2020.121013

Bressanelli, G., Pigosso, D. C. A., Saccani, N., & Perona, M. (2021). Enablers, levers and benefits of circular economy in the electrical and electronic equipment supply chain: A literature review. *Journal of Cleaner Production*, *298*, 126819. doi:10.1016/j.jclepro.2021.126819

Bressanelli, G., Saccani, N., Perona, M., & Baccanelli, I. (2020). Towards circular economy in the household appliance industry: An overview of cases. *Resources*, *9*(11), 128. doi:10.3390/resources9110128

Casper, R., & Sunding, E. (2018). Addressing Today's challenges in automotive remanufacturing. *Journal of Remanufacturing*, *8*(3), 93–102. doi:10.100713243-018-0047-9

Chen, Y., Cai, G., Zheng, L., Zhang, Y., Qi, X., Ke, S., Gao, L., Bai, R., & Liu, G. (2021). Modelling waste generation and end-of -life management of wind power development in Guangdong, China until 2050. *Resources, Conservation and Recycling*, *169*, 105533. doi:10.1016/j.resconrec.2021.105533

Chesbrough, H. (2010). Business model innovation: Opportunities and barriers. *Long Range Planning*, *43*(2-3), 354–363. doi:10.1016/j.lrp.2009.07.010

Cong, L., Zhao, F., & Sutherland, J. W. (2019). A design method to improve end-of use product value recovery for Circular Economy. *Journal of Mechanical Design*, *141*(4), 044502. doi:10.1115/1.4041574

de los Ríos, I. C., & Charnley, F. J. S. (2017). Skills and capabilities for a sustainable and circular economy: The changing role of design. *Journal of Cleaner Production*, *160*, 109–122. doi:10.1016/j.jclepro.2016.10.130

den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a Circular Economy development of a typology of key concepts and terms. *Journal of Industrial Ecology*, *21*(3), 517–525. doi:10.1111/jiec.12610

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In D. A. Buchanan & A. Bryman (Eds.), *The Sage handbook of organizational research methods* (pp. 671–689). Sage Publications.

Dominish, E., Retamal, M., Sharpe, S., Lane, R., Rhamdhani, M. A., Corder, G., Giurco, D., & Florin, N. (2018). Slowing and Narrowing the flow of metals for consumer goods: Evaluating opportunities and barriers. *Sustainability*, *10*(4), 1096–1119. doi:10.3390u10041096

Dong, L., Fujita, T., Dai, M., Geng, Y., Ren, J. Z., Fuijii, M., Wang, Y., & Ohnishi, S. (2016). Towards preventative eco-industrial development: An industrial and urban symbiosis case in one typical industrial city in China. *Journal of Cleaner Production*, *114*, 387–400. doi:10.1016/j.jclepro.2015.05.015

Durán, A., del Río, M. C., & Álvarez, J. (2017). Bibliometric analysis of publications on wine tourism in the databases Scopus and WoS. *European Research on Management and Business Economics*, *23*(1), 8–15. doi:10.1016/j.iedeen.2016.02.001

Ellegaard, O., & Wallin, J. A. (2015). The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*, *105*(3), 1809–1831. doi:10.100711192-015-1645-z PMID:26594073

Ellen MacArthur Foundation. (2015). *Delivering the Circular Economy. A toolkit for policy makers. Resource document.* https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthurFoundation_PolicymakerToolkit.pdf

European Commission. (2015). *Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Closing the loop-An EU action plan for the Circular Economy. COM/2015/0614 final.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., & Barlow, C. (2017). Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models. *Business Strategy and the Environment*, *26*(5), 597–608. doi:10.1002/bse.1939

Evrard, D., Rejeb, H. B., Zwolinski, P., & Brissaud, D. (2021). Designing immortal products: A lifecycle scenario-based approach. *Sustainability, 13*(6), 3574.

Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., & Ribeiro-Soriano, D. (2020). Circular economy business models: The state of research and avenues ahead. *Business Strategy and the Environment*, *29*(8), 3006–3024. doi:10.1002/bse.2554

Fetscherin, M., & Heinrich, D. (2015). Consumer brand relationships research: A bibliometric citation meta-analysis. *Journal of Business Research*, *68*(2), 380–390. doi:10.1016/j.jbusres.2014.06.010

Fraccascia, L., Giannoccaro, I., & Albino, V. (2019a). Business models for industrial symbiosis: A taxonomy focused on the form of governance. *Resources, Conservation and Recycling*, *146*, 114–126. doi:10.1016/j.resconrec.2019.03.016

Gaur, J., & Mani, V. (2018). Antecedents of closed-loop supply chain in emerging economies: A conceptual framework using stakeholder's perspective. *Resources, Conservation and Recycling*, *139*, 219–227. doi:10.1016/j.resconrec.2018.08.023

Geissdoerfer, M., Morioka, S. N., De Carvalho, M. M., & Evans, S. (2018a). Business models and supply chains for the circular economy. *Journal of Cleaner Production*, *190*, 712–721. doi:10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. J. (2017). The Circular Economy-A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. doi:10.1016/j.jclepro.2016.12.048

Geissdoerfer, M., Vladimirova, D., & Evans, E. (2018b). Sustainable business model innovation: A review. *Journal of Cleaner Production*, *198*, 401–416. doi:10.1016/j.jclepro.2018.06.240

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, *114*, 11–32. doi:10.1016/j.jclepro.2015.09.007

Ghisellini, P., & Ulgiati, S. (2020). Circular economy transition in Italy. Achievements, perspectives and constraints. *Journal of Cleaner Production*, *114*, 11–32. doi:10.1016/j.jclepro.2015.09.007

Girard, L. F., & Nocca, F. (2019). Moving towards the circular economy/city model: Which tools for operationalizing this model? *Sustainability*, *11*(22), 6253. doi:10.3390u11226253

Gontard, N., Sonesson, U., Birkved, M., Majone, M., Bolzonella, D., Celli, A., Angellier-Coussi, H., Jang, G. W., Verniquet, A., Broeze, J., Schaer, B., Batista, A. P., & Sebok, A. (2018). A research challenge vision regarding management of agricultural waste in a circular bio-based economy. *Critical Reviews in Environmental Science and Technology*, *48*(6), 614–654. doi:10.1080/10643389.2018.1471957

Gunarathne, N., de Alwis, A., & Alahakoon, Y. (2020). Challenges facing sustainable urban mining in the e-waste recycling industry in Sri Lanka. *Journal of Cleaner Production*, *251*, 119641. doi:10.1016/j.jclepro.2019.119641

Hahladakis, J. N., & Iacovidou, E. (2018). Closing the loop on plastic packaging materials: What is quality and how does it affect their circularity? *The Science of the Total Environment*, *630*, 1394–1400. doi:10.1016/j.scitotenv.2018.02.330 PMID:29554759

Heyes, G., Sharmina, M., Mendoza, J. M. F., Gallego-Schmid, A., & Azapagic, A. (2018). Developing and implementing circular economy business models in service-oriented technology companies. *Journal of Cleaner Production*, *177*, 621–632. doi:10.1016/j.jclepro.2017.12.168

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. *Futures*, *82*, 15–25. doi:10.1016/j.futures.2016.05.012

Hughes, M. (2011). Do 70 per cent of all organizational change initiatives really fail? *Journal of Change Management*, *11*(4), 451–464. doi:10.1080/14697017.2011.630506

Hussain, Z., Mishra, J., & Vanacore, E. (2020). Waste to energy and circular economy: The case of anaerobic digestion. *Journal of Enterprise Information Management*, *33*(4), 817–838. doi:10.1108/JEIM-02-2019-0049

Jensen, J. P., Prendeville, S. M., Bocken, N., & Peck, D. (2019). Creating sustainable value through remanufacturing: Three industry cases. *Journal of Cleaner Production*, *218*, 304–314. doi:10.1016/j.jclepro.2019.01.301

Jørgensen, M. S., & Remmen, A. (2018). A methodological approach to development of circular economy options in business. *Procedia CIRP*, *69*, 816–821. doi:10.1016/j.procir.2017.12.002

Kalverkamp, M., & Young, S. B. (2019). In support of open-loop supply chains: Expanding the scope of environmental sustainability in reverse supply chains. *Journal of Cleaner Production*, *214*, 573–582. doi:10.1016/j.jclepro.2019.01.006

Karman, A. (2020). Towards crystallizing circular business models: A critical analysis of literature. *Journal of Sustainability Science and Management*, *15*(6), 175–194. doi:10.46754/jssm.2020.10.001

Koksharov, V., Starodubets, N., & Ponomareva, M. (2019). Assessment of an enterprise circular economy development. *WSEAS Transactions on Business and Economics*, *63*, 559–567.

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, *115*, 36–51. doi:10.1016/j.jclepro.2015.12.042

Linder, M., & Williander, M. (2017). Circular business model innovation: Inherent uncertainties. *Business Strategy and the Environment*, *26*(2), 182–196. doi:10.1002/bse.1906

López, F. J. D., Bastein, T., & Tukker, A. (2019). Business model innovation for resource-efficiency, circularity and cleaner production: What 143 cases tell us. *Ecological Economics*, *155*, 20–35. doi:10.1016/j.ecolecon.2018.03.009

Lüdeke-Freund, F., Gold, S., & Bocken, N. (2018). A review and typology of circular business model patterns. *Journal of Industrial Ecology*, *23*(1), 36–61. doi:10.1111/jiec.12763

Manninen, K., Koskela, S., Antikainen, R., Bocken, N., Dahlbo, H., & Aminoff, A. (2018). Do circular economy business models capture intended environmental value propositions? *Journal of Cleaner Production*, *171*, 413–422. doi:10.1016/j.jclepro.2017.10.003

Markov, T., & Font, V. (2018). Does the circular economy grow the pie? The case of rebound effects from smartphone reuse. *Frontiers in Energy Research*, *6*, 1–11.

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, *178*, 703–722. doi:10.1016/j.jclepro.2017.12.112

Moktadir, M. A., Ahmadi, H. B., Sultana, R., Tuj-Zohra, F., Liou, J. J. H., & Rezaei, J. (2020). Circular economy practices in the leather industry: A practical step towards sustainable development. *Journal of Cleaner Production*, *251*, 119737. doi:10.1016/j.jclepro.2019.119737

Mugge, R., Jocking, B., & Bocken, N. (2017). How to sell refurbished smartphones? An investigation of different customer groups and appropriate incentives. *Journal of Cleaner Production*, *147*, 284–296. doi:10.1016/j.jclepro.2017.01.111

Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, *140*(3), 369–380. doi:10.100710551-015-2693-2

Nußholz, J. L. K. (2017). Circular business models: Defining a concept and framing an emerging research field. *Sustainability*, *9*(10), 1810–1826. doi:10.3390u9101810

Nußholz, J. L. K., Rasmussen, F. N., & Milios, L. (2019). Circular building materials: Carbon saving potential and the role of business model innovation and public policy. *Resources, Conservation and Recycling*, *141*, 308–316. doi:10.1016/j.resconrec.2018.10.036

Oghazi, P., & Mostaguel, R. (2018). Circular business model challenges and lessons learned -An industrial perspective. *Sustainability*, *10*(3), 739–758. doi:10.3390u10030739

Perey, R., Benn, S., Agarwal, R., & Edwards, M. (2018). The place of waste: Changing business value for the circular economy. *Business Strategy and the Environment*, *27*(5), 631–642. doi:10.1002/bse.2068

Pesce, M., Tamai, I., Guo, D. Y., Critto, A., Brombal, D., Wang, X. H., Cheng, H. G., & Marcomini, A. (2020). Circular economy in China: Translating principles to practice. *Sustainability*, *12*(3), 832. doi:10.3390u12030832

Pla-Julián, I., & Guevara, S. (2019). Is the circular economy the key to transitioning towards sustainable development? Challenges from the perspective of care ethics. *Futures*, *105*, 67–77. doi:10.1016/j.futures.2018.09.001

Prendeville, S., & Bocken, N. (2017). Sustainable Business Models through service design. *Procedia Manufacturing*, *8*, 292–299. doi:10.1016/j.promfg.2017.02.037

Ramakrishna, S., Ngowi, A., Jager, H. D., & Awuizie, B. O. (2020). Emerging industrial revolution: symbiosis of industry 4.0 and circular economy: the role of Universities. *Science, Technology & Society*, *25*(3), 505–525. doi:10.1177/0971721820912918

Sacchi, A., Galvão, G., Gamboa, L., & Carvalho, M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, *175*, 525–543. doi:10.1016/j.jclepro.2017.11.064

Santa, S., & Herrero-Solana, V. (2010). Cobertura de la ciencia de América Latina y el Caribe en Scopus vs. Web of Science [Latin America and Caribbean Science Coverage in Scopus vs. Web of Science]. *Investigación Bibliotecológica*, *24*(52), 13–27. doi:10.22201/iibi.0187358xp.2010.52.27451

Schulte, U. G. (2013). New business models for a radical change in resource efficiency. *Environmental Innovation and Societal Transitions*, *9*, 43–47. doi:10.1016/j.eist.2013.09.006

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699–1710. doi:10.1016/j.jclepro.2008.04.020

Shukla, M., & Jharkharia, S. (2013). Agri-fresh produce supply chain management: A state-of-the-art literature review. *International Journal of Operations & Production Management*, *33*(2), 114–158. doi:10.1108/01443571311295608

Todeschini, B. V., Cortimiglia, M. N., & de Medeiros, J. F. (2020). Collaboration practices in the fashion industry: Environmentally sustainable innovations in the value chain. *Environmental Science & Policy*, *106*, 1–11. doi:10.1016/j.envsci.2020.01.003

Unal, E., & Shao, J. (2019). A taxonomy of circular economy implementation strategies for manufacturing firms: Analysis of 391 cradle-to-cradle products. *Journal of Cleaner Production*, *212*, 754–765. doi:10.1016/j.jclepro.2018.11.291

Ungerman, O., & Dedková, J. (2019). Model of the circular economy and its application in business practice. *Environment, Development and Sustainability*, *22*(4), 3407–3432. doi:10.100710668-019-00351-2

United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.* https://sustainabledevelopment.un.org/post2015/transformingourworld

van Weelden, E., Mugge, R., & Bakker, C. (2016). Paving the way towards circular consumption: Exploring consumer acceptance of refurbished mobile phones in the Dutch market. *Journal of Cleaner Production*, *113*, 743–754. doi:10.1016/j.jclepro.2015.11.065

Wang, X., Li, D., & Li, L. (2009). Adding value of food traceability to the business: A supply chain management approach. *International Journal of Services Operations and Informatics*, *4*(3), 232–237. doi:10.1504/IJSOI.2009.026951

Weissbrod, I., & Bocken, N. (2017). Developing sustainable business experimentation capability-A case study. *Journal of Cleaner Production*, *142*, 2663–2676. doi:10.1016/j.jclepro.2016.11.009

Yang, M. Y., Smart, P., Kumar, M., Jolly, M., & Evans, S. (2018). Product-service systems business models for circular supply chain. *Production Planning and Control*, *29*(6), 498–508. doi:10.1080/09537287.2018.1449247

Yu, D., & Hang, C. C. (2010). A reflective review of disruptive innovation theory. *International Journal of Management Reviews*, *12*(4), 435–452. doi:10.1111/j.1468-2370.2009.00272.x

Zhu, Q., Geng, Y., & Lai, K. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management*, *91*(6), 1324–1331. doi:10.1016/j.jenvman.2010.02.013 PMID:20223586

Zucchella, A., & Previtali, P. (2019). Circular business models for sustainable development: A "waste is food restorative ecosystem". *Business Strategy and the Environment*, *28*(2), 274–285. doi:10.1002/bse.2216

Zufall, J., Norris, S., Schaltegger, S., Revellio, F., & Hansen, E. G. (2020). Business models patterns of sustainability pioneers -Analizing cases across the smartphone life cycle. *Journal of Cleaner Production*, *244*, 118651. doi:10.1016/j.jclepro.2019.118651

# Chapter 11
# Fostering Circular Economy in Urban Areas

**K. Orkun Aktaş**
*Kirikkale University, Turkey*

**Can B. Aktaş**
*TED University, Turkey*

## ABSTRACT

*The 21st century is an urban world. Strategies that aim to tackle the urban material challenge and promote circular economy are necessary to achieve sustainable development. Having established the importance of circular economy towards sustainable development, this study presents applicable strategies to reduce consumption and promote circularity specifically in urban centers. Main strategies may be categorized into three areas: reducing material use through better design, efficient manufacturing and processing, and more intensive recycling. For materials use reduction, dematerialization, appropriate design based on product service lifetime, design for X principles and extended producer responsibility are identified as prominent design approaches or policies. For effective manufacturing and processing, the implementation of best available technologies and additive manufacturing were identified to have potential significant impact. For end-of-life phase management, differences between upcycling, recycling, and downcycling require targeted industry-specific policies.*

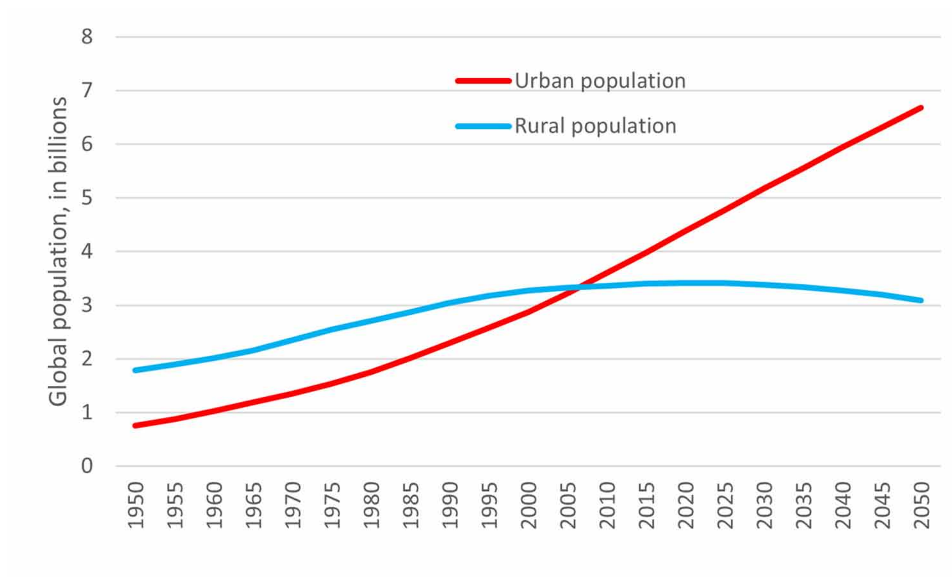
## INTRODUCTION

From a human development and civilization perspective, the 21st century is and will continue to be an urban world. For the first time in human history, in 2007, global human population living in urban centers has exceeded those living in rural areas as demonstrated in Figure 1 (UN, 2018). The growth of the urban population has continued to increase linearly following 2007 up to 2017 which was the latest year on record with reliable global data. On the other hand, the rural population has increased at a much slower pace since 2007 (Ritchie and Roser, 2018). However, what is more striking in these trends is the forecasts for the 21st century. The global urban population is expected to continue to increase at the same

DOI: 10.4018/978-1-7998-8482-8.ch011

steady pace up to mid-century, thereby reaching 6.7 billion by 2050, and recording a staggering increase of almost 6 billion between 1950-2050. The trend may be expected to continue to increase following mid-century. On the other hand, global rural populations were expected to peak at 2021, the year of this writing, and then start a steady decline which continues at least up to mid-century. The expected 2050 rural population of 3.1 billion indicates a decline to early 1990s levels. In terms of percentages, 68% of global population is expected to reside in urban areas by 2050.

*Figure 1. Population trends in rural and urban populations globally between 1960-2017, and forecasts leading up to mid-century (UN, 2018)*




With increased public interest and recognition towards sustainability, it is necessary to update our approach towards resolving global sustainability challenges we face. The statistics on urbanization trends indicate that today as well as the 21st century will be an urban world. Hence, that is where most of the sustainability efforts must focus to achieve desired gains. Material consumption is fundamental to many sustainability problems of today. Having established the importance of material consumption towards sustainable development this study presents applicable strategies to reduce material consumption specifically in urban centers. More specifically, material use strategies from product design phase to end-of-life phases have been evaluated within the text.

## Role of Circular Economy in Urban Areas for Sustainable Development

There have been international efforts to address the pressing issues of our times. One of the landmark reports on the subject was the UN Report of the World Commission on Environment and Development 'Our Common Future', more commonly known as the Brundtland Report. The report is significant for a number of reasons. It is one of the first international reports that identifies sustainable development as a goal that needs to be strived for to alleviate global problems faced when the report was written in

1987. The report also had a chapter dedicated to 'The Urban Challenge', where many of the problems that are being observed today were foreseen (WCED, 1987). This indicates that the challenges we face today were not completely unknown, but rather are the accumulation of problems over the past decades. More recently, the '2030 Agenda for Sustainable Development' adopted by UN member states in 2015 embodies 17 concrete Sustainable Development Goals (SDGs), which includes set goals and lay out the path to achieve them. Examination of SDGs reveals that handling the urban materials challenge would directly address SDGs 11 and 12, namely 'Sustainable Cities and Communities', and 'Responsible Consumption and Production', respectively. Furthermore, the urban materials challenge indirectly touches on several other SDGs when a life cycle perspective is applied including health and well-being, clean water and sanitation, economic growth, industry and innovation, climate action, and life in the biosphere (UN SDG, 2020). In fact, its significant impact on multiple SDGs indicate that it needs to be evaluated seriously with clear goals, strategies, and science-based targeted policies to reduce impacts. Hence, tackling the materials challenges specific to urban centers would enable significant progress towards achieving global SDGs set out by the UN and adopted by member countries.

In addition to constituting more than half of global human population, the urban population is responsible for consuming an even higher share of global resources when direct and indirect material flows are accounted for. The materials that matter most, and therefore have high consumption rates are (Smil, 2014): biomaterials; construction materials; metals; plastics; industrial gases; fertilizers and materials in electronics. The majority of some on this list such as construction materials, plastics, and industrial gases are directly used in urban areas. However, even other materials such as biomaterials, fertilizers, and materials in electronics are indirectly consumed by the urban population if the end user is tracked rather than the point of extraction of such materials. With urban populations having a higher per capita material consumption rates than rural populations, combined with a higher share of global population living in urban areas, material consumption, waste generation, and associated environmental problems clearly shift towards urban areas.

## EFFECTS OF URBANIZATION

The foreseeable future of the human race appears to be an urban one. That by itself is not the problem, although there are economic, societal, and environmental implications. The main issue, at least environmentally, is the increasing consumption of materials that are being concentrated in urban areas. There are multiple factors at play here: increasing urban populations; higher economic activity in urban areas that have traditionally been coupled with increased material consumption; the urban pace of life requiring faster mobility, accessibility, and transportation to enable them; and other social and economic factors that shape residents' lives in urban areas. These are discussed in this section with implications for materials use.

### Social and Economic Impacts of Urbanization

Urbanization result in significant societal and economic change in societies. Among the more important changes from a societal perspective are: large families replaced with the core family; better integration of women into the workforce and associated improvements in social standing; better access to education and healthcare opportunities, reduction in fertility rates and the realization of the demographic transition.

On the other hand, besides these positive impacts, urbanization is also reported to bring about loneliness and anxiety, and be a contributor for depression (Bradbury et al., 2007).

Among the main drivers of urbanization is economic factors. Urbanization may be deemed to bring positive economic change to society. The diversity of commercial opportunities in urban areas including for services, easier access to technology and equipment that leads to increases in productivity, and increased availability of transportation modes that enables quick access to markets may be listed as positive economic factors brought by urbanization. Furthermore, increased purchasing power enabled by increased income is an important economic driver too.

Most, if not all, societal and economic impacts of urbanization have material consumption implications. However, they should not be seen as negative phenomenon, nor something that can be or should be stopped. Increasing global urbanization rates indicate that humans are willingly moving to urban areas, and even to urban areas with substandard housing, for prospects of a better life. Therefore, the individual incentive still appears to favor urban living compared to rural life. In fact, some factors listed above such as improved education and training opportunities, more and easier access to technology, improved income, and improved standing of women in society are positive factors that governments around the globe try to promote. On the other hand, they also happen to increase material consumption. The solution then may come from better decision-making and planning for minimizing impacts by improving efficiency and minimizing waste by facilitating a transfer to circular economy, and not from trying to reverse the societal and economic factors listed above.

## Environmental Effects of Urbanization

The environmental effects of urbanization span a diverse list of effects and impacts. This has led to the need for a common metric at the macro-scale to compare impacts. Like in many fields of sustainable development, greenhouse gas emissions have been commonly used to assess environmental impacts of urban areas. Hence, the environmental impacts of urbanization have frequently been expressed in terms of greenhouse gas emissions as the metric of choice.

Three major aspects have been identified in studies that link environmental impact with greenhouse gas emissions at the country level: economic growth; international trade; and urbanization (Adedoyin et al. 2020; Nathaniel and Khan, 2020). Ssali et al. (2019) have stated that the development rate of nations increases the need for energy resources. On the other hand, energy consumption is proven to be in positive correlation with increase in emissions. Dogan and Turkekul (2016) have proposed a relationship between greenhouse gas emissions and urbanization. In their study researchers identified a meaningful and dual relationship between emissions, gross domestic product, and urbanization. In another study by Baek et al. (2009), results indicate that international trade and growth in income tend to raise environmental conditions in developed countries, but result in environmental pollution to occur in developing countries. Hossain (2011) states that greenhouse gas emissions, energy consumption rates, economic progress, international trade, and urbanization in developed countries are interrelated.

It can be concluded that urbanization brings about increased environmental impacts, mainly due to increased economic activity and changing social patterns and preferences. Increased mobility, increased purchasing power and access to more products, access to products obtained from international markets that need shipment over long distances, increased share of built infrastructure per capita in urban areas contribute towards increasing environmental impact of urbanization. However, as was stated in the preceding section, the solution may come from better decision-making and planning for minimizing impacts through a transition to circular economy, and not from trying to reverse global urbanization trends.

## Built Environment and Urbanization

The emerging global trend for human populations in a globalized world seems to be that of densely accommodating urban areas. This growth is fueled by rapid population growth and the global migratory trend of moving from rural to urban areas. Civic dwellings when concentrated in local areas result in obligatory modifications regarding the spatial organizations besides economic and social adjustments. Such modifications exceed the visible territorial borders of cities thus having a larger footprint. Resources needed in urban areas are not obtained from within urban boundaries, but rather are derived from and transported from places afar. Therefore, the material impacts of urban areas exceed the visible built environment with buildings, pavements, and other essentials, but also span its mostly invisible infrastructure such as pipe networks underneath the city, or power lines that bring essential electricity from factories far away. Furthermore, raw material extraction that takes place in rural areas mostly serves the needs of the urban population, necessitating additional infrastructure elements for storage, transportation, and processing of materials, and thus copious amounts of construction materials to construct and upkeep the built environment. Hence, the built environment has undergone great expansion in the past century in line with global urbanization trends.

There are also positive results of urbanization with respect to availability and scale of the built environment in urban areas. Increased population density and higher concentration of material consumption in a smaller region presents opportunities to plan, implement, and manage measures and initiatives to reduce environmental footprint. An example might be the collection, processing, and recycling of municipal solid waste, which requires additional infrastructure elements to successfully and feasibly carry out. Overall, urbanization may lead to lower costs per capita in the provision of public services (Ling, 2005). Hence, urbanization should not only be seen as the problem but also as the solution to managing the environmental impacts of a growing global human population. More specifically, the solution needs to come from management of materials consumption related to urban living. Failure to do so, or a continuation of business as usual, may render the achievement of the UN SDGs virtually impossible.

# REDUCING MATERIAL CONSUMPTION

Global urbanization trends together with its societal, economic, and environmental impacts together with their implications for sustainable development, and for the UN SDGs specifically, were stated in the preceding section. It is not urbanization per se that is driving the impacts, but rather urban materials consumption that has been identified as a leading cause of urban impacts. Thus, strategies that aim to tackle the urban material challenge are necessary to achieve sustainable development. Such strategies may be focused on the pre-manufacturing phase including raw materials extraction, the manufacturing phase, the use phase, or the end-of-life phases.

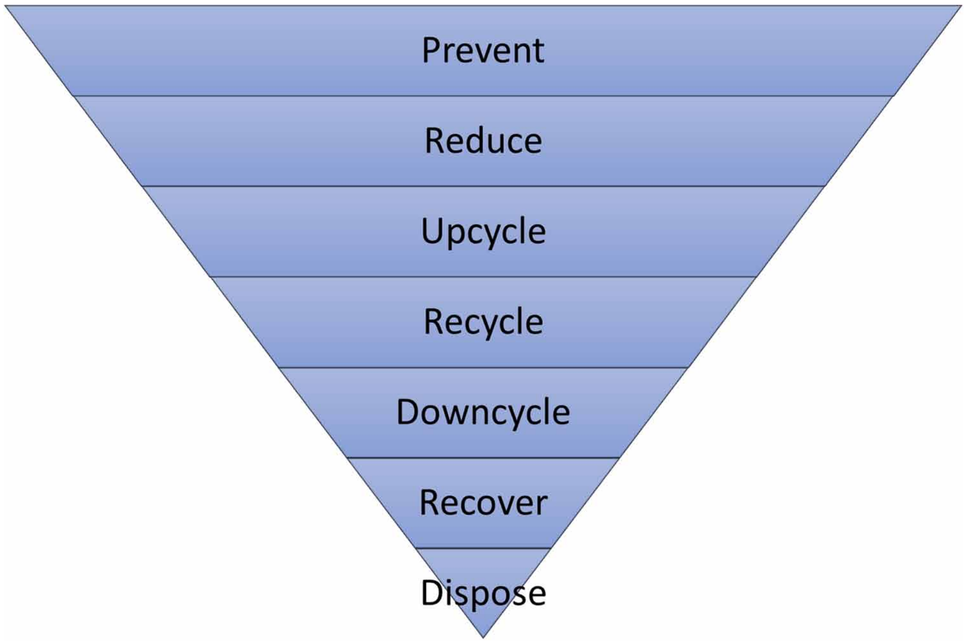
Regarding strategies that aim to reduce material consumption by focusing on end-of-life, there needs to be a paradigm shift on our approach to waste. The concept of 'waste' may be defined in association to the production processes, or as the ultimate result of materials used and discarded by consumers. By-products that do not have a practical application may be used as an example for the former, whereas products with expired healthy use, substances that are degraded or subjected to misuse may be an example for the latter type. Either way, it is paramount to consider waste when evaluating impacts of urban areas and their material needs. In general, waste refers to all kinds of substances created as a result of any activity, thrown or released into the environment. Data on 27 member countries of the European Union indicate that 30-50 billion $m^3$ of waste material has been generated in the last 50 years and this amount has been mostly used in landfilling (Vossen, 2013). Traditionally, waste was regarded as pollution, a nuisance that needed to be hidden, carried out of sight, and often, ultimately landfilled. With rising awareness towards global environmental issues, concepts that aim to reduce or altogether eliminate waste has received renewed attention. The concept of Zero Waste refutes the assumption that some waste is unavoidable and has no value, by focusing on waste avoidance to begin with, and seeking ways to incorporate waste back into the economy if its creation is inevitable.

Environmental impacts of urban areas may be mitigated or lessened to a great degree should waste not be seen as something to get rid of, but rather an opportunity. It is known that there are various applications regarding waste materials. Among these, storage, incineration, recycling, re-production and new material production methods have various effects on the environment. In terms of the monetary value of the wastes, burning, storage, and recycling methods decrease the value of the wastes, hence lead to downcycle. However, remanufacturing and new material production methods are applications that increase the value of wastes that enable upcycling.

Despite decades of technological and material innovations and improvements at various stages of production and a product's life cycle, there still remain substantial opportunities for improving efficiency and therefore wasting less (Smil, 2014). Main application fields may be categorized into three areas: reducing or avoiding material use through better design or through material substitutions; more efficient manufacturing; and more intensive recycling. From a product life cycle perspective, the above may be classified as the raw material acquisition and design phases, manufacturing phase, and end-of-life phase. Managing the sustainable materials challenge requires a diverse range of approaches and strategies geared towards each life cycle phase as priorities and realities of each phase cannot be extrapolated to others. These categories will be discussed in this section.

The preferred order to manage waste is presented in Figure 2, with management techniques towards the top being the more preferable ones. The ideal approach would be to prevent waste generation altogether. Should some waste be inevitable, design strategies and mechanisms to reduce amount of waste should be employed. Then comes a series of material reuse options such as upcycling, recycling, and downcycling, in decreasing preferential order. Although all three result in material circularity, there are technical differences among them which are covered in the latter sections. Towards the end of the list of strategies are material recovery and dispose. Material recovery is not a desirable management strategy as you lose most of the value of the recovered material. Burning or incinerating combustible materials for heat or energy generation is an example to recovery. While some gains are made to offset energy, the strategy has significant environmental impacts. The least desirable technique would be to dispose of waste in a landfill. All value embedded in materials are lost, and furthermore, the landfill itself becomes a public burden economically, socially, and environmentally. Hence, this option should be avoided wherever possible. Efficiently handling materials for sustainable development requires moving away from the latter options towards the ones at the top of the diagram. Unfortunately, current materials and waste management practices resemble more a pyramid shape, rather than the reverse pyramid diagram indicated by the hierarchy in Figure 2. Thus, there are important advances necessary to reverse the trend.

*Figure 2. Hierarchy to manage waste (EPA, 2017; ZWE, 2019). Preferred solutions towards the top, and strategies to avoid are towards the bottom.*




## Reducing Material Use Through Better Design

The ideal approach would be to prevent waste generation altogether. Should some waste be inevitable, design strategies and mechanisms to reduce amount of waste should be employed.

This may be partially achieved through dematerialization. A direct and efficient way would be to increase efficiency of materials use for products and services. In practice, with passing time and improved technology available to industrial sectors, material efficiencies rise as corporations find new and better ways to deliver products or services by using less resources. Many dematerialization successes may in fact fall into this category. Another method where dematerialization may be achieved is through materials substitution. Industries may opt for alternative materials for a variety of reasons. Economic reasons being among the top, there have been other reasons for material transition such as for lighter alternatives in transportation vehicles to reduce fuel consumption, or to switch from environmentally harmful materials to benign alternatives due to corporate social responsibility, or due to fear of a public backlash.

The increasing turnover speed of consumer products have been affecting people's lifestyles, more so in urban centers compared to rural areas due to socioeconomic factors among others. Accordingly, the useful life of products has shortened and periodic renewal of products has become the norm for many established industries spanning electronics and clothing to construction. It is not always necessary for products to complete their lifecycles for their renewal and change, a process characterized by a divergence between design and service lifetimes of products (Aktas and Bilec, 2012). This is a global problem that appears to be challenging to tackle as it is more socioeconomic rather than technical, hence that is where the solution needs to come from. On the technical side, designers should move away from aiming to design for eternity, but rather should factor in market forces and realities to design products appropriately.

A product design approach that has gained recognition is Design for X. The topic is studied as a subset of industrial ecology. The X may be replaced with manufacturability, recycling, disassembly, serviceability, or environment to name a few. A set of specific design guidelines may be used for each design goal. With the widespread use of modern computer aided design tools available to designers, it should not be difficult to incorporate ideas and design strategies that facilitate disassembly and recycling at the end of product lifetime. This would be especially beneficial for increasing the recycling rates of electronic waste, which brings a special subset of environmental problems due to the nature of materials, elements such as heavy metals, and manufacturing techniques that require high refining and thus energy necessary in its creation. However, these tools and techniques rarely are implemented in practice (Smil, 2014).

A concept that is increasing in recognition globally is Extended Producer Responsibility, where the development of an environmental protection strategy that places the responsibility on the producer throughout the entire life cycle of the product and for all subsequent recycling, recycling and disposal processes (Gülenç, 2010). With growing public recognition of environmental problems and associated demands that policies be enacted to limit impacts, it may be reasonable to expect to hold companies responsible for environmental impacts that occur throughout the lifecycle of products rather than the current focus on manufacturing only. Such policy measures would promote adoption of preferred solutions presented in the hierarchy to manage waste diagram. Therefore, it may be seen as an indirect, but equally effective strategy to manage urban materials consumption.

## More Efficient Manufacturing and Processing

Perhaps the most indirect way to reduce material consumption remains with manufacturing industries. This strategy does not require new innovation or novel technologies, but rather the application of best practices that already exist. An analysis by Jacobs and IPST (2006) have determined that application of best available technologies in the paper and pulp industry would reduce energy consumption by 26% compared to then average manufacturing energy. Gains in energy efficiency do not remain limited to energy, but have significant material and environmental implications too, primarily as a result of fossil fuel use reduction and associated environmental impacts. Savings in energy in the order of 20-30% was estimated to be within reach for many other industries by the application of best available technologies (Smil, 2014).

Among novel manufacturing technologies, additive manufacturing holds the most promise in reducing materials consumption, where parts and products are printed in three-dimensional physical form from a digital 3D model. Advantages brought about by additive manufacturing include rapid prototyping, and the ability to produce parts with complex geometries that would be very difficult to obtain through traditional approaches. The technology has progressed sufficiently and now is being used for commercial purposes in industries spanning manufacturing industries, medical field, education, and safety. The technology is not limited to producing prototypes of parts and products, but with a capacity to use different materials in printing, may produce or manufacture the intended part or product itself. From a purely materials perspective, this approach significantly improves material and energy efficiency for manufacturing, with a potential 97% reduction of manufacturing waste, and 90% reduction reported compared to traditional subtractive manufacturing (Peng et al., 2018). Beyond direct manufacturing gains, the technology also has the potential to produce products on-site with rapid sharing of digital information, thereby reducing the need for long-distance transportation. It may be expected that application examples will diversify and scale of application grow bolder with further advancements in this technology.

Though not directly part of manufacturing, packaging that immediately follows the manufacturing step is an important consumer of resources as well. There is proliferation of packaging material used for individual wrapping of products, which are often discarded soon after delivery or purchase. Packaging remains a hidden material flow in most analysis perhaps as it appears small compared to the product it aims to protect, but when looking at cumulative impacts, there was about 16 million tons of packaging material consumed in the EU in 2008, with a per capita consumption of about 30 kg. Its global impact combined with the passage of more than a decade is of course much higher today. The EU 'Packaging and Packaging Waste Directive' set specific targets of 65% and 70% reduction of packaging materials for 2025 and 2030, respectively. Among other rules, EU countries need to ensure that extended producer responsibility schemes are established for all packaging (EC, 2021). Such directives are important not for their direct contribution towards reducing impacts, but to also demonstrate that such targets and gains may be achieved with current technologies if there is a will. Application of similar laws and regulations in other countries would aid a global reduction of packaging materials use.

## More Intensive Recycling

Even though urban populations enjoy a higher per capita material consumption than rural populations, from an environmental management strategy, this brings certain opportunities. More specifically, increased population density enables several waste management strategies that would not be possible or feasible with the low-density settlements typical of rural areas. Solutions may come in the form of new industries and commercial activity, or via civil infrastructure solutions. This includes collecting, sorting, processing, and recycling of waste for the majority of solid waste, or being able to fund and operate wastewater infrastructure networks in large urban centers, better management of point sources for other forms of pollution to land or air. The distributed nature of such pollution in rural areas makes it more difficult, but not impossible, to implement environmental strategies effectively and feasibly.

With increasing urbanization rates coupled with rising population has brought the concept of urban waste, and its management to the forefront. Rightly so, as current estimates put global urban waste quantities at 2 billion tons of municipal solid waste per year (Wilson, 2015). Municipal solid waste systems that mainly serve urban populations are under pressure to sustain the load and international institutions from the World Bank's Urban Development Division to the United Nations Environmental Programme has raised alarm to direct attention to problems around waste. Based on the 2013 World Economic and Social Survey, reduction of waste generation, and mechanisms and strategies to improve waste collection and its management including recycling systems are among the pressing challenges of our times, where investments in such strategies are needed in most urban areas globally (UN DESA, 2013). The European Union had initiated policy efforts before such reports, with the Circular Economy Directive being among the more direct approaches to managing waste, including for example mandating 50% recycling of urban waste by 2020, as well as facilitating the reuse of waste at the source through replacing raw materials with recycled content at manufacturing plants (Knickmeyer, 2020).

Recycling in general may be classified into categories by comparing the end product produced with initial materials used as feed. Upcycling indicates that recycled materials are used in technically advanced applications. There are multiple success stories of companies applying upcycling and making environmental and economic gains as a result. Having materials such as metals at higher concentrations to begin with compared to concentrations of raw materials extracted from the Earth makes upcycling attractive for a range of industries including technology companies. Then there is recycling in a technical sense, where recovered waste materials are reused to produce products of similar value and function. Recycling materials is another method aimed at reducing pressures on raw materials extraction. History of materials recycling at the industrial scale goes back several decades. Benefits of recycling include a reduction in primary materials use due to offset by available secondary materials, less materials extraction, and reduced waste disposed to the environment. A common example for this would be glass or aluminum recycling. If that is not possible technically, recovered materials may be downcycled to be used in less technically demanding applications, such as reusing recovered plastic bags as bench material as recycled plastic fibers do not possess the same tensile strength to produce plastic bags identical to the original product.

For all forms of material recycling from municipal urban waste, pre-sorting of waste by residents is a pre-condition for the feasibility and effectiveness of the recycling program (Varotto and Spagnolli, 2017). Therefore, efficient recycling systems depend on how much and how well the public participates in the recycling effort. However, Miafodzyeva and Brandt (2013) have found that densely populated urban areas perform poorly compared to less densely populated areas. This result may come as a surprise, and indicate that more needs to be done to raise awareness in densely populated urban areas together with ideally coupling such efforts with policy measures through taxation or subsidies. Also, the social aspects of recycling and factors affecting individual participation or not need to be better understood to improve the effectiveness of urban recycling. Research indicate that family size and household income, correlated with density and standard of living, are primary determinants of household waste, while the effect of environmental awareness on waste generation is rather small (Knickmeyer, 2020; Lehmann, 2011).

## Considerations for Upcycling, Recycling, and Downcycling

Waste management strategies that align mid-tier along the hierarchy to manage waste involve different forms of recycling. Although similar in some aspects, there are important differences among them. It would be a missed opportunity to use recycled materials in downcycled products when an alternative to use in upcycled products exists. Such decisions may be deemed to be equally wasteful as not managing materials in the first place. Therefore, both designers and decision-makers need to be sufficiently aware of differences among waste management strategies.

Although there is more than one method related to the down or up cycling of wastes, two concepts will be emphasized here. The first concept of recycling has been expressed as the recycling of waste materials. Recycling may be defined as re-integrating waste into the production process by transforming materials into secondary raw materials through processes. These processes may involve chemical or physical processes, or both. However, it is not always possible to convert the waste material to its pre-manufacturing state by going through chemical processes. The use of waste materials through physical changes is also considered within the recycling activity.

Downcycling is the process of recycling waste material into uses and products of lower quality or lower functionality items compared to the feedstock. Contamination during primary use phase of the material is a common reason for downcycling. High purity materials in products may come into contact with other elements that may cause impurities, or lessen the purity of the main element, thus requiring costly and energy intensive processes to reverse contamination. Rather, the contaminated material may be used to produce materials and products that do not have stringent specifications or in less technically demanding applications. Less desirable than upcycling or recycling, downcycling still has the advantage of keeping primary materials in use longer, contributing to circular economy, and reducing environmental impacts associated with primary raw material extraction and processing.

It should be remembered that recycling is not a completely benign process in itself. While the amount of existing waste is reduced, energy and materials are used for recycling, which have their own environmental impacts. The goal therefore should be to make sure such added impacts do not completely offset potential gains due to recycling.

Upcycling on the other hand aims to make better use of materials, from waste or used products, by incorporating them in more sophisticated, technically advanced, or demanding applications. There are commercial companies performing upcycling applications worldwide. It is noted that upcycling practices are generally driven by consumer preferences. General opinion on the upcycling applications carried out by the relevant companies is that the upcycling of high-quality products is a more profitable practice than low-priced products (Larsson, 2018). Ideally, a material that completes its life cycle and becomes waste in this product cycle constitutes the raw material of another product cycle (McDonough and Braungart, 2002). The use of waste materials in the manufacture of a new product within the scope of upcycling applications includes advantages related to more efficient use of embedded energy, production of higher quality products thereby making better use of existing refined materials, and reduced environmental impacts overall.

## CONCLUSION

The future of global human societies appears to be an urban one. Although there are economic, societal, and environmental implications of increased urbanization, that by itself is not the problem. The main issue, at least environmentally, is the increasing consumption of materials that are being concentrated in urban areas. There are multiple factors at play here: increasing urban populations; higher economic activity in urban areas that have traditionally been coupled with increased material consumption; the urban pace of life requiring faster mobility, accessibility, and transportation to enable them; and other social and economic factors that shape residents' lives in urban areas. As a result, in addition to constituting more than half of global human population, the urban population is responsible for consuming an even higher share of global resources when direct and indirect material flows are accounted for.

Even though urban populations enjoy a higher per capita material consumption than rural populations, from an environmental management strategy, this brings certain opportunities. More specifically, increased population density enables several waste management strategies that would not be possible or feasible with the low-density settlements typical of rural areas. Thus, urban areas are their economies are ideal locations to implement circular economy practices to make best use of materials.

The global material challenge is a consumption problem. Future projections for sustainability will have to maintain a certain level of balance among material extraction, consumption, reuse, and ultimate waste. The solution may be approached from multiple angles. While measures should be taken to reduce demand on the consumption side, careful consideration must be dedicated to product design, manufacturing, and distribution phases of products. The hierarchy for waste management provides some guidance on what to aim for when designing products or systems.

Material use strategies spanning product design phase, manufacturing phase, use phase, and end-of-life phase and related waste management options have been evaluated. The most prominent strategies may be categorized into three areas: reducing material use through better design; efficient manufacturing and processing; and more intensive recycling. For materials use reduction, dematerialization, appropriate design based on product service lifetime, Design for X principles, and extended producer responsibility were identified as prominent design approaches or policies. Application of one does not preclude the use of other techniques, but rather reinforces the other. For gains towards effective manufacturing and processing, the implementation of best available technologies rather than the need for invention of novel technologies, additive manufacturing, and a focus on packaging were identified to have potential significant impact on materials use reduction. For end-of-life phase management of materials, the differences between upcycling, recycling, and downcycling need to be understood with targeted industry specific policies. Identified strategies applied fully or jointly would aid in reducing material pressures and consumption in urban areas thereby contributing towards meeting multiple UN Sustainable Development Goals set forth and adopted by member states.

## REFERENCES

Adedoyin, F. F., Nathaniel, S., & Adeleye, N. (2020). An investigation into the anthropogenic nexus among consumption of energy, tourism, and economic growth: Do economic policy uncertainties matter? *Environmental Science and Pollution Research International*, *28*(3), 2835–2847. doi:10.100711356-020-10638-x PMID:32895794

Aktas, C. B., & Bilec, M. M. (2012). Service life prediction of residential interior finishes for life cycle assessment. *The International Journal of Life Cycle Assessment*, *17*(3), 362–371. doi:10.100711367-011-0367-6

Baek, J., Cho, Y., & Koo, W. W. (2009). The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics*, *68*(8-9), 2255–2264. doi:10.1016/j.ecolecon.2009.02.021

Bradbury, A., Tomilnson, P., & Millington, A. (2007). Understanding the Evolution of Community Severance and its Consequences on Mobility and Social Cohesion Over the Past Century. *Proceedings of the European Transport Conference 2007*.

Dogan, E., & Turkekul, B. (2016). $CO_2$ emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research International*, *23*(2), 1203–1213. doi:10.100711356-015-5323-8 PMID:26351068

EC. (2021). *Packaging and Packaging Waste Directive.* European Commission. https://ec.europa.eu/environment/topics/waste-and-recycling/packaging-waste_en#ecl-inpage-508

EPA. (2017). *Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy.* United States Environmental Protection Agency. https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

Hossain, M. S. (2011). Panel estimation for $CO_2$ emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy*, *39*(11), 6991–6999. doi:10.1016/j.enpol.2011.07.042

Jacobs and IPST. (2006). *Pulp and Paper Industry: Energy Bandwidth Study.* Institute of Paper Science and Technology, Georgia Institute of Technology, Atlanta, GA. https://www.energy.gov/sites/prod/files/2013/11/f4/doe_bandwidth.pdf

Knickmeyer, D. (2020). Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. *Journal of Cleaner Production*, *245*, 118605. Advance online publication. doi:10.1016/j.jclepro.2019.118605

Larsson, M. (2018). *Circular Business Models - Developing a Sustainable Future*. Palgrave Macmillan. doi:10.1007/978-3-319-71791-3

Lehmann, S. (2011). Optimizing Urban Material Flows and Waste Streams in Urban Development through Principles of Zero Waste and Sustainable Consumption. *Sustainability*, *3*(1), 155–183. doi:10.3390u3010155

Ling, O. G. (2005). *Sustainability and Cities: Concept and Assessment*. Institute of Policy Studies. doi:10.1142/5755

McDonough, W., & Braungart, M. (2002). Cradle to Cradle: Remaking the Way We Make Things. North Point Press.

Miafodzyeva, S., & Brandt, N. (2013). Recycling behaviour among householders: Synthesizing determinants via a meta-analysis. *Waste and Biomass Valorization*, *4*(2), 221–235. doi:10.100712649-012-9144-4

Nathaniel, S., & Khan, S. A. R. (2020). The Nexus Between Urbanization, Renewable Energy, Trade, and Ecological Footprint in ASEAN Countries. *Journal of Cleaner Production*, *272*, 122709. Advance online publication. doi:10.1016/j.jclepro.2020.122709

Peng, T., Kellens, K., Tang, R., Chen, C., & Chen, G. (2018). Sustainability of additive manufacturing: An overview on its energy demand and environmental impact. *Additive Manufacturing*, *21*, 694–704. doi:10.1016/j.addma.2018.04.022

Ritchie, H., & Roser, M. (2018). *Urbanization. Published online at OurWorldInData.org*. Retrieved from: https://ourworldindata.org/urbanization

Smil, V. (2014). *Making the modern world: materials and dematerialization*. Wiley.

Ssali, M. W., Du, J., Mensah, I. A., & Hongo, D. O. (2019). Investigating the nexus among environmental pollution, economic growth, energy use and foreign direct investment in 6 selected sub-saharan african countries. *Environmental Science and Pollution Research International*, *26*(11), 11245–11260. doi:10.100711356-019-04455-0 PMID:30796658

UN. (2018). *World Urbanization Prospects: The 2018 Revision*. United Nations, Department of Economic and Social Affairs, Population Division. https://population.un.org/wup/DataQuery/

UN DESA. (2013). *World Economic and Social Survey 2013*. United Nations Department of Economic and Social Affairs (UN DESA). https://www.un.org/en/development/desa/policy/wess/wess_current/wess2013/WESS2013.pdf

UN SDG. (2020). *The 17 Goals – Sustainable Development Goals*. United Nations Department of Economic and Social Affairs (UN DESA). https://sdgs.un.org/goals

Varotto, A., & Spagnolli, A. (2017). Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. *Journal of Environmental Psychology*, *51*, 168–188. doi:10.1016/j.jenvp.2017.03.011

Vossen, V. W. (2013). *Feasibility Study Sustainable Material and Energy Recovery from Landfills in Europe*. Istanbul International Solid Waste, Water and Wastewater Congress, Istanbul.

WCED. (1987). *Our Common Future. World Commission on Environment and Development*. Oxford University Press.

Wilson, D. C. (2015). *Global Waste Management Outlook*. United Nations Environment Programme (UNEP). https://digitallibrary.un.org/record/1324051

ZWE. (2019). *Zero Waste Hierarchy, Press Release: A Zero Waste hierarchy for Europe.* Zero Waste Europe. https://zerowasteeurope.eu/2019/05/press-release-a-zero-waste-hierarchy-for-europe/

# Chapter 12
# European Manufacturers Towards the Circular Economy:
## Barriers That Hinder the Effective Implementation

**Alessia Pisoni**
*University of Insubria, Italy*

**Fabio Sirigu**
*University of Insubria, Italy*

## ABSTRACT

*The chapter aims at investigating the barriers that overall hinder the implementation of the circular economy (CE) principles within the European manufacturing sector. Based on an in-depth literature review carried out with a systematic approach, the chapter aims at identifying and in-depth describing the external and internal barriers that affect the implementation of CE principles. In the end, a comprehensive map of such barriers and possible ways to overcome these are reported as the main contributions of the study.*

## INTRODUCTION

The current linear production and consumption model is increasingly proving to be unsuitable to ensure both a healthy environment and, clearly, the health of the entire humanity (Geissdoerfer et al., 2017; Gusmerotti et al., 2019; Kirchherr et al., 2017; Schröder et al, 2020). The consequences triggered by this model are evident to everybody: starting from global warming, this is the cause of glacial melting, the rise of ocean levels, widespread fires, strange atmospheric events, the loss of animal and plant species, and so on (EMAF, 2019). Therefore, the question arises: how did we get to this point?

The origins can be mainly traced back to the growing and unstoppable human activities arisen since the Industrial Revolution, and which have given rise to an intensive use of raw materials to meet the growing needs of society (Geissdoerfer et al., 2017; Brem and Puente-Díaz, 2020). This model is so

DOI: 10.4018/978-1-7998-8482-8.ch012

deeply rooted in societal mindset that has completely changed the consumers lifestyles and habits, defining in 4 simple phases – take, make, use, dispose – what should have been the normal life cycle of a product intended to prematurely become waste (EMAF, 2015). This has inevitably led to a decrease of the intrinsic value of raw materials, as well as a perpetual dependence on mining activities which feed the production sector. In turn, this is strongly dependent on fossil fuels, the main driver of the linear economy and at the same time the main source of greenhouse gas emissions (GHG) (UNEP, 2019).

It is evident that a linear production and consumption approach is increasingly amplifying the gap between intensive human activities and the (in)capacity of natural capital to regenerate itself at the same pace (Zucchella and Previtali, 2019). It is crucial today to intervene in order to counteract the further potential serious implications to ensure enough resources, food, space for a constantly growing global population over time, restoring a stable balance between nature and man towards a more sustainable future (Brem and Puente-Díaz, 2020; Gusmerotti et al., 2019; Murray et al., 2015; Ranta et al., 2018; Zucchella and Previtali, 2019).

In this regard, the Circular Economy (CE) may represent at least part of the solution, bringing significant economic, environmental and social benefits to all the European Union States members. The Ellen MacArthur Foundation (EMAF) defines the CE as "*an alternative development strategy aimed at: decoupling economic activity from resource consumption, designing waste and pollution out of the system and keeping products and materials in use*". However, several barriers are hindering the transition towards a complete implementation of the CE principles.

In this perspective, the objective of this chapter is to investigate the origins of the CE first of all, but the real focus is to contribute to the academic debate on the evaluation of those barriers that overall hinder the implementation of CE principles within European manufacturing sector, providing also new entrepreneurs, or "traditional" business, useful hints. Starting with an in-depth literature review with a systematic approach, it was possible to identify 35 articles that have been in-depth analysed. The initial output of the literature review is the systematization of the barriers resulted from scattered contributions, first of all categorized into external and internal – referring if they originate within a company or from outside, thus not controllable – and then enriched with further sub-barriers. In the end, a comprehensive map of such barriers is reported as the main contribution of the study.

The remainder of the Chapter is structured as follows. First, we introduce the concept of Circular Economy. Then, the systematic literature review approach adopted is presented. Second, results on the main barriers that inhibit a successful implementation of CE principles are discussed. Lastly, concluding remarks and possible ways to overcome these barriers complete the chapter.

## CIRCULAR ECONOMY: AN ALTERNATIVE PRODUCTION AND CONSUMPTION MODEL

The linear logic typical of the prevailing production and consumption system driven by 'take-make-use-dispose' mindset is undoubtedly no longer sustainable. In order to limit risks mainly linked to climate change and resource depletion and, at the same time, increase well-being and guarantee a global growth, an alternative model based on a new paradigm of value should be created. Therefore, it appears crucial to re-establish the relationship between human and nature (Prieto et al., 2018; Ranta et al., 2018). In this attempt, moving towards the implementation of *Circular Economy*'s principles appears to be at least part of a solution to be adopted right now against the further damages that could be caused by human activities if the trend will be not inverted (Brem and Puente-Díaz, 2020; Gusmerotti et al., 2019; Murray et al., 2015; Ranta et al., 2018; Zucchella and Previtali, 2019).

The Circular Economy (CE) is committed to proposing different sets of actions, strategies for production and business models (Zucchella and Previtali, 2019; Guldmann and Huulgaard, 2020; Lewandowski, 2016; Oghazi and Mostaghel, 2018; Ranta et al., 2018) to companies of all sizes in order to decouple growth from resource consumption, thus aimed at reducing conflicts between businesses' priorities and their environmental footprint (i.e., lowering resource consumption, improving efficiency and reducing waste) (Gusmerotti et al., 2019; Yang et al., 2014). In this respect, Figure 1 provides a comparison between the widespread linear production and consumption model and the emerging circular one.

*Figure 1. Shifting from linear to circular models*
*Source: personal elaboration*

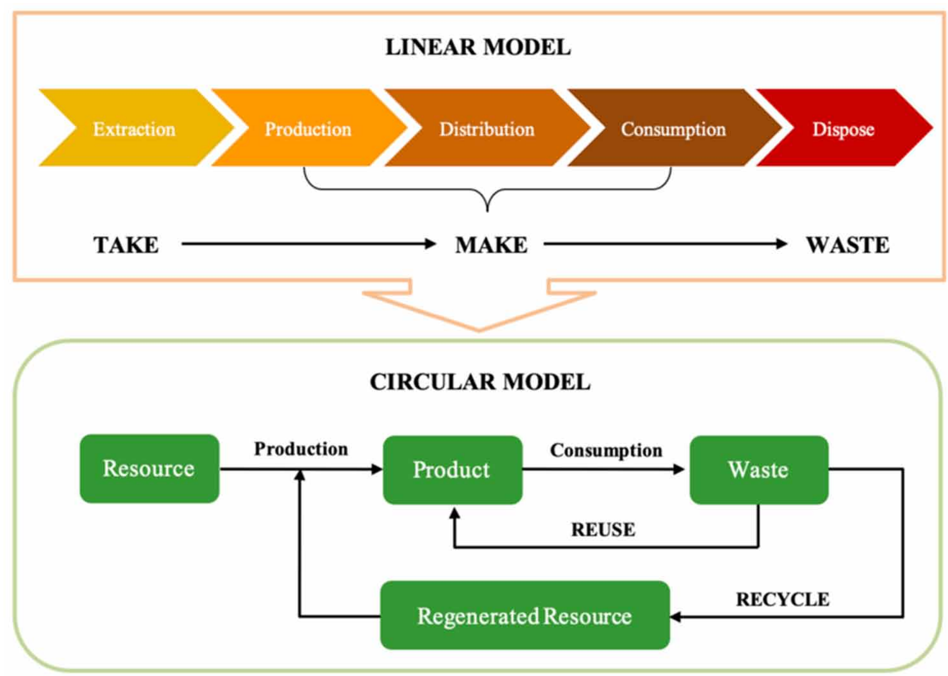



Figure 1 shows how the circular model differs from the linear one for the flow of materials, which are reintegrated back in the various industrial processes instead being disposed (Ranta et al., 2018). This allows to bring the attention on activities such as *reduce*, *reuse* and *recycle* that would enhance the properties of materials in order to keep them in use as long as possible within closed loops; in turn, this could extend their life cycle by maintaining them at their highest utility and value over time, as well as reduce resources extraction and waste generation (EMAF, 2013; Ranta et al., 2018). The term "circular" refers to something that continuously repeats as happens within a *cycle* with an arrow that chases the other; from this point of view, the CE aims at taking as an example the cycles already existing in nature, trying to imitate them in order to restore a sustainable balance between human harmful activities and Earth's ability to bear them (Murray et al., 2017). Taking the *cycle of water* as an example – i.e. one of the most fundamental biological cycles for life on Earth – it may be easier to understand the idea behind the CE: water evaporates from the oceans forming rain clouds, the rain falls on land, becomes ice on the mountains that ends to melt and form rivers that flow back again to the oceans. Each cycle starts and ends naturally, and perpetually repeats taking more or less the same amount of time (Murray et al., 2017; Korhonen et al., 2018).

Moving from nature to social life, rules are not the same; each human activity including production of goods, services, their use (or reuse) requires energy and capital consumption, meaning that socioeconomics resources are *construct* and not *given* as may happen for natural resources. This inevitably has led to a large gap between the extensive productive activities of the human being driven by the linear economy and the (in)ability of natural capital to regenerate at the same pace (Zucchella and Previtali, 2019). Over time, the vast majority of natural cycles – and thus the delicate biodiversity equilibrium – has been altered as consequence of the human activities led by the linear production and consumption system. Taking as a cue the flawless millennial functioning of the non-linear mechanisms that guide the natural ecosystems, the concept of CE is aimed at slowing or restoring – when possible – the equilibrium of flows linked to human activity, basically by taking every possible action linked to the cycle of materials. Therefore, the main challenge of the CE is to align human production and consumption cycles with the regeneration capacity of natural capital. It is useful to remember that the concept of material cycles was already existing since the dawn of industrialization, to whom has been given particular attention by the climate changes of nowadays discussions (Murray et al., 2017; Korhonen et al., 2018).

In the following paragraphs, we aim at providing a definition of CE, an in-depth explanation of its driving principles, i.e. *reduce*, *reuse* and *recycle*, along with the main benefits that a CE implementation brings to companies and the overall society.

## DEFINITIONS OF CE

As stated by scholars, “there are various possibilities for defining CE” (Lieder and Rashid, 2016) or “there is no commonly accepted definition of CE” (Yuan et al., 2008). So far, scholars offered a wide range of definitions of the term CE, mainly resulting from a fragmented collection of ideas from a variety of scientific disciplines. According to Korhonen et al. (2018), the presence of multiple different definitions is plausible because of the numerous stakeholders involved, including policymakers, businesses, researchers, and consumers. Hence, the replacement with a unique universal definition should not be attempted, since it would exclude the interests of some of them. In addition, the concept of CE is dynamic and evolving according to technological innovations, to changing mindsets, to institutional support, to public policy incentives (Zucchella and Urban, 2019), thus confirming again that a universal definition would not match with this continuously evolving framework. As a consequence, the concept of CE is often left somehow vague.

Just to give an idea of extant literature, Kirchherr et al. (2017) performed a systematic assessment of 114 CE definitions available. Table 1 summarizes some of the definitions commonly adopted in literature. Another important contribution comes from the Ellen MacArthur Foundation[1] (EMAF), a major think-tank born to spread the CE philosophy and facilitate the transition towards the implementation of circular principles. Even the foundation has provided more than one definition over time. According to Kirchherr et al. (2017) and Geissdoerfer et al. (2017), among the most employed definitions there is one of the EMAF: “*CE is an industrial system that is restorative or regenerative by intention and* *design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models*". More precisely, according to EMAF website "*Looking beyond the current take-make-waste extractive industrial model, a Circular Economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles: 1) design out waste and pollution* [to reduce GHG emissions across the value chain]*; 2) keep products and materials in use to retain the embodied energy in products and materials; 3) regenerate natural systems*".

*Table 1. Definition of CE*

| Definitions | Reference |
|---|---|
| "The CE concept aims for circular flows of resources in the economy as opposed to the currently dominant linear flows from extracting through use to landfill disposal" | Giurco et al. (2014) |
| "CE is a strategy for decoupling economic growth from resource consumption, and hence secure continued economic growth without destroying the environment" | Dajian et al. (2008) |
| "CE advocates that economic systems can and should operate according to the materials and energy cycling principles that sustain natural systems" | Zhu et al. (2011) |
| "CE is an important way to protect the environment and resource, and to achieve sustainable development; it can transform a traditional linear growing economy, which depends on resource consumption into an economy, which relies on the development of ecological resources circulation" | Wang et al. (2014) |
| "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generation" | Kirchherr et al. (2017) |
| "CE aims to achieve optimum production by minimizing natural resource utilization and pollution emission simultaneously, and minimum wastage by reusing the wastes from production and minimum pollution by recycling and restoring the technically useless wastes" | Wu et al. (2014) |
| "A Circular Economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times" | Webster (2015) |
| "Circular Economy is a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" | Geissdoerfer et al. (2017) |
| "Circular Economy is a general term covering all activities that reduce, reuse, and recycle materials in production, distribution, and consumption processes" | Blomsma and Brennan (2017) |

Source: personal elaboration

Summarizing, CE could be considered as an alternative development strategy that aims at decoupling the rapid economic growth from consumption of finite resources, building economic, natural and social capital at all scales. This is made possible through the adoption of a more efficient resources management and renewable fluxes system that should minimize waste, energy consumption and therefore reduce the potential risks related to climate change already underway (EMAF, 2019; Ghisellini et al., 2016; Kumar et al., 2019).

## THE 3RS PILLARS OF CE

Although the dynamism of CE combined with technological advancement is providing an increasing number of solutions for an effective transition in the implementation of the circular principles, there are some in particular that lay the foundations and are widely recognized and shared by scholars. The so-called *3Rs principles* in fact include three main activities that have shaped the CE framework; these are *reduce*, *reuse* and *recycle* (Ghisellini et al., 2016; Kumar et al., 2019; Prieto et al., 2018; Ranta et al., 2018; Yang et al., 2014; Yuan et al., 2008; Wang et al., 2014). According to scholars, the 3Rs principles have the capability to promote the shift from the prevailing linear model of economic growth to a circular model of resource-product-waste (Yang et al., 2014; Wang et al., 2014).

A description of the 3Rs principles is provided in the following.

### Reduce

Reduction is aimed at minimizing the erosion of the natural ecosystems by reducing consumption of virgin raw materials, energy and waste generation within companies that should improve the efficiency of both production and consumption processes. In this regard, the term *eco-efficiency* specifically refers to the economic and environmental dimension of the companies, rather than the social one. According to the theory behind, a company can increase its eco-efficiency by keeping or increasing the products' value and thus reducing, at the same time, its environmental impact. For instance, this may happen with the introduction of new and better technologies, investing in R&D, in finding alternative lighter packaging solutions, increasing the efficiency of household appliances and so on (Ranta et al., 2018; Su et al., 2013; Ghisellini et al., 2016). A similar concept is the *zero-emission strategy*, whose goal is to maximize the value of goods and, in parallel, bringing the level of the environmental impact towards zero (Ghisellini et al., 2016).

### Reuse

The second 'R' stands for *reuse*; according to European Commission, the term describes those operations through which any product, material or component that is not waste, are re-used again for the same purpose for which they were conceived[2] (Ranta et al., 2018). This is an important principle in terms of environmental safeguard: by reducing the production of new components or products from virgin materials, follows that the consumption of resources, energy and labour, is reduced compared to the traditional manufacturing process for a brand-new product (Ghisellini et al., 2016; Ranta et al., 2018). Clearly, higher the number of the companies that apply the reuse in their items production (i.e., glass, clothes, furniture, plastic bottles, etc.), higher the benefits brought to the environment; the most evident one is the avoidance or, at least, the widely reduction of noxious substances emission that should be achieved by adopting an effective lifecycle assessment (LCA) approach[3].

A successful reuse strategy should lead to an increase in customers demand for reused and remanufactured products on the one side and, on the other, to the engagement of companies in designing and producing durable products for multiple cycles of use and their availability – with the support of particular incentives – in taking-back the products, everything accompanied by effective marketing strategies aimed at raising the customers awareness (Prendeville et al., 2014; Ghisellini et al., 2016). In this regard, a new economic tool was introduced in the Germany's legislation on packaging of 1992 and subsequently within the Waste Directive of EU: Extended Producers Responsibility (EPR). The EPR was aimed at enhancing the circularity of materials and products (i.e. their reuse and recycling) leading the producers to bear the costs of disposal and recovery. This would have undoubtedly incentivized the producers in reusing, recycling and disposing waste materials. Yet, for some products such approach is not possible because they do not have the characteristics to be reused or recycled; in this case, according to Connett (2013), such products should not even be produced and should not be bought by customers (Ghisellini et al., 2016).

## Recycling

The third R refers to *recycling*; in this case, the handled components are effectively waste products that are subjected to "*any recovery operation by which they are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations*"[4]. Thanks to recycling, it is possible to benefit from still usable resources and thus to reduce the environmental impact. Nevertheless, if companies were able to completely recycle their waste, probably they would not be interested to decrease their amount (Ghisellini et al., 2016).

Eventually, although one can easily link and associate mainly the recycle principle to the circular economy, it is important to highlight the fact that, actually, scholars consider it the least sustainable solution in terms of resource efficiency and profitability (Kirchherr et al., 2017; Ranta et al., 2018; Su et al., 2013). The reason behind is clear: several limitations hinder an effective recycle of materials. As an example, waste materials could be recycled for a limited number of times (maybe only for 3, 4 cycles and then they must be disposed) or could even not be recycled (Ghisellini et al., 2016; Ranta et al., 2018). The uncertainty linked to the recycling process leads therefore to consider reduction and reuse the most effective path towards more sustainable activities, that should be prioritized with adequate policies (Su et al., 2013). However, as Ranta et al. (2018) suggest, it is useful to underline that if on the one hand recycling is the least sustainable practice, on the other one there is "reduction". According to the authors, the practices related to reduction may be considered the best solutions since they aim to completely eliminate the need to reuse or recycle materials.

Concluding, 3Rs principles result to be transversal in the circular economy model, meaning that they can be applied through the whole cycle of production, consumption and return of resources (Prieto et al., 2018).

## BENEFITS AND OPPORTUNITIES OF CE IMPLEMENTATION

Extant literature stresses the numerous *benefits* associated with the employment of the CE principles, that range from environmental, economic, social and political ones. As said, CE aims at protecting the environment by using and reusing resources, keeping them – and their intrinsic value – within a cycle for as long as possible. Therefore, this would undoubtedly lead to a decrease in extraction and use of virgin resources, depicting the CE as a means for decoupling economic activities – linked to overall well-being – from raw materials consumption (Rizos et al., 2016). It follows that resource recovery should also reduce waste generation and pollution (EMAF, 2019; Ghisellini et al., 2016; Kumar et al., 2019); it has been estimated that 6/12% of all material consumption in Europe is being avoided thanks to circular behaviors such as recycle and waste prevention. In this regard, EMAF (2012) rejects the concept itself of waste, arguing that it may be avoided by planning since the initial designing phase what will be done with a product at the end of its life cycle (Kumar et al., 2019; Ghisellini et al., 2016). Clearly, as a waterfall, there would be further consequences, such as a marked improvement in the air quality and a significant reduction in water contamination, positively reflected on public health and on the safeguard of biodiversity, now under threat.

Under the socio-political perspective, CE, by emulating natural closed cycles for a better management of resources, offers the possibility to create an intensive and collaborative extended supply chain, strengthening the connection between society – which no longer constitutes the final phase of the product life cycle as it is reintroduced into the value chain – and industry (Geng et al., 2008, EMAF, 2013; Kumar et al., 2019). Following closed-loops, businesses have the opportunity to better understand consumers' needs and expectations, and thus manufacture better products. This is further enforced if businesses adopt *rental models* in all sectors, guaranteeing more customized products and thus increasing the quality of life (EMAF, 2013). Furthermore, if people are satisfied with environmentally friendly products, the likelihood of expanding the customer network increases, and therefore the CE spread; this would generate an overall increase in consumer awareness, who will pay more and more attention in choosing sustainable products rather than harmful ones (Elia et al., 2017; Lieder and Rashid, 2016; Kumar et al., 2019).

Following this path, companies are encouraged and favored to operate in accordance with policies, creating an organizational legitimacy and improving companies' environmental consciousness. Therefore, CE could also be considered as a strategy to gain economic benefits. The idea is to bound to the potential rise of new markets for recycling and remanufacturing, representing a new profit channel besides having competitive advantages over the rivals. Such new strategies would lead to a consequent increase in job opportunities (European Commission, 2020; EMAF, 2013; Geng et al., 2008; Ghisellini et al., 2016; Kumar et al., 2019; Zucchella and Urban, 2019). According to the Ellen MacArthur Foundation (2015) in fact, once the CE will be fully implemented, it will be able to generate a global economic benefit of $1.8 trillion (Korhonen et al., 2018; Rizos et al., 2016), offering the opportunity to create about 2 million employment opportunities by 2030, since activities such as reuse or remanufacturing are more labor intensive rather than resource intensive (Ghisellini et al., 2016). More specifically, according to the EEA Report (2016), 178,000 new direct jobs linked to the CE may rise in Europe (EMAF, 2013; Kumar et al., 2019). Considering the European manufacturing companies producing durable goods with medium lifespan (in particular, motor vehicles, machineries, etc.), the implementation of CE principles would generate a potential material cost savings between $340B and $630B per year, as estimated, only in Europe. The potential save would increase if specific consumer goods such as textiles and packaging are considered, generating a $700B in material saving per year (Kumar et al., 2019; Rizos et al., 2016). Moreover, through a working closed-loop supply chain and end-of-life management, companies may save money and increase their profitability by selling their wastes instead of being disposed; recalling the concept of "waste-is-food", turning wastes into raw materials to be sold to other businesses represents an interesting economic opportunity, besides reducing waste generation and thus advancing the availability of materials while protecting natural resources, minerals, water and energy. Additional benefits may be brought also to local governments which can cut their costs as well as they could increase their profits by collecting and re-selling wastes to recycling businesses. In the end, a sort of mutual financial benefit also allows society itself to pay less for waste since its amount is overall minimized (Kumar et al., 2019; Ghisellini et al., 2016).

As stated, the advantages related to the circular economy strategies are numerous and mainly linked to maintaining products at their highest value for as long as possible, as well as the adoption of an efficient management of resources along the entire value chain.

## BARRIERS THAT HINDER THE CE IMPLEMENTATION IN THE EUROPEAN MANUFACTURING SECTOR: A SYSTEMATIC LITERATURE REVIEW APPROACH

As previously pointed out, our aim is to devote a deeper assessment in understanding the specific factors that enable and/or inhibit the successful implementation of CE principles. Accordingly, a wide literature review adopting a multistep systematic approach (Tranfield et al., 2003), has been performed to provide a comprehensive framework able to shed new light on the proposed issue and to provide guidance for future research directions. Thus, the purpose of the chapter was threefold: 1) to investigate the state of the art (and the progress) of a specific stream of research by analyzing authors' contributions to a specific topic; 2) to identify factors that enable and/or hinder CE principles' implementation and to develop a framework as well; 3) to provide future research directions.

In order to perform the review process, the authors, basing on prior experience and preliminary assessment of the existing literature, identified a broad range of keywords such as: "circular economy" and "barriers", "obstacles". We searched for these concepts on title, abstract and/or keywords in Scopus (Elsevier), which is the most comprehensive database of peer-reviewed journals in the fields of management, organization, and social science. Moreover, Web of Science and Google Scholar were used too, to identify other possible contributions.

A set of inclusion and exclusion criteria such as:

- document type: both articles and conference papers,
- only contributions written in English, to facilitate comparison of different works,
- only contributions published in the last ten years, as we are interested in the latest studies on the topic, were considered as well.

The results were then combined with those emerging both from a further snowballing search and from cross-references. All materials were labelled and stored, and duplications (i.e., journal articles that may appear more than once when searching different keywords) were deleted. Overall, we read 147 abstracts and we discarded those papers not considered relevant to our research (or simply not focused on the manufacturing sector). In doing so, we ended up with 35 papers considered relevant to enhance our understanding on the key factors that hinders a successful implementation of CE principles.

The next step involved the in-depth analysis of each article. Each one of the 35 contributions were read and coded according to the following categories: article type (empirical/conceptual/review), methodology (qualitative/quantitative), type of data collected/analyzed (survey/interview/secondary data/sample size/geographic scope) and exploratory factors studied. Furthermore, data regarding the objective of the analysis and key findings were collected and treated as qualitative information to describe the key aspects under investigation and to provide future research directions in this stream of research.

As said, the focus is on the manufacturing sector where a widespread and comprehensive circular change in the production and consumption system, along with radical innovations, are required. Yet, this may be beyond the reach of most companies, especially for those that are already accustomed in using traditional linear models. This transition, especially in manufacturing companies, may happen with gradual changes rather than with radical ones (Gusmerotti et al., 2019). Traditional manufacturing companies, thanks to an increasing environmental awareness and a need for social responsibility combined with environmental legislation, are constantly looking for new ways to do their business (Kumar et al., 2019). In this framework, CE has the potential to eliminate or, at least, reduce large volumes of waste among manufacturers. According to statistics recently published by Eurostat (2018), this specific sector in fact is the third most waste-generating one (10.6%) after construction (36%) and mining (26.2%), considering that the total waste generated in the EU-27 by all economic activities and households amounted to 2.3 billion tons[5]. Thus, manufacturers should take the opportunity to increase their commitment towards environmental issues by working on key activities mainly related to *material efficiency*, i.e. reintroduce used materials into material flow as well as favouring the use of renewable energy sources with a view of sustainability (Kumar et al., 2019; Shahbazi et al., 2016; Yuan et al., 2008).

In any case, it is evident that the transition from a linear to a circular model results challenging for several reasons. First of all, the limited understanding of the barriers that hinder the implementation of CE constitutes an important research gap, probably due to fragmented literature in this field of research. Second, the unclear practices to deliver a CE makes the concept more blurred and uncertain (Gusmerotti et al., 2019; Ranta et al., 2018; Shahbazi et al., 2016).

Many traditional manufacturing companies, indeed, have started implementing the CE principles or have thought of doing so, but, as scholars have suggested, the presence of *barriers* of different nature encountered during the CE implementation may have slowed down or hindered the process or even prompted companies to give up. This is the reason why, despite the considerable number of contributions published within this field, a systematization of the literature could help in shedding new light on the extant of such barriers.

The next paragraphs provide an in-depth description of the main barriers identified in the literature review, which are also graphically summarised in Figure 2. Based on the relevant contributions of de Jesus and Mendonça (2018) and Kirchherr et al. (2018), we grouped barriers in the following categories: *Socio-Cultural, Technological, Economic/Financial/Market*, and *Institutional/Regulatory* barriers.

## Socio-cultural Barriers

Socio-cultural barriers include multiple aspects of analysis that need to be considered such as consumer habits and businesses routines (de Jesus and Mendonça, 2018; Kumar et al., 2019). According to Kirchherr et al. (2019), the socio-cultural barriers are the most important ones to be addressed since all the other barriers originate from them. On the other hand, de Jesus and Mendonça (2018) argue that socio-cultural barriers are the least influential, thus categorized them as “soft barriers”. Nevertheless, they represent critical barriers to overcome when implementing CE principles. Starting from the classification provided by Kumar et al. (2019), it is possible to define socio-cultural barriers as affected by the following socio-cultural factors.

## Lack of Consumers Interest and Public Awareness

Kumar et al. (2019) categorized the *lack of consumer interest and public awareness* as an 'external barrier' (i.e., not dependent from the company). In this respect, also Kirchherr et al. (2018) and Geng et al. (2008) support the fact that this is one of the most pressing socio-cultural barrier. More precisely, the latter has also depicted the *limited consumer acceptance* as one of the most significant constraint hindering an effective implementation of CE principles. Accordingly, it seems that people prefer to buy new and good-looking products instead of thinking about their possible effects on the environment, which could be potentially mitigated by considering recycled or reused products. This is mainly due to an *incorrect perception* of reused materials value that makes people reluctant in making sustainable choices (Kumar et al., 2019; Ranta et al., 2017; Shahbazi et al., 2016). In addition, the majority of consumers prefers to use products beyond the contracts signed with the vendor, hindering the return of materials to be re-introduced in the closed loops of material flow (Kumar et al., 2019). Furthermore, this general *lack of awareness* is reinforced by the fact that people, in general, frequently change their minds.

Overall, all these aspects together lead to a *lower demand* for recycled/remanufactured products, thus hindering the production of durable products that may result useless if the fashion trend turns out to be shorter than the lifespan of the products themselves (Kirchherr et al., 2018; Kumar et al., 2019).

Concluding, these socio-cultural gaps could be explained by a *lack of public knowledge* about the opportunities of the circular economy and, in general, by a *lack of public sensitivity towards environmental issues*, which in turn are the result of an *inadequate education* and *promotion* of the topics (de Jesus and Mendonça, 2018; Rizos et al., 2016). According to literature, this may depend on a limited general knowledge of the subject at the institutional level (Kumar et al., 2019; Su et al., 2013; Tura et al., 2019; Tecchio et al., 2017).

## Company Culture

Company culture includes those barriers referred to the philosophy, habits and attitudes of company's managers and employees (Rizos et al., 2016), i.e. everything that has to do and originate within a company. As Kumar et al. (2019) suggest, these are "internal barriers". According to Kirchherr and colleagues (2018), company culture results to be the second most pressing socio-cultural barrier. The authors claim that CE is not still integrated in the strategy, mission, vision, goals and in key performance indicators. This may be due to a *conservative behavior* and a *risk-averse profile* of management that makes companies reluctant to move away from traditional linear models (Kumar et al., 2019). According to Rizos et al. (2016), this aspect occurs more frequently within SMEs rather than in large companies since the figure of the owner often overlaps with the one of the manager. Therefore, the owner has a significant say over strategic decisions of the company, in some cases affected by an *altered perception of actual risks*, resulting in a slowed down implementation of CE principles (Rizos et al., 2016). Furthermore, the hesitant corporate culture can also have a negative influence on employee attitudes; while working for an environmentally conscious company can represent a source of motivation for some employees, others may become *demotivated* due to a *lack of awareness* of *how to change business-as-usual operations* or because of the perceived *additional workload* needed to implement circular strategies (Rizos et al., 2016).

### Limited Willingness to Collaborate in the Value Chain

To effectively implement the CE principles, the collaboration of all the figures involved in the value chain is required. For instance, if a company decides to embrace the CE approach, this does not necessarily mean that also its supply chain will do the same (Kirchherr et al., 2018). The lack of support from the supply network is also highlighted by Rizos et al. (2016) and Kumar et al. (2019) as the most cited item within the socio-cultural barriers. In this respect, scholars agree on the fact that there is an overall unwillingness to collaborate – especially from the suppliers' side – mainly because of a conservative mindset (Rizos et al., 2016). Suppliers, as well as the service partners, result to be reluctant to get involved in innovative circular processes, probably because of *perceived risks* related to the unavoidable *increased complexity* throughout the supply chain (e.g., in terms of logistics, finance and legal aspects).

Therefore, the general lack of collaboration in the value chain clearly hampers the potential flow of materials, forcing companies – SMEs in particular – to remain tied to supplier decisions often still involved in high environmental impact activities (Kirchherr et al., 2018; Rizos et al., 2016; Termeer and Metze, 2019). Following the concept of nesting proposed by Kirchherr et al. (2017), cultural barriers represent an obstacle to technological progress since, according to the author, both aspects go hand in hand very slowly.

## Technological Barriers

According to extant literature, the liability for the limited progress in the implementation of the CE principles accomplished so far is frequently attributed to *technological barriers* – those that have been depicted as "internal barriers" by Kumar and colleagues (2019) and as an "hard factor" by de Jesus and Mendonça (2018). According to de Jesus and Mendonça (2018) and Kirchherr et al. (2018) in fact, 35% of the literature has raised far more concerns about these aspects than for any other category of barriers. This probably depends on the idea that technologies are the main tools for triggering change. Having the right technical capacities and equipment is considered a prerequisite for the CE transition (Kirchherr et al., 2018; Shahbazi et al., 2016; Pheifer, 2017; Rizos et al., 2016). Nonetheless, today it seems that the technologies adopted in the prevailing linear production and consumption models are keeping the economy locked into its current form, particularly hindering SMEs from adopting or integrating new sustainable technologies, crucial to effectively implement the CE principles. In this regard in fact, the demand as well as the investments for environmentally friendly technologies (e.g., for advanced resource efficiency or to boost circular product designs), are not that consistent (Rizos et al., 2016).

Besides the general *lack of appropriate technology* to face the transition (e.g., the adoption of old machines not designed to work with new technologies) there is also a *lack of personnel with sufficient technical knowledge* needed to find lower-impact materials, solutions or services. According to Kirchherr et al. (2018), this may be due to the fact that, in general, technological development is a time-consuming process.

Among the technological barriers, *limited circular design* has been emphasized by scholars as a major technological impediment to the CE transition (de Jesus and Mendonça, 2018; Shahbazi et al., 2016; Pheifer, 2017). In this respect, technical and engineering competences are required to create not only durable, efficient and high-quality products but also, at the same time, guarantee an 'optimal product life-cycle scenarios for new products and processes' through the efforts of designers in the early phases (de Jesus and Mendonça, 2018). This aspect is particularly relevant when products are intended to be rented and restored several times, thus requiring an in-depth knowledge on how to replace components in optimized way (de Jesus and Mendonça, 2018). Moreover, technological barriers could depend also on other interconnected aspects, such as economic (e.g., to face the necessary investments for technologies, equipment, R&D, etc.) and also cultural ones (e.g., due to conservative approach towards linear models thus reluctance to make a "green" transition). As an example, there are many landfilling and incineration businesses operating within dysfunctional facilities employing some old technologies as they are unable to replace the equipment due to the "high upfront investment costs". Therefore, these companies find themselves polluting and consuming more energy, because they are economically 'forced' to use these obsolete machineries, causing huge and irreversible environmental losses (Kumar et al., 2019; Geng et al., 2008).

Concluding, it is clear that without the right technologies and highly skilled workers, it will result *difficult to deliver high quality remanufactured o recycled products* (Kirchherr et al., 2018).

## Economic/Financial/Market Barriers

Despite, in some cases, the technical solutions may be already available "out there", their practical application is often hindered by economic and market aspects, broadly cited in the extant literature as one of the most salient barriers (Rizos et al., 2016; de Jesus and Mendonça, 2018; Kumar et al., 2019). More precisely, de Jesus and Mendonça (2018) group them among the 'hard barriers'. These kinds of barriers – detailed in the following – limit new investments due to costs and market uncertainty, often characterized by inertia and locks-in.

### High Upfront Investment Costs

The *lack of capital* to face the *high upfront investment costs* falls among the most pressing "internal barriers" as argued by Kumar et al. (2019) and Rizos et al. (2016). The implementation of the CE principles is undoubtedly an expensive process that requires manufacturing companies significant investments, especially to develop and implement the innovations necessary to create new sustainable circular models in the early stages (Shahbazi et al., 2016): this implies the purchase of suitable machineries and, above all, in learning and studying new technologies (e.g., through R&D). This last point is particularly crucial (de Jesus and Mendonça, 2018). In this perspective, a distinction between large and small companies should be made: even if both types of companies face such barriers, while, on the one hand, the formers are financially strong enough to support circular technology development and decide the direction of circular initiatives (e.g., through investments in R&D, change in production planning, etc.), on the other hand, small businesses are often constrained to adopt technologies already available on the market, hence they are driven by trends instead being able to decide by themselves how the CE strategies should be adopted (Rizos et al., 2016). Thus, it is necessary to highlight how the small-medium enterprises (SMEs) are the most disadvantaged, since they can rely on a *limited financial capability* to face the innovation necessary to shift to a CE. Further pressure is put by uncertainties embodied within the CE, that make companies doubtful to implement or not remanufacturing processes since their future sustainability and profitability is still uncertain. First of all, there is the problem of the economic return which is projected in the long term, thus putting the company itself in difficulty, since SMEs in particular are more sensitive to any additional costs than larger companies (de Jesus and Mendonça, 2018; Kumar et al., 2019; Rizos et al., 2016; Shahbazi et al., 2016). Secondly, it results difficult to simultaneously adapt and *maintain competitive prices* on products – thus keeping the business profitable – compared their new equivalents basing on current costs (Kumar et al., 2019; Rizos et al., 2016). However, according to Kirchherr et al. (2018), this barrier – i.e. high upfront investment costs – is strictly connected to 'hesitant company culture' one, thus resulting apparently an excuse to not embrace CE investments since other authors (Shahbazi et al., 2016) also found that 'limited funding for circular initiatives' represents one of the less pressing barriers.

### Limited Funding for Circular Economy

Besides the issue of 'high upfront investment costs', there is also an external obstacle preventing them from being overcome. Let's consider a company – a SME in particular – that is willing to implement a circular strategy, but it has not the financial capacity to face it. In this case, the company could ask for external financial support, for example by accessing to the EU or government grants. Differently from large ones, SMEs could encounter more problems, mainly due to some restrictions that do not usually allow them to easily access such opportunities (Rizos et al., 2016). If, instead, SMEs take in consideration commercial bank financing, in this case they may often face some complications in obtaining the necessary guarantees required by the credit institutions, which are often inflexible with respect to possible occasional delays in repayments by companies. This approach adopted by the bankers seems due to a difficult understanding of the commercial potential for circular initiatives and products still not available on the market (Rizos et al., 2016).

Hence, new ways to overcome such financial barriers through new financial tools should be created, otherwise this would lead companies to be further discouraged in implementing the CE principles although they are willing to do so (de Jesus and Mendonça, 2018; Kumar et al., 2019). This is the reason why institutional intervention is crucial to support and speed up the transition towards an effective implementation of CE principles (Kumar et al., 2019).

### Low Price of Raw Materials

The current low prices for the purchase of virgin raw materials, supported by the *inadequate taxation system*, do not favor an efficient use of resources. This situation makes companies prefer to buy cheaper raw materials rather than consider recycled ones that often need additional processing costs, hence hindering the transition to a circular economy (Kirchherr et al., 2018; Rizos et al., 2016). This aspect may fall under economic-market barriers as claimed by Kirchherr et al. (2018), but also under regulatory ones (Rizos et al., 2016) since it is governments responsibility to regulate markets. The reason why such prices are low is that their environmental costs (i.e., the so called "externalities") related to the misuse of raw materials are not included in the price of products, leading to negative effects in particular on public health and environment (Rizos et al., 2016). Therefore, this situation often makes the circular products (e.g., recycled) or services not competitive if compared to their linear equivalents (Kirchherr et al., 2018).

## Institutional / Regulatory Barriers

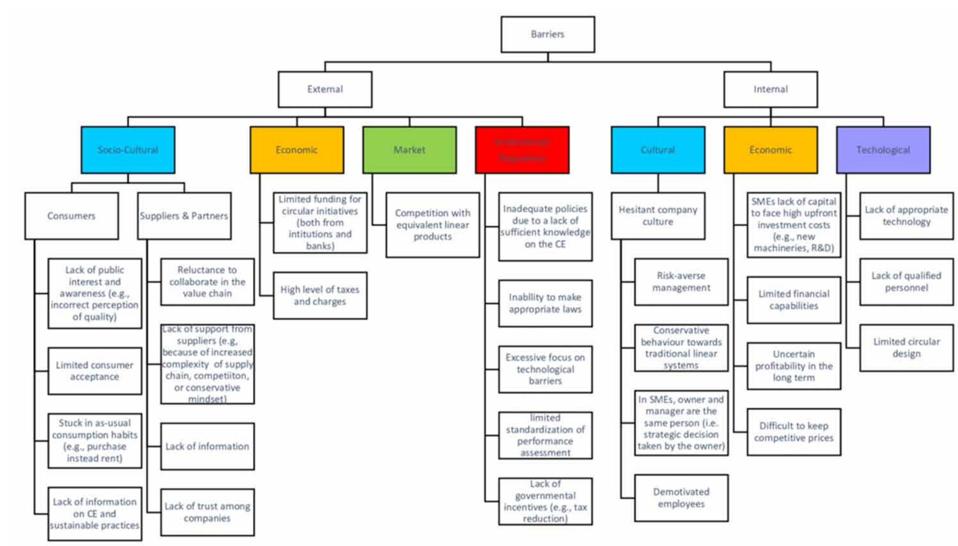
Institutional and regulatory barriers result to be the second most cited ones in the literature (de Jesus and Mendonça, 2018) and fall within the most pressing 'external barriers' according to Kumar and colleagues (2019). Such barriers mainly refer to the leading role that governments should have in promoting an institutional framework to facilitate the CE (Kumar et al., 2019). Among these barriers, it is possible to cite *inadequate policies and regulations*. Many scholars have in fact included the *lack of supportive policy framework* among the barriers against a successful implementation of the CE principles (Kumar et al., 2019; Rizos et al., 2016). This was particularly relevant before CE emerged on political and corporate agendas, when many governments lacked of a general awareness of main principles, benefits and practices of the CE, resulting therefore *unable to lead companies* and *make appropriate laws* (Geng et al., 2008; Kumar et al., 2019). For instance, within European waste legislation, a clear definition or classification of waste materials is not reported; in particular, there is no distinction among waste and byproduct materials used for recycling (Rizos et al., 2016). Hence, this kind of situations may induce limitations on cross-border transportation of waste. In this regard, Kirchherr et al. (2018) make the example about the inclusion of recycled materials in asphalt, which is not allowed by the regulations of some countries or there are regulations that impede to cross the borders with specific materials even if another country has the tools and authorization to recycle them.

Governments encountered several difficulties in defining a clear vision, goals and objectives, targets and indicators to facilitate the implementation of CE, preventing policy makers to formulate standard systems useful to assess the performances, collect data, make calculations, submissions and punishments (Kumar et al., 2019; Su et al., 2013). As anticipated, the current level of *taxes and charges* applied to virgin resources purchases and to recycled/reused/remanufactured ones are the same, thus making unfavorable the shift towards the implementation of green practices; this further highlights how the *lack of governmental incentives* and *taxes regulation* represent a hindering barrier, inevitably leading companies to be discouraged in transitioning towards a CE because of their financial burden (Geng et al., 2008; Kumar et al., 2019; Rizos et al., 2016). In addition, the circular approach should envisage the creation of a network of companies aimed at collaborating close to the loops of materials and products. Unfortunately, this aspect is hindered by the current *competition legislation*: sharing knowledge on business processes in a collaborative context could in fact damage the competitiveness of a company, which therefore finds itself stuck between an unsuitable legislative framework and the desire to implement sustainable strategies. Furthermore, besides competition issues, there is also a general *lack of trust* among companies, an aspect that prevents businesses to create an *efficient information exchange system* (Rizos et al., 2016). According to Kirchherr et al. (2018), current governmental strategies could have not work since they were strictly focused on overcoming only technological barriers – considered by majority of scholars as the most complex ones – neglecting the other aspects. The involvement of governmental bodies becomes fundamental for the transition towards a CE. It is indeed the governments intervention that *establishes an ideal environment* for the development of the CE, providing both a solid system for education and the conditions to favor entrepreneurial activities in this direction (de Jesus and Mendonça, 2018).

Focusing on the European framework, further progress has been accomplished so far, underlining the importance of the institutions and their contribution. In this respect, the EU has proclaimed the circular economy as a priority policy since 2015, introduced through an Action Plan, which "[...] *establishes a concrete and ambitious programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials*", including both legislative aspects and funding tools (de Jesus and Mendonça, 2018). In this respect, Kirchherr et al. (2018) point out how the previous market barriers have been partly induced by governmental interference, first because the price for raw materials is artificially low since energy for production is often provided at subsidized rates and secondly because the 'high upfront investment costs' may be lowered through governments themselves.

Concluding, as emerged in the previous paragraphs, the attention on the theme of the Circular Economy has increased, almost recording an exponential growth in recent years. This led to a growing interest to the topic both from scholars and practitioners, thus widening the possibilities for discussion. A series of barriers that hinder its effective implementation have been identified and summarized in Figure 2.

*Figure 2. Barriers to CE implementation: A summary from the literature review*
*Source: personal elaboration*




As shown in Figure 2, a first categorization separates *external barriers* from *internal* ones. This was crucial to understand which of them originate from the company itself, i.e. 'internal', or come from outside, therefore not controllable by companies themselves, i.e. 'external'. A further sub-categorization of the barriers was made. These refer to *socio-cultural*, *economic*, *market*, *institutional/regulatory* and *technological* aspects. Clearly, some of them may appear twice, under both internal and external barriers, this happens with cultural and economic ones. More fine-grained aspects related to each barrier have been identified as described in the previous paragraphs.

## DISCUSSION AND CONCLUSION

The Chapter aims at investigating the barriers that overall hinder the implementation of CE principles within European manufacturing sector. After having provided a definition of CE and its basic principles, based on an in-depth literature review carried out with a systematic approach, *external* and *internal* barriers that affect the implementation of CE principles have been identified. As shown in Figure 2, these are socio-cultural barriers, economic/financial and market barriers, technological barriers and institutional/regulatory barriers

As concluding remarks, we aim at presenting possible ways to overcome these barriers, as reported by scholars. The systematic literature review specifically focused on the barriers that hinder the implementation of the circular economy principles in manufacturing sector, also shows possible "solutions" to be implemented to overcome such barriers (de Jesus and Mendonça, 2018; Kirchherr et al., 2018). In order to achieve a successful transition towards a CE, it is necessary to overcome the general *lack of information* on circular topics by disseminating and exchanging knowledge among all the stakeholders involved in the value chain, community in the first place: *increase social sensitivity to environmental problems*, for example by providing an extensive public education throughout schools, TVs advertisement, magazines, government policies, etc. Such activities are necessary to show to the public the numerous opportunities of CE, aimed at increasing the desire and the acceptance of consumers in making more sustainable choices and thus, such as moving from ownership to services models (de Jesus and Mendonça, 2018; Kumar et al., 2019; Rizos et al., 2016). On the company side, they may enhance contracts with customers to limit the usage of products and guarantee their return, crucial to set a regular flow of materials that could be utilized in remanufacturing activities (Kumar et al., 2019). Businesses may also benefit from increasing social sensitivity to environmental problems since it would unlock their general conservative behavior towards the prevailing linear systems necessary to make them begin with the necessary investments (e.g., for R&D, machineries, equipment, etc.). To make this possible and trigger circular activities, the intervention of EU – and governments in general – is essential. First of all, there is a need to support these actions by unlocking economic barriers mainly due to the 'high upfront investment costs' and 'limited financial capability' and, secondly, to increase competitiveness of recycled/remanufactured products, hindered by low prices for virgin raw materials. This is possible, for instance, by *establishing new financial instruments* for those businesses that are already 'culturally' ready to start circular initiatives and, at the same time, *incorporating all the externalities into the final price* of resources and energy. Such measures would favor the transition towards a full implementation of the CE principles (Kirchherr et al., 2018).

## REFERENCES

Blomsma, F., & Brennan, G. (2017). The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *Journal of Industrial Ecology*, *21*(3), 603–614. doi:10.1111/jiec.12603

Brem, A., & Puente-Díaz, R. (2020). Are you acting sustainably in your daily practice? Introduction of the Four-S model of sustainability. *Journal of Cleaner Production*, *267*, 122074. doi:10.1016/j.jclepro.2020.122074

Connett, P. (2013). Zero waste 2020: Sustainability in our hands. In R. Crocker & S. Lehmann (Eds.), Motivating Change: Sustainable Design and Behaviour in the Built Environment (pp. 343–361). Academic Press.

Dajian, Z. (2008). Background, pattern and policy of China for developing circular economy. *Zhongguo Renkou Ziyuan Yu Huanjing*, *6*(4), 3–8. doi:10.1080/10042857.2008.10684889

De Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, *145*, 75–89. doi:10.1016/j.ecolecon.2017.08.001

Elia, V., Gnoni, M. G., & Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of Cleaner Production*, *142*, 2741–2751. doi:10.1016/j.jclepro.2016.10.196

Ellen MacArthur Foundation (EMAF). (2013). *Towards the Circular Economy: Economic and business Rationale for an Accelerated Transition*. Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

Ellen MacArthur Foundation (EMAF). (2015). *Towards a Circular Economy: Business Rationale for an Accelerated Transition*. Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf

Ellen MacArthur Foundation (EMAF). (2019). *Completing the picture – how the circular economy tackles climate change.* Retrieved from: https://www.ellenmacarthurfoundation.org/publications/completing-the-picture-climate-change

European Commission. (2020). *Leading the way to a global circular economy: state of play and outlook*. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/31079d7e-3a96-11eb-b27b-01aa75ed71a1/language-en

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainable paradigm? *Journal of Cleaner Production*, *132*, 757–768. doi:10.1016/j.jclepro.2016.12.048

Geng, Y., Zhang, P., Cote, R. P., & Fujita, T. (2008). Assessment of the National Eco-Industrial Park Standard for Promoting Industrial Symbiosis in China. *Journal of Industrial Ecology*, *13*(1), 15–26. doi:10.1111/j.1530-9290.2008.00071.x

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic system. *Journal of Cleaner Production*, *114*, 11–32. doi:10.1016/j.jclepro.2015.09.007

Giurco, D., Littleboy, A., Boyle, T., Fyfe, J., & White, S. (2014). Circular economy: Questions for responsible minerals, additive manufacturing and recycling of metals. *Resources*, *3*(2), 432–453. doi:10.3390/resources3020432

Guldmann, E., & Huulgaard, R. D. (2020). Barriers to circular business model innovation: A multiple-case study. *Journal of Cleaner Production*, *243*, 1–13. doi:10.1016/j.jclepro.2019.118160

Gusmerotti, N. M., Testa, F., Corsini, F., Pretner, G., & Iraldo, F. (2019). Drivers and approaches to the circular economy in manufacturing firms. *Journal of Cleaner Production*, *230*, 314–327. doi:10.1016/j.jclepro.2019.05.044

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence from the European Union (EU). *Ecological Economics*, *150*, 264–272. doi:10.1016/j.ecolecon.2018.04.028

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. doi:10.1016/j.resconrec.2017.09.005

Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essential contested concept. *Journal of Cleaner Production*, *175*, 544–552. doi:10.1016/j.jclepro.2017.12.111

Kumar, V., Sezersan, I., Garza-Reyes, J. A., Gonzalez, E. D. R. S., & AL-Shboul, M. A. (2019). Circular economy in the manufacturing sector: Benefits, opportunities and barriers. *Management Decision*, *57*(4), 1067–1086. doi:10.1108/MD-09-2018-1070

Lewandowski, M. (2016). Designing the Business Models for Circular Economy—Towards the Conceptual Framework. *Sustainability*, *8*(1), 1–28. doi:10.3390u8010043

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, *115*, 36–51. doi:10.1016/j.jclepro.2015.12.042

Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics*, *140*(3), 369–380. doi:10.100710551-015-2693-2

Oghazi, P., & Mostaghel, R. (2018). Circular business model challenges and lessons learned-An industrial perspective. *Sustainability*, *10*(3), 10. doi:10.3390u10030739

Pheifer, A. G. (2017). *Barriers & Enablers to Circular Business Models.* Retrieved from: https://www.circulairondernemen.nl/uploads/4f4995c266e00bee8fdb8fb34fbc5c15.pdf

Prendeville, S., Sanders, C., Sherry, J., & Costa, F. (2014). *Circular Economy. Is it enough?* EcoDesign Centre.

Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, *179*, 605–615. doi:10.1016/j.jclepro.2017.12.224

Ranta, V., Aarikka-Stenroos, L., & Mäkinen, S. J. (2018). Creating value in the circular economy: A structured multiple-case analysis of business models. *Journal of Cleaner Production*, *201*, 988–1000. doi:10.1016/j.jclepro.2018.08.072

Ranta, V., Aarikka-Stenroos, L., Ritala, P., & Mäkinen, S. J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*, *136*, 70–82. doi:10.1016/j.resconrec.2017.08.017

Rizos, V., Behrens, A., van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garbers, M., & Topi, C. (2016). Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers. *Sustainability*, *8*(11), 1–18. doi:10.3390u8111212

Schröder, P., Lemille, A., & Desmond, P. (2020). Making the circular economy work for human development. *Resources, Conservation and Recycling*, *156*, 104686. doi:10.1016/j.resconrec.2020.104686

Shahbazi, S., Wiktorsson, M., Kurdve, M., Jöonsson, C., & Bjelkemyr, M. (2016). Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies. *Journal of Cleaner Production*, *127*, 438–450. doi:10.1016/j.jclepro.2016.03.143

Su, B., Heshmati, A., Geng, Y., & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*, *42*, 215–227. doi:10.1016/j.jclepro.2012.11.020

Tecchio, P., McAlister, C., Mathieux, F., & Ardente, F. (2017). In search of standards to support circularity in product policies: A systematic approach. *Journal of Cleaner Production*, *168*, 1533–1546. doi:10.1016/j.jclepro.2017.05.198 PMID:29200663

Termeer, C. J. A. M., & Metze, T. A. P. (2019). More than peanuts: Transformation towards a circular economy through a small-wins governance framework. *Journal of Cleaner Production*, *240*, 240. doi:10.1016/j.jclepro.2019.118272

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207–222. doi:10.1111/1467-8551.00375

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., & Valkokari, P. (2019). Unlocking circular business: A framework of barriers and drivers. *Journal of Cleaner Production*, *212*, 90–98. doi:10.1016/j.jclepro.2018.11.202

United Nations Environment Programme (UNEP). (2019). *Global Resource Outlook – natural resources for the future we want.* UNEP.

Wang, P. C., Che, F., Fan, S. S., & Gu, C. (2014). Ownership governance, institutional pressures and circular economy accounting information disclosure: An institutional theory and corporate governance theory perspective. *Chinese Management Studies*, *8*(3), 487–501. doi:10.1108/CMS-10-2013-0192

Webster, K. (2015). *The Circular Economy: A Wealth of Flows*. Ellen MacArthur Foundation.

Wu, H., Shi, Y., Xia, Q., & Zhu, W. (2014). Effectiveness of the policy of circular economy in China: A DEA-based analysis for the period of 11th five-year-plan. *Resources, Conservation and Recycling*, *80*, 163–175. doi:10.1016/j.resconrec.2013.10.003

Yang, Q. Z., Zhou, J., & Xu, K. (2014). A 3R Implementation Framework to Enable Circular Consumption in Community. *International Journal of Environmental Sciences and Development*, *5*, 217–222. doi:10.7763/IJESD.2014.V5.481

Yong, R. (2007). The circular economy in China. *Journal of Material Cycles and Waste Management*, *9*(2), 121–129. doi:10.100710163-007-0183-z

Yuan, Z., Jiang, W., Liu, B., & Bi, J. (2008). Where Will China Go? A Viewpoint Based on an Analysis of the Challenges of Resource Supply and Pollution. *Environment and Progress*, *27*(4), 503–514. doi:10.1002/ep.10300

Zhu, Q., Geng, Y., & Lai, K. (2011). Environmental Supply Chain Cooperation and Its Effect on the Circular Economy Practice-Performance Relationship Among Chinese Manufacturers. *Journal of Industrial Ecology*, *15*(3), 405–419. doi:10.1111/j.1530-9290.2011.00329.x

Zucchella, A., & Previtali, P. (2019). Circular business models for sustainable development: A "waste is food" restorative ecosystem. *Business Strategy and the Environment*, *28*(2), 274–285. doi:10.1002/bse.2216

Zucchella, A., & Urban, S. (2019). *Circular Entrepreneurship – Creating Responsible Enterprise*. Springer Nature Switzerland AG. doi:10.1007/978-3-030-18999-0

## ENDNOTES

1 https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy
2 https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Reuse_of_waste
3 Lifecycle assessment, the analysis of the impact an object has on the world around it (retrieved from: https://ecochain.com/knowledge/life-cycle-assessment-lca-guide/)
4 https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Recycling_of_waste
5 https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics#Total_waste_generation

# Chapter 13

# The Asymmetric Impact of Economic Growth, Energy Consumption, Population, and R&D on Carbon Emission in Turkey:

## Evidence From ARDL and Non-Linear ARDL

**Nurcan Kilinc-Ata**
https://orcid.org/0000-0001-8780-1983
*National Research University Higher School of Economics, Russia*

## ABSTRACT

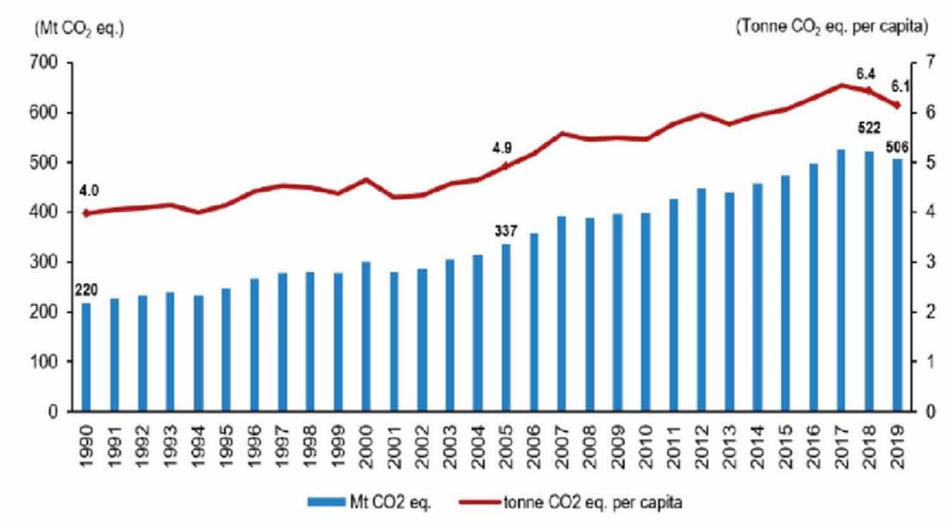
*The presented study analyzes the asymmetry effect of research and development (R&D) expenditures, population growth, energy consumption, and economic growth on carbon emissions in the sample of Turkey for the period 1990-2020. Nonlinear ARDL is used to control the asymmetry of the variables. Linear ARDL is used to control the long-term and short-term relationships between the variables. The findings show that there is a symmetrical or linear relationship between the variables of R&D expenditures, population growth, energy consumption, economic growth, and carbon emissions. The findings display that economic growth and R&D are effective in reducing carbon emissions, while energy consumption seems to increase carbon emissions. Interestingly, the population was found to be effective in reducing carbon emissions in the study. In order for Turkey to reach its 2050 target, it is necessary to give priority to environmental regulations and policies.*

## INTRODUCTION

With the industrial revolution and globalization, an increase in the amount of carbon emissions has been seen in many countries. Because, the industrialization that developed as a result of the countries' desire

DOI: 10.4018/978-1-7998-8482-8.ch013

*Figure 1. Total and per capita Carbon Emission, 1990-2019*
*Source: TUIK, (2021).*




to achieve more economic growth has increased carbon emissions by causing the ozone layer to thin and global warming to increase (Martinez, 2005). One of the most striking difficulties of the 21st century is climate change. Climate change directly affects the natural and social environment. Climate change is both global warming affected by human-induced carbon emissions and large-scale changes in weather patterns as a result (Gruber, 2011). In other words, the industrialization that developed with the 21st century brings a welfare society to the ecological environment. As a result of the extraordinary use of natural resources for economic development, climate change, which can be described as an environmental problem, has come to the fore. The destruction caused by climate change and the threats it contains have reached the level that would affect all humanity and have become a global problem. Climate change ranks second among the risks that may affect global development (Hanbay Kahriman, 2020). At the Climate Change Conference held in Paris in 2015, the Paris Agreement was accepted with the participation of 195 countries. This agreement is aimed at solving the problems that arise as a result of climate change with a common policy. Action needs to be taken today to avoid the more negative and costly effects of climate change in the future (United Nations, 2015).

Turkey is one of the six countries that did not sign Paris agreement. However, Turkey, which ranks 15th in the world in carbon emissions that trigger global warming, released 506.1 million tons of carbon in 2019. The carbon emission per capita in Turkey was 6.4 tons in 2019. In 2019, the energy sector had the largest share in total greenhouse gas emissions with 72%. The agriculture sector with 13.4%, manufacturing procedures and merchandise usage with 11.2% and waste with 3.4% follow the energy sector (TUIK, 2021). In this context, the change in carbon emissions between 1990 and 2019 is shown in Figure 1 below.

According to Figure 1, total greenhouse gas (GHG) emissions as CO2 equivalent for 2019 reduced by 3.1% associated to the previous year and amounted to 506.1 million tons (Mt). While total GHG emissions per capita were 4 tons of CO2 in 1990, this figure was computed as 6.4 tons of CO2 in 2019.

Correspondingly, high financial development and varying lifestyles lead to increased CO2 emissions (Shan et al. 2018). Looking at the economic growth and carbon emission statistics about Turkey, it can be said that there is a positive relationship between economic growth and environmental pollution in Turkey, which is a developing country, and that economic growth injuries the ecosystem (Bayramoglu and Yurtkur, 2016). One of the reasons for the increase in increasing CO2 emissions is rapid urbanization and population growth. Although urbanization has a positive effect on the growth of the economies of countries, it poses serious threats to the environment and is one of the chief problems in sustainable development (Liu et al. 2016; Kaygalak and Isik, 2007). With the increase in urbanization, the lifestyle of a large population has changed, which causes an increase in CO2 emissions as a result of people's increasing energy needs. In other words, economic growth is closely related to increased use of electricity/energy in general. In addition, it is known that it can cause an increase in CO2 emissions (Ozturk and Kusmez, 2019). In addition, R&D activities bring more innovation with technology and help reduce CO2 emissions. Therefore, allocating more budgets to R&D activities provides significantly to the decline of CO2 emissions (Fernadez et al. 2018).

Turkey's environmental legislation journey started in 1982 with two basic regulations. The first is the 1982 Constitution and the other is the Environmental Law No. 2872. Article 56 of the 1982 Constitution states that "*Everyone has the right to live in a healthy and well-adjusted ecosystem. It is the responsibility of the state and citizens to progress the ecosystem, protect environmental health and avoid environmental pollution."* The provisions that deal with the environment indirectly are also a reflection of the change in the environmental perspective. There are many environmental regulations in the Constitution. The Environmental Law No. 2872, which was enacted after the 1982 Constitution came into force, is a basic regulation that includes sustainable development (Turan and Guler, 2013). These regulations have continued until today and aim to reduce Turkey's greenhouse gas emissions to net zero by 2070 but Europe's greenhouse gas emissions target for 2050 is net zero (The Climate Transparency Report 2020, 2020). Turkey implements various environmental policies to control CO2 emissions and achieve its intended targets.

Many research have discovered the relationship between environment, energy consumption, carbon emission and economic growth (Katircioglu, 2014). However less study has been carried out on the more particular relationship between economic growth, energy consumption, R&D and population variables and carbon emission and to date, no study has been carried out on this relationship in the Turkey. The objective of the present proposal is to take a sole method, linked to previous researches, to scrutinize the relationship between carbon emission and selected variables for the Turkey. Environmental issues are studied significant essentials of well-designed strategies and economic growth. The aim of this proposal is to analysis the current literature on the relationship between carbon emission and economic growth, energy consumption, R&D and population variables for Turkey. The conducting questions of this proposal are: *'What is the effect of economic growth, energy consumption, R&D and population variables on carbon emissions in Turkey?'*

Particularly, the present study purposes to reveal the influence of economic growth, R&D, population growth and energy consumption on carbon emissions. In order to reveal the asymmetric effect of environmental regulation on CO2 emissions, the period 1990-2020 was analyzed using econometric methods. The theme of this chapter makes a contribution to the well-developed energy and economics literature on energy economics for Turkey. The current section reveals whether economic growth, energy consumption, R&D and population variables have an asymmetrical effect on carbon emissions.

The current proposal is prepared as follows: Section 2 reviewed a brief literature and an evaluation of connected papers conducted to understand policies for carbon emission reduction. In section 3, the empirical methodology is presented. The outcomes and discussion is in section 4. Section 5 ensured the conclusions and the limitations of the proposal.

## LITERATURE REVIEW

There is extensive literature on economic growth, population growth, fiscal development, the role of energy consumption and its influence on carbon emissions in high, middle and low-income countries by diverse econometric methods and period zones (Shuai and Fan, 2020; Khan et al. 2019; Balsalobre-Lorente at al. 2018; Nisha and Chen, 2017; Panayotou, 2016; Kasman and Duman, 2015; Kivyiro and Arminen, 2014; Shahbaz et al. 2013; Yang, 2012)

Numerous papers have observed at the link between environmental regulations and economic growth at the country or area level. Studies review the economic growth and carbon emissions connection with the principal goal being the testing of the validity of the Environmental Kuznets Curve (EKC) theory. The EKC simulates that environmental degradation first raises as income growth then uplands when income gets a particular high level and lastly declines. Empirical consequences in literatures concerning this opposite U-shaped link between $CO_2$ emissions and economic growth are numerous but indecisive (Fodha and Zaghdoud, 2010). On the opposing, Saboori and Sulaiman, (2013) study for the short and long-term link between economic growth, carbon dioxide ($CO_2$) emissions and energy consumption, applying the EKC both the aggregated and disaggregated energy consumption data in Malaysia for the 1980–2009 years. The findings demonstrate that there is bi-directional causality among the economic growth and carbon emissions. From the review of related literatures, nation analyses display changeable outcomes on the validity of EKC and there is casual correlation with economic growth.

While most of the current empirical researches emphasis on the influence of environmental policies on the formation of new clean technologies, applying patents as an empirical proxy, some od empirical papers have started investigating the effect of environmental or climate parameter on high-tech innovation. For instance, Johnstone et al. (2010) who scrutinized the overall green policies significantly affect private innovators, while the force of the effects differs over high-tech innovation. While quantity-based policies such as compulsions and tradable certificates were established to be most effective for wind technology, price-based policies, for instance, investment encouragements, tax reductions and tariffs demonstrated most effective in encouraging innovation in solar. In other study by Veugelers (2012) reviewed policy instruments to support clean renovating and the enlargement and acceptance of green technologies by the private sector essentials to be guaranteed to reduction GHG emissions. In another empirical papers, Dechezleprêtre and Glachant, (2013) and Wu et al. (2013) approved that commonly based on connection analysis, which may not ensure enough proof of causality. Particularly, Wu et al. (2013) examined China's green strategies/policies and economic growth empirically with operating in period time 2000-2009. They show that city-level environmental investment is cost-effectively considerably interrelated with green consequences.

Generally, the empirically proof from the economics literature is not uncomplimentary for the influence of green policies. While the proof recommend that the nature of the ecological effect (e.g. decreasing carbon emissions against increasing energy efficiency) all seem to matter for usefulness, the paper still has a very inadequate vision on which combination of policy tools is most successful in encouraging green innovation. This comes on top of a lack of evidence on the effectiveness of R&D infrastructure.

Essentially, there is a strong connection between economic growth and green policies. For the green technologies, government intervention is needed, which must be designed to reduce carbon emissions at the lowest conceivable cost for economic development (Veugelers, 2012). Green policies that warranty the environmental use of sustainable resources can be understood as providing a definite level of aggregate economic development over the long period. Commonly, green policies are eco-friendly taxes; tradable emission licenses; water and wastewater handling charges impose a supplementary production-related cost. Green policies are promoting the construction of productions or actions (Kozluk and Zipperer, 2015).

From the perspective of Turkey, there is no study in the literature on the impacts of economic growth, energy consumption, population and R&D on carbon emissions in Turkey. In the case of Turkey, the literature indicates the relationship between economic growth and carbon emissions (Apaydin and Tasdogan, 2019; Kirci et al. 2018; Pala 2018; Bayramoglu and Yurtkur, 2016; Cetintas et al. 2016), the effect of energy consumption on carbon emissions (Cetin et al. Yuksel, 2018; Kirci et al. 2018; Pala 2018; Cetintas et al. 2016; Akay et al. 2015), the effect of population density on carbon emissions (Memis et al. 2019; Pata and Yurtkuran, 2018; Bozkurt and Okumus 2015). In this respect, the presented study is expected to contribute to the literature.

Turkey should prioritize environmental policies in order to achieve its carbon reduction targets. However, there are gaps between some integrated planning and environmental policy harmonization in Turkey. First, with the integration of environmental policies into other policies (such as energy policies), the science and technology sectors need to play an acceptable role in environmental security by increasing participation. Lastly, an assessment procedure for green policies should be founded and developed (Zhang et al., 2014). Conversely, Turkey effectively has particular policy difficulties, for instance, green laws and strategies/policies. For example, there are no satisfactory observing facilities. Also, there is no national-level process for calculating and publishing periodic emissions inventories of pollutants such as volatile organic compounds or sulfur oxides (Yener, 2007). In addition, Turkey's economic growth and environmental concerns about its high production and consumption pose a threat to the country's prospects for sustainable expansion (Dahlberg, 2009).

## DATA AND METHODS

### Data

The present chapter analyzes the asymmetry or non-linear effect of variables such as R&D, population growth, economic development, and energy consumption on carbon emissions over the period of 1990–2020 in case of Turkey. Data were collected from the World Bank database and all variables were taken in logarithmic transformed form. The gathered data were analyzed using the Eviews software program. Information about the variables used in the analysis is given in Table 1 below.

*Table 1. Variable description*

| Symbol* | Variables | Definition |
|---|---|---|
| **$CO_2$** | Total CO2 emission | Metric tons per capita |
| **GDP** | GDP per capita | Current US$ |
| **Pop** | Total Population | Amount |
| **EC** | Energy Consumption | Thousand tonnes of oil equivalent |
| **RD** | Research &Development | % of GDP |

* Variables with natural log transformations are $lCO_2$, lGDP, lPop, lEC, lRD

## Method

The current chapter used Autoregressive distributed lags model (ARDL) to reveal the asymmetric impact of selected variables on carbon emissions since traditional cointegration approaches do not include the asymmetric effect. The current study uses nonlinear ARDL to test asymmetric or symmetrical relationship. If there is a symmetrical link between the variables, the ARDL will advance. If the relationship between the variables is asymmetrical, non-linear ARDL will be used. Studies using this method in the literature have progressed in this way (Malik et al. 2020; Khan et al. 2019; Bildirici and Ozaksoy, 2017; Ibrahim, 2015; Shin et al. 2014; Verheyen, 2013). To extend the model of the present chapter, a simple equation is given in the following form:

$$CO2_t = y_0 + y_1 GDP_t + y_2 Pop_t + y_3 EC_t + y_4 RD_t + \varepsilon_t \,. \tag{1}$$

According to equations, $CO_2$ is carbon emissions, GDP is economic growth per capita, Pop is population, EC is energy consumption and RD is research and development.

The ARDL bounds test, on the other hand, eliminates the difficulties of predetermining the stationarity properties of the series in cointegration tests and enables the analysis of the existence of long and short-run relationships. If some of the series are stationary at the level and some are stationary at their first difference, cointegration analysis in a multivariate model can be performed with this method (Acaravci and Bostan, 2011). In the ARDL cointegration method, the long-term link between the variables in equation (1) is determined by the following equation:

$$\Delta CO2_t = \beta_1 + \sum_{a=1}^{f} \beta_{2a} \Delta GDP_{t-a} + \sum_{b=0}^{g} \beta_{3b} \Delta Pop_{t-b} + \sum_{c=0}^{h} \beta_{4c} \Delta EC_{t-c} + \sum_{d=0}^{k} \beta_{5d} \Delta RD_{t-d} +$$

$$\delta_1 CO2_{t-1} + \delta_2 GDP_{t-1} + \delta_3 Pop_{t-1} + \delta_4 EC_{t-1} + \delta_5 RD_{t-1} + \varepsilon_{1t} \textbf{.2)}$$

In the equation, f, g, h, k denotes the lag orders. The ARDL bounds test approach is established on testing the null hypothesis ( $H_0 : \delta_n = 0$ ) .bout the coefficients of the variables against the alternative hypothesis ( $H_1 : \delta_n \neq 0$ ) .y means of the F-test or Wald test.

*Table 2. Unit Root Test results*

| Variables | ADF | | PP | |
|---|---|---|---|---|
| | I(0) t-statistics (p-values) | I(1) t-statistics (p-values) | I(0) t-statistics (p-values) | I(1) t-statistics (p-values) |
| **CO2** | -3.2826 | -5.8329 | -3.2504 | -8.6488 |
| | (0.0885)* | (0.0003)*** | (0.0941)* | (0.0000)*** |
| **EC** | -4.1765 | -6.7978 | -4.4367 | -16.5432 |
| | (0.0132)** | (0.0000)*** | (0.0072)*** | (0.0000)*** |
| **GDP** | -1.0639 | -5.7163 | -1.1718 | -5.7163 |
| | (0.9187) | (0.0003)*** | (0.8984) | (0.0003)*** |
| **POP** | -0.0232 | -7.9413 | -1.6886 | -5.7681 |
| | (0.9933) | (0.0001)*** | (0.7313) | (0.0001)*** |
| **RD** | -1.1075 | -5.788 | -1.1162 | -5.9255 |
| | (0.9110) | (0.0003)*** | (0.9093) | (0.0002)*** |

**Notes:** (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%.

If there is a long-term link between the variables, the error correction term (ECT) and short-term dynamics of the equation are shown as in equations (3) and (4), respectively:

$$ECT_t = CO2_t - \theta_1 - \theta_2 GDP_t - \theta_3 Pop_t - \theta_4 EC_t - -\theta_5 RD_t \,. \tag{3}$$

$$\Delta CO2_t = \alpha_1 + \sum_{a=1}^{f} \alpha_{2a} \Delta GDP_{t-a} + \sum_{b=0}^{g} a_{3b} \Delta Pop_{t-b} + \sum_{c=0}^{h} \alpha_{4c} \Delta EC_{t-c} + \sum_{d=0}^{k} \alpha_{5d} \Delta RD_{t-d} + \psi\, ECT_{t-1} + \varepsilon_{2t} \,. \tag{4}$$

The coefficient of ECT has a negative sign, and the magnitude of its coefficient indicates the extent to which it will return to long-term equilibrium in each period when there is a deviation from the long-run equilibrium.

## Empirical Results and Discussion

This section discusses the empirical consequences attained throughout the proposed method, interpretation, and discussion of the results. Initial, unit root test results, then model selection standards, outcomes of both long and short term relationships, and bounds test method results for cointegration are given respectively. This analysis used two usually employed unit root test (ADF and PP) to check the stationary of the variable. The unit root test outcomes obtained Table 2. ADF test was performed with the assumption that the variables contain trend and constant coefficients.

According to Table 2, only the CO2 and energy consumption variables are stationary at the I (0) level, while the others are not stationary at the I (0) level. When the first differences of the variables are taken, all of them became stationary at the I(1) level. A nonlinear or asymmetry autoregressive distribution lag model was used to find the long-term, short-term and cointegration relationships between the variables with the limited test approach. Table 3 shows the nonlinear ARDL short-term results. Nonlinear or asymmetry ARDL is used to monitor the hidden cointegration or asymmetry link between selected variables and carbon emissions.

*Table 3. Asymmetry ARDL short-term results*

| Variables | Coefficient | t-statistics | Probability (p-values) |
|---|---|---|---|
| **Δ EC** | 0.904187*** | 6.745469 | 0.0001 |
| **Δ GDP** | -0.055782* | -1.857380 | 0.0962 |
| **Δ POP** | -65.24663* | -1.886734 | 0.0918 |
| **Δ RD** | -0.000593 | -0.146398 | 0.8868 |
| ***3*** | 0.142028* | 1.937831 | 0.0846 |

**Notes:** (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%.

In Table 3, carbon emission is a dependent variable and it is seen that there is a negative link between economic growth, population and R&D expenditures for reducing carbon emissions. In other words, energy consumption positively and significantly affects carbon emissions. ϒ is the error correction term indicating the speed of adaptation regarding equilibrium. As a result of the analysis, the asymmetry for ARDL is corrected for 14% imbalance each year regarding long-term equilibrium. Table 4 below shows the nonlinear long-term ARDL test results.

*Table 4. Asymmetry ARDL short-term results*

| Variables | Coefficient | t-statistics | Probability (p-values) |
|---|---|---|---|
| **Δ EC** | 1.247473 | 1.705809 | 0.1222 |
| **Δ GDP** | -0.165501*** | -3.434855 | 0.0075 |
| **Δ POP** | -10.98267** | -2.712557 | 0.0239 |
| **Δ RD** | -0.154333 | -2.000766 | 0.0765 |

**Notes:** (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%.

According to the results in Table, it shows that the positive component affects the carbon emissions negatively and the negative component affects the carbon emissions positively. Conversely, both effects are statistically not significant in the case of nonlinear ARDL. R&D negatively impacts carbon emissions, but is negligible. Economic growth and population negatively affect carbon emissions in the case of Turkey. Energy consumption is positive but insignificant in the long term. Boundary testing was performed to confirm cointegration among the selected variables and the findings are displayed in Table 5.

*Table 5. F-Bound Test for Asymmetry ARDL*

| **F-statistics** | **9.553437******** | |
|---|---|---|
| **Critical Value Bounds** | | |
| **Significance** | **I(0) Bound** | **I(1) Bound** |
| **10%** | 3.03 | 4.06 |
| **5%** | 3.47 | 4.57 |
| **2.5%** | 3.89 | 5.07 |
| **1%** | 4.4 | 5.72 |

**Notes:** (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 2.5% and (****) Significant at the 1%.

According to the F-stats value of 9.55, it shows that there is a cointegration link between ER, R&D, GDP and POP for carbon emissions at 10%, 5%, 2.5% and 1% significance level for the upper limit. Wald test was performed to check if there is any asymmetry between the variables. The Wald test consequences for both the long and short term is revealed in Table 6.

*Table 6. Wald Test results for long-term and short-term*

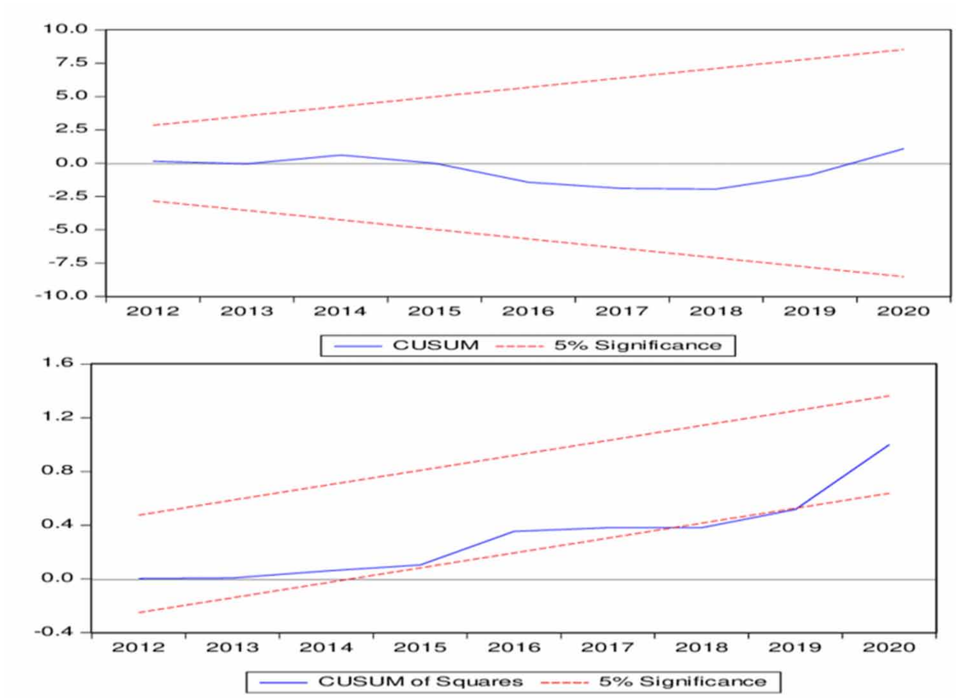
| **Long-term Wald Test** | | | |
|---|---|---|---|
| **Test Statistic** | **Value** | **df** | **Probability** |
| **F-statistic** | 3.829406 | (5, 13) | 0.0236 |
| **Chi-square** | 19.14703 | 5 | 0.0018 |
| **Short-term Wald Test** | | | |
| **Test Statistic** | **Value** | **df** | **Probability** |
| **F-statistic** | 0.262791 | (4, 13) | 0.8966 |
| **Chi-square** | 1.051163 | 4 | 0.9019 |

As seen in Table 6, both short and long term asymmetry results show that there is no asymmetry in both positive and negative components of environmental regulation in both the long and short term. Generally, the outcomes confirm that there is no asymmetry (or symmetry) between carbon emissions and the variables. In this case, it permits to usage the linear ARDL model. Finally, the consequences of the heteroscedasticity test are presented in Table 7 below.

*Table 7. Heteroscedasticity Test: Breusch/Pagan-Godfrey*

| | | | |
|---|---|---|---|
| F-statistic | 1.362430 | **Prob. F (17,10)** | 0.3152 |
| **Obs*R-squared** | 19.55643 | **Prob. Chi-Square (17)** | 0.2975 |
| **Scaled explained SS** | 1.387570 | **Prob. Chi-Square (17)** | 1.0000 |

*Figure 2. CUSUM and CUSUM of Squared results*




According to Table 7, since F-statistics = 1.362430, p-value = 0.3152>0.05, H0 Hypothesis will be accepted and residuals at 5% significance level statistically have constant variance. In other words, the results show that the data for the present chapter are usually allocated and there is no drawback of varying variance and serial correlation in the model. CUSUM and CUSUM squared results were examined to control the stability of the variance or parameters examined in the chapter at the 5% significance level, and the outcomes are shown in Figure 2.

According to the results in Figure 2, it was stated that the parameters in this chapter were constant at the 5% significance level operating both CUSUM and CUSUM squares.

## CONCLUSION AND POLICY IMPLICATIONS

In the present chapter, the asymmetry effect of variables such as economic growth, R&D, population growth and energy consumption on carbon emissions in Turkey for the years 1990-2020 is examined both theoretically and empirically. The outcomes from non-linear ARDL show that there is no asymmetry that allows the use of linear ARDL to find long- and short-term relationships between carbon emissions and variables, both in the short and long term.

According to the econometric findings in the study, while the outcomes obtained through asymmetric ARDL in both short and long terms display that there is a positive link between carbon emissions and energy consumption, there is a negative link between the other three variables. Economic growth encourages reducing carbon emissions in Turkey confirmed by the econometrical results by Ozdemir and

Koc (2020), Bayramoglu and Yurtkur (2016), Bozkurt and Okumus (2015) in the case of Turkey. R&D expenditures to decrease carbon emissions seem to help carbon reduction. This finding obtained in the study is in line with many studies in the literature (Churchill et al. 2019; Jiao et al. 2018; Lee and Min, 2015; Garrone and Grilli, 2010). Findings on energy consumption raise carbon emissions in the case of Turkey and this conclusion is supported by the literature (Li et al. 2019; Rauf et al. 2018; Rahman and Kashem, 2017; Alkhathlan and Javid, 2013; Zhang and Cheng, 2009). There is a negative link between population growth and carbon emissions. In fact, a positive relationship was expected between these two variables, and this result is different from many results in the literature.

Turkey has crucial green policy purposes, which are climate change mitigation, decline of air pollution, enhancement low carbon technologies (McCollum et al. 2013). One of the essential purposes of green policies is to promote innovation in environmental friendly technologies (Dechezleprêtre and Glachant, 2013). The other purpose of green policies is to develop green results, determined by the pursuit of purposes of wider wellbeing and providing sustainable development. Green policies purpose to accomplish their goal by rising the opportunity expenditures of pollution and green damage, shortening pollution behavior, helping investment and encouraging innovation in less ecologically damaging technologies and so forth. Conversely, they are likely to effect simply economic consequences as well, specifically in the shorter term; these effects are of concern to policy makers when selecting to take action to progress green performance and choosing the appropriate policy tools (Kozluk and Zipperer, 2015). Political leaders across countries consistently argue that encouraged green policies so improving the competitiveness of the national economy and creating jobs (Dechezleprêtre and Glachant, 2013). The policy suggestions of the present chapter consequences are theoretically essential for Turkey. The chapter proposes a few policy recommendations in the case of Turkey:

- Ecological environmental construction planning should be developed in Turkey.
- Environmental laws and regulations should be improved.
- The use of renewable energy resources should be raised and the use of fossil energy resources should be decreased.
- There should be checks and penalties to ensure compliance with environmental laws.
- In addition, there is a need for appropriate policies regarding the efficient use of energy resources and the consumption of renewable energy resources.
- According to EU regulations, Turkey should improve its environmental commitments and duties.

Finally, the chapter has some limitation. The first limitation for this study is the scope of the study is limited to Turkey. Therefore, the findings may not be meaningful to oversimplify to other country perspectives. In addition, this chapter primarily covers the period 1990-2020. Since it is very challenging to get larger data in Turkey, a limited number of variables have been used for the model.

## REFERENCES

Acaravci, A., & Bostan, F. (2011). Makroekonomik değişkenlerin doğrudan yabancı yatırımlar üzerine etkileri: Türkiye ekonomisi için ampirik bir çalışma. *Çağ Üniversitesi Sosyal Bilimler Dergisi*, *8*(2), 56-68.

Agan, Y., Acar, M. F., & Borodin, A. (2013). Drivers of environmental processes and their impact on performance: A study of Turkish SMEs. *Journal of Cleaner Production*, *51*, 23–33. doi:10.1016/j.jclepro.2012.12.043

Akay, E. Ç., Abdieva, R., & Oskonbaeva, Z. (2015). Yenilenebilir enerji tüketimi, iktisadi büyüme ve karbondioksit emisyonu arasındaki nedensel ilişki: Orta Doğu ve Kuzey Afrika ülkeleri örneği. In *International Conference on Eurasian Economies. Çevre ve Enerji* (pp. 628-636). Academic Press.

Alkhathlan, K., & Javid, M. (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. *Energy Policy*, *62*, 1525–1532. doi:10.1016/j.enpol.2013.07.068

Apaydin, Ş., & Tasdogan, C. (2019). Türkiye'de İktisadi Büyüme Ve Birincil Enerji Tüketiminin Karbon Salınımı Üzerindeki Etkisi: Yapısal Var Yaklaşımı. *Akademi Sosyal Bilimler Dergisi*, *6*(16), 19–35.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to $CO_2$ emissions? *Energy Policy*, *113*, 356–367. doi:10.1016/j.enpol.2017.10.050

Bayramoglu, A. T., & Yurtkur, A. K. (2016). Türkiye'de karbon emisyonu ve ekonomik büyüme ilişkisi: Doğrusal olmayan eşbütünleşme analizi. *Bolu Abant İzzet Baysal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *16*(4), 31–46.

Bildirici, M., & Ozaksoy, F. (2017). The relationship between woody biomass consumption and economic growth: Nonlinear ARDL and causality. *Journal of Forest Economics*, *27*, 60–69. doi:10.1016/j.jfe.2017.01.002

Bozkurt, C., & Okumus, İ. (2015). Türkiye'de Ekonomik Büyüme, Enerji Tüketimi, Ticari Serbestleşme ve Nüfus Yoğunluğunun CO2 Emisyonu Üzerindeki Etkileri: Yapisal Kirilmali Eşbütünleşme Analizi. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *12*(32), 23–35.

Cetin, M., & Yüksel, Ö. (2018). Türkiye ekonomisinde enerji tüketiminin karbon emisyonu üzerindeki etkisi. *Mehmet Akif Ersoy Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *5*(2), 169–186.

Cetintas, H., Bicil, İ. M., & Türköz, K. (2016). Türkiye'de CO2 Salınımları EnerjiTüketimi ve Ekonomik Büyüme İlişkisi. *Finans Politik ve Ekonomik Yorumlar*, (619), 57–67.

Churchill, S. A., Inekwe, J., Smyth, R., & Zhang, X. (2019). R&D intensity and carbon emissions in the G7: 1870–2014. *Energy Economics*, *80*, 30–37. doi:10.1016/j.eneco.2018.12.020

Dahlberg, E. (2009). *Turkey Environmental and Climate Change Policy Brief.* https://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2013/04/Turkey-Environment-and-Climate-Change-Policy-Brief-Draft-090213.pdf

Dechezleprêtre, A., & Glachant, M. (2014). Does foreign environmental policy influence domestic innovation? Evidence from the wind industry. *Environmental and Resource Economics*, *58*(3), 391–413. doi:10.100710640-013-9705-4

Fernández, Y. F., López, M. F., & Blanco, B. O. (2018). Innovation for sustainability: The impact of R&D spending on CO2 emissions. *Journal of Cleaner Production*, *172*, 3459–3467. doi:10.1016/j.jclepro.2017.11.001

Fodha, M., & Zaghdoud, O. (2010). Economic growth and pollutant emissions in Tunisia: An empirical analysis of the environmental Kuznets curve. *Energy Policy*, *38*(2), 1150–1156. doi:10.1016/j.enpol.2009.11.002

Garrone, P., & Grilli, L. (2010). Is there a relationship between public expenditures in energy R&D and carbon emissions per GDP? An empirical investigation. *Energy Policy*, *38*(10), 5600–5613. doi:10.1016/j.enpol.2010.04.057

Gruber, S. (2011). The impact of climate change on cultural heritage sites: Environmental law and adaptation. *Carbon & Climate L. Rev.*, *5*(5), 209–219. doi:10.21552/CCLR/2011/2/181

Hanbay Kahriman, E. (2020). An Evaluation on Positive and Negative Externalities of Global Climate Change. *Journal of Turkish Court of Accounts*, *33*(118), 101–131.

Ibrahim, M. H. (2015). Oil and food prices in Malaysia: A nonlinear ARDL analysis. *Agricultural and Food Economics*, *3*(1), 1–14. doi:10.118640100-014-0020-3

Jiao, J., Jiang, G., & Yang, R. (2018). Impact of R&D technology spillovers on carbon emissions between China's regions. *Structural Change and Economic Dynamics*, *47*, 35–45. doi:10.1016/j.strueco.2018.07.002

Johnstone, N., Hascic, I., & Popp, D. (2010). Renewable energy policies and technological innovation: Evidence based on patent counts. *Environmental and Resource Economics*, *45*(1), 133–155. doi:10.100710640-009-9309-1

Kasman, A., & Duman, Y. S. (2015). $CO_2$ emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*, *44*, 97–103. doi:10.1016/j.econmod.2014.10.022

Katircioglu, S. T. (2014). International tourism, energy consumption, and environmental pollution: The case of Turkey. *Renewable & Sustainable Energy Reviews*, *36*, 180–187. doi:10.1016/j.rser.2014.04.058

Kaygalak, İ., & Isik, Ş. (2007). Kentleşmenin Yeni Ekonomik Boyutları. *Ege Coğrafya Dergisi*, *16*(1-2), 17–35.

Khan, Z., Sisi, Z., & Siqun, Y. (2019). Environmental regulations an option: Asymmetry effect of environmental regulations on carbon emissions using non-linear ARDL. *Energy Sources. Part A, Recovery, Utilization, and Environmental Effects*, *41*(2), 137–155. doi:10.1080/15567036.2018.1504145

Kirci, B., Cetin, M., Saygın, S., & Alaşahan, Y. (2018). Ekonomik Büyüme, Finansal Gelişme, Enerji Tüketimi Ve Dış Ticaretin Çevre Kirliliği Üzerindeki Etkisi: Türkiye Ekonomisi İçin Bir Nedensellik Analizi (1960-2013). *Balkan Sosyal Bilimler Dergisi*, *7*(13), 26–43.

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy*, *74*, 595–606. doi:10.1016/j.energy.2014.07.025

Kozluk, T., & Zipperer, V. (2015). Environmental policies and productivity growth. *OECD Journal: Economic Studies*, *2014*(1), 155–185.

Lee, K. H., & Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534–542. doi:10.1016/j.jclepro.2015.05.114

Li, Z., Fu, J., Lin, G., Jiang, D., Liu, K., & Wang, Y. (2019). Multi-scenario analysis of energy consumption and carbon emissions: The case of Hebei province in China. *Energies*, *12*(4), 624. doi:10.3390/en12040624

Liu, Y., Yan, B., & Zhou, Y. (2016). Urbanization, economic growth, and carbon dioxide emissions in China: A panel cointegration and causality analysis. *Journal of Geographical Sciences*, *26*(2), 131–152. doi:10.100711442-016-1259-2

Malik, M. Y., Latif, K., Khan, Z., Butt, H. D., Hussain, M., & Nadeem, M. A. (2020). Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. *The Science of the Total Environment*, *726*, 138421. doi:10.1016/j.scitotenv.2020.138421 PMID:32481222

Martinez, L. H. (2005). Post industrial revolution human activity and climate change: Why The United States must implement mandatory limits on industrial greenhouse gas emissions. *Journal of Land Use & Environmental Law*, 403–421.

McCollum, D. L., Krey, V., Riahi, K., Kolp, P., Grubler, A., Makowski, M., & Nakicenovic, N. (2013). Climate policies can help resolve energy security and air pollution challenges. *Climatic Change*, *119*(2), 479–494. doi:10.100710584-013-0710-y

Memis, A., Kupusuzoglu, A., & Ceylan, N. B. (2019). Avrupa Birliği'ne Aday Ülkelerde Yenilenebilir Enerji Tüketimi, Ekonomik Büyüme Ve Nüfus Yoğunluğu'nun Karbon Emisyonu Üzerindeki Etkisi: Panel Veri Analizi. *International Conference on Empirical Economics and Social Science (ICEESS' 19),* 703-712.

Nisha, J., & Chen, S. (2017). A study on the relationship of environmental regulations and economic performances. *IOP Conference Series. Earth and Environmental Science*, *94*(1), 012035. doi:10.1088/1755-1315/94/1/012035

Ozdemir, B. K., & Koc, K. (2020). Türkiye'de Karbon Emisyonları, Yenilenebilir Enerji ve Ekonomik Büyüme. *Ege Stratejik Araştırmalar Dergisi*, *11*(1), 66–86. doi:10.18354/esam.665191

Ozturk, S., & Kusmez, T. (2019). Elektrik Tüketimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisi (1995-2014). *Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *12*(2), 316-327.

Pala, A. (2018). Gelişmekte Olan Ülkelerde Enerji Tüketimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisinin ARDL Yaklaşımı İle İncelenmesi. *Ekonomik ve Sosyal Araştırmalar Dergisi*, *14*, 1–29.

Panayotou, T. (2016). Economic growth and the environment. *The environment in anthropology,* 140-148.

Pata, U. K., & Yurtkuran, S. (2018). Yenilenebilir Enerji Tüketimi, Nüfus Yoğunluğu Ve Finansal Gelişmenin Co2 Salımına Etkisi: Türkiye Örneği. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 303-318.

Rahman, M. M., & Kashem, M. A. (2017). Carbon emissions, energy consumption and industrial growth in Bangladesh: Empirical evidence from ARDL cointegration and Granger causality analysis. *Energy Policy*, *110*, 600–608. doi:10.1016/j.enpol.2017.09.006

Rauf, A., Zhang, J., Li, J., & Amin, W. (2018). Structural changes, energy consumption and carbon emissions in China: Empirical evidence from ARDL bound testing model. *Structural Change and Economic Dynamics*, *47*, 194–206. doi:10.1016/j.strueco.2018.08.010

Saboori, B., & Sulaiman, J. (2013). Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. *Energy Policy*, *60*, 892–905. doi:10.1016/j.enpol.2013.05.099

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and $CO_2$ emissions in Indonesia. *Renewable & Sustainable Energy Reviews*, *25*, 109–121. doi:10.1016/j.rser.2013.04.009

Shan, Y., Guan, D., Zheng, H., Ou, J., Li, Y., Meng, J., Mi, Z., Liu, Z., & Zhang, Q. (2018). China CO 2 emission accounts 1997–2015. *Scientific Data*, *5*(1), 1–14. doi:10.1038data.2017.201 PMID:30482902

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In *Festschrift in honor of Peter Schmidt* (pp. 281–314). Springer. doi:10.1007/978-1-4899-8008-3_9

Shuai, S., & Fan, Z. (2020). Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model. *Journal of Environmental Management*, *261*, 110227. doi:10.1016/j.jenvman.2020.110227 PMID:32148297

The Climate Transparency Report 2020. (2020). https://www.climate-transparency.org/wp-content/uploads/2020/11/Turkey-CT-2020-WEB.pdf

TUIK. (2021). *Greenhouse Gas Emissions Statistics, 1990-2019.* https://data.tuik.gov.tr/Bulten/Index?p=Sera-Gazi-Emisyon-Istatistikleri-1990-2019-37196

Turan, A., & Guler, M. (2013). Türkiye'de sürdürülebilir çevre politikaları: iklim değişikliği örneği. Internatıonal Conference On Eurasıan Economıes.

United Nations. (2015). *The Paris Agreement.* https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Verheyen, F. (2013). Interest rate pass-through in the EMU–new evidence using the nonlinear ARDL framework. *Economic Bulletin*, *33*(1), 729–739.

Veugelers, R. (2012). Which policy instruments to induce clean innovating? *Research Policy*, *41*(10), 1770–1778. doi:10.1016/j.respol.2012.06.012

Wu, J., Deng, Y., Huang, J., Morck, R., & Yeung, B. (2013). *Incentives and outcomes: China's environmental policy (No. w18754)*. National Bureau of Economic Research.

Yener, D. (2007). *Importance of Environmental Policy in Turkey for a Sustainable Future*. http://www.unaturkey.org/dergiler-bulletins/51-say-15-number-15-spring-2007/149-importance-of-enviromental-policy-in-turkey-for-a-sustainable-future-.html

Zhang, H., Liu, G., Hao, H., & Liu, S. (2014). Review, assessment and recommendations on environmental policies in Western China. *Zhongguo Renkou Ziyuan Yu Huanjing*, *12*(1), 42–51. doi:10.1080/10042857.2013.874521

Zhang, X. P., & Cheng, X. M. (2009). Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics*, *68*(10), 2706–2712. doi:10.1016/j.ecolecon.2009.05.011

## KEY TERMS AND DEFINITIONS

**ARDL Approach:** The ARDL approach can test the existence of a cointegration relationship between series with different degrees of stationarity.

**Asymmetric Impact:** The asymmetric effect is expressed as a large return on you when you spend very little energy on a job, or no return on you after working on a job for days.

**Carbon Emissions:** Carbon emission simply means the release of carbon into the atmosphere. Because greenhouse gas emissions are usually calculated in carbon dioxide equivalents, they are often referred to as "carbon emissions" in any discussion of global warming or greenhouse gas impacts.

**Economic Growth:** At its simplest, economic growth is an increase in the production of goods and services in an economy. Economic growth is measured by the increase in the collective market value of additional goods and services produced using estimates such as GDP. Generally, but not necessarily, total gains in production are associated with increasing average marginal productivity.

**R&D:** R&D means research and development. Today, it is one of the activities that almost all countries attach great importance to. It is used in R&D institutions or businesses to increase efficiency, reduce costs, and create more advanced products for production.

# Chapter 14
# Redefining Smart Cities, Urban Energy, and Green Technologies for Sustainable Development

**Ayfer Gedikli**
*Duzce University, Turkey*

**Cihan Yavuz Taş**
*Bahçeşehir University, Turkey*

**Nur Billur Taş**
*Bilkent University, Turkey*

## ABSTRACT

*Increasing greenhouse effects and global warming have been threatening the environment. Cities have directed their development strategies towards smart policies aiming to improve the quality of life of their inhabitants through sustainable environment and energy resources. Therefore, it became a very critical strategy to redefine urban energy sources and apply green technologies in all means of city lives for sustainable cities and reaching Sustainable Development Goals. In this chapter, background information for the role of cities in climate change and environmental pollution globally will be explained. Then a theoretical framework for smart cities and their important features focusing on technology innovation, smart governance, energy efficiency, waste management, as well as green buildings, smart grid-smart lighting, and smart mobility will be analyzed. Finally, sustainable development policy suggestions for sustainable plans and programs at the urban level within the current legislative framework will be put forth.*

## INTRODUCTION

The smart city is a relatively new concept that has been on policymakers' agenda since there are rising problems due to rapid urbanization, population growth. The fact is that modern cities have been strug-

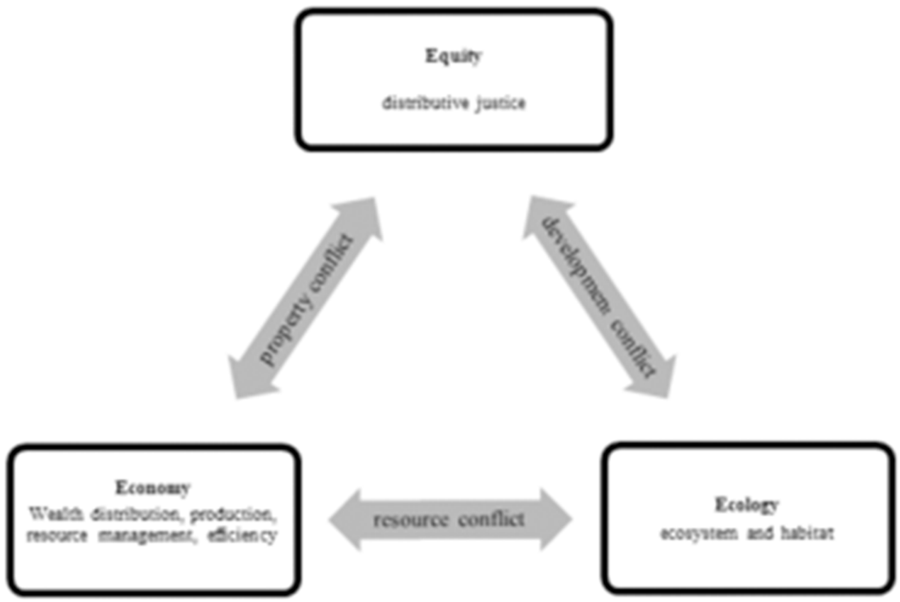
DOI: 10.4018/978-1-7998-8482-8.ch014

gling with providing high living habitats with a quality environment due to limited resources and space. Since city planners cannot propose to reduce the population density per square kilometer to meet the needs of the residents, they suggest improving energy efficiency, applying more renewable resources, increasing productivity, and public awareness. In many metropolises, offices are automatically turned off lights if not necessary, thermostats are set to higher temperatures to decrease the energy need from air conditions, and streetlamps are changed to LED from mercury vapor. Furthermore, the adoption of renewable energy sources is obligated to reduce the dependence on oil and coal consumption both in heating/cooling and transportation (Cram, 2019:3).

The smart city is found to be a good solution to the problems that stem from lack of energy efficiency, insufficient energy supply to increasing demand, waste management, migration, and mobility. Hence, smart cities include power management, reducing environmental pollution footprints, improving public safety, and offering better services to residents. Cities that deploy ICT (Information and Communication Technologies) are the pioneer ones embossing digital systems and infrastructure. Those cities were first called “wired cities” by Dutton et al. (1987). Ishida and Isbister (2000) introduced the “digital cities” concept and today this concept became “smart cities”. During the improvement of the smart city concept, there has been a deepening relationship between ICT and urbanization. Policymakers utilized ICT on infrastructure forming, urban modeling, and modes of living and established the basics of “smart city”, a term that is the subject of business, government, and academia. Aguilera et al. (2013) defined the smart city as a broad concept that includes not only physical infrastructure but also human and social factors. Kourtit et al. (2012) emphasized the development of a knowledge economy for a city to have “smart” notions. With a broader definition, a smart city is a city that offers a sustainable and efficient urban environment with its high quality to its inhabitants through optimal energy management and a livable environment (Calvillo, Sanchez-Miralles, and Villar, 2016:273-274). European Commission (2021a) defines the smart city as a place where traditional networks and services are provided by digital solutions for the benefit of citizens and companies. The commission also points out the usage of digital technologies for better resource use and less greenhouse gas emissions. Therefore, urban transport networks, better water supply, and waste management, disposal facilities as well as efficient lighting and heating/cooling mechanisms are included in the smart city definition. Similarly, Su, Li, and Fu (2011) addressed the technological aspect of smart cities and focused on how next-generation information technology is the key to the future of cities. The authors described the smart city as an important strategy that mainly focuses on applying the next-generation information technology to all means of life by embedding sensors and equipment to railroads, highways, hospitals, power grids, bridges, buildings, water and sanitation systems, dams, oil and gas pipelines, and forming the “Internet of Things” via the Internet”. Furthermore, a smart city is expected to have a balance between environmental, economic, and social goals of integrated processes to reach long-term sustainable development goals. Such a balance contains greener, fairer, and more energy-efficient systems. In other words, there must be a harmonization between three cornerstones: equity, economy, and ecology. As illustrated in Figure-1, three cornerstones may conflict with each other during sustainable development processes offering a green, fair, and livable environment (Bibri and Krogstie, 2020b:3).

Economic development is the greatest target for all developing countries. However, in many countries, environmental degradation is accepted as a trade-off for economic growth. Besides, distributing wealth among citizens is another conflict in this process. Having all of them efficiently with optimum satisfaction may be possible with smart and eco-city applications. Thus, smart cities have been getting more interest in many countries to satisfy the need for high-quality life standards and a quality environ-

*Figure 1. Conflicts among cornerstone contributors to achieve sustainability*
*Source: Bibri and Krogstie (2020b:3).*




ment. However, with the increasing population in major cities around the world, the energy requirements of cities are getting more complex and abundant. By 1990, 90% of population growth was recorded in metropolitans with a population of more than 1 million people. Today, 54% of all people around the globe live in city centers. It is estimated that 60% of the world's population will be urbanized by 2030, and 70% by 2050 (Cram, 2019:2).

Urbanization also contributes to climate change since the 20 biggest cities around the world consume 80% of the world's total energy generating 80% of greenhouse gas emissions. Yet, they account for not more than 2% of the Earth's surface (UN, 2021a). Thus, not only energy efficiency strategies, but also effective and efficient urban planning should be implemented for sustainable development. Modern cities need to implement new solutions in a well-organized and coordinated way and through optimal energy solutions. In this vein, a low carbon electricity ecosystem is necessary to eliminate greenhouse emissions by constructing more livable urban areas. Increasing energy demand, poor energy-efficient transport systems, and renewable energy sources that cannot be a complete substitute for fossil fuels are some of the important challenges for cities that cause environmental degradation. On the contrary, smart cities may also contribute to alleviate population pressure on biodiversity and natural habitats. A less degraded environment will have lower risks to face natural disasters. In addition, by having smart resource management powered by a smart grid, there will be low carbon emissions and a low carbon footprint (Bhatt, Jani, and Bhatt, 2020:95-96).

It should be noted that there is no single model of a successful smart city or a sophisticated way to transform a traditional city into an innovative metropolis with a new concept of growth or development. In addition, all cities have unique specialties and needs. Therefore, instead of formulating one model for all cities, benefiting from successful smart city experiences can be more effective. For example, how a successful smart city could manage to be more efficient, livable, and functional should be analyzed in detail before adopting its strategies to the target city. What makes the difference is the combination of many factors such as the role assigned to citizens, implementing new technologies, the structure of bureaucracy, business models, and public administration. Therefore, the design of the smart city with all components as well as social, technological, and economic inclusion of all is critical parameters in this process. Table-1 illustrates the most successful smart cities and their strategies.

Besides, as one of the successful smart cities, San Francisco could manage to reduce the total greenhouse emissions in 20 years by applying information technologies and environmental protection policies to improve the environment quality. The city has suffered from human-caused climate change for a long time. By applying measures on citywide emissions from electricity, natural gas, transportation, fossil fuels, and wastes, the city showed a remarkable performance (www.sfgov.org). As illustrated in Figure-2, while it was 2% in 2000, it could reduce to -26% in 2015 and -36% in 2018.

Hence, while analyzing the smart city performances, climate change, energy scarcity, and environmental degradation problems should be considered as the major challenges of rapid urbanization that need to have significant attention, efforts, and wise policies. This chapter has two main objectives. The first objective is to develop insight into green energy technologies in a smart city context. The second objective is to provide policymakers with the design of energy solutions for smart cities by suggesting effective strategies. Accordingly, the chapter begins with a conceptual framework and later identifies key critical parameters for smart cities for smart environments. Then, the chapter presents challenges and some policy suggestions for urban energy and urban technologies for sustainable development.

## SMART CITY EVOLUTION

While the cities are growing at an unpredictable speed, the increasing crowding of city centers, irregular migration, and unplanned construction activities conveyed more and more energy consumption. Big cities consume approximately 70% of global energy and generate 75% of total greenhouse gases emissions all over the world. They also host 50% of the world population and are expected to reach 70% in 2050 (Bibri and Krogstie, 2020a). The fact is that urban growth raises environmental problems. Furthermore, although many big cities adopt smart applications, they may have troubles from an environmental sustainability perspective as well due to increasing energy consumption because of energy efficiency and less prices. Hence, big and grown cities may face more environmental degradation. UN (2021b) declared the Sustainable Development Goal (SDG) 13 aims to take urgent actions to combat climate change and its impacts. The 2030 Agenda for SDG, was pointed to protect the planet from degradation and take serious actions on climate change. Climate change was described in paragraph 14 as *"one of the greatest challenges of our time"*. SDG 13 focuses on the integration of climate change precautions and measures with national policies such as raising institutional capacity on environmental protection, improving awareness, and education. It was also stated in the same paragraph that *"its adverse impacts undermine the ability of all countries to achieve sustainable development. Increases in global temperature, sea-level rise, ocean acidification, and other climate change impacts are seriously affecting coastal areas and low-lying coastal countries, including many least developed countries and Small Island Developing States. The survival of many societies, and of the biological support systems of the planet, is at risk"*. Similarly, in the Rio+20 Conference climate change was described as

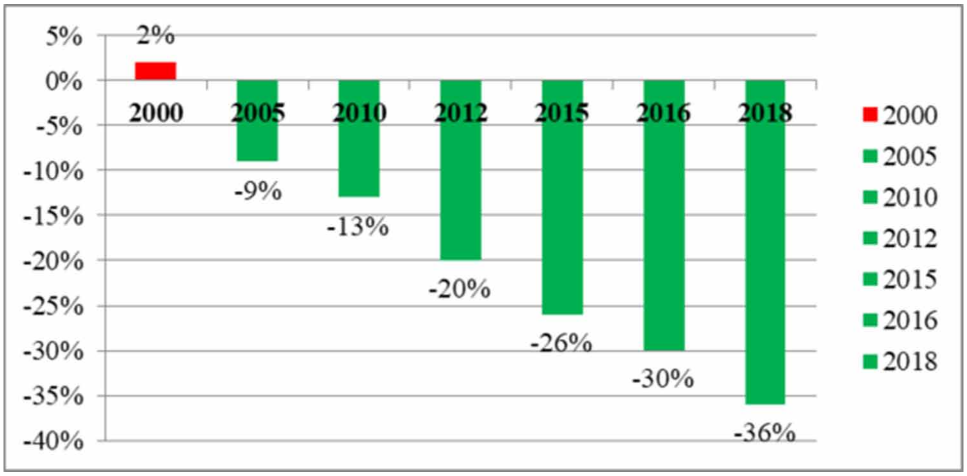
*Table 1. Top ten smart cities*

| Order | Smart City | Features |
|---|---|---|
| 1 | New York | With its 8.6 million people and successful smart applications, New York City was chosen as the best smart city. Based on the program hundreds of smart sensors and emerging technologies throughout different districts were located in 2020. Waste management and collection were more efficient through the collected data. Online charging stations are replacing phone booths to develop connectivity for the residents. |
| 2 | Singapore | Singapore has an ageing population with its 5.9 million people. The government focused on digital technologies and initiatives to raise productivity in the country's advanced economy. By 2022, the government plans to have energy-efficient lighting on all public roads, and solar panels on the rooftops of at least 6,000 buildings. |
| 3 | Amsterdam | Amsterdam's smart city studies began in 2009. Transportation and traffic data were shared with developers, who can use the data to create mapping apps that can then be integrated into the city's transportation system. Automation is also widely used as a form of delivery vehicle in Amsterdam called 'roboats'. Amsterdam also has floating villages which aim to overcome overcrowding and promote a sustainable living environment to further construction inland. (Population: 1.1 million) |
| 4 | Dubai | Dubai initiated a seven-year plan to digitally transform all government and economic services, including communications, urban planning, and transportation. Smart traffic technology also helps to reduce fatigue-related traffic collisions. Police stations are also automated. (Population: 2.9 million) |
| 5 | London | With its growing population (9,4 million), London has set up several smart city initiatives. The Civic Innovation Challenge is an incubator platform to help startups develop solutions to the growing amount of urban issues. Also, 5G connectivity and fiber-optic coverage are other important initiatives. London lamp posts are fitted with sensors and electric vehicle charging points. |
| 6 | Hong Kong | Hong Kong fitted its streets with smart lamp posts embedded with sensors. Besides, the city developed them for future 5G compatibility. (Population: 7.5 million) |
| 7 | Copenhagen | The Copenhagen Solutions Lab received an award for its system of monitoring air quality, energy consumption, traffic, and waste management in 2017. This system connects traffic lights, electric vehicle charging points, and smart metering to a single platform to provide an efficient automotive experience and delivery services. The city has been collaborating with The Massachusetts Institute of Technology (MIT) to develop its intelligent bike system. (Population: 1.3 million) |
| 8 | Barcelona | Barcelona hosted the first *'Smart City Expo and World Congress'* in 2011. Since then, Barcelona has implemented various smart city innovations, such as pedestrian activity, LED light poles to monitor traffic and congestion. The system also records air quality and noise pollution. The streets are also lined with smart bins that vacuum waste into underground storage tanks to reduce the need for excessive collection trucks and eliminate bad odors. (Population: 5.6 million) |
| 9 | Boston | Boston is one of the first cities that initiated smart programs. Boston's long-term plan is to create "participatory urbanism" based on the use of mobile apps to help its population receive quick and easy information such as parking availability, easy communication, reporting city-wide issues, and track public transport performance. (Population: 695,000) |
| 10 | Chicago | Chicago initiated many smart city technologies and strategies to continue their growth and development. Its Open Data portal plans to address the city's issues with poor air quality, congestion, climate change, and pollution. (Population: 2.6 million) |

Source: Samarasinghe (2021)

*"an inevitable and urgent global challenge with long-term implications for the sustainable development of all countries". Accordingly, all countries were invited to have wider cooperation and participation in an effective international reaction to climate change (UN, 2021b). Also, during the International Forum on National Sustainable Development Strategies (NSDS) that was held in Accra, Ghana in 2001, NSDS*

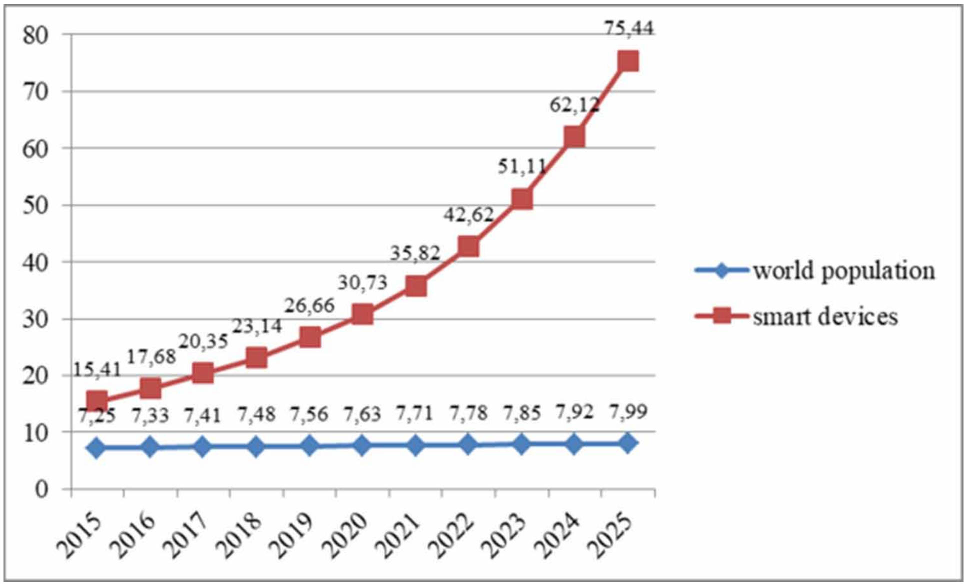
*Figure 2. Total emissions reduction in San Francisco (2000-2018)*
*Source: www.sfgov.org*




*was defined as "a coordinated, participatory and iterative process of thoughts and actions to achieve economic, environmental and social objectives in a balanced and integrative manner" (UN, 2021c).*

Following the SDGs, not only economic entities but also big cities set certain objectives for the sake of environment and sustainable living conditions. Particularly in metropolises, smart applications were thought to be good initiatives for sustainable cities. Converting homes and buildings into smart ones would be the first step of the transformation of traditional cities into smart cities aiming to preserve the environment through efficient energy consumption and lower carbon emissions. The original concept of smart home took great interest and therefore expanded to smart building. Office complexes, hotels, hospitals, and centers followed them. Smart buildings are equipped with automated subsystems to provide routine operations (heating-cooling, lighting, etc.), security, safety, communication, and entertainment. Smartness is related to both applications of automated sensors and control systems, and efficient energy consumption. In addition, smart buildings are surrounded by a smart environment. A smart environment is the real-world physical ecosystem for living and working in such smart buildings which are deployed with special sensors, actuators, and control devices for continuous controlling and monitoring. The smart environment includes air quality, water quality, easily applicable technological devices to serve the residents' comfort, safety, etc. (Bhatt, Jani, and Bhatt, 2020:96). There are certain parameters for smart buildings and smart environments. Room temperature and humidity are some of the key parameters of smart buildings that directly affect comfort and living conditions. Regulated ambient temperature and humidity provide not only thermal comfort to the residents but also efficient energy consumption. Illumination is another parameter of smart buildings. Light is one of the key factors taken into account in the construction processes of smart buildings. Those buildings are located and designed to get the optimum level of daylight. That design will bring both comfort and energy saving. Similarly, with new-generation devices, noise pollution may be limited. With quality technologies, air and water quality can be controlled and protected. From the citizens' perspective, the adoption of smart technologies leads to the deployment of home microgrids, smart home tools, water-saving appliances, and less consumption and less payment for electricity and energy due to energy efficiency. Thus, smart applications cause a

*Figure 3. Expectation of number of smart devices with respect to world population (Billion) (2015-2025)*
*Source: Alavi et al. (2018:593)*




reduction in citizen expenditures on utilities. Combination of smart homes and smart buildings, smart districts and smart cities are established.

At a sustainable smart city the following elements should be provided (European Commission, 2021a):

- Establishing a sustainable environment
- Sustainable urban mobility
- Integrated infrastructures and efficient energy supply, information and communication technologies, and transport
- Citizen participation in all processes
- Launching regulations, measures, and policies for sustainable smart city habitat
- Integrated planning and management
- IT applications and knowledge sharing
- Open big data governance
- Setting standards and monitoring
- Smart business models, procurement, and funding

With all these properties, the quantity of smart devices is increasing dramatically all over the world. In their study, Alavi et al. (2018) estimated the number of smart device usage concerning the world population.

As demonstrated in Figure-3, while it was 15,41 billion when the world population was 7,25 billion in 2015, it is expected to reach 75,44 billion devices in 2025. In 2015, number of smart devices was two times of word population. It reached to 30,73 billion (more than four times of the world population) and is expected to be almost eleven times of the world population in 2025.

## BIG DATA FOR SMART CITIES

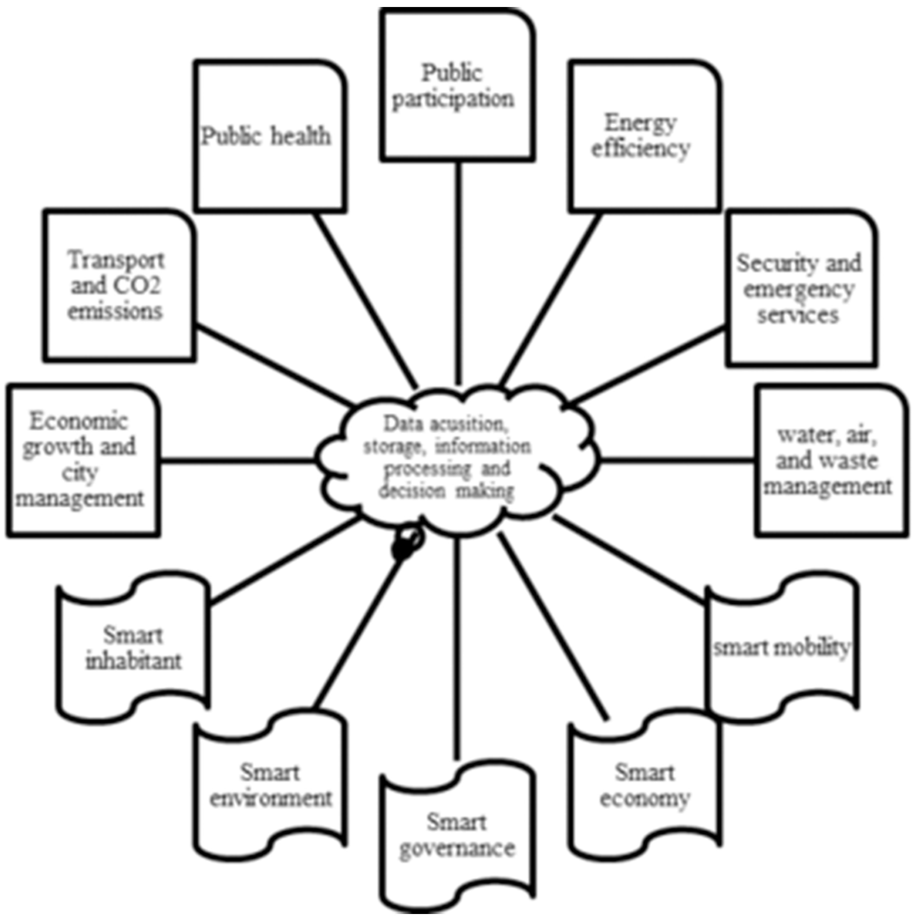
In metropolises, governments need to collect big data sets to obtain enough and valuable information that helps policymakers to set policies and improve the quality of living standards and sustainability in their environment. The quality of life standard can be improved by reduction in costs that cause to improve performance in education, health-care, security, transport, and emergency services (Pérez-Chacón et al., 2018:1). Big data are huge in volume with its terabytes or petabytes of data, high in velocity that are ready to service near real-time, diverse in variety, either structured or unstructured, exhaustive in scope, indexical in identification, containing common fields, and provides relations among them, flexible and can be expanded in size easily (Kitchin, 2013). Therefore, big data is the heart of smart city innovation that offers alternative solutions to infrastructural challenges of big cities such as population growth or climate change. By utilizing big data through smart devices, public agencies, citizens, and city systems can optimize their operations. Drones can generate quality, rich and applicable data from hard-to-reach locations, and guide decisions not only on traffic bottlenecks but also in different areas such as dam maintenance. Vulnerabilities can be determined by monitoring and collecting smart data and check for anomalies. Furthermore, big data can be utilized in cities' arteries pumping and long-term integrity. Quality highways, sound bridges, and well-operating rail systems are necessary for an uninterrupted supply chain. And also, data on energy supply, demand, and climate will enable IoT (Internet of Things) devices to feed operators information in real-time. Data on resource availability is vital for intelligent decisions about supply management during peak and off-peak hours for electric grid management. Data can also be used by city planners and municipalities to make decisions with a holistic perspective (Kaplan, 2019). The fact is that big data is growing very fast and at a projected rate of 40% growth in the global data is expected to generate only 5% growth in global IT spending. 90% of the global digitalized data were generated in the last few years. Therefore, many countries have initiated policies to utilize big data to support the development of smart cities and the sustainability of habitats. Sustainability and development of smart cities include resilience, governance, quality of life, and smart management of natural resources, city facilities as well as applications and large computational services and storage facilities. To handle such platforms, cloud computing can be a good alternative that has many advantages to support smart city big data management. Figure-4 demonstrates the relationship between cloud computing, big data collection, and cloud nodes. (Al Nuaimi et al., 2015:2).

As shown in Figure-4, smart mobility, smart economy, smart governance, smart environment, and smart inhabitant are the main pillars of a smart city. The other components are some of the possible basic city applications.

Advantages of smart cities can be categorized as follows (Campisi, 2021:2-4; Khvoynitskaya, 2020; Kaplan, 2019):

a. ***More efficient and effective decision-making processes:*** ICT can integrate conventional data with digital information through digital devices. Advance in big data may provide a higher opportunity to this integration that can provide higher satisfaction with the broader information as well as more accurate decision-making processes.
b. ***More government and citizen engagement:*** Through modern websites, mobile applications, self-service applications, easy access to government entities has become standard in smart cities that promote a more sophisticated experience for the residents. These intelligent technologies help better excess to municipal officials and more engagement of citizens.

*Figure 4. Cloud storage for smart cities*
*Source: Al Nuaimi et al. (2015:2)*




c. ***Smart cities and smart energy solutions:*** With the increasing population, reducing energy consumption became one of the greatest challenges for the metropolises. Innovation technologies offer energy-efficient technologies adopted by smart cities. Smart cities may deploy IoT sensors and innovative technologies to collect necessary data from different parts of cities such as roads, major buildings, communications, water, electricity, and waste collection, etc. Those data can be used as a valuable source to make perfect predictive analyses that may provide safety and better quality services.
d. ***Reduction in ecological footprint:*** Modernization and increasing population brought more energy consumption, more waste to pollute the environment. Smart cities offer to reduce the adverse effects of rising greenhouse gases, rubbish on the streets in metropolises. Energy-efficient smart buildings, air, water, and noise sensors, renewable energy sources, and innovative technologies are used to reduce the ecological footprint.
e. ***Smart grid infrastructure:*** Grid structure refers to urban power, district energy networks, smart infrastructure, thermal and other means of energy sources. The fact is that electricity is the backbone of a city that transfers energy from generators to consumers with enough quality and reliability.

Smart grid combines digital technology with the traditional electrical grid that offers bidirectional communication between consumers and power supplier that provides implementing information and communication technologies. Hence, consumers can keep track of the amount of electricity they consume. Electricity suppliers can also contact the consumers to inform them about the service. For example, it may be good for a consumer to be informed about the time when the price of energy is lowest, or if there is enough power in the grid. Smart grids also offer to have a minimal environmental impact, reliability, and lower costs by applying high technology sensors that bring more efficiency while transmitting and gathering data. Every unit and device of a smart grid is expected to have information on its own energy consumption and to follow a schedule of loading, pricing, and contractual obligations. Besides, smart grids are expected to provide enough capacity to meet the increasing demands of consumers without building new infrastructure, causing more energy consumption or more carbon emissions. Moreover, a smart grid has the endurance to attacks and natural disasters with its self-healing features and microgrids that can combine power-source structure exchanging power and operating independently and separately as well as providing real-time communication between all participants facilitating the service (Calvillo, Sanchez-Miralles, and Villar, 2016: 278).

f. ***Greater digital equity:*** Smart cities can offer a creative ecosystem to their citizens high-speed and low-cost public services via their high-tech applications such as public WiFi hotspots and real-time information.
g. ***Public lighting:*** In smart cities, LED has been adopted in streetlights. Intelligent streetlights offer smart controls and motion sensors that enable switching on and off automatically if necessary. Also, the light level can be changed if there are accidents or poor weather conditions that need more light. Besides, these streetlights can be connected to central control systems through high-tech communication networks to import data to the management server. In this way, remote controls can be done easily and more precise electricity consumption measures for every single street light can be calculated to figure out the actual amount residents need to pay for the power they consume.
h. ***Intelligent traffic management:*** Data collected from different areas of smart cities through IoT sensors and CCTV cameras can be utilized to provide an excellent source of information to address bottlenecks and heavy traffic points to city planners and municipal planners. By using those data, they can create more efficient traffic flow and reduce congestion. Commuters can also utilize the data to get real-time access to traffic density, plan their journeys accordingly, and avoid congestion.
i. ***Public safety:*** GPS data that is the collection of data from IoT devices and sensors can be used to provide crucial information to emergency cases. It can also be used for criminal activities through heat maps, gunshot detection technologies, and smart cameras. Besides, intelligent buildings can provide perfect health and safety monitoring for the inhabitants. For example, automatic alarm systems with cameras and smart locks for home security, remote control systems, automatic fire tools are all facilities of smart applications.
j. ***More efficient public services:*** Smart sensors allow identifying leaks and damages in pipelines and reducing the amount of water lost. Similarly, through electricity grids, there can be bidirectional communication between suppliers and consumers to have more efficient power usage.
k. ***Reduce the burden of workers:*** Implementing smart applications decrease the burden of manual tasks that many employees confront every day.
l. ***Migrating to Renewable Sources:*** Renewable energy sources investments may bring mid-to long-run energy self-efficiency without sacrificing the environment and compromising the future

generations. Besides, non-renewable sources, such as combined heat and power with natural gas and biomass generation can be applied for reducing carbon emissions and meeting the needs in the short run and long run.

## SMART CITIES AND TRANSPORTATION

In many cities, the most important problem became air pollution that most comes from carbon congestion. According to WHO, nine out of ten people breathe polluted air causing 7 million deaths every year. The higher the population of the city and traffic volume, the higher risk of pollution. Besides, mobility within the city and transportation has a major cost for commuters, cities, and companies. At this point, smart technologies and smart solutions become vital. With IoT sensors, all city roads can be detected. While traffic volume can be followed with those technologies and immediate solutions, there will be a great energy saving by dimming streetlights automatically if there is little or even no pedestrian or road traffic. Also, traffic accidents can be reported in real-time. Pressure, temperature, air quality, and humidity can be followed accurately and data can be provided for the commuters. These data may cause less traffic volume, and mitigate the harms of air conditions (Baker, 2020). Furthermore, deploying smart city technologies can optimize the use of existing road capacity and reduce traffic and transportation costs. Electronic toll collection, intelligent traffic lights, and vehicle to infrastructure systems can be applied for smart applications. While these costs have a great proportion in government budgets, they have a great share in citizens' budgets as well. After housing costs, transportation is the second-largest expenditure in family budgets. Citizens can save money by applying smart strategies such as mobility as a service or ridesharing (Nolan, 2018).

## SMART CITIES, ECO-CITIES, AND ENERGY

Although by definition a smart city is a city fulfilling its responsibilities through ICT-based technologies, those cities need to have sustainable environment strategies as well. Therefore, smart cities and eco-cities are intricate and cannot be analyzed separately. An eco-city is a settlement that has its own sustaining resilient system and function of ecosystem and natural life. These cities target to consume more renewable resources to provide a healthy and livable environment with minimum pollution. Mostly, applying more solar systems and having more green areas and green technologies are the key elements of eco-cities. With a holistic approach, eco-cities, green cities, sustainable cities, zero energy cities, zero-carbon cities, net-zero carbon communities, smart eco-city are similar applications of smart cities (Bibri and Krogstie, 2020b:4). Hence, energy consumption models and energy efficiency strategies are critical decisions for smart cities. Accordingly, smart cities need to include the following elements (Soe, 2017):

- Smart energy generation including renewables, ICT-based energy grids, and metering
- Energy and resource use efficiency
- Re-use, recycle, and resource substitution of buildings
- Green buildings and renovation
- Green city planning
- Pollution control and monitoring

- Sustainable facilities such as solar street lighting, waste management, drainage, and water resource systems
- Measures and regulations

Global energy-related emissions from the construction sector raised by 25% during the 2000-2017 period. It needs to be reduced by 30% until 2030 for the targets of the Paris Agreement. Thus, improving energy efficiency in the building sector is crucial to reduce energy consumption and carbon emissions. Smart buildings can offer a good solution to this problem. However, in the EU countries, 2/3 of residential buildings were constructed before 1980, and one quarter was built before 1945. These buildings are poor in energy efficiency and thus, it is hard to reduce energy consumption. Therefore, especially in the EU, investment in energy-efficient building construction may provide benefits to reduce energy expenditure that can contribute to a green recovery (OECD, 2021). European Commission declared the energy union strategy in 2015 aiming to build an energy union that offers secure, sustainable, competitive, and affordable energy (European Commission, 2021b). Besides, municipalities can ensure energy efficiency strategies. Mitigation and adaptation measures can be complementary to each other to bring low-carbon economic growth. City planners and policymakers should make the city plans according to the impacts of climate change. Also, a long-term vision can be created which satisfy both economic and environmental expectations (Scholtz et al., 2014:20)

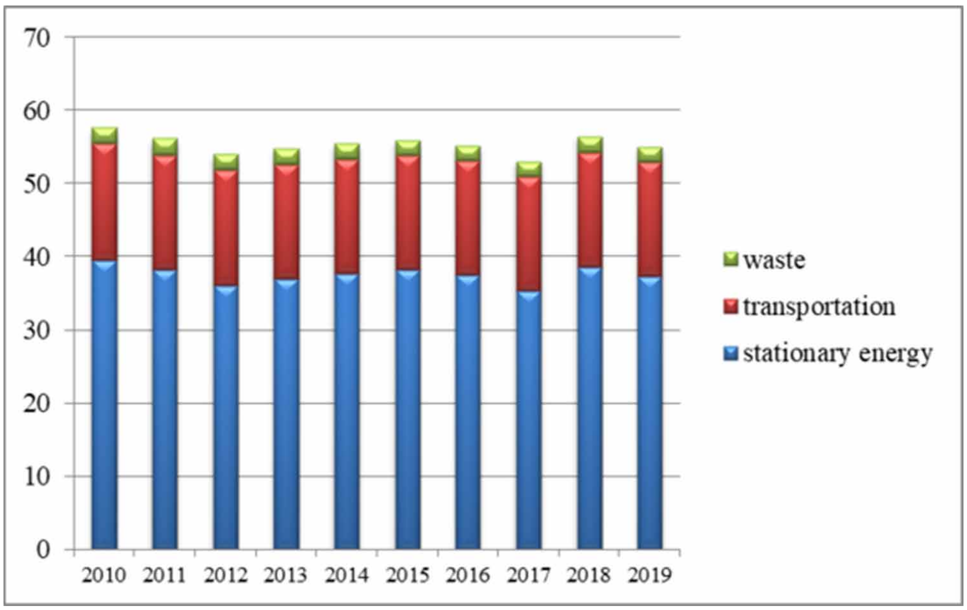
## LEARNING FROM SUCCESSFUL SMART CITIES

There are many successful cities on smart applications such as New York, San Francisco, Dubai, and Singapore as illustrated in Table-1. It may be a wise policy to get their experiences during the adoption of smart technologies. For example, as one of the global smart city leaders, Singapore allocated a great source for digital innovation and connected technologies. GovTech and Smart Nation Singapore initiatives allow tackling a range of problems related to high-density living. To achieve these goals, data with technologies from different government entities need to be gathered to reach a comprehensive unit that operates in similar expectations. By utilizing these data, Singapore has several data supporter innovations such as e-payments to autonomous shuttles and driverless taxis. Similarly, the government has a huge data to understand traffic flows, provides GPS support and bus arrival predictions more accurately (Baker, 2020).

Another successful smart city, New York initiated its strategies to reduce its greenhouse emissions by 80% until 2050 compared to its 2005 levels. The policymakers also put the targets of the Paris Agreement to achieve carbon neutrality by 2050. So far, they could manage to remove 10 million tons of carbon dioxide equivalents from the air until 2020. These strategies are expected to remove 500.000 pounds of fine particulate matter and reduce its greenhouse emissions by 80% by 2050. Governors also expect to improve public health, more quality jobs, and economic innovation through these strategies. The city of New York initiated its strategies through three pillars. They are energy consumption (building, fugitive emissions from natural gas), combustion from transportation (on-road transportation, railroads, aviation, marine navigation), and waste (wastewater and solid wastes) are kept all within city limits. (New York City Mayor's Office of Sustainability, 2020). New York has now the lowest per capita rate of greenhouse gas emissions in the world and is now extremely green. The city reached this remarkable performance by eliminating coal-fired energy generation. Besides transportation is now provided by an energy-efficient smart network system and home appliances are transferred to energy-efficient models (Hulkower, Doulis, and Friedfel, 2019:32).

Figure-5 illustrates the greenhose gas emissions by sectors in New York City. According to New York City Mayor's Office of Sustainability (2020), New York has been very successful in decreasing greenhouse emission reduction. The total amount of greenhouse emission recorded in 2019 is 4,5% less than its 2010 level and 15% less than its 2005 level. In addition, energy consumption has declined due to smart tools and applications that offer energy efficiency.

*Figure 5. The City of New York Greenhouse Gas Emissions by Sectors (Million metric tons of CO2 equivalent)*
*Source: New York City Mayor's Office of Sustainability, 2020*




## Challenges of Smart Energy Adoption

There are some obstacles to smart energy solution deployment. They are (Khvoynitskaya, 2020; Antova, 2020):

- *Security problems:* All IT technologies have security risks. Smart grid hacking or cyber-attacks may result in electricity outrages that cost a lot to households and companies. Those attacks may also violate privacy. In a smart city, there are millions of sensors that representing a potential point of entry for an attack. The system also presents more chances to hide his track and makes it more difficult to detect vicious behaviors. If individual devices and operating systems are poorly protected, the risk is exacerbated. Besides, increasing interconnectivity between smart city infrastructures and the conventional IT networks of private and public sectors cause even more risk.

- *Lack of standardization:* Since there is still no policy or standardization for interoperability and safety of energy-efficient systems, it is hard to push people to follow the instructions. Therefore, there should be standards and requirements for smart energy solutions and operations.
- *Public awareness:* False learning or myths maybe even harmful for public awareness. Many people believe that smart tools in homes may cause health problems due to electromagnetic radiation fields. Therefore, consumer awareness and training programs may be useful to attract people's interest in smart solutions.

## POLICY SUGGESTIONS FOR SUCCESSFUL SMART CITIES

Not only the UN but also WHO encourages the policymakers to initiate the policies to reduce air and water pollutions, better waste management with cleaner technologies. Besides, less fossil fuel consumption for household needs, heating, and lighting. In addition, the UN Environment's Share the Road Program suggests walking and cycling instead of driving. Riding bicycles may reduce traffic congestion and contribute to improving air quality (UN, 2021a).

The fact is that smart cities should transfer to a full renewable-energy scheme, a goal that can bring sustainable development. However, conventional energy generation will be present in the short and medium run (Calvillo, Sanchez-Miralles, and Villar, 2016:274).

There may be still hesitations and reluctance to transfer to a smart network in the cities. To overcome this challenge, city stakeholders should encourage having a marketplace, multiple ecosystem partners, vendor-agnostic platforms, and data services and applications. Those will positively affect the stakeholders to provide lower costs for deploying new appliances, platforms, and networks while serving with high quality and less pollution.

Other policies are as follows (Hulkower, Doulis, and Friedfel, 2019:32-39):

- *Initiating carbon pricing by including all sectors with transportation:* Carbon pricing will affect the purchase and sale behavior both in the short-term and long-term. There are (a) cap-and-trade systems and (b) carbon fees. Both models bring the cost of carbon into the delivered price of energy which leads to an increase in energy prices. If it covers all sectors it will be even more effective.
- *Carbon fee:* A carbon tax is a Pigouvian tax that puts a reasonable price on the carbon in the fuel. The price should be also high enough to cause an impact on people's behaviors. To be more effective, the fee should be added to all means of fuels and it should cover all sectors. Canada, Mexico, Argentina, Finland, Norway, and Sweden have initiated carbon fees. With its effective application, carbon emissions reduced by 5%-10% in Canada since it has been implemented. The important point is that the revenue coming from the carbon tax should not be an extra income of the government, and should be expended on environmental recovery.
- Targeting to reduce greenhouse emissions in all sectors
- Initiating an economy-wide carbon fee system to have an effective price for energy consumers. The tax rate should be high enough to consume more efficiently, and it should be low enough in order not to bring excessive expenditures
- Having partnerships with more experienced smart cities
- Applying more nuclear energy for cleaner technologies
- Improving broader transportation solutions with clean energy (or with less energy consumption)

## CONCLUSION

In addition to the economic, social and cultural problems experienced in rapidly growing cities, one of the most important problems that concern future generations is the destruction of the environment. Besides, as economies grow, environmental pollution has been accepted as a trade-off for economic development. Rapid urbanization and construction processes cause permanent destruction in the environment. Furthermore, due to massive migration and increasing population, cities are under greater risks in recent years. Since it is impossible to reduce the population, smart city networks offer a good alternative solution to having a livable environment in cities with the deployment of IT technologies.

Smart city applications have been accelerated in many cities around the world, especially in developed cities such as New York, London and Amsterdam. Smart home and smart buildings have an important place in smart city modeling. In addition to providing energy efficient solutions in heating-cooling systems, energy consumption is arranged automatically in accordance with light and climate conditions that will ensure energy efficiency and less bills.

Smart cities also offer clean energy production through renewable resources such as solar, wind biomass. Since fossil fuels are one of the main sources carbon emissions, environmental-friendly energy sources are mostly suggested in smart cities. Encouraging bicycle riding, increasing green areas as well as green buildings are the main characteristics of smart cities. Indeed, smart cities' structure is in accordance with SDGs that emphasizes the protection of environment.

However, in order to create such a sustainable and livable system, there is a need for both a strong technical infrastructure and all kinds of security measures related to them, as well as the safe processing of big data and its presentation to users.

## REFERENCES

Aguilera, G., Galan, J. L., Campos, J. C., & Rodríguez, P. (2013). *An Accelerated-Time Simulation for Traffic Flow in a Smart City*. FEMTEC. 4th Itern. Congress on Computational Engineering and Sciences, Las Vegas, NV.

Al Nuaimi, E., Al Neyadi, H., Mohamed, N., & Al-Jaroodi, J. (2015). Applications of big data to smart cities. *Journal of Internet Services and Applications*, *6*(25), 1–15. doi:10.118613174-015-0041-5

Alavi, A. H., Jiao, P., Buttlar, W. G., & Lajnef, N. (2018). Internet of Things-enabled smart cities: State-of-the-art and future trends. *Measurement*, *129*, 589–606. doi:10.1016/j.measurement.2018.07.067

Antova, G. (2020). *Securing the smart cities of the future*. ITProportal. https://www.itproportal.com/features/securing-the-smart-cities-of-the-future/

Baker, R. (2020). *Powering the era of smart cities*. ITProPortal, April 09, 200. https://www.itproportal.com/features/powering-the-era-of-smart-cities/

Bhatt, J. G., Jani, O. K., & Bhatt, C. B. (2020). Automation based smart environment resource management in smart building of smart city. In T. M. V. Kumar (Ed.), *Smart environment for smart cities* (pp. 93–107). Springer. doi:10.1007/978-981-13-6822-6_3

Bibri, S. E., & Krogstie, J. (2020a). Environmentally data-driven smart sustainable cities: Applied innovative solutions for energy efficiency, pollution reduction, and urban metabolism. *Energy Inform*, *3*(1), 29. doi:10.118642162-020-00130-8

Bibri, S.E., & Krogstie, J. (2020b). *Smart Eco-City Strategies and Solutions for Sustainability: The Cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden*. Urban Science, Case Report, March 03, 2020.

Calvillo, C. F., Sanchez-Miralles, A., & Villar, J. (2016). Energy management and planning in smart cities. *Renewable & Sustainable Energy Reviews*, *55*, 273–287. doi:10.1016/j.rser.2015.10.133

Campisi, T., Severino, A., Al-Rashid, M. A., & Pau, G. (2021). The Development of the Smart Cities in the Connected and Autonomous Vehicles (CAVs) Era: From Mobility Patterns to Scaling in Cities. *Infrastructures, MDPI*, *6*(100), 1–21. doi:10.3390/infrastructures6070100

City and County of San Francisco. (2021). *Greenhouse gas emissions*. https://sfgov.org/scorecards/environment/greenhouse-gas-emissions

Cram, M. (2019). *Smart cities run on smart power*. Ranitan, White Paper. https://www.raritan.com/eu/assets/uploads/Whitepapers/white-paper_smart-cities_A4_EN.pdf

Dutton, W. H., Blumler, J. G., & Kraemer, K. L. (1987). *Wired cities: Shaping future communication*. Macmillan.

European Commission. (2021a). *Smart cities-Cities using technological solutions to improve the management and efficiency of the urban environment*. https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

European Commission. 2021b). *Energy union*. https://ec.europa.eu/energy/topics/energy-strategy/energy-union_en

Hulkower, S., Doulis, M., & Friedfel, D. (2019). Getting Greener: Cost-Effective Options for Achieving New York State's Greenhouse Gas Goals. Citizen Budget Commission.

Ishida, T., & Isbister, K. (2000). Digital cities: Technologies, experiences, and future perspectives. LNCS, 1765.

Kaplan, A. (2019). *How big data will drive smart city innovation*. ITProPortal. https://www.itproportal.com/features/how-big-data-will-drive-smart-city-innovation/

Khvoynitskaya, S. (2020). *Paving the way for lower energy consumption in smart cities*. ITProPortal. https://www.itproportal.com/features/paving-the-way-for-lower-energy-consumption-in-smart-cities/

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1–14. doi:10.100710708-013-9516-8

Kourtit, K., Nijkamp, P., & Arribas-Bel, D. (2012). Smart cities perspective—A comparative European study by means of self-organizing maps. *Innovation*, *25*(2), 229–246.

New York City Mayor's Office of Sustainability. (2020). *Inventory of New York greenhouse gas emissions.* https://nyc-ghg-inventory.cusp.nyu.edu/#:~:text=The%20City%20of%20New%20York,achieve%20carbon%20neutrality%20by%202050

Nolan, J. (2018). *What makes smart cities, smart?* ITProPortal. https://www.itproportal.com/features/what-makes-smart-cities-smart/

OECD. (2021). *Building energy efficiency in cities and regions*. https://www.oecd.org/cfe/cities/energy-efficiency-cities.htm

Pérez-Chacón, R., Luna-Romera, J. M., Troncoso, A., Martínez-Álvarez, F., & Riquelme, J. C. (2018, March 18). Big data analytics for discovering electricity consumption patterns in smart cities. *Energies*, *11*(683), 683. Advance online publication. doi:10.3390/en11030683

Samarasinghe, S. (2021). *Top 10 smart cities worldwide*. Businesschief. https://businesschief.com/top10/top-10-smart-cities-worldwide

Scholz, S.M., Rescalvo, M., Sugar, L., Lasa, M., D'Silva, N., Barrios, R., Mata, J., Gallegos, J.B., & Perry, J. (2014). *The low carbon city development program (LCCDP) guidebook- A systems approach to low carbon development in cities*. The World Bank & DNV KEMA Energy & Sustainability.

Soe, R.-M. (2017). *Data-based energy provision for smart cities*. *Conference Paper*. 10.1007/978-3-319-69784-0_27

Su, K., Li, J., & Fu, H. (2011). Smart city and the applications. *Electronics, Communications and Control (ICECC), 2011 International Conference on IEEE*, 1028–1031.

UN. (2021a). *Cities and pollution*. https://www.un.org/en/climatechange/climate-solutions/cities-pollution

UN. (2021b). *Climate change.* Department of Economic and Social Affairs Sustainable Development. https://sdgs.un.org/topics/climate-change

UN. (2021c). *National Sustainable Development Strategies (NSDS) Department of Economic and Social Affairs Sustainable Development*. https://sdgs.un.org/topics/national-sustainable-development-strategies

# Chapter 15
# Sustainable Resilience in Urban Land Use

**José G. Vargas-Hernández**
https://orcid.org/0000-0003-0938-4197
*Tecnológico Mario Maolina, Zapopan, Mexico*

**Elsa Patricia Orozco-Quijano**
https://orcid.org/0000-0002-6616-3174
*Laurentian University, Canada*

## ABSTRACT

*Humanity is facing a series of important challenges, global warming being one the most important. Consequently, sustainability and resilience have become key elements in providing a better response to the crisis and in maintaining an equilibrium between ecology, economics, and various social domains. The design and use of urban land should consider the inclusion of a multi-functional green infrastructure to obtain different benefits, from ecosystem services to value creation. Additionally, the urban land-use planning system contributes to economic growth, social development, and environmental sustainability, while biodiversity is able to provide renewal and reorganization capacities for changes in social-ecosystems. All these elements bring forth a different paradigm for the future decisions of communities.*

## INTRODUCTION

Human development has had a profound imprint on nature and co-evolving ecosystems. This has resulted in complex, economic-socio-ecological challenges for sustainability and future development. Human activity alters the dynamics of ecosystems with its important impact on the atmosphere, climate, land surface, forest, sea, and waters. Cities have been portrayed as predominantly monumental static and architectural structures of ever evolving and increasing ecological complexity. Disturbances change the resilient capacity of nature to supply ecosystem services, they can degrade socio-ecological systems and lead to social and economic vulnerability. Urban dwellers pose a high impact on ecosystem services with

DOI: 10.4018/978-1-7998-8482-8.ch015

their habits in trade and consumption, claiming support in waste absorption, carbon emissions, residential water use and wood for industrial purposes (Folke et al., 1997, Grimm et al., 2008).

According to Levin (1999), humans depend on fragile ecosystem services. A global health control of the ecosystems, published in 2005 by The United Nations Millennium Ecosystem Assessment (MA) observed that the technological advancement is the main cause of degradation of the Earth's ecosystem services, which are being used unsustainably. The growing eco-deterioration also impedes in the battle against poverty (Millennium Ecosystem Assessment (MA), 2005). The ecosystem and natural resources are controlled by a few people who do it for short-term economic gain.

The survival of humankind is also dependent on healthy and resilient social-ecological systems and sustainable environments. Meanwhile, human well-being, economic growth and social development are dependent on the interrelationships between and within regions and environmental sustainability (Arrow et al., 1995; Folke et.al., 1998). Uncertainty, diversity and variability of social-ecosystems are all factors that contribute to their diminishing capacity to cope with disturbance and change within functional groups in the adaptive capacity of ecosystems (Folke et al. 2002; Jackson et al. 2001; Scheffer et al. 2001).

In order to conserve ecological resources, it is essential to promote sustainable and resilient lifestyles in sustainable urban social-ecosystems. This can be done with various activities that range from the construction of green spaces, sustainable architecture, green housing, eco-villages, green business and green economic sectors, sustainable urban agriculture and farming, green technologies, renewable energies and designing reversible and flexible systems (Zhang and Babovic, 2012). Sustainable architecture or ecological economics, sustainable technology, and agriculture (Costanza and Patten, 1995) stand out as specific types of sustainable and resilient urban development. Thus, sustainable, environmental and ecological systems are being identified within resilient social-ecosystems as the elements that have the capacity to continue functioning despite being confronted with natural and anthropogenic disturbances, anticipating and preparing ahead for them.

The resilience approach provides a conceptual and theoretical framework for interdisciplinary collaboration with ecological economics, sustainable development and governance (Lambin, 2005). Contextual and conceptual factors of urban change can be assembled into a framework of ecological urban design. Adverse human impacts on the social-ecosystem and the biosphere can be minimized through the use of resilient and sustainable environmental approaches such as environmental resource management, conservation biology, environmental and ecological economics, bio economics, green technology, etc.

On the other hand, ecology refers to the paradigm, knowledge, methods and procedures of contemporary ecological science (Kolasa & Pickett, 2005), and is a multidimensional and complex concept that requires an interdisciplinary framework of analysis for its application in urban spaces (Pickett & Cadenasso, 2002). The dimensions of ecology are the notion, the models and the metaphors used to communicate assumptions, values and experiences (Cadenasso et al., 2006a)

Urban land-use is inextricably interrelated with resilient social-ecosystems, which is influenced by the behavior of individuals, groups, organizations and communities. Urban land-use is targeted at specific and limited functions of the city, such as biomass and water passage and accumulation. In recent population trends, urban land-use and vacancy patterns must consider their impacts on vacant land and structures. In densely populated areas, urban farming, agriculture and gardening offers an alternative use and integrates multiple functions. However, current land-use practices in urban sustainable planning prohibit agricultural and farming activities in urban spaces while there is a significant loss of farmland nearby (Pothukuchi & Kaufman, 1999; 2000).

Another important element is urban green space, or an underdeveloped piece of land located within the territorial context of a city and open to the public. Urban green spaces are pressured to provide economic, social, cultural and ecological functions. These spaces provide ecosystems services to human beings and must simultaneously meet the needs and preferences of local population.

Therefore, urban green spaces play a critical role in conserving biodiversity, mitigating the impacts of climate change, sequestering carbon, improving micro-climate, protecting water resources, conserving biodiversity, protecting water resources and supplying fresh food. Urban agriculture, farming and gardening have become increasingly necessary and are supported by sustainable urban planning and designing to improve the quality of life in the city. The benefits of urban agriculture are recognized for their multicultural traditions, recreational trends and poverty alleviation (Hough, 1995, p. 230).

Also, urban ecosystems are a potential solution for future ecological and environmental issues caused by the loss of natural landscapes. When the natural resources and the ecosystem are controlled by a few privileged people, the capacity of adaptive development is reduced, the resilience diminishes and there is more disequilibrium. The balance between natural and urban ecosystems and the surrounding regional landscape is limited. Urban ecosystem services are important in the conception of urban green spaces and the biodiversity, micro-climate control, carbon sequestration, soil infiltration, food production and recreation that it can contribute to its community.

Sustainable urban planning seeks to create attractive land-use combinations to meet the needs of residents and environmental challenges through initiatives like urban farming, agriculture and gardening. Urban planning seeks to create and incorporate attractive land-use combinations to sustainable development plans, and provide recreational, educational, cultural and agricultural resources, as well tourism, farming and gardening, urban forestry, aquaculture, health services and commerce, (van de Berg and van Veenhuizen, 2005; Deelstra et all, 2006). However, the urban land-use planning and design authorities don't always consider the relevance of natural resources and land provision to support urban food production (except for urban planning policies that support gardening). Therefore, urban land-use policies and rules may have negative impacts on local food production and distribution (City of Portland, 2007).

Innovative types of land-use can offer benefits to vulnerable groups (Clement 2013, p. 76). The innovation of productive land-use as landscape typology is designated for local food production and, with innovation in ecological resilience, these open spaces require decommissioning of urban services, and encourage residents to seek employment in agriculture. On the other hand, multi-functional urban planning involves the participation of various stakeholders in making decisions on green infrastructure planning. Furthermore, community greening initiatives are a community-based effort to transform underutilized sites and areas into valuable green spaces like community gardens (Tidball and Krasny, 2009). Community organizations for nature conservation focus on the preservation of urban social-ecosystems and protect them from dysfunctional anthropogenic activities in order to adapt the development and achieve economic efficiency.

Innovative and integrated sustainable initiatives and strategies in urban land-use planning can contribute to green resilient economic growth, as well as social development issues such as inclusion and equality, and environmental sustainability. For the implementation of strategies, it is important to create a typology of community land-use types based on vacancy characteristics, the income of the area's residents and vacancy market rates. This will allow the transformation of vacant spaces into resilient green spaces, and allow them to carry out their many inherent functions (Akers, 2013; Detroit Works Project, 2014, p. 51). Vacant land restoration should be an interdisciplinary approach that combines economic and socio ecosystem concerns from a holistic urban land use perspective.

## SUSTAINABILITY AND GREEN SOCIAL-ECOSYSTEM RESILIENCE

Human beings have had a profound imprint on nature and now, we must deal with the resulting challenges. One of the most difficult realities is the phenomenon of global warming. Some options and practices drawn from sustainability and green social-ecosystem resilience could very well help communities in the fight against global warming. Sustainability is a set of goals combining social equity, economic viability and ecological integrity (Curwell, Deakin, & Symes, 2005; Jenks & Jones, 2010). Sustainability is also defined by the capacity of a system or process to be preserved, enhanced, upheld, or maintained. It is the capacity of biological systems and processes to endure disturbances and remain vigorously diverse, remaining as the systematic combination of environmental science and sustainable development (Lynn et al., 2014).

One of the core values in sustainable practices is the sustainable development and interconnection in the domains of ecology, culture, politics, and economics (James, et al., 2015). From this social perspective, sustainability is a challenge that has an impact on economic efficiency, production, distribution, urbanization, transportation, lifestyles and ethical consumerism, and it involves local and global efforts to meet core human needs without distorting the ecosystem (Kates et al., 2005; IISD, 2009; Eur Activ, 2004).

Sustainable development also implies proactive and responsible decision-making. It requires innovative processes that maintain balanced social and ecological systems between resilience, economic efficiency, social inclusion and equality, political justice and vibrant cultural values that work to ensure a lively, desirable and sustainable ecosystem for all of its residing species (Liam et al., 2013). Sustainability is also a normative social goal that can be promoted with the mechanisms of ecological resilience.

Resilience is defined as the capacity of socio-ecological systems to self-reorganize after any disturbance. Resilience is a concept and model framework used to operationalize normative sustainability (Childers, Pickett, Grove, Ogden, & Whitmer, 2014). It refers to the ability of an ecosystem to respond productively to significant disruptive change and adapt to external variables that threaten its existence. At the same time, resilience is a system´s ability to adapt to any kind of disturbance and self-reorganize while undergoing transformation, and retaining its initial forms, roles, identity, and feedback characteristics (Walker et al., 2004).

The concept of resilience is defined by its capacities to absorb the uncertainty that follows any kind of shocking event or conflict, to maintain its primary functions, and to go through self-growth, renewal, development and re-organization (Gunderson and Holling, 2002; Berkes et al., 2003). Any disturbance of a strong and resilient socio-economic and ecological system can have the potential to create new opportunities for innovation and advancement. However, when the system is weak, any slight disturbance can be disastrous (Adger, 2006).

## SOCIAL ECOSYSTEM RESILIENCE

Resilience is also a dynamic process that forms symbiotic relationships within and between the social ecosystem and its environment. Social-ecosystem resilience is found in the continuous cycle of adaptation and transformation all while maintaining the system's integrity and viability. It is the reaction of the socio-ecological system towards disruption and destruction, and its capacity to recover and develop in a state of uncertainty, discontinuity, and emergency. Social-ecosystem resilience happens when self-organization and learning meet adaptation and persistence.

Resilience is concerned with the management of sustainable interactions between human-developed systems and natural ecosystems. Social resilience linked to social change is the communities' capacity to cope with extrinsic disturbances to their social infrastructure, such as political turbulence, socio-economic reforms, and environmental variability (Adger 2000; Anderies et al., 2004). Resilience can interfere and be in conflict with other beneficial social objectives, such as economic efficiency, due to the costs of redundancy. In other words, economic efficiency reduces resilience. The resilience of social-ecosystems requires more adaptability to stress while maintaining stability in the face of extrinsic disturbances and to find a solution to the conflict between stability and resilience for sustainable development in terms of complex system cycles.

Apart from representing the measures taken by a social-ecosystem to self-organize and cope with disturbances while still maintaining its inertia, attraction and capacities for learning and adaptation (Carpenter et al. 2001), resilience can also be an approach for cogitating and critiquing social–ecological systems, with policy implications for sustainable development (Folke et al., 2002). Social-ecosystem resilience is an essential factor to cope with uncertain and complex systems for sustainable natural resources and ecosystem services (Gunderson and Holling, 2002). Any disequilibrium between sustainability and development change leads to the collapse of ecosystems. In addition, it is extremely difficult to transform a resilient ecosystem into a more congenial one (Scheffer et al., 2001; Gunderson and Holling, 2002; Walker et al., 2004). In other words, it is possible to prevent degradation by promoting the system's congeniality with nature.

A sustainable and resilient social-ecosystem does not largely depend on human input or activity due to the fact that anthropogenic interferences can interrupt the provision of inputs. Instead, it is more reliant on the ways of nature. The social ecosystem is currently threatened by anthropogenic activities that find themselves at the brink of collapse, and this requires prompt action. In the context of social-ecological systems, management and flexible collaboration are crucial; they help develop policy frameworks as a basis to build adaptive capacity. Nature should be strengthened to stimulate development through the interaction and interdependence with humankind to enhance resilience in social-ecosystems.

## ECOLOGICAL RESILIENCE

On the other hand, resilience plays an important role in the field of ecology. (Holling, 1973; Wu & Wu, 2013) Ecological resilience is a concept that must be operationalized to be applied in urban environments and cities (Musacchio, 2008). Older perspectives of resilience assumed that a stable and static equilibrium between socio-economic and ecological systems was required in order to adapt to nature (Berkes et al., 2003, Smit and Wandel, 2006). Resilience has tools that were developed upon structured scenarios and adaptive management that can be used to build complex and uncertain systems. These tools increase the capacity to build ecological resilience.

Ecological resilience is the capacity of a site in an urban system to adjust and control its interactions with external vulnerabilities, disruptions and shock, thus ensuring a more sustainable urban component of the ecosystem. Ecological resilience is the ecosystem´s capacity to cope with disturbance all while maintaining its structure and functions. Unlike engineering resilience which has the capacity of returning to its previous existing state before perturbation, ecological resilience refers to patch ecology or landscape and the notion of metacity and experimental modeling and design.

Sources of natural resilience and complex adaptive systems are more than just the preservation of ecosystems and resistance to change. Traditional and dominant theoretical perspectives assume a certain stability and resilience in the environment, as well as a static equilibrium in the natural elements of the system after the external disturbances have been dealt with and removed from the system (Holling, 1973).

## RESPONSE DIVERSITY

Resilience sustains the urban ecosystem under uncertain and complex situations. Because of this, human activity can have direct consequences and cause shifts in resilient social ecosystems. Response diversity among species within a functional group is a component of resilience and is critical to ecosystem reorganization. It is a fundamental capacity of individuals, groups, organizations, and ecosystems to respond to significant disruptive changes.

Response diversity is the set of reactions among species belonging to one ecosystem, whose functions promote environmental change. Species and populations diversity within functional groups maintain ecological redundancy in ecosystem services (Luck et al. 2003). Resilience in relation to species should consider that the loss of species is non-random in relation to response diversity and the functions of the ecosystem. However, response diversity in ecosystem resilience is linked to ecosystem disturbances and environmental changes. Biological diversity is essential in social ecosystem resilience and in sustainable ecosystem change (Peterson et al. 1998). Biological diversity enhances the social ecosystem resilience and ensures the production of ecosystem services.

For this reason, resilience approaches the opportunities that arise from ecosystem changes in its structures, processes, emergence of great developments and in its coping with disturbances. Resilience is an essential factor for sustainable development, especially to maintain a dynamic equilibrium with the natural disturbances of the social–ecosystem's functioning. Response diversity as a method to sustain ecosystem states, functional groups and ecosystem services come together to face disturbances and environmental change. Response diversity operates across spatial and temporal scales.

High response diversity increases the insuring buffer for resilience and the effectiveness of ecosystem management policies and actions. Response diversity is relevant to resilience because the diversity of species contributing to an ecosystem's functions work towards the renewal and reorganization of environmental changes. In addition, it contributes to resilience when planning, managing and restoring social ecosystems. Finally, it provides adaptive capacity in uncertain and complex systems and human-dominated environments.

Moderate perturbations and disturbances on the stability of resilient social-ecosystems may either be absorbed by their ability to reorganize, or may bring small changes in resilience supported by response diversity (Deutsch et al. 2003). For example, response diversity helps maintain resilience in ecosystems that are affected by toxic chemicals and acidification, such as lakes (Carpenter and Cottingham, 1997).

Response diversity does not necessarily support the notion that a high biodiversity is synonymous to high ecosystem resilience, and that the ecosystem is less vulnerable to environmental change. The migration of population to urban centers has led to a reduction in ecosystem biodiversity (MA, 2005; Sala et al., 2000). Biodiversity and response diversity, which is a variability in responses of species to environmental change, are both critical factors of social-ecosystems. On the other hand, cultural diversity and common property systems are linked to building resilience in urban socio-ecological systems. Urbanization processes have led to higher levels of cultural diversity in cities (Zanoni and Janssens, 2009).

## URBAN AND ECOSYSTEM RESILIENCE

The terms "urban" and "city" are used to describe densely settled regions. These urban systems have spatial and functional contexts that combine social, biological, architectural and geophysical components (Graham & Marvin, 2001; Seto et al., 2010; Naveh, 2000; Pickett & Grove, 2009). Some of the main social dimensions of urban systems are economics of production and consumption, economic and political power, social inclusion, identity, equality and change, social justice and vulnerability, the nature of livelihood and lifestyle (Dow, 2000; Grove et al., 2006; Machlis, Force, & Burch, 1997).

Urban spaces have a direct influence on the environmental values of urban populations (Miller, 2005; Tidball et al., 2010). Urban spaces and territories are changing rapidly, becoming globally interconnected across contrasting types of landscapes and are always facing new environmental, demographic and social threats.

Additionally, urban green commons (UGCs) have the potential to facilitate civic participation and cultural integration, to manage urban land and biological diversity in urban spaces and promote urban resilience building (Colding and Barthel, 2012). Urban transformation is benefiting from the shift in the framework of urban ecology, which has seen an evolution from its earlier approach to metabolic urban energy budgets to that of city resilience, focusing on hybrid systems such as the biophysical - social structures and processes (Cadenasso et al., 2006b; Cadenasso & Pickett, 2013; Cadenasso & Pickett, 2008; Pickett, Cadenasso, & Grove, 2004).

Urban resilience in cities is the ecological approach used to analyze changes, disturbances, vulnerabilities and mutability of a city's development and its relationship with climate change. On the other hand, sustainability measurement requires transparent accountability between the resources depleted and those used to replace them in the ecosystem. The accountability of natural resources in an ecosystem occurs through the adaptation process after an external disturbance. Adaptive processes contribute to the adaptive cycle in urban socio-ecological systems.

An ecosystem is a structural and functional unit of the biosphere. Ecosystems have complex interrelationships with human activities that constantly threaten their sustainability. The vulnerability of an ecosystem is related to the other organisms that exist within that functional group. Contraction of spatial resilience increases the disturbance to catastrophic levels (Nyström and Folke, 2001).

Ecosystem resilience is the capacity to accommodate and adapt to disturbances, and the ability to buffer and persist in the face of external interference. In other words, it is the amount of disturbance that a system can absorb while still remaining in the same state and maintaining its attraction (Holling 1973, 1996). Ecosystem resilience also represents the degree of ability that a system has to learn, adapt and self-organize when confronted with external disturbances (Carpenter et al. 2001). The dynamic changes of ecosystem resilience are related to the diversity of species and functional groups (Walker 1992, 1997; Norberg et al. 2001).

Ecosystem resilience has a cross-scale response diversity. This means that biodiversity has an important role in formulating policy for sustained economic and socio-ecological development. Managing for resilience is to constantly work with uncertainty in the biosphere shaped by human action (Folke et al. 2002).

The preservation of congenital features leads to the robustness of the ecosystem, despite alterations in its behavior and changes in its environment. The resilience of ecosystems provides backups to replace failures in the species. This is done through the diversification and redundancy of biodiversity, which overlaps with ecological functions in natural ecosystems. Ecological functions of various kinds are often confronted with external disturbances. Ecological disruption occurs across a limited range of spatial and time scales allowing undisturbed scales to persist and ecological functions to operate.

## GREEN RESILIENCE

The framework for sustainable planning in urban ecosystems draws notions from urban ecology, green resilience, green infrastructure, multifunctional and sustainable landscape planning, etc., with the purpose of creating and developing healthy and sustainable economic and social–ecological urban systems. Urban ecology is rooted in landscape ecology and combines principles from physical and atmospheric sciences, soil, hydrology and social sciences, etc. (Sukopp, 1990; Collins et al., 2000; McDonnell & Hahs, 2009; Pickett, Burch, Dalton, & Foresman, 1997; Redman, Grove, & Kuby, 2000). Green resilience deals with the coping of our planet with anthropogenic disturbances and ensures that it remains viable for future generations.

The concept of green resilience may be seen from a narrow interpretation to broader one of the socio-economic and ecological contexts. An ecological unit is the functioning of components and their relationships and interactions with each other, forming a complex and dynamic whole. Sustainable and green resilience of ecosystems can be measured at event junctures, where naturally occurring regenerative forces interact with the energy released into disturbances. These regenerative forces are the solar energy, water, soil, atmosphere, vegetation, and biomass (Ben, 2013). Green resilience is an institutional capacity to cope and deal with stress and conflicts arising from climate change, unforeseen contingencies, unsustainable development to live and other emerging environmental issues within the ecosphere.

Green resilience sources intertwine with complex adaptive systems of dynamic changes in the ecosystem. The dynamic adaptive capacity of the ecosystem is provided by the connection between resilience, development change and sustainability (Smit and Wandel, 2006). The key to coping with change in social systems is in anticipating and combating disturbances, in adaptive development and in integrating resilience in the interactions with ecological sustainable development. Adaptive development in the social ecosystems has the ability to carry out the ecological assessment of actual events and taking corrective action.

Sustainable development pretends to reduce social and ecological damage on both a local and a global scale through the operation of fairness and social inclusion, protection of the environment, and economic efficiency. Green resilience-building in complex, uncertain and unpredictable urban ecosystems is supported by structured scenarios and active adaptive management for sustainable development. Green resilience management enhances sustainable development in changing complex environments where the future is uncertain and unpredictable (Walker et al., 2004; Adger et al., 2005). The strategies in any system of urban green resilience focus on green infrastructure and aim to transform and adapt various resources to face future challenges such as climate change and food insecurity.

## THE ISSUE OF LAND USE IN URBAN AREAS BASED ON KNOWLEDGE

The term “ecosystem”, coined by Roy Clapham in 1930, describes the biological and physical environmental components that come together as a unit, and where all the elements coexist in relation to one another. The ecosystem was described as the interaction between the living creatures (biocenosis) and the environment where they live, or (biotope) (Tansley, 1935). According to the Convention on the Biological Diversity (1992), ecosystems are dynamic and complex systems, where communities of plants, animals and micro-organisms live in harmony with their non-living environment in a functional unit.

Other definitions of "ecosystems" define it as biological organizations formed by living organisms interacting with each other and in a symbiotic relationship with their environment. An ecosystem is capable of harnessing solar energy during photosynthesis and convert it into carbon dioxide and other inorganic chemicals that are essential to organic life. An ecosystem is an open system that requires a flow of energy and matter between diverse organisms and their environment, driving biogeochemical processes.

A functioning system has living and non-living components interacting with each other (Christopherson, 1997). Therefore, any ecosystem has both living organisms and abiotic (non-living matter) elements. The biotic components are the living forms that inhabit the ecosystem and have a biogeochemical energy cycle. Actually, the term "ecosystem" refers to the bionic community of living organisms and biocenosis in continuous interaction with their environment or biotope and functioning in a space as a unit.

The abiotic elements represent the nonorganic material of the environment that determine which life forms can thrive in the ecosystem. Energetic processes in ecosystems are formed by tropic levels that are in turn, defined by the role of organisms and their flow of energy. Ecosystems fall between the extremes of biological complexity (Odum, 1971). In sum, living organisms are continuously interacting with environmental biotic and abiotic components (Golley, 1993). Besides being complex and adaptive systems characterized by historical dependency and non-linear dynamics, ecosystems have multiple basins of attraction (Levin 1999). The biosphere is the largest ecosystem, and it interacts and exchanges matter and energy with the lithosphere, hydrosphere and atmosphere.

Ecosystem processes respond seasonally to solar activity, which represents the largest biogeochemical carbon cycle on the planet (Odum, 1971). An ecosystem-level process can be represented by a biogeochemical exchange cycle between organisms and their environment (Golley, 1993). Energy transfer and matter cycling processes are essential in determining ecosystem structures and functions of a wide diversity of species, as well as in defining the interactions between organisms and their environment (Golley, 1993). The living elements are continuously competing to reproduce and survive among each other. When the strength of dominant species begins to decline, other subdominant species in the same functional group are able to survive (Elmqvist et al. 2001).

The ability of a social ecosystem to sustain itself relies on its ability to adapt to the environmental changes that often occur in multiple-equilibrium systems and human-dominated environments (Folke et al. 1996; Norberg et al. 2001; Luck et al. 2003). Environmental change with low response diversity may result on extinct or ecologically insignificant functional groups that contribute to ecosystem services. Protecting a social ecosystem from compounded perturbations requires the functional groups of species to be ready for renewal and reorganization (Lundberg and Moberg, 2003). Response diversity management sustains and enhances the flow of ecosystem services that are confronted with disturbances and that operate within and across spatial and temporal scales.

The impact of disturbances on the loss of species has many implications for social ecosystems and their flow of services (Zimov et al. 1995). The persistence of functional groups of species prevents shifts to ecosystem states and helps sustain the flow of ecosystem services. Species loss may entail low rates of ecosystem processes. Low or absent response diversity redirects ecosystem development into a different pathway. Stress-sensitive species populations tend to decline, and response diversity deteriorates while less sensitive species experience minimal changes in ecological processes (Schindler, 1990; Frost et al. 1995, Rudd et al. 1988).

## URBAN LAND USE

On the other hand, urbanization is rapidly expanding in cities, which are becoming frontiers for landscape ecology in urban ecosystem science. Urban land is a natural resource-constraint threatening the prospect to meet the needs of increasing urban population, the economic prosperity and socio-political stability of the city, and is constantly influencing policy decisions. Resource depletion and pollution are two global issues that are directly related to land-use change. The movement of people into more densely populated urban settlements can lessen pressure on urban and suburban sprawl and more remotely located ecosystems (Colding, 2011).

In regard to eco-oriented urban land uses, there has been an increasing emphasis on sustainable urbanization since metropolitan areas are engaged to upgrading land-use regulations, infrastructure, urban form and ecosystem services, etc. This has been done in an effort to protect urban biodiversity and to create a better urban resilient socio-ecosystem, capable of developing a sustainable urban environment with more social justice and economic growth, all while improving competitiveness and attractiveness of the city (de Jong et al. 2015). Additionally, urban land maintains its relationships with the urban land market, local government regulations, management practices and with technology innovations. It is influenced by the complexity of societal processes and ignores the systemic consequences and effects on the resilient socio-ecosystem services.

Land use must prioritize nature and biodiversity in order to support the sustainable urban development in a territorial context. Networks of open urban spaces unite nature and gardening with the goal to build green and resilient cities inspired by nature and biodiversity (Quincerot & Weil, 2009, p. 175; Daune & Mongé, 2011). Land uses can be appropriate to develop a network of green open spaces for gardening in core areas of the city (Quincerot & Weil, 2009).

A contemporary and ecological movement advocates for principles of sustainable land use in urban planning even though this movement is not always involved in projects that demonstrate those principles (Seana, Johnson & Peters, 1999). Furthermore, the integration of land-use initiatives as formulated in urban planning are not always implemented or realized and can become negotiation spaces for less formalized land-use initiatives and practices. A sustainable urban transportation system that uses renewable resources and energy and that operates efficiently and affordably helps minimize the use of land and limits emissions the emission of waste and noise in the atmosphere.

Biodiversity in suburbs constitutes both natural and semi-natural land with an increase in the semi-rural urban fringe (Blair, 2001; McKinney, 2002; Sukopp et al., 1979 Colding et al., 2006). Urban development emerges in high levels of biodiversity areas with high ecosystem productivity (Ricketts and Imhoff, 2003; Hansen et al., 2004; Ljungqvist et al., 2010).

In addition, cities that show a commitment to urban planning and to the implementation of ecosystem services in support of greening projects for transforming urban green infrastructure are likely to benefit from the value creation of these projects, which would in turn, be beneficial for all of the population. The modernist model of urban development is described as a life cycle of cities moving from commodity exchange and industrialization, through an ecological version that mitigates all the ills of the urban ecosystem. Therefore, urban design and planning take into account the coordination of resources, capacities and efforts to be implemented in comprehensive agendas across the city.

Landscape ecology comprises the concepts of landscape sustainability. It represents the capacity to consistently provide long-term and landscape-specific ecosystem services that are essential for maintaining and improving human well-being (Wu, 2013) and ecosystem services in changing landscapes (Wu & Qu, 2013).

Urban green infrastructure is a strategically planned and manages an urban network of natural lands, working landscapes, and urban open green spaces that provide a range of diverse benefits. Ecosystem services for example, can offer many benefits to human beings (Millennium Ecosystem Assessment 2005). The social-ecosystems capacity to minimize the impact of disturbances affects the flow of the services required for the well-being of its community. Landscape services can offer some benefits to the population because it functions as a structure–function-value chain to create landscape development (Termorshuizen Opdam, 2009).

Urban planners and landscape designers can coordinate activities across different fields and urban functions, allowing these spaces to fulfill their full potential as multifunctional and sustainable spaces. The multi-scale analysis of land-use compositions is a useful element for the planning of land use and for the design of policy for urban sustainability. This analysis of land uses may be conducted with a participatory design process of visioning, defining, relating the elements, elaborating the site plan and the implementation process. Multiple land-use scenarios simulate the future changes in composition of their functions, such as self-sufficiency in vegetable production. Changes in land use may lead to inaccurate counts of land abandonment and vacant land (Bowman and Pagano, 2004).

Furthermore, multifunctional landscape frameworks are applied to both agroecosystems and planning urban ecosystems, and it provides beneficial production, ecological, and cultural functions, considering the needs and preferences of users and owners (Otte et al. 2007; Lovell et al. 2010). A commitment to multifunctional urban green infrastructure brings value of ecosystem services to urban populations. The optimization of urban green space functions can be put to the test by using a multifunctional landscape framework for sustainable urban design and planning of green infrastructure. Multifunctional green infrastructure provides ecosystem services and the presence of biodiversity in urban areas can bring many benefits to the environment and society.

These urban ecosystem services are supplied through participatory planning processes that are focused on multifunctional green resilience infrastructure, and that are developed to contribute to sustainable ecological, social and economic welfare of the city. Ecosystem services transform urban green infrastructure through the integration of empowerment and creative processes into small-scale greening projects. A multi-functional role of land uses can provide urban corridors of gardening spaces to preserve nature, agriculture and farming practices, and to perform educational and recreational activities that help protect biodiversity and the natural environment all while improving resilient socio ecosystems and inner-city densification.

The relationship between biological diversity and the various functions of an ecosystem is founded on the abilities of self-renewal and reorganization that biodiversity can bring to stimulate change and growth in social-ecosystems (Loreau et al. 2001; Kinzig et al. 2002). Despite the diversity in compositions and considerable species turnover, the organization and functioning of social-ecosystems can be seen as conservative due to patterns of species loss. (Schindler 1990; Kalin Arroyo et al. 1995; Forys and Allen 2002; Brown et al. 2001, Havlicek and Carpenter 2001). Otherwise, social-ecosystems may change when some species are lost or when there is an invasion of other new species (Estes and Duggins 1995; Terborgh et al. 2001; Vitousek and Walker 1989).

Some spaces can also be used for the reuse and recycling of waste. On a long-term basis, this specific type of land use can help reduce transportation and improve city management. Cities often struggle to manage opposing external and internal frontiers of land and should be more spontaneous in the decisions they make regarding land-use management of soils. (Berger 2007). This constant tension between the expansion of urban periphery and unused spaces has always existed in the internal frontier of the urban core. (Rusk 1993).

## LAND USE CHANGE

The accelerated conversion and change of land use from arable or forested lands to urban land use is threatening the biodiversity, the species and the natural resources which have historically provided the sustenance, valuable goods and services, climate regulation, water recharging, nutrient recycling, agricultural products, timber, seafood and waste assimilation, etc. All of these benefits are in danger of extinction due to increasing urban land use. In response to the growing challenges posed by the conversion from agricultural to urban land uses, it is crucial that local governments formulate and implement urban development strategies that ensure more eco-efficient benefits in terms of economic growth and productivity as well as more socially equitable, inclusive and environmental sustainability.

Land-use issues require a multi-disciplined and cross-departmental approach that will have a direct impact on economic efficiency and urban growth, employment, social inclusion and equality, health and sustainable environment. Urban zoning, neighborhood plans, and the spatial-temporal patterns of inequality are other factors that have significant impact on land use. However, the use of land for agriculture and farming are not broadly accepted by local governments because they believe that there are possible health risks associated to these practices. Urban agriculture and farming practices can sometimes be divisive within their societies, especially when the spaces could be used for other scarce economic activities.

Urban land-use planning and zoning is growing exponentially and conflicts with other similar practices that question the usefulness of urban agriculture. Enhanced security is required around the physical limitations of the urban spaces, and although this has potential productive qualities, it also causes the spaces to become unbuildable and their urban parcels, underutilized. (Pagano and Bowman 2000) The high land prices, the exposure to pollution, the contamination of water, air and soil from industrial and commercial activities and traffic affect the land use for housing, education, recreation, agriculture, farming and gardening. This causes hampering investments and leads to poor land-use security (Mougeot, 2000).

In addition, buildings and infrastructure put great pressure on urban land use. Vacant residential yards and industrial rooftop spaces are considered different land uses. Some land-use maps do not distinguish parking lots from other vacant spaces. A good example that was reported by Hui in 2011, is the abandoned land used to plant flowers, ornamental plants, herbs and vegetables, next to a government building. However, urban land use for agriculture, farming and gardening have become quite attractive because of their potential to meet multiple needs of their community, such as supplying fresh and healthy food in neighborhoods with limited access, articulating the linkages between the built environment, food systems and health while offering opportunities to residents for employment, recreation and education (Hodgson et al., 2011; Redwood, 2011). Montreal for example, has the largest municipal urban agriculture program in Canada, and has effective land-use designation (Cosgrove, 2001).

Public actions can be taken to promote the social dimensions of urban public spaces as part of collective re-appropriated spaces for diversified uses of unused vacant land around housing areas. Recovered unused land is often used for agriculture, farming and temporary gardening projects created on constructible land and adapting to the demands of residents. These public actions for more integral city development are aimed to foster conviviality, proximity and social cohesion between residents (Canton de Genève, 2013), and enhance the urbanite social interaction and cohesion while improving quality of life.

The urban land-use planning system contributes to the economic growth, social development and environmental sustainability of a city. Vancouver's Food Action Plan (City of Vancouver, 2003) supported the land-use decision to serve as a public resource to support the city's commitments to sustainability. In states like Oregon, the land-use planning system demands that each city set an urban growth boundary to show the physical limits and control of "sagebrush subdivisions, coastal condo-mania, and the ravenous rampage of suburbia", and the protection of farm and forest lands (McCall, 1973).

The awareness of sustainable urban land-use planning reinforces the development and maintenance of a data-based development system. It manages issues of urban growth or decline as well as rundown and waste resources. (Carley, 1995; Curwell and Cooper, 1998; Department of the Environment, Transport and the Regions (DETR), 1998). The decision-making process around land use, urban development and parallel policies are made in support of sustainable planning. The policies are made based on an inventory of natural resources. In most cities, urban land-use planning for commercial farming requires special permits and must follow zoning and building regulations and city codes for water sources, fire and energy as well as waste disposal.

Urban planning and food production policies developed by local authorities may connect the issues of land-use planning and sustainable development. Some cities have already implemented an urban land-use and comprehensive plan that includes urban farming and agriculture. In order to do so, they adjusted zoning and permission granting procedures and included infrastructure, materials, knowledge, and other resources in their city plans (Mukherji and Morales, 2010). The land-use planning system fills the middle layer vacuum. Although land availability and land use are not statutory requirements for sustainable urban planning, they are at the center of the development of urban food production.

Land-use planning has an important role in urban policy as it delivers sustainable development ideas. Urban gardening for example, contributes to the growth of cities' economies by promoting health practices. (Hynes, 1996, p. 161). Urban land use policies and regulations are also used for the management of vacant city spaces, which in in turn, creates networks of sustainable urban spaces and provides better ecosystem services for the development of more sustainable cities. Long-term vacancy requires more oriented regeneration policies (National Land Use Database, 2000). Vacant buildings require the recording of reliable and comprehensive information. The rights to access the city and its built environments are other key elements that grant citizens the right to part-take in the development of their community. It allows them to participate and help make democratic decisions about their city planning, and grants them the right to access, occupy and use urban spaces (Lefebvre, 1996).

The term "built environment" refers to "the human-made structures that provide the setting for human activity such as buildings, parks and green spaces, neighborhoods and cities. The supporting infrastructures of built environments, such as water supply or energy networks is often incorporated within these environments. "The built environment is a material, spatial, and cultural product of human labor that combines physical elements and energy in forms for living, working, and playing." (Kaklauskas & Gudauskas, 2016, p.413). These concepts underline the communities' opportunity to care for their surroundings and increase the quality of life by providing the necessary elements to propitiate a resilient and sustainable environment.

## CHALLENGES AND RECOMMENDATIONS

Pressures arising from climate change are related to some extent, to the increasing scarcity of land for urban use and other natural resources, such as water and natural nutrients. In many places, population is continuing to rise and becoming an important concern for the policy agenda. The orientation toward resilient and ecological land use is only one of municipal governments' challenges as they must work to converge the structures and processes of urban social-ecosystems with energy, fuel, climate, water and food. These challenges incorporate economic, social and environmental perspectives, and integrate initiatives of diverse stakeholders to invest in natural resources and capital projects and generate development of green resilience in the city.

The phenomenon of resilience in sustainable development may lead to some policy recommendations to improve the interrelationships between the economic efficiency and the social-ecosystems and biosphere, to develop flexible and innovative relationships of collaboration, and to achieve sustainability and its operationalization in the context of socio-ecological resilience. Other policy recommendations should focus on the development of indicators to measure any change in the level of resilience and to signal and monitor uncertainties of social–ecosystem variables and to manage diversity.

Human beings are living in a time of qualitative changes in many areas of urban life. These changes have a great impact on city management. Seemingly, now is the time to redefine the city's functional structure; many countries still operate under obsolete and ineffective functional and spatial divisions. In the face of significant changes in civilization, many existing regulations impose barriers and impede the rational development of communities; it's time to introduce new and innovative solutions. Notably, there are urban land-use plans that propose innovative and pro-environmental solutions that support green, resilient and eco-oriented uses of urban ecosystems and promote a better quality of life in the city. In sum, urban land is scarce, and it should be treated in a more sustainable manner.

City planners and landscape designers consider agricultural and farming landscapes to be important areas for the future of sustainable urban development. The urban agriculture and farming lands are inherently multi-functional and can offer many public benefits beyond the provision of sustainability and commodity outputs. The amount of vacant land in urban centers is increasing, especially where land-use densities are declining. This is the result of the decline seen by manufacturing activities after limits on employment creation and population density have been reached.

Urban land use scenarios are a tool that helps to allocate vacant urban spaces to vegetable production in residential green spaces like gardens and rooftops. Land-use control and building regulations constraint and limit farming and gardening in urban areas. In order to determine the current characteristics of land uses, it is necessary to conduct some data-base analysis from primary and secondary sources. This approach allows cities to broaden their vision by considering the multiple functions of a specific site and defining its various components by comparing data with other cities. Then, land uses are identified for specific functions such as education and recreation, etc. Land-use components, their dimensions and locations are included in the proposals. This whole process serves to identify the needs and expectations of the urban community regarding land uses, spatial design and site plans.

Urban sustainable planning systems can encourage the use of urban land for more sustainable development like the production of local food. Sustainable urban planning fails to consider that the food system is its turf, pointing the responsibilities to land-use regulations and built environment. The temporal urban land-use plans that are applied to open green spaces have formalized the concept of urban gardening and farming initiatives to help provide more qualitative resilient ecosystem services that contribute to the development of more resilient cities.

In addition, land-use planning must meet the demands posed by the socio-economic activities and urban growth to ensure the effective management of value creation and environmental sustainability. However, farming and gardening may not always be alternatives in an urban setting, especially when other competing lands with higher value can meet the needs of the city. Urban agriculture, farming and gardening are integrated into the city's sustainable planning for land use and policy processes. These sustainable practices offer new frontiers for sustainable land use planners and landscape designers and offer endless possibilities for sustainable urban development and transformation of urban spaces.

City authorities and local governments should adopt innovative urban planning and sustainable development strategies based on the use of land, resource protection practices, environmental and ecological services, social inclusion and egalitarian issues, economic growth and efficiency, etc. A strategic orientation of initiatives could seriously obstruct zoning plans. On the other hand, sustainable urban planning aims to encourage urban agriculture, farming and gardening as an effective use of land. Land-use planning and landscape design should reconcile demands of socio-economic activities and urban growth.

Ultimately, new forms of value are ascribed to public and private urban properties in order to meet other land use priorities such as housing, commercial areas, urban green areas and open spaces, roads and other infrastructure. Efficiency of urban land use can be achieved through different means and variables, such as energy consumption, water, other natural resources and waste management.

Finally, urban land use has different applications for the multiple levels of society: from the entire city to small neighborhoods, from communities to small vacant lots, houses and buildings. Urban land use should be evaluated on a basis of landscape multi-functionality, and account for the various contributions, functions, services and benefits that it can provide. The urban social-ecosystem's cultural functions, biodiversity, ecological services, economic efficiency, social inclusion and equality have the potential to bring great benefits to communities and neighborhoods and to society as a whole.

## REFERENCES

Adger, W. N. (2000). Social and ecological resilience: Are they related? *Progress in Human Geography*, *24*(3), 347–364. doi:10.1191/030913200701540465

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. doi:10.1016/j.gloenvcha.2006.02.006

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockstrom, J. (2005). Social– ecological resilience to coastal disasters. *Science*, *309*(5737), 1036–1039. doi:10.1126cience.1112122 PMID:16099974

Akers, J. (2013). Making markets: Think tank legislation and private property in Detroit. *Urban Geography*, *34*(8), 1070–1095. doi:10.1080/02723638.2013.814272

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society, 9*(1), 18. http://www.ecologyandsociety.org/vol9/iss1/art18/

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B. O., Levin, S., Mäler, K. G., Perrings, C., & Pimentel, D. (1995). Economic growth, carrying capacity and the environment. *Science*, *268*(5210), 520–521. doi:10.1126cience.268.5210.520 PMID:17756719

Berger, A. (2007). *Drosscape: Wasting Land Urban America*. Princeton Architectural Press.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating Social–Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press.

Blair, R. B. (2001). Birds and butterflies along urban gradients in two ecoregions of theU.S. In J. L. Lockwood & M. L. McKinney (Eds.), *Biotic Homogenization* (pp. 459–486). Kluwer. doi:10.1007/978-1-4615-1261-5_3

Brown, J. H., Ernest, S. K. M., Parody, J. M., & Haskell, J. P. (2001). Regulation of diversity: Maintenance of species richness in changing environments. *Oecologia*, *126*(3), 321–332. doi:10.1007004420000536 PMID:28547444

Cadenasso, M. L., & Pickett, S. T. A. (2008). Urbanprinciples for ecological landscape design and management: Scientific fundamentals. *Cities and the Environment*, *1*(2), 4. doi:10.15365/cate.1242008

Cadenasso, M. L., & Pickett, S. T. A. (2013). Three tides: The development and state of the art of urban ecological studies. In S. T. A. Pickett, M. L. Cadenasso, & B. P. McGrath (Eds.), *Resilience in urban ecology and design: Linking theory and practice for sustainable cities* (pp. 29–46). Springer. doi:10.1007/978-94-007-5341-9_2

Cadenasso, M. L., Pickett, S. T. A., & Grove, J. M. (2006a). Dimensions of ecosystem complexity: Heterogeneity, connectivity, and history. *Ecological Complexity*, *3*(1), 1–12. doi:10.1016/j.ecocom.2005.07.002

Cadenasso, M. L., Pickett, S. T. A., & Grove, J. M. (2006b). Integrative approaches to investigating human-natural systems: The Baltimore EcosystemStudy. *Nature Sciences Sociétés*, *14*(1), 1–14. doi:10.1051/nss:2006002

Canton de Genève. (2013). Plan directeur cantonal 2030. A14: Promouvoir de nouvelles formes de jardins fa-miliaux et encourager la création de plantages. Geneva, Switzerland: République et Canton de Genève.

Carley, M. (1995). The bigger picture: Organising for sustainable urban regeneration. *Town and Country Planning*, *64*(9), 236–239.

Carpenter, S. R., & Cottingham, K. L. (1997). Resilience and restoration of lakes. *Conservation Ecology*, *1*(1), 2. doi:10.5751/ES-00020-010102

Carpenter, S. R., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: Resilience of what to what? *Ecosystems (New York, N.Y.)*, *4*(8), 765–781. doi:10.100710021-001-0045-9

Childers, D. L., Pickett, S. T. A., Grove, J. M., Ogden, L., & Whitmer, A. (2014). Advancing urban sustainability theory and action: Challenges and opportunities. *Landscape and Urban Planning*, *125*, 320–328. doi:10.1016/j.landurbplan.2014.01.022

Christopherson, R. W. (1997). Geosystems: An Introduction to Physical Geography (3rd ed.). Upper Saddle River, NJ: Prentice Hall Inc.

City of Portland. (2007). *ENN-1.01: Food Policy Council (Binding city policy)*. Retrieved September 24, 2007, from http://www.portlandonline. com/auditor/index.cfm?a=ihci&c=checj

City of Vancouver. (2003). *Action plan for creating a just and sustainable food system for the City of Vancouver (RTS Number: 3755)*. Author.

Clement, D. (2013). *The spatial injustice of crisis-driven neoliberal urban restructuring in Detroit* (Unpublished master's thesis). University of Miami. Retrieved from http://scholarlyrepository.miami.edu/oa_theses/406/

Colding, J. (2011). The role of ecosystem services in contemporary urban planning. In Urban Ecology. Patterns, Processes and Applications. Oxford University Press. doi:10.1093/acprof:oso/9780199563562.003.0028

Colding, J., & Barthel, S. (2012). *The potential of Urban Green Commons in the resilience building of cities*. Elsevier B.V.

Colding, J., Lundberg, J., & Folke, C. (2006). Incorporating green-area user groups in urbanecosystem management. *Ambio*, *35*(5), 237–244. doi:10.1579/05-A-098R.1 PMID:16989508

Collins, J. P., Kinzig, A., Grimm, N. B., Fagan, W. F., Hope, D., Wu, J., & Borer, E. T. (2000). A new urban ecology. *American Scientist*, *88*(5), 416–425. doi:10.1511/2000.5.416

Convention on the Biological Diversity. (1992). The Earth Summit. United Nations, General Assembly.

Cosgrove, S. (2001). *Montréal's community gardening program*. Retrieved July 29, 2007, from http://www.cityfarmer.org/Montreal13.html

Costanza, R., & Patten, B. C. (1995). Defining and predicting sustainability. *Ecological Economics*, *15*(3), 193–196. doi:10.1016/0921-8009(95)00048-8

Curwell, S., & Cooper, I. (1998). The implications of urban sustainability. *Building Research and Information*, *26*(1), 17–28. doi:10.1080/096132198370074

Curwell, S., Deakin, M., & Symes, M. (Eds.). (2005). *Sustainable urban development, volume 1: The framework and protocols for environmental assessment*. Routledge. doi:10.4324/9780203299913

Daune, L., & Mongé, N. (2011). L'agriculture urbaine, un fondement dans le projet de territoire. *Urbia—Les Cahiers du développement urbain durable, 12*, 85-106.

de Jong, M., Joss, S., Schraven, D., Zhan, Ch., & Weijnen, M. (2015). Sustainable–Smart–Resilient–Low Carbon–Eco–Knowledge Cities; Making Sense of a Multitude of Concepts Promoting Sustainable Urbanization. *Journal of Cleaner Production*, *109*(1), 25–38. doi:10.1016/j.jclepro.2015.02.004

Deelstra, T., Boyd, D., & van den Biggelaar, M. (2006). Multifunctional land use, promoting urban agriculture in Europe. In Sustainable Development: Opportunities for Change. Department of the Environment, Transport and the Regions. Consultation Paper on a Revised UK Strategy, DETR, London.

Detroit Works Project. (2014). *Detroit future city: Detroit strategic framework plan*. Retrieved from http://detroitfuturecity.com/wp-content/uploads/2014/12/DFC_Full_2nd.pdf

Deutsch, L., Folke, C., & Skanberg, K. (2003). The critical natural capital of ecosystem performance as insurance for human well-being. *Ecological Economics*, *44*(2-3), 205–217. doi:10.1016/S0921-8009(02)00274-4

Dow, K. (2000). Social dimensions of gradients in urban ecosystems. *Urban Ecosystems*, *4*(4), 255–275. doi:10.1023/A:1015767231137

Elmqvist, T., Wall, M., & Berggren, A. L. (2001). Tropical forest reorganization after cyclone and fire disturbance in Samoa: remnant trees as biological legacies. *Cons Ecol, 5*, 10. http://www.consecol.org/vol5/iss2/art10

Estes, J. A., & Duggins, D. O. (1995). Sea otters and kelp forests in Alaska: Generality and variation in a community ecological paradigm. *Ecological Monographs*, *65*(1), 75–100. doi:10.2307/2937159

EurActiv. (2004). *Sustainable Development: Introduction*. Author.

Falk, B. (2013). The resilient farm and homestead. Chelsea Green Publishing.

Folke, C., Carpenter, S. R., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *Ambio*, *31*(5), 437–440. doi:10.1579/0044-7447-31.5.437 PMID:12374053

Folke, C., Holling, C. S., & Perrings, C. (1996). Biological diversity, ecosystems and the human scale. *Ecological Applications*, *6*(4), 1018–1024. doi:10.2307/2269584

Folke, C., Jansson, A., Larsson, J., & Costanza, R. (1997). Ecosystem appropriation by cities. *Ambio*, *26*, 167–172.

Folke, C., Pritchard, L., Berkes, F., Colding, J., & Svedin, U. (1998). *The Problem of Fit Between Ecosystems and Institutions.* International Human Dimensions Programme (IHDP). IHDP Working Paper No 2. www.uni-bonn.de/IHDP/public.htm

Forys, E. A., & Allen, C. R. (2002). Functional group change within and across scales following invasions and extinctions in the Everglades ecosystem. *Ecosystems (New York, N.Y.)*, *5*(4), 339–347. doi:10.100710021-001-0078-0

Frost, T. M., Carpenter, S. R., Ives, A. R., & Kratz, T. K. (1995). Species compensation and complementarity in ecosystem function. In C. G. Jones & J. H. Lawton (Eds.), *Linking species and ecosystems*. Chapman & Hall. doi:10.1007/978-1-4615-1773-3_22

Golley, F. B. (1993). *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts*. Yale University Press.

Graham, S., & Marvin, S. (2001). *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. Routledge.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *Science*, *319*(5864), 756–760. doi:10.1126cience.1150195 PMID:18258902

Grove, J. M. (2009). Cities: Managing densely settled social–ecological systems. In F. S. Chapin III, G. P. Kofinas, & C. Folke (Eds.), *Principles of ecosystem stewardship: Resilience-based natural resource management in a changing world* (pp. 281–294). doi:10.1007/978-0-387-73033-2_13

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: Understanding Transformations in Human and Systems*. Island Press.

Hansen, A. J., Defries, R., & Turner, W. (2004). Land use change and biodiversity: a syn-thesis of rates and consequences during the period of satellite imagery. In G. Gutman & C. Justice (Eds.), *Land Change Science: Observing, Monitoring, andUnderstanding Trajectories of Change on the Earth's Surface* (pp. 277–299). Springer Verlag.

Havlicek, T. D., & Carpenter, S. R. (2001). Pelagic species size distributions in lakes: Are they discontinuous? *Limnology and Oceanography*, *46*(5), 1021–1033. doi:10.4319/lo.2001.46.5.1021

Hodgson, K., Caton Campbell, M., & Bailkey, M. (2011). Urban agriculture: growing healthy, sustainable places. Washington, DC: American Planning Association.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. doi:10.1146/annurev.es.04.110173.000245

Holling, C. S. (1996). Engineering resilience versus ecological resilience. In P. C. Schulze (Ed.), *Engineering within ecological constraints*. National Academy Press.

Hough, M. (1995). *Cities and Natural Process*. Routledge. doi:10.4324/9780203292433

Hui, S. C. M. (2011). *Green roof urban farming for buildings in high-density urban cities.* Invited paper for the Hainan China World Green Roof Conference 2011, Hainan, China.

Hynes, H. P. (1996). *A Patch of Eden: America's Inner-city Gardeners*. Chelsea Green Publishing Company.

IISD. (2009). *What is Sustainable Development?* International Institute for Sustainable Development.

Jackson, J. B. C., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., Bradbury, R. H., Cooke, R., Erlandson, J., Estes, J. A., Hughes, T. P., Kidwell, S., Lange, C. B., Lenihan, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R. S., Tegner, M. J., & Warner, R. R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science*, *293*(5530), 629–638. doi:10.1126cience.1059199 PMID:11474098

James, P., Magee, L., Scerri, A., & Steger, M. B. (2015). *Urban Sustainability in Theory and Practice*. Routledge.

Jenks, M., & Jones, C. (Eds.). (2010). Dimensions of the sustainable city. New York: Springer.

Kahle, L. R., & Gurel-Atay, E. (Eds.). (2014). *Communicating Sustainability for the Green Economy*. M.E. Sharpe.

Kaklauskas, A., & Gudauskas, R. (2016). Intelligent decision-support systems and the Internet of Things for the smart built environment. In *Start-Up Creation* (pp. 413–449). Woodhead Publishing. doi:10.1016/B978-0-08-100546-0.00017-0

Kalin Arroyo, M. T., Zedler, P. H., & Fox, M. D. (Eds.). (1995). *Ecology and biogeography of Mediterranean ecosystems in Chile, California, and Australia*. Springer-Verlag. doi:10.1007/978-1-4612-2490-7

Kates, R., Parris, T., & Leiserowitz, A. (2005). What is Sustainable Development? Goals, Indicators, Values, and practice. *Environment*, *47*(3), 8–21. doi:10.1080/00139157.2005.10524444

Kinzig, A. P., Pacala, S. W., & Tilman, D. (Eds.). (2002). *The functional consequences of biodiversity*. Princeton University Press.

Kolasa, J., & Pickett, S. T. A. (2005). Changing academic perspectives of ecology: A view from within. In M. J. Mappin & E. A. Johnson (Eds.), *Environmental education and advocacy* (pp. 50–71). Cambridge University Press.

Lambin, E. F. (2005). Conditions for sustainability of human-environment systems: Information, motivation, and capacity. *Global Environmental Change*, *15*(3), 177–180. doi:10.1016/j.gloenvcha.2005.06.002

Lefebvre, H. (1996). The right to the city. *Writings on Cities, 63181*.

Levin, S. (1999). *Fragile dominion: complexity and the commons*. Perseus Books.

Liam, M., Andy, S., Paul, J., Thom, J. A., Padgham, L., Hickmott, S., Deng, H., & Cahill, F. (2013). Reframing social sustainability reporting: Towards an engaged approach. *Environment, Development and Sustainability*, *15*(1), 225–243. doi:10.100710668-012-9384-2

Ljungqvist, J., Barthel, S., Finnveden, G., & Sörlin, S. (2010). The Urban Anthropocene: Lessons for Sustainability from the Environmental History of Constantinople. In P. Sinclair, F. Herschend, C. Isendahl, & G. Nordquist (Eds.), *The Urban Mind, cultural and environmental dynamics Studies in Global Archaeol-ogy* (Vol. 15, pp. 368–394). University Press.

Loreau, M., Naeem, S., & Inchausti, P. (2001). Biodiversity and ecosystem functioning: Current knowledge and future challenges. *Science*, *294*(5543), 804–808. doi:10.1126cience.1064088 PMID:11679658

Lovell, S. T., DeSantis, S., Nathan, C. A., Olson, M. B., Mendez, V. E., Kominami, H. C., Erickson, D. L., Morris, K. S., & Morris, W. B. (2010). Integrating agroecology and landscape multifunc-tionality in Vermont: An evolving framework to evaluate the design of agroecosystems. *Agricultural Systems*, *103*(5), 327–341. doi:10.1016/j.agsy.2010.03.003

Luck, G. W., Daily, G. C., & Ehrlich, P. R. (2003). Population diversity and ecosystem services. *Trends in Ecology & Evolution*, *18*(7), 331–336. doi:10.1016/S0169-5347(03)00100-9

Lundberg, J., & Moberg, F. (2003). Mobile link organisms and ecosystem functioning: Implications for ecosystem resilience and management. *Ecosystems (New York, N.Y.)*, *6*(1), 87–98. doi:10.100710021-002-0150-4

Machlis, G. E., Force, J. E., & Burch, W. R. Jr. (1997). The human ecosystem. 1. The human ecosystem as an organizing concept in ecosystem management. *Society & Natural Resources*, *10*(4), 347–367. doi:10.1080/08941929709381034

McCall, T. (1973). *Legislative address, Governor Tom McCall, Oregon, (1973).* Retrieved July 20, 2008, from http://arcweb.sos.state.or.us/governors/McCall/legis1973.html

McDonnell, M. J., & Hahs, A. (2009). Comparative ecology of cities and towns: Past, present and future. In M. J. McDonnell, A. Hahs, & J. Breuste (Eds.), *Ecology of cities and towns: A comparative approach* (pp. 71–89). Cambridge University Press. doi:10.1017/CBO9780511609763.006

McKinney, M. L. (2002). Urbanization, biodiversity, and conservation. *Bioscience*, *52*(10), 883–890. doi:10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2

Millennium Ecosystem Assessment (MA). (2005). http://www.MAweb.org

Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in Ecology & Evolution*, *20*(8), 430–434. doi:10.1016/j.tree.2005.05.013 PMID:16701413

Mukherji, N. & Morales, A. (2010). *Zoning for urban Agriculture*. Zoning Practice 3.

Musacchio, L. R. (2008). Metropolitan landscape ecology: Using translational research to increase sustainability, resilience, and regeneration. *Landscape Journal*, *27*(1), 1–8. doi:10.3368/lj.27.1.1

National Land Use Database. (2000). *Previously Developed Land (PDL): Vacant Sites and Derelict Sites, and Other Previously Developed Land and Buildings that May be Available for Redevelopment, Data Specification*. NLUD.

Naveh, Z. (2000). The total human ecosystem: Integrating ecology and economics. *Bioscience*, *50*, 357–361.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environment and Resources*, *32*, 395–419.

Nyström, M., & Folke, C. (2001). Spatial resilience of coral reefs. *Ecosystems (New York, N.Y.)*, *4*(5), 406–417. doi:10.100710021-001-0019-y

O'Bowman, A. M., & Pagano, M.A. (2004). Terra Incognita: Vacant Land and UrbanStrategies. Georgetown University Press.

Odum, E. P. (1971). *Fundamentals of Ecology* (3rd ed.). W. B. Saunders.

Otte, A., Simmering, D., & Wolters, V. (2007). Biodiversity at the landscape level: Recent concepts and perspectives for multifunctional land use. *Landscape Ecology*, *22*(5), 639–642. doi:10.100710980-007-9094-6

Pagano, M. A., & Bowman, A. (2000). Land in Cities: An Urban Resource. Brookings Institution, Center on Urban and Metropolitan Policy.

Peterson, G., Allen, C.R., & Holling, C.S. (1998). Ecological resilience, biodiversity, and scale. *Ecosystems, 1*, 6–18.

Pickett, S. T. A., Burch, W. R. Jr, Dalton, S., & Foresman, T. (1997). Integrated urban ecosystem research: Themes, needs, and applications. *Urban Ecosystems*, *1*(4), 183–184. doi:10.1023/A:1018579628818

Pickett, S. T. A., & Cadenasso, M. L. (2002). Ecosystem as a multidimensional concept: Meaning, model and metaphor. *Ecosystems (New York, N.Y.)*, *5*(1), 1–10. doi:10.100710021-001-0051-y

Pickett, S. T. A., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: Meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and Urban Planning*, *69*(4), 369–384. doi:10.1016/j.landurbplan.2003.10.035

Pickett, S. T. A., Groffman, P. M., Brush, G. S., Galvin, M. F., Grove, J. M., ... Troy, A. R. (2008). Exchanges across land-water-scape boundaries in urban systems: Strategies for reducing nitrate pollution. *Annals of the New York Academy of Sciences*, *1134*(1), 213–232. doi:10.1196/annals.1439.012 PMID:18566096

Pothukuchi, K., & Kaufman, J. (1999). Placing the food system on the urban agenda: The role of municipal institutions in food systems planning. *Agriculture and Human Values*, *16*(2), 213–244. doi:10.1023/A:1007558805953

Pothukuchi, K., & Kaufman, J. (2000). The food system: A stranger to the planning field. *Journal of the American Planning Association*, *66*(2), 112–124. doi:10.1080/01944360008976093

Quincerot, R., & Weil, M. (2009). *Genève 2020: Plan di-recteur communal de la Ville de Genève*. Ville de Genève.

Redman, C., Grove, J. M., & Kuby, L. (2000). *Toward a unified understanding of human ecosystems: Integrating social sciences into long-term ecological research*. White Paper of the Long-Term Ecological Research. Albuquerque, NM: LTER Network.

Redwood, M., & Bahri, A. (2010). *Wastewater Irrigation and Health: Assessing and Mitigation Risks in Low-income Countries*. Earthscan/IDRC/IWMI.

Ricketts, T., & Imhoff, M. (2003). Biodiversity, urban areas, and agriculture: Locating prior-ity ecoregions for conservation. *Conservation Ecology*, *8*(2), 1. http://consecol.org./vol8/iss2/art1. doi:10.5751/ES-00593-080201

Rudd, J. W. M., Kelly, C. A., Schindler, D. W., & Turner, M. A. (1988). Disruption of the nitrogen cycle in acidified lakes. *Science*, *240*(4858), 1515–1517. doi:10.1126cience.240.4858.1515 PMID:17798981

Rusk, D. (1993). *Cities without Suburbs*. The Woodrow.

Sala, O. E., Chapin, F. S. I., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., Leemans, R., Lodge, D. M., Mooney, H. A., Oesterheld, M., Poff, N. L., Sykes, M. T., Walker, B. H., Walker, M., & Wall, D. H. (2000). Global biodiversity scenarios for the year 2100. *Science*, *287*(5459), 1770–1774. doi:10.1126cience.287.5459.1770 PMID:10710299

Scheffer, M., Carpenter, S. R., Foley, J. A., Folke, C., & Walker, B. H. (2001). Catastrophic shifts in ecosystems. *Nature*, *413*(6856), 591–596. doi:10.1038/35098000 PMID:11595939

Schindler, D. W. (1990). Experimental perturbations of whole lakes as tests of hypotheses concerning ecosystem structure and function. *Oikos*, *57*(1), 25–41. doi:10.2307/3565733

Seana I., Johnson, L. & Peters, K. (1999). Community gardens and sustainable land use planning: A case-study of the Alex Wilson community garden. *Local Environment*, *4*(1), 33-46. doi:10.1080/13549839908725579

Seto, K. C., De Groot, R., Bringezu, S., Erb, K., Graedel, T. E., Ramankutty, N., & Skole, D. L. (2010). Stocks, flows, and prospects of land. In T. E. Graedel & E. van der Voet (Eds.), *Linkages of sustainability* (pp. 72–96). MIT Press.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. doi:10.1016/j.gloenvcha.2006.03.008

Sukopp, H., Hejny, S., & Kowarik, I. (Eds.). (1990). *Urban ecology: Plants and plant communities in urban environments*. SPB Academic Publishing.

Sukopp, H., Trautmann, W., & Korneck, D. (1979). The soilflora and vegetation of Berlin'swastelands. In I. Laurie (Ed.), *Nature in Cities*. John Wiley.

Tansley, A. G. (1935). The use and abuse of vegetational concepts and terms. *Ecology*, *16*(3), 284–307. doi:10.2307/1930070

Terborgh, J., Lopez, L., & Nunez, P. (2001). Ecological meltdown in predator-free forest fragments. *Science*, *294*(5548), 1923–1926. doi:10.1126cience.1064397 PMID:11729317

Termorshuizen, J. W., & Opdam, P. (2009). Landscape services as a bridge between landscape ecology and sustainable development. *Landscape Ecology*, *24*(8), 1037–1052. doi:10.100710980-008-9314-8

Tidball, G. K., Krasny, E. M., Svendsen, E., Cambell, L., & Helphand, K. (2010). Stewardship, learning and memory in disaster resilience. *Environmental Learning Research*, *16*(5–6), 591–609. doi:10.1080/13504622.2010.505437

Tidball, K. G., & Krasny, M. E. (2009). *From risk to resilience: what role for community greening and civic ecology in cities?* Wageningen Academic Publishers.

van de Berg, L., & van Veenhuizen, R. (2005). Multiple functions of urban Agriculture. *Urban Agriculture Magazine*, 14.

Walker, B. H., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society, 9*(2), 5. http://www.ecologyandsociety. org/vol9/iss2/art5/

Walker & Salt. (2012). *Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function.* Island Press.

Wu, J., & Wu, T. (2013). Ecological resilience as a foundation for urban design and sustainability. In S. T. A. Pickett, M. L. Cadenasso, & B. McGrath (Eds.), *Resilience in ecology and urban design: Linking theory and practice for sustainable cities* (pp. 211–229). Springer. doi:10.1007/978-94-007-5341-9_10

Yohe, G., & Tol, R. S. J. (2002). Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. *Global Environmental Change*, *12*(1), 25–40. doi:10.1016/S0959-3780(01)00026-7

Zanoni, P., & Janssens, M. (2009). Sustainable DiverCities. In M. Janssens, D. Pinelli, D. C. Reyman, & S. Wallman (Eds.), *Sustainable Cities. Diversity, Economic Growthand Social Cohesion* (pp. 3–25). Edward Elgar.

Zhang, S. X., & Babovic, V. (2012). A real options approach to the design and architecture of water supply systems using innovative water technologies under uncertainty (PDF). *Journal of Hydroinformatics*, *488*. www.frontiersinecology.org

Zimov, S. A., Chuprynin, V. I., Oreshko, A. P., Chapin, F. S. III, Reynolds, J. F., & Chapin, M. C. (1995). Steppe–tundra transition: An herbivore-driven biome shift at the end of the Pleistocene. *American Naturalist*, *146*(5), 765–794. doi:10.1086/285824

## KEY TERMS AND DEFINITIONS

**Eco-Urban:** Those urban environments that are characterized by having a series of characteristics that define them as sustainable and ecological.

**Green Resilience:** Green resilience is based on the infrastructure of urban green areas applied to cities and is that they have the capacity to prepare, resist and recover from a crisis.

**Land Use:** Encompasses the management and modification of the natural environment to convert it into agricultural land: arable fields, grasslands; or human settlements. The term land use is also used to refer to the different land uses in zoning.

**Resilience:** The word resilience refers to the ability to overcome critical moments and adapt after experiencing some unusual and unexpected situation. It also indicates return to normal.

**Urban:** Makes reference to that belonging to or relating to the city.

**Urban Ecology:** Is a discipline whose object of study is the interrelationships between the inhabitants of an urban agglomeration and its multiple interactions with the environment.

**Urban Socio-Ecological Systems:** Are a complex urban structures that can be analyzed considering the social subsystem and the ecological subsystem.

# Chapter 16
# Local Perspectives of Sustainable Urbanism:
## The Spanish Legislative Model

**María Jesús Garcia García**
*University of Valencia, Spain*

## ABSTRACT

*The protective actions of rehabilitation, especially when they affect urban spaces formally declared as areas of rehabilitation, must have an urban reflection and be projected and reflected in the corresponding planning and management techniques. Planning legislation provides the instruments (plans) and the proper techniques to make urban planning adjusted to the parameters of the rehabilitation performing actions that seek to promote the rational use of the natural and cultural resources, in particular the territory, the soil, and the urban and architectural heritage that are the support, the object, and the scene of the quality of life.*

## INTRODUCTION

After a few years of uncontrolled urban development, the public authorities seem once again interested in urban rehabilitation policies. The urban planning model based on uncontrolled urban growth seems to have come to an end, more because of economic problems than because of the pernicious effects of all kinds that it has generated. In this cyclical alternation of public policies, it seems that the time has come again to return to the virtues of urban rehabilitation. However, it is not the first time that the public authorities show their interest in it. The successive housing plans that have been approved both at the regional and state levels have opted for rehabilitation, financing and subsidizing actions in this regard, and during the nineties there were several local administrations that created rehabilitation offices determined to promote these actions. However, currently the interest in rehabilitation is no longer limited only to the norms on development, of individual scope and little economic importance, but splashes the urban legislation, to propose a model of urban rehabilitation with the participation of public powers, but also of the private sector to channel the activity of a sector that has been badly damaged as a result of

DOI: 10.4018/978-1-7998-8482-8.ch016

the urban model of recent years. It is about turning urban rehabilitation into a profitable urban activity. Rehabilitation policies seem to be resurfacing not so much because of their virtues or because of their adaptation to constitutional objectives, as because of the exhaustion of an urban model of unsustainable development. From these premises, the following questions are analyzed.

The term rehabilitation is synonymous with re-enabling or restoring to a property the conditions of use that it has lost. When we refer to urban rehabilitation, we are talking about a set of both public and private actions that fall on both the urbanized and built-up heritage of cities and that are aimed at restoring the conditions of use and utility to the properties or spaces (Kennedy C, Cuddihy J, Engel-Yan J, 2020). These are actions that are supported by the built heritage, mainly destined for a residential purpose, but also the urbanized heritage and the urban spaces deteriorated in their elements due to the passage of time, lacking the necessary public endowments, which have lost their original functionality and are in an advanced state of physical deterioration with the economic and social implications derived from these processes. Very fundamentally the spaces that are affected are the historic centers of the cities, although urban rehabilitation is not sticks exclusively to this context, but manifests itself in t more general terms, such as a need to rehabilitate degraded urban spaces and to preserve the properties that should be the object of preservation. Urban rehabilitation affects the deteriorated or degraded heritage of cities and tries to recover these elements, but it also has a broader purpose, to the extent that it is crossed by social and economic objectives. Thus, the rehabilitation processes are intended to maintain the existing population in these areas, avoiding their eviction, and at the same time they intend to economically and functionally revitalize these spaces by implanting in them activities and services, public and commercial uses, etc. that are demanded by society and that they endow them with a new functionality. Thus, urban rehabilitation is transcended by numerous economic, sociological, etc. factors that are articulated on the premise of the physical and material recovery of urban spaces and the elements that make them make up.

The Constitution links the right to decent housing and the right to an adequate environment with the regulation of land uses. But it also advocates the rational use of natural resources. Urban planning must be oriented towards rehabilitation to comply with the constitutional precept, given that rehabilitation does not consume land and allows to take advantage and use, reuse the existing heritage (Freytag T, Gössling S, Mössner S, 2019).

In short, and as established in the statement of reasons of state Law 7/2015, October 30th, which approves the revised text of the Land Law, seeks to promote the rational use of the natural and cultural resources, in particular the territory, the soil and the urban and architectural heritage that are the support, the object and the scene of the quality of life.

Likewise, the same legal text also states in its explanatory statement that “the urban land— the city already made-also has an environmental value, as a collective cultural creation that is the object of a permanent recreation, so its characteristics must be an expression of its nature and its management must favor its rehabilitation and encourage its use”.

All this shows an interest in the rehabilitation of the consolidated urban fabric, for the city already made. Urban rehabilitation as rehabilitation of urban spaces requires urban treatment. Urban planning can not only deal with the growth and expansion of population centers, but also with the action on the interior of cities to adapt them to the new demands of higher quality of life in an urban context that allows the enjoyment of adequate housing with adequate spaces and equipment.

Recent legislation, both at the state and regional levels, has affected the treatment of rehabilitation, establishing some provisions that tend to favor these actions. In addition to the techniques and instruments it makes available for rehabilitation, it allows the resources obtained by the Administration derived from urban management to be used to finance these actions.

Thus, the Urbanism Law 7/2015, October 30th, extends the purposes of the municipal land heritage (Webster C, Lai LWC, 2003), allowing the alienation of the land of the same to be used for rehabilitation operations. This is evident in article 86 of this Law, which establishes that the income obtained by the Administration as a result of the alienation of land will be used for the conservation and extension of the municipal land heritage or by specific agreement of the competent body for the following purposes:

- Obtaining and executing local endowments on consolidated urban land.
- Actions of public initiative of urban renewal, interior reform or rehabilitation of housing.
- Relocation and return expenses
- Purchase and, where appropriate, rehabilitation of buildings for protected housing or public facilities.

And these same provisions are extended by the urban planning legislation to the event that there is the replacement of the use that corresponds to the Administration by its economic equivalent that can be used for the same purposes.

The rehabilitation actions are also contemplated by the urban regulations on the occasion of the regulation of the reserve of land for the construction of protected housing (Law 8/2013, June 26th) . According to this regulation, the General Urban Plans and in accordance with them the development planning instruments must establish in sectors or units of unconsolidated or developable urban land whose characteristic use is residential, land reserves for the construction of protected housing. However, according to the same article, when it is not possible to establish these reservations, they may be replaced by rehabilitation actions outside the scope of action.

In any case, a certain skepticism about the possibility that through the generality of these precepts the expected results will be obtained cannot be overemphasized. It is not the first time that the standards take urban rehabilitation as a reference, however the experience of recent years shows that the economic benefits of uncontrolled urban growth have won over to rehabilitation. Rehabilitation policies therefore seem to resurface not because of their virtues or their adaptation to constitutional precepts, but because of the exhaustion of an urban development model that no longer gives more of itself.

In any case, the current interest of the public authorities in this option is undeniable, which gives rise to their intervention from very different points of view, both regulatory and management. In this sense it can be said that the various forms of administrative activity are projected in a more complete way on the rehabilitation activity, although it can be said that urban rehabilitation is primarily urban rehabilitation (Wolman A, 1965).

Thus, to the extent that the rehabilitation consists of actions on the public spaces of urbanization or redevelopment we are talking about a public function that can be managed both directly and indirectly (Chance T, 2009)). In contrast to urban renewal or urbanization of developable land, where the economic benefits are substantial and stimulate private investment and indirect management systems, in the case of rehabilitation, the absence of profitability retracts private subjects from carrying out these actions, resulting in the need for greater investment by the public sector that thus supplements the inhibition of the private sector.

In other cases, the rehabilitation actions are carried out by the administration, but the Administration, based on the interest they have, intervenes by encouraging these activities or checking their compliance with the law.

Hence the need to delimit the competences in the field of rehabilitation to specify which public administrations are competent to act in the matter and what their level of intervention must be.

## BACKGROUND

Because of the importance of the actions being carried out, two types of rehabilitation can be distinguished: isolated rehabilitation and integrated rehabilitation. The first is the one that considers the object on which it falls in its own individuality, without major implications or connections with the surrounding elements. On the contrary, integrated rehabilitation is one that considers the element on which it is projected included in a larger space in which it is integrated. Integrated rehabilitation is the rehabilitation of urban spaces. It does not dispense with the rehabilitation of individual elements, but those are taken into consideration insofar as they are included in an urban context that interests to revitalize and their effects transcend the individual element on which they fall to be projected on the physical space that contains it.

The distinction mentioned is of fundamental importance because it affects the transcendence of the actions that are going to be developed, and the breadth of them, conditioning the techniques used and the legal instruments put at the service of rehabilitation.

### 1. Rehabilitation of Individual Elements

It is the rehabilitation of buildings and homes intended primarily for residential use that aims to provide housing with the necessary living conditions for that residential use and is carried out by the owners or holders of some right over the property on which it acts.

In this type of rehabilitation, the public activity usually consists of financing and promotion activities based on economic incentives, the main exponent of which is usually the provision of subsidies.

It can be distinguished between rehabilitation actions that seek to achieve a structural and constructive adaptation of those others that are aimed at achieving a functional adaptation. By structural adaptation works are understood all those that provide the house with constructive security conditions, so that its stability, resistance, firmness and solidity is guaranteed. This is to ensure that the property meets sufficient guarantees of security and stability.

With regard to those works of rehabilitation aimed at achieving the functional suitability, it should be noted that the criterion that guides the performance of the same is based on the achievement of habitability, integrating in this concept, according to the Law 8/2013, June 26$^{th}$ the improvement of the conditions of access of people with disabilities, the existence and proper functioning of health services, electrical installations, sanitation and plumbing, heating, smoke extraction and ventilation, actions related to thermal and acoustic insulation and those that promote energy saving systems. As can be seen, this is an ecological and sustainable rehabilitation (Batty M, 2013).

The rehabilitation is usually voluntary in these cases and is limited by the duty of conservation of the owner and the declaration of ruin that are configured as duties consubstantial with the property right.

## 2. Integrated Rehabilitation or Rehabilitation of Urban Spaces

In urban spaces rehabilitation involves a set of actions that involve the protection, conservation, restoration and improvement of its urban fabric, through the enhancement and more appropriate use of the urbanized and built heritage contained in its perimeter.

In these areas, rehabilitation actions go beyond the purely material or physical perspective, so that they also have a social or economic dimension of recovering degraded environments. Thus, for example, it is a question of maintaining the existing population, improving their living conditions and especially the quality of housing and the promotion of economic activities compatible with the aforementioned objectives. the State Housing Plan states that protected rehabilitation actions must ensure social diversity and rehousing of the resident population. The Law of the Community of Madrid on degraded urban spaces (Allen C, Clouth, 2012) also includes rehabilitation actions proposals to revive the activity in the degraded area, with special reference to the maintenance of existing functions and, in particular, trade and crafts and the creation of new ones, taking into account the socio-economic, cultural and technical structure of the area.

In short, the rehabilitation of these spaces aspires to the achievement of a plurality of social and community purposes (improvement or recovery of urban complexes or rural areas, of economic and social activities and the living conditions of their residents) but always on the budget of an action on urban spaces and the elements that compose them.

Normally the rehabilitation processes will be carried out on urban land consolidated by the building located in the historic center of the cities. However, areas or neighborhood that are undergoing a process of deterioration or degradation may also undergo rehabilitation. We can talk about suburbs or slums, outskirts of cities not coinciding with the historic Center and where the limits to rehabilitation will not be as intense as in the historic centers.

This configuration of the urban space as an object of rehabilitation requires in any case an urban instrument (urban planning) that delimits the affected space and that foresees these actions in the framework of urban planning, which leads us to consider the rehabilitation from an urban perspective

## 3. Results and Discussion

The term rehabilitation is primarily coined by the state and regional regulations that address the financing of public housing and urban planning policies. But to the extent that it affects urban spaces and configures urban planning, it has an urban vocation that must be contemplated by this sectoral legislation.

The protective actions of rehabilitation, especially when they affect urban spaces formally declared as areas of rehabilitation, must have an urban reflection and be projected and reflected in the corresponding planning and management techniques.

Planning legislation provides the instruments (plans) and the proper techniques to make a urban planning adjusted to the parameters of the rehabilitation performing actions that tend to increase the endowments, to the estate or redevelopment of urban spaces and even the construction of houses subjected or not to a regime of protection to the public (Donatiello JE, 2015).

The rehabilitation has a clear urban vocation, and that urban vocation is made effective through planning. The plans, transferred by the budgets of the rehabilitation, affect the urban spaces, the city already consolidated, and order it in the indicated sense. The development of rehabilitation actions through urban planning through planning has the following effects:

- It allows to configure urban planning in advance based on a plurality of actions that do not appear disconnected from each other, but integrated within the framework of general forecasts that is only possible to establish if there is an urban figure that anticipates these contents.
- The planning contemplates the rehabilitated element not in its own individuality but in the framework of a broader urban context that interests to rehabilitate, so that its effects go beyond the individual plane to produce broader effects.
- Determines the result of the provision and promotion activity that will tend to develop within the framework of the coordinates laid down by the plan.
- It is able to integrate the different sectoral rules that affect the same urban space and combine the different declarations and legal regimes to which they are subject with the urban planning of the same. Thus regulations on rehabilitation, areas of integrated rehabilitation for promotion purposes, regulations on historical heritage, declaration of cultural interest, etc.
- The plans establish the distinction between consolidated and unconsolidated urban land, which determines the form of execution of the rehabilitation actions, the subjects involved in it and the duties of the affected owners.

Contrary to what it might seem, a planning that starts from rehabilitating premises is not characterized by the extreme maintenance of the existing patrimonial elements, but also admits alterations of the same (demolition, substitutions), as long as these actions are informed by rehabilitating purposes. Urban planning can contribute to promote the rehabilitation and conservation of buildings basically in two ways:

- Not creating urban expectations higher than those already existing.
- Establishing a duty to rehabilitate.

It should be borne in mind that degraded urban spaces have traditionally been considered from the urban perspective, mainly through internal reform operations, although it is not until relatively recent dates when urban legislation and urban plans adopt the perspective of rehabilitation and are transcended by their objectives.

There is no single typology of urban planning with the capacity to influence the rehabilitation, but there can be several urban figures that adapt to these objectives (Adhya A, Plowright P, Stevens J 2011). In any case, it should be noted that urban rehabilitation actions require detailed planning that can be provided by different plans.

For example, general plans if they contain a detailed arrangement. Law 8/2013, June 26$^{th}$ provides that the general plan may delimit one or several traditional historical centers where the urban planning does not allow the indiscriminate replacement of buildings and requires that their conservation, implementation, reform or renovation harmonize with the historical typology.

In the absence of such a detailed arrangement, the approval of the relevant special plan will be required (Moroni S, 2015). The special plans of interior reform have been the figure of planning that has usually affected the urban fabric already consolidated, that is, in the city already made to undertake operations of interior reform (Roggema R, 2012a). But its content has not always been transcended by the purposes of rehabilitation. On the contrary, sometimes such planning has served to carry out renovation operations that are totally opposed to those of rehabilitation (Alfasi N, Portugali J 2007).

In any case, and transcended by these purposes and objectives, the special interior reform plans are well adapted to the actions of urban rehabilitation. Thus, among the objectives of the aforementioned plans are: decongestion or renewal of urban land use, creation of urban development and community equipment, sanitation of unhealthy neighborhoods, resolution of traffic or aesthetic problems and improvement of the urban environment or public services or other similar purposes (Cohen J, Stewart I, 1994)).

All these purposes coincide to a large extent with the objective scope of rehabilitation, but at the same time the breadth of the expression other similar purposes, allow the objectives of these plans to be extended to other purposes related to it.

The approval of special plans for the protection of cultural heritage is unavoidable in those cases in which the affected urban space has been declared a site of cultural interest. Article 59 of the Law 8/2013, June 26th establishes that the declaration of set of cultural interest will determine the obligation of the city council to draft a number of special plans for the protection and, where appropriate, sanitation and renovation of the affected area (Sharifi A, 2016), in accordance with the provisions of the cultural heritage legislation.

This type of plan clearly shows its capacity to integrate the different rules and legal regimes that coexist in the same urban space (De Roo G, Hillier J, van Wezemael J, 2020). Aragonese legislation is a good example. Such legislation states that the special plan will establish for all public uses the priority order of its installation in buildings and spaces that are suitable for them. This same planning will determine the areas of rehabilitation. Urban renovations will be possible but only if they involve an improvement with the territorial and urban environment. At the same time the planning will establish the limits to the rehabilitation in accordance with the cultural legislation. The replacement of buildings is therefore considered exceptional and may only be carried out when it contributes to the general conservation of the complex. In any case, the urban alignments will be maintained.

On some occasions urban spaces subject to rehabilitation are the subject of a formal declaration by the administration, giving rise to the concept of rehabilitation area. It is in these cases when the link between rehabilitation and urban planning is most clearly seen.

This expression refers to a space legally delimited by an administrative declaration on which the various rehabilitation actions are planned and affected. The legal delimitation to which we refer is carried out through an administrative act that establishes the presence in the area subject to the declaration of the necessary requirements to confer such character.

The declaration of rehabilitation area is a complement to urban planning. Through them, the aim is to complement the urban perspective from which degraded urban spaces have traditionally been contemplated, and allow the coordination of the activity of the different public administrations, especially with regard to the financing of actions carried out in these urban contexts.

Keep in mind that the statement of area of rehabilitation involves the determination by the Administration of certain physical circumstances that are present in the urban space, but does not by itself the capacity to implement the interventions planning to need to undergo spatial domains on which it acts, interventions that have come previously determined for the plan.

The rehabilitation areas therefore constitute the space on which the rehabilitation actions previously defined by the planning are projected, hence the importance of having the appropriate determinations in this regard prior to the declaration. Article 55 of the State Housing Plan (RD 801/2005, of 1 July) is clear in this regard, since it states that the protected rehabilitation actions must “conform to the regulations of the current urban planning that is applicable...».

## 4. CONCLUSION

The urban rehabilitation presents the peculiarity that it affects spaces on which there is consolidated building where there is an urban development already materialized on which the urban planning is projected.

For its part, planning can establish a subjective use different from the materialized use. In this way, it should be noted that for a plan to have a content adjusted to the parameters of rehabilitation in the sense that it promotes the maintenance of constructions and buildings, it is necessary that its determinations maintain the balance between the use already materialized and the use susceptible of appropriation that results from the planning. Thus two magnitudes appear on whose balance will depend the decisions of individuals when it comes to the verification or not of rehabilitation actions. They are ultimately entrusted with the verification or not of voluntary rehabilitation interventions

The rupture of the equation between both magnitudes can be given by two circumstances:

1. By the need to proceed with the legal duty to cede the land in which the corresponding use is located to the city council as a result of the realization of rehabilitation actions. Situation already seen in the previous section
2. As a result of a modification of the planning that involves the alteration of the uses and intensities foreseen in the previous arrangement. Indeed, the modification of the planning can lead to an imbalance between the use susceptible of appropriation and the materialized use in those cases in which the urban planning alters the uses or intensities foreseen in the previous planning. To favor the conservation of the properties, the planning must avoid creating expectations higher than those already existing (increases in use) and must tolerate certain situations previously defined based on the previous management when the materialized use exceeds the objective use foreseen by the plan. This provision is contained in Article 102.2 of Spanish urban planning legislation. Thus in the isolated operations of rehabilitation whenever the buildings are conserved, if it gives the circumstance that the buildability materialized historically exceeds the objective use, such buildability will be taken as a reference of subjective use.

Indeed, the alteration of the use susceptible of appropriation with respect to the already materialized is a factor of considerable importance for the decision to verify rehabilitation actions.

In urban land consolidated by the urbanization, subject to isolated actions, the appropriate use refers to the plot. And if the materialized use is higher than the objective use marked by the planning, the materialized use will be taken as a reference of the subjective use, as long as the building is preserved and it is not in a situation of out of order

This provision favors the conservation and rehabilitation of buildings, especially once the legal duty of conservation and rehabilitation has ceased, since it allows to maintain the materialized use as long as the property in question is maintained (Shafiea FA, Dasimah O, Karuppannanb S 2013).

Also the urbanism state Law 7/2015, October 30th establishes special treatment to the unique properties of the cultural heritage. The general Plan may provide that the destination of the unique properties of cultural heritage and protected by the planning applications in hospitality and commercial to not consume the area corresponding to the execution unit or sector.

On the other hand, this legislation allows, within the framework of the provisions of the state legislation, that the urban development that has to be transferred to the city council can be replaced by its economic equivalent (transitional provision second b) of the Land Law).

Other urban duties inherent in rehabilitation: the duty of conservation and the duty of rehabilitation (Roggema R, 2015))

The duties of conservation and rehabilitation oblige owners to maintain their properties in conditions of safety, health and safety.

accessibility and adornment, and to keep the goods in a condition to serve for their use to the extent of the legal duty of conservation.

These duties of conservation and rehabilitation are established in the basic legislation, specifically article 9 of the T. R. of the Land Law, establishes them within the duties and burdens that make up the essential content of the property right.

For its part, article 31 of the same Law states that failure to comply with the duties of building or rehabilitation will entitle for expropriation for failure to fulfill the social function of the property or for the application of the regime of forced sale or replacement.

The duty of conservation reaches and is enforceable to the owner up to the limit provided for in the urban legislation. However, it must be borne in mind that the limit of the duty of conservation is not established in the basic state legislation, unlike what happened in the previous regulation, so that the autonomous regulations will establish the aforementioned limits.

Planning legislation autonomic based on these forecasts state ends up shaping the content of these duties, establishing in the majority of cases, a regime more benevolent to the conservation of the property as set forth in the regulations of state (first in the Revised Text of the Land Law of 1992 and later, after the declaration of unconstitutionality of article 247 of the mentioned legal text, for in article 183 of the Revised Text of the Land Law of 1976), where the declaration of ruin entailed as a legal consequence the demolition of the property. In this sense, the regional legislation has had an impact both in the regulation of the scenarios that may lead to the declaration of ruin (yet very linked to economic criteria), as in the legal consequences of that declaration, that allow the owner to preserve or demolish, through the intervention of the Administration to which they are recognized ability to alter the physical state of ruin.

A good example of these statements is Spanish urban planning legislation that distinguishes between the limit of the duty of conservation of the owner and the limit of the duty of conservation of the property.

The limit of the legal duty of conservation for the owner is constituted by an economic magnitude and is reached when the conservation work exceeds half the value of the buildings, excluding the soil under section 186.2 of the urban legislation. The economic limit of the duty of conservation that is demanded to the owner is constituted by the 50 percent of the value of the buildings excluding the soil. Or what is the same, the only thing that can be imposed on the owner is a conservation that does not exceed 50 percent of the value of the property.

However, the assessment of this limit does not automatically determine the declaration of ruin and subsequent demolition, but once the same has been established, the owner can choose between requesting subsidies or aid to the administration in the part that exceeds the previous limit, or requesting the declaration of ruin of the buildings. It must be borne in mind that the limit of 50% of the value of the building that marks the cessation of the duty of conservation coincides with the first assumption of ruin, physical ruin. On the other hand, the assumptions of technical ruin can also be traced back to economic criteria.

In short and always before the declaration of ruin, it allows the owners to choose either to request the formal declaration of ruin or for the conservation of the property with the limit to their charge of 50 percent of the value of the building, paying the administration the remaining part.

The declaration of ruin marks the limit of the duty of conservation of the property. The binomial ruin demolition is maintained so that declared the ruin proceeds the demolition of the property, but to declare the ruin it is necessary to take into consideration two circumstances: material, physical or factual and formal, consisting in the assessment by the Administration of such circumstances.

For this reason, the declaration of ruin is subject to the will of the Administration, since concurring the factual situation of ruin in a property, the Administration can prevent the declaration of it through the alteration of the physical state of the property by initiating the necessary conservation works to eliminate the state of ruin and all the possible effects derived from it. The owner must pay the amount of the works corresponding to half of the value of the buildings, excluding the land. Again, the owner is subject to a limit of 50 percent of the value of the building, and the Administration must pay for the works in the amount that exceeds that percentage. This demonstrates the involvement of the Administration in the duty of conservation.

## REFERENCES

Adhya,, A., Plowright,, P., & Stevens,, J. (2011) Defining sustainable urbanism: towards a responsive urban design. In *Proceedings of the conference on sustainability and the built environment*. King Saud University.

Alfasi, N., & Portugali, J. (2007). Planning rules for a self-planned city. *Planning Theory*, *6*(2), 164–182. doi:10.1177/1473095207077587

Allen,, C., & Clouth,, S. (2012). *A guidebook to the green economy*. UNDESA.

Batty,, M. (2013). *A new science of cities*. MIT Press.

Birkmann, J., Garschagen, M., Kraas, F., & Quang, N. (2010). Adaptive urban governance: New challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science*, *5*(2), 185–206. doi:10.100711625-010-0111-3

Chance, T. (2009). Towards sustainable residential communities; the Beddington zero energy development (BedZED) and beyond. *Environment and Urbanization*, *21*(2), 527–544. doi:10.1177/0956247809339007

Cohen,, J., & Stewart,, I. (1994). *The collapse of chaos: discovering simplicity in a complex world*. Penguin Group Ltd.

De Roo,, G., Hillier,, J., & van Wezemael,, J. (Eds.). (2020). *Complexity and planning: systems, assemblages and simulations*. Ashgate Publishing. doi:10.4337/9781786439185

Donatiello, J. E. (2015). The world's population: An encyclopedia of critical issues, crises, and ever-growing countries. *Reference and User Services Quarterly*, *54*(4), 85. doi:10.5860/rusq.54n4.85b

Drury, F. (2019). *Enchanting photos of the abandoned village taken over by hippies living in fairytale houses in the Spanish mountains*. MailOnline. http://www.dailymail.co.uk/news/article-3139295/Enchanting-photos-abandoned-village-taken-Spanish-hippies-living-fairytale-houses-mountains.html

Freytag,, T., Gössling,, S., & Mössner,, S. (2019). Living the green city: Freiburg's Solarsiedlung between narratives and practices of sustainable urban development. *Local Environment*, *19*(6), 644–659.

Girardet,, H. (1996). *The GAIA atlas of cities: new directions for sustainable urban living*. Gaia Books Limited.

Habitat III. (2016). *Revised zero draft of the new urban agenda.* https://www.habitat3.org/zerodraft

Kennedy,, C., Cuddihy,, J., & Engel-Yan,, J. (2020). The changing metabolism of cities. *Journal of Industrial Ecology*, *11*(2), 43–59.

Kennedy,, C., Pincetl,, S., & Bunje,, P. (2010). The study of urban metabolism and its applications to urban planning and design. *Environmental Pollution*, *159*(8–9), 1965–1973. PMID:21084139

Kreimer,, A., Arnold,, M., & Carlin,, A. (Eds.). (2003). *Building safer cities: the future of disaster risk*. The International Bank for Reconstruction and Development/The World Bank.

Moroni, S. (2015). Complexity and the inherent limits of explanation and prediction: Urban codes for self-organising systems. *Planning Theory*, *14*(3), 248–267. doi:10.1177/1473095214521104

Roggema, R. (2012a). *Swarm planning: the development of a spatial planning methodology to deal with climate adaptation* (PhD thesis). Delft University of Technology.

Roggema,, R. (2012c). Shifting paradigms. In R. Roggema (Ed.), *The design charrette: ways to envision sustainable futures*. Springer.

Roggema, R. (2014). Towards enhanced resilience in city design: A proposition. *Land (Basel)*, *3*(2), 460–481. doi:10.3390/land3020460

Roggema, R. (2015). Three urbanisms in one city: Accommodating the paces of change. *Journal of Environmental Protection*, *6*(09), 946–956. doi:10.4236/jep.2015.69084

Searns,, R.M. (1995). The evolution of greenways as an adaptive urban landscape form. *Landscape and Urban Planning*, *33*(1), 65–80.

Shafiea,, F.A., Dasimah,, O., & Karuppannanb,, S. (2013). Urban metabolism: a research methodology in urban planning and environmental assessment. *Proceedings of the 1st international conference on research methodology for built environment and engineering.*

Sharifi, A. (2016). From garden city to eco-urbanism: The quest for sustainable neighborhood development. *Sustainable Cities and Society*, *20*, 1–16. doi:10.1016/j.scs.2015.09.002

Webster,, C., & Lai,, L.W.C. (2003). *Property rights, planning and markets*. Edward Elgar.

Wolman,, A. (1965). The metabolism of cities. *Scientific American*, *213*(3), 179–190. PMID:14338520

World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.

# Chapter 17
# The Role of Municipalities in Achieving Water Security:
## The Case of Turkey

**Seda H. Bostancı**
https://orcid.org/0000-0002-3559-2224
*Tekirdağ Namık Kemal University, Turkey*

**Seda Yıldırım**
https://orcid.org/0000-0003-4367-6652
*Tekirdağ Namık Kemal University, Turkey*

## ABSTRACT

*The world has realized the fact that the limited resources can't be sustainable for a long time. Sustainable transformation is a key issue to save the current resources and natural environment for the next generation. 2030 Sustainable Development Goals (SDGs) can help governments to focus on main issues to achieve a balance between social, environmental, and economic development. At this point, Goal 6 points out the importance of saving clean and safe freshwater resources. This chapter aims to present the link between municipalities and water security in Turkey. Turkey case was selected according to its risky position in the level of water stress. This study used recent reports and statistical data on environmental indicators related with freshwater resources and the implications of municipalities in Turkey. Environmental Indicators 2020 Report guided the authors to determine water indicators in Turkey. In addition, the available open access data from TURKSTAT is used to determine water supply services of municipalities.*

## INTRODUCTION

Water security is a vital issue for the sustainability of humanity and biodiversity in the Earth. The environmental damages, climate change and global warming all threaten the water resources. Therefore, water pollution is getting higher due to the human activities recently. "Water pollution occurs by mixing

DOI: 10.4018/978-1-7998-8482-8.ch017

inorganic, biological, organic and radioactive materials with water to an extent that disrupts the use of water resources" (Keleş, et al., 2012). Water security represents the available level of water resources for all people and eco-system in the Earth (Bakker, 2012). "Water security is a cycle with the implication of multiple interdependent and interconnected dimensions (hydrologic, economic, geographic, environmental, political, social, legal, financial, etc.) at local, national, regional, and global scales" (Moumen, 2019). The term 'security' is conceptualized as a function of 'availability', 'accessibility to services', 'safety and quality', and 'management" (Gain, 2016).

The water security issue is related with economic, social environmental issues in the context of the climate change (Allan, et al., 2013). Staddon ve Scott (2018) determined that the topic of water security was so popular by linking them to studies of hydropolitics when considering that arguments on the sustainability were outdated. Studies on the water security include both of physical and social sciences (Cook and Bakker, 2012). UNESCO's International Hydrological Program's (IHP) Strategic Plan is an important plan studying on the water security (Moumen, 2019).

The availability of clean water resources seems to challenge with the growing population while this sources gives a life for all ecosystems in the Earth. Recent findings have showed that most of the wetlands have disappeared. The usage of freshwater is a fundamental consumption for people but the growing population, agriculture, pollution and climate change increase the water scarcity (see Table 1) during the present period. Accordingly, near future as in 2025, the most proportion of the World will challenge with water scarcity (WWF, n.d.).

*Table 1. The causes of water scarcity*

| Causes | The link |
|---|---|
| Water Pollution | Water pollution threatens human health, agriculture, ecosystem and etc. Preventing water pollution is the primary goal of policy makers and all people if they want to get access to clean water in the long term. |
| Agriculture | Agriculture needs specific quantity of freshwater frequently to give agricultural product efficiently. Thus, the usage of water resources by agriculture should be planned carefully in the context of sustainable agriculture methods. |
| Population Growth | The estimation on the future World population seems to demand more water resources. At this point, the water availability can challenge the population. |
| Climate change | Climate change brings the global warming at the global level. Higher warm weathers cause lower rain and downfall and so, the number of freshwater resources such as river, lake, stream etc. will reduce over time. |

Source: Adapted from WWF, (n.d.).

Water scarcity makes trouble in access to clean and safe water in urban areas. When there is a limit in the water availability, the cost of drinking water and freshwater increase (UNICEF, n.d.). Water scarcity and insecurity seem to be the biggest danger against the sustainability of the life in the future. Economic, social and environmental issues are all affected by the water insecurity. Leichenko and O'Brien (2019) also mentioned that water insecurity increased the inequalities for women especially living in Sub-Saharan Africa, South Asia and some regions of the Middle East. In addition, they mentioned that women were living in South Asia and Sub-Saharan Africa, had a risk of sexual violence while they were looking for clean water resources from far areas of their homes.

Climate change affects vulnerable populations highly in the context of water insecurity. Developing countries have small water infrastructures, but their rates of urbanization and populations are increasing

(Briscoe, 2009). With these aspects, water management and water security are very important for the sustainable future of developing countries. The impacts of water insecurity can be presented in Table 2:

*Table 2. The impacts of water insecurity*

| Factors | Impact | How |
|---|---|---|
| Education | Decreasing the quality and equality in education | Many girls living in regions with limited water sources, has to look for clean and safe water sources and they have to leave from school or delay their education. |
| Waterborne | Increasing water pollution | Higher pollution in water sources cause a higher risk of diseases such as *diarrhea, malaria and schistosomiasis.* |
| Food | Decreasing the agriculture products | With decreasing water sources, agriculture can't get sufficient quantity and quality of water for production. |
| Industry | Decreasing the production | To sustain industrial production, water sources are vital element. |
| Violence | Increasing the conflicts | Reducing water resources cause big conflicts between regions and governments. |

Source: Adapted from BBC, (n.d.) and complied by the authors.

The city life or urban living areas can provide higher living standards for people when there is a balance between the population density, resources and efficient management of public services in a city. On the other side, higher population density with low-quality public services can cause lower living standards in urban areas. At this point, policy makers aim to create healthy cities with healthy citizens. This is also related with creating resilient cities. For example, investing in a public water system will contribute the well-being of people as preventing them several kinds of diseases. Water and food are vital needs for the humanity and there is a strong link between them. The availability of clean and fresh water will support the food security in the long term (Yıldırım and Yıldırım, 2021). United Nations also points out the importance of access to fresh water and clean water by Goal-6 in the context of 2030 Sustainable Development Goals (Bostancı and Yıldırım). Accordingly, ensuring clean and fresh water for citizens in cities is primary duty and responsible of local governments (European Environment Agency, 2018).

Water security and water stress are main issues in the strategic planning of governments recently. When considering the limited water resources (fresh water) in the Earth, it is highly expected that the future World population will challenge with water stress. Water stress threatens human lives and biodiversity in the long term. Recent studies have showed that urbanization, population growth, rapid economic development increased water demand while water resources decreased due to the negative impacts of climate change. Every country will challenge with water stress in the near future. To get over water stress, countries should secure water supplies with efficient management (Hofste et al., 2019). The management of water supplies can be varied by regional differences. It can be suggested countries to focus on their local management to develop efficient water management system in urban areas.

"Climate is a fundamental component of Earth's life-supporting mechanisms" (McMichael, et al., 2016). "The ability of species to respond to climate change will largely depend on their ability to 'track' shifting climate through colonizing new territory, or to modify their physiology and seasonal behaviour to adapt to the changed conditions where they are" (Thuiller, 2007). "With so many potential climate-sensitive factors to consider, scientists need ways to narrow down the range of possible environmental outcomes so that they know what specific problems to tackle" (McNutt, 2013). And water is one of a main are in all climate change studies. It is a fact that the climate change plays a major role in the rising water stress as global warming. To prevent global warming can increase the possibility of achieving water security in the long term (Acciona, n.d.). But, governments should support their sustainable policies against climate change by controlling the usage of water resources in urban areas. Municipalities are responsible to ensure clean drinking water to urban areas in most countries. In addition, municipalities have to consume water for their public service production. Drinking water supply also varies from country to country. Municipalities generally perform for the central water network system. Cleaning services are at the top of the wide range of services that municipalities provide for their citizens. Municipalities also have some duties in protection of the natural resources in cities and providing sustainability. Bostancı (2015) grouped the project-based sustainability applications as sustainable urban planning, green transportation planning, waste management and recycling projects, sustainable urban transformation projects, renewable energy projects for sustainability, green public building projects, energy efficiency projects for buildings, and water efficiency projects. Landscaping in public places such as parks, gardens and playgrounds is among the important environmental activities of the municipalities. Water usage is required in most of these fields of activity. In many countries such as Turkey, there are institutions affiliated to the municipalities responsible for the central water infrastructure of housing and working areas. In this respect, municipalities are institutions that provide both water supply and water demand. Municipalities develop some policies to inform the citizens about reducing waste of water.

This chapter aims to give a sample case study on the link between municipalities and water security in Turkey. Turkey case was selected based on its risky conditions in water stress. The potential risks of the quantity and quality of water sources (renewable) is estimated to challenge the human and other bio diversities' sustainability. So, the water stress gives a clue for policy makers about the decrease of water resources (Esen et al., 2020). Turkey was categorized under high baseline water stress country in general (Hofste et al., 2019). According to World Resources Institute's tool of Aqueduct, Turkey's level in water stress can be presented in Table 3.

*Table 3. The water stress risk in Turkey*

| The risk level | Total Score | Level |
|---|---|---|
| Baseline Water Stress* | 3.56 | High |
| Drought Risk** | 0.60 | Medium-High |
| Riverine Flood Risk*** | 2.09 | Medium-High |
| * World Resources Institute, (n.d.a).<br>** World Resources Institute, (n.d.b).<br>*** World Resources Institute, (n.d.c). | | |

Source: Created by authors.

The water exploitation index (WEI) also gives important results to determine water stress. WEI is obtained by dividing the average annual total amount of water abstracted from freshwater by the average annual total renewable freshwater resources at the country level and is expressed as a percentage. Turkey's WEI result was found as 26.3% in 2018. When WEI is found above 20%, it indicates water scarcity, and when WEI is found above 40%, it indicates severe scarcity and water management is not sustainable. This indicator shows that Turkey should take measures regarding sustainable water policies (General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020: 62).

McMichael et al. (1996) presented a scenario for the link between climate change, water sources and population for some European countries (Bartam et al., 2002). Table 4 shows the result of this scenario for Turkey as below:

*Table 4. A Scenario on estimated water availability in Turkey*

| Period | Water availability (M3 per person per year) |
|---|---|
| Climate change in 1990 | 3070 |
| Climate change in 2050 | 1240 |
| Three scenarios in 2050 | 700-1910 |

Source: Adapted from McMichael et.al., 1996; Bartam et.al., 2002.

According to McMichael et al. (1996)'s scenario, it can be said that Turkey should immediately monitor its water sources whether the availability and the quality of drinking and freshwater would be sufficient for the long term due to the rising population in a country.

## TURKEY CASE: THE ROLE OF MUNICIPALTIES ON WATER SECURITY

Turkey is located in a semi-arid region due to its freshwater availability. While water-rich countries provide 10.000 m3 per capita yearly, Turkey currently provides freshwater as 1.350m3 per capita against to total population. In addition, this value will be expected decrease to 1000m3 by 2030. Accordingly, the efficient management of water resources is a vital issue for Turkey Republic of Turkey Ministry of Foreign Affairs, (n.d.). Santos et al.(2016) prepared a report on Turkey and water resources whether Turkey is under the risk of water stress or not. According to this report, Turkey was found in a risky position in the near future. When comparing Turkey's water resources to others in the region, it was seen that Turkey was not water-rich country as many European countries. Turkey will probably face with the regional water stress. In addition, "unregistered and inefficient" water consumption was the most effective factor as making the highest risk of water stress in Turkey. In this context, this study claims that local governments such as municipalities can play a positive role to improve efficiency in water management in the regional side. In fact, the local governments and municipalities are responsible in ensuring the clean drinking water as a public service (Yıldırım et.al., 2017).

To determine main functions of Turkish municipalities in water management, this study used recent reports and statistical data on environmental indicators related with water and water management. Environmental Indicators 2020 Report guided us to determine water indicators in Turkey. In addition, the available open access data from TURKSTAT (Turkish Statistical Institute), we categorized main water services of municipalities. The below parts will present the water indicators and water services as it is purposed.

## WATER INDICATORS AND MUNICIPALITIES IN TURKEY

There are several kinds of indicators for determining the quality of environmental development. For example, PSR (Pressure-State-Response) and DPSIR (Driving forces-Pressure-State-Impact- Response) are seen as the most accepted indicators in the theory. PSR was developed by OECD (The Organization for Economic Co-operation and Development) developed a tool of PSR in 1994 and then EEA (European Environment Agency) presented tool of DPSIR which was derived from the model of PSR (General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020:2).

*Table 5. Water indicators from environmental indicators*

| Indicators | Definition | Water indicators |
|---|---|---|
| Driving forces | All economic activities(human activities) included in this indicator. | - |
| Pressure | Variables that cause or may cause environmental problems. | Use of Freshwater Resources<br>Municipal Water Supply |
| State | Variables that reveal the current state of the environment | Nutrients in Coastal and Marine Waters<br>Bathing Water Quality<br>Nutrients in Freshwater<br>Oxygen Consuming Substances in Rivers<br>Chlorophyll Concentration in Coastal and Marine Waters |
| Impact | These are the most extreme impacts such as health problems caused by environmental changes. | - |
| Response | Indicators related to solutions brought against environmental pollution fall into this category. | Municipalities Served by Sewerage Systems<br>Treatment Unit<br>Municipalities Served by Wastewater |
| *The info is based on General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020 | | |

Source: Created by authors.

Table 5 summarized the main water indicators from environmental indicators. It can be said that water indicators mostly represent indicators of pressure, state and response. When observing municipality's responsible in water management, it is determined that sustainable freshwater and clean water can be achieved by successful water management. To understand the duty and responsible of municipalities, main water indicators can be explained in Table 6.

Republic of Turkey Ministry of Environment and Urbanization categorizes some main titles in water and wastewater based on Environmental Indicators 2020 Report as Table 5.

Both the consumption of freshwater and drinking water and also water treatment services all give the primary responsibility to the municipalities in the protection of freshwater resources. When we look at the water usage data for 2018 in Turkey as given by Table 7, it can be seen the position of municipalities in achieving water security in the long term.

In Turkey, the amount of water resources can be changed due to the precipitation regime in winter and spring. When there is a decrease in winter precipitation, there may be a decrease in water reserves. At this point, the municipalities should manage water resources efficiently. Dams are the most important water resource of the municipalities. Then, wells, springs, streams, lakes and ponds are all used by the

*Table 6. Titles of water and wastewater*

| Titles | Express |
|---|---|
| Use of Freshwater Resources | This indicator shows the use of fresh water resources (surface and groundwater) to meet the water needs of drinking water, industry and agriculture sectors. |
| Oxygen Consuming Substances in Rivers | The main indicator for oxygenation status in water bodies is the biochemical oxygen demand (BOD) parameter, which expresses the oxygen demand of aquatic organisms that consume oxidizable organic materials. |
| Nutrients in Freshwater | High amounts of nitrogen and phosphorus entering water resources from urban areas, industrial and agricultural areas can cause eutrophication. |
| Chlorophyll Concentration in Coastal and Marine Waters | Chlorophyll-a, which is an indicator of phytoplankton biomass, performs photosynthesis and this mechanism ensures the production of primary organic matter in the food cycle. |
| Nutrients in Coastal and Marine Waters | The nutrients indicator is a status indicator used to show geographic changes in current nutrient concentrations and temporal trends. |
| Bathing Water Quality | The indicator is a status indicator and is associated with the effects of urban wastewater on marine and coastal water quality. |
| Municipal Water Supply | Dams are the most important and most used water resource of the municipalities. In years when precipitation decreases, the rate of water withdrawn from dams for drinking and utility water use by municipalities may decrease, and the rate of water drawn from rivers, lakes and ponds may increase. |
| Municipalities Served by Wastewater Treatment Unit | It is important in monitoring frequently whether policies of controlling the pollution level in domestic wastewater. |
| Municipalities Served by Sewerage Systems | It presents the ratio of the population of the municipality served by the sewerage network for the total municipal population. |

Source: Adapted from General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020.

municipalities. During the years with low rainfall, the rate of water withdrawn from dams for drinking and utility water usage by municipalities may decrease. On the other side, the rate of water drawn from rivers, lakes and ponds may increase (Republic of Turkey Ministry of Environment and Urbanization, n.d.a).

In 2018, 17.5 billion m3 of water was directly drawn from water resources by municipalities, villages, manufacturing industry, thermal power stations, OIZ and mining enterprises. We can summarize the amount of water which was drawn by several water resources (TURKSTAT, 2019a):

*Table 7. The usage amount of water drawn from water bodies (Billion M3/Year)*

| Units | Year |
|---|---|
| | 2018 |
| Irrigation | 43.95 |
| Thermal Power Station | 7.87 |
| Municipalities | 6.19 |
| Manufacturing Industry | 2.68 |
| Villages | 0.39 |
| Mining Facilities | 0.24 |
| Organized Industrial Zones(OIZ) | 0.16 |
| Total | 61.48 |

Source: General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020:61.

56.2% of the water drawn from water resources is from seas,
15.1% of the water drawn from water resources is from dams,
14% of the water drawn from water resources is from wells,
8.7% of the water drawn from water resources is from springs,
3.9% of the water drawn from water resources is from rivers,
1.8% of the water drawn from water resources is from lakes
0.2% of the water drawn from water resources is from other water resources.

Table 8 presents the amount of water abstracted by sectors and resources between 2012 and 2018.

*Table 8. Water abstraction for municipal water supply network, 2012 – 2018*

| | **Years** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2012** | | **2014** | | **2016** | | **2018** | |
| **Resources** | **Amt.** | **(%)** | **Amt.** | **(%)** | **Amt.** | **(%)** | **Amt.** | **(%)** |
| Dam | 2 416 018 | 48.9 | 1 886 617 | 36.0 | 2 618 225 | 44.8 | 2 468 103 | 39.9 |
| Well | 1 395 957 | 28.3 | 1 423 751 | 27.2 | 1 563 154 | 26.8 | 1 740 116 | 28.1 |
| Spring | 948 133 | 19.2 | 984 869 | 18.8 | 1 000 205 | 17.1 | 1 138 388 | 18.4 |
| River | 78 282 | 1.6 | 652 370 | 12.5 | 552 624 | 9.5 | 560 356 | 9.0 |
| Lake - artificial lake /sea | 97 953 | 2.0 | 289 800 | 5.5 | 104 354 | 1.8 | 286 196 | 4.6 |
| Water abstraction for municipal water supply network | 4 936 342 | 100.0 | 5 237 407 | 100.0 | 5 838 561 | 100.0 | 6 193 158 | 100.0 |

Source: adapted from TURKSTAT, (2019b).

In 2018, the water drawn for drinking and utility water network was provided from dams by 39.9 percent; from wells by 26.1 percent; from springs by 18.4 percent; from rivers by 9 percent and from lake-pond / seas by 4.6 percent in Turkey (see Table 5).

In 2018, the proportion of the municipal population served by the drinking and utility water network to the total municipal population was 98.6%, and the ratio of the municipal population served by drinking and utility water treatment facilities to the total municipal population was 60.1%. As of 1994, 3.24 billion m3 of water was drawn to be distributed by the municipalities through the drinking and potable water network, while this figure increased to 6.2 billion m3 in 2018. 3.6 billion m3 of the total 6.2 billion m3 of water drawn to drinking and utility water networks was treated in drinking and utility water treatment plants. 92.1% of the treated water was conventionally treated, 7.8% was advanced, and 0.1% was physically treated. (General Directorate of Environmental Impact Assessment, Permit and Inspection, 2020:83).

The most amount of fresh water is drawn by municipalities to provide drinking water in general. According to TURKSTAT's 2016 data, there were 1397 municipalities in Turkey and 1394 municipalities served with drinking and utility water networks. In addition, the total number of surface water resources in Turkey was 508 in 2017 according to the data obtained from the Technical Assistance Project Final Report for the Evaluation of Drinking Water Resources and Treatment Plants. The total number of drinking water treatment facilities was 489 and 397 of them were active and 92 are not active due to planning, construction or out of service. In Turkey, the drinking and utility water is mostly lost in transmission lines. For example, the amount of water lost in transmission lines was estimated as 30% (red) for 2019 and it was estimated to decrease 25% (green) for 2023. During the transmission process of the water supplied as drinking and utility water, there are lost in water sources due to some problems such as leakage etc. As a result of this loss, more water will be withdrawn and this will cause an increase in costs. Therefore, every environmental problem brings along an economic problem (TMMOB Çevre Mühendisleri Odasi, 2019:21).

When considering environmental quality performance, environmental protection expenditures can guide policy makers to develop new strategies. In Turkey, total environmental protection expenditures were 38.2 billion TL by 2018. 56.6 percent of environmental protection expenditures were made by financial and non-financial companies, 36.3% by government (and local government) and non-profit organizations serving households, and 7.1% by households. The proportion of environmental protection expenditures in gross domestic product decreased from 1.18% (2013) to 1% in 2018. The environmental protection expenditures-2018 was rated according to the related items as follows (Republic of Turkey Ministry of Environment and Urbanization, n.d.b):

47.5 percent by waste management services

35.6 percent by wastewater management services,

6.8 percent by protection of biological diversity and landscape,

3.6 percent by protection and quality of soil, ground and surface water environmental protection expenditures for improvement

6.5% percent by other issues.

Environmental expenditures and environmental protection expenditures are both important indicators to determine environmental quality in general. Local governments such as municipalities work with their budget and manage their budget to provide public services efficiently. The municipalities have environmental expenditures which are mostly related with water and wastewater management. Table 9 presents environmental expenditure of municipalities during the period between 2008 and 2016 in Turkey.

Wastewater treatment includes one or more of the physical, chemical and biological processes applied to make the wastewater not change the physical, chemical, bacteriological and ecological properties of the receiving environment from which it is discharged. Units where foreign substances causing pollution in wastewater are removed from wastewater by different methods (physical, biological, advanced) are called wastewater treatment plants. The numbers of all kinds of wastewater treatment plants increased to 991 by 2018 (Republic of Turkey Ministry of Environment and Urbanization, n.d.c).

Wastewater treatment is an important practice to use water more efficiently and protect existing resources. Turkey has launched serious investments in this field. For example, the proportion of the numbers of municipality which were serving with wastewater treatment plants to the total number of municipalities increased to 46% by 2018. The proportion of the municipal population which were serving with wastewater treatment facilities to the total municipal population increased to 78.7% (Republic of Turkey Ministry of Environment and Urbanization, n.d.c).

As it is given in Table 12, the population of a country is also important for the success level of municipality's services. When there is higher population living in urban areas, the demand of public services from local governments will be higher. The population of Turkey was 83 million 614 thousand 362 people in 2020 (December 31th). While the male population was calculated as 41 million 915 thousand 985 people, the female population was calculated as 41 million 698 thousand 377 people. In other words, 50.1% of the total population was men and 49.9% were women. The proportion of people living

*Table 9. Environmental expenditure of municipalities by environmental activities between 2008-2016*

| | Years | Total | Current expenditure | Investment expenditure |
|---|---|---|---|---|
| Water services | 2008 | 3 235 441 028 | 1 769 955 272 | 1 465 485 756 |
| | 2009 | 2 380 438 207 | 1 498 851 982 | 881 586 225 |
| | 2010 | 2 571 995 369 | 1 472 383 248 | 1 099 612 121 |
| | 2012 | 3 532 738 004 | 2 191 832 437 | 1 340 905 567 |
| | 2013 | 4 709 185 565 | 2 857 662 352 | 1 851 523 213 |
| | 2014 | 4 956 827 530 | 3 128 303 131 | 1 828 524 399 |
| | 2015 | 7 419 206 081 | 4 169 177 176 | 3 250 028 905 |
| | 2016 | 8 890 385 908 | 4 544 400 301 | 4 345 985 607 |
| Wastewater management services | 2008 | 850 127 515 | 331 542 468 | 518 585 047 |
| | 2009 | 1 340 117 156 | 563 327 760 | 776 789 396 |
| | 2010 | 1 385 669 727 | 543 653 604 | 842 016 123 |
| | 2012 | 1 473 460 916 | 544 949 234 | 928 511 682 |
| | 2013 | 2 070 691 038 | 700 503 772 | 1 370 187 266 |
| | 2014 | 2 535 368 628 | 906 100 539 | 1 629 268 089 |
| | 2015 | 2 891 469 296 | 1 124 145 731 | 1 767 323 565 |
| | 2016 | 3 414 259 911 | 1 326 759 116 | 2 087 500 795 |
| Waste management services | 2008 | 2 475 803 358 | 2 245 518 522 | 230 284 836 |
| | 2009 | 3 307 416 664 | 3 093 063 322 | 214 353 342 |
| | 2010 | 2 928 991 827 | 2 854 189 965 | 74 801 862 |
| | 2012 | 3 700 832 724 | 3 562 821 899 | 138 010 825 |
| | 2013 | 4 210 001 951 | 4 106 990 680 | 103 011 271 |
| | 2014 | 5 037 087 787 | 4 894 537 081 | 142 550 706 |
| | 2015 | 6 181 420 674 | 5 994 399 579 | 187 021 095 |
| | 2016 | 7 615 403 858 | 7 367 172 323 | 248 231 535 |
| Protection of biodiversity and landscape | 2008 | 325 377 150 | 128 119 747 | 197 257 403 |
| | 2009 | 291 587 414 | 131 372 505 | 160 214 909 |
| | 2010 | 221 235 743 | 155 696 278 | 65 539 465 |
| | 2012 | 245 411 296 | 230 269 254 | 15 142 042 |
| | 2013 | 335 154 588 | 320 331 200 | 14 823 388 |
| | 2014 | 369 761 879 | 360 835 953 | 8 925 926 |
| | 2015 | 410 101 666 | 380 822 383 | 29 279 283 |
| | 2016 | 535 796 624 | 488 962 326 | 46 834 298 |
| Research and development | 2008 | 458 451 | 448 421 | 10 030 |
| | 2009 | 1 972 356 | 1 972 356 | - |
| | 2010 | 5 148 927 | 5 146 367 | 2 560 |
| | 2012 | 3 434 701 | 2 874 611 | 560 090 |
| | 2013 | 5 501 711 | 4 521 211 | 980 500 |
| | 2014 | 3 144 109 | 3 144 109 | 0 |
| | 2015 | 694 083 | 694 083 | 0 |
| | 2016 | 780 266 | 780 266 | 0 |
| Activities leading to indivisible expenditure (1) | 2008 | 875 442 841 | 713 507 288 | 161 935 554 |
| | 2009 | 1 055 598 082 | 843 049 695 | 212 548 387 |
| | 2010 | 1 264 380 952 | 969 302 792 | 295 078 160 |
| | 2012 | 1 281 113 911 | 899 455 603 | 381 658 308 |
| | 2013 | 598 477 565 | 518 078 638 | 80 398 927 |
| | 2014 | 528 982 426 | 430 326 142 | 98 656 284 |
| | 2015 | 525 012 722 | 425 228 449 | 99 784 273 |
| | 2016 | 430 005 729 | 326 246 768 | 103 758 961 |
| Total environmental expenditure | 2008 | 7 762 650 343 | 5 189 091 718 | 2 573 558 626 |
| | 2009 | 8 377 129 879 | 6 131 637 620 | 2 245 492 259 |
| | 2010 | 8 377 422 545 | 6 000 372 254 | 2 377 050 291 |
| | 2012 | 10 236 991 552 | 7 432 203 038 | 2 804 788 514 |
| | 2013 | 11 929 012 418 | 8 508 087 853 | 3 420 924 565 |
| | 2014 | 13 431 172 359 | 9 723 246 955 | 3 707 925 404 |
| | 2015 | 17 427 904 522 | 12 094 467 401 | 5 333 437 121 |
| | 2016 | 20 886 632 296 | 14 054 321 100 | 6 832 311 196 |
| (1) It is composed of the indivisible expenditure that is related to water, wastewater and waste services. | | | | |

Source: Adapted from TURKSTAT, (2018).

*Table 10. Disposal/recovery methods and amount of municipal waste, 2012-2018*

| | Years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | | 2014 | | 2016 | | 2018 | |
| Waste disposal and recovery methods | Amt. | % | Amt. | % | Amt. | % | Amt. | % |
| Amount of municipal waste collected | 25 845 | 100,0 | 28 011 | 100,0 | 31 584 | 100,0 | 32 209 | 100,0 |
| Waste delivered to municipality's dumping site | 9 771 | 37,8 | 9 936 | 35,5 | 9 095 | 28,8 | 6 521 | 20,2 |
| Waste delivered to controlled landfill sites | 15 484 | 59,9 | 17 807 | 63,6 | 19 338 | 61,2 | 21 644 | 67,2 |
| Burning in an open area | 105 | 0,4 | 4 | 0,01 | 10 | 0,032 | 6 | 0,019 |
| Lake and river disposal | 33 | 0,1 | 16 | 0,06 | 0,5 | 0,002 | 0,5 | 0,002 |
| Burial | 94 | 0,4 | 7 | 0,02 | 7 | 0,021 | 2 | 0,006 |
| Other disposal methods | 202 | 0,8 | 114 | 0,41 | 41 | 0,130 | 65 | 0,20 |
| Waste delivered to composting plants | 155 | 0,6 | 126 | 0,4 | 146 | 0,5 | 123 | 0,38 |
| Waste delivered to other recovery facilities | - | - | - | - | 2 946 | 9,3 | 3 848 | 11,9 |

Source: Adapted from TURKSTAT, (2019c).

in provincial and district centers in Turkey was found 93% in 2020. On the other hand, the proportion of people living in towns and villages decreased to 7% in 2020 (TURKSTAT, 2021a).

Table 13 shows the ratio of city and village population between 2007 and 2020. During this period, the population was calculated by address based population registration system. It can be said that the population in village shows the falling trend over the years. On the other side, the population living in city seems to be increased in the long term. This means that Turkey should strengths its water management systems in urban areas to meet future demand in these areas.

Turkey can be perceived as a lucky country with having four seas (Yıldırım and Kaplan, 2020) but there is a huge risk in the availability of fresh waters in the country. Accordingly, the management of freshwater resources should be monitored carefully in the context of regional perspective. The legal implications are also strong motives for keeping water resources clean and safe. The Public Health Law No. 1593 and the Decree Law No. 663 on the Organization and Duties of the Ministry of Health and its Affiliates are implemented for the water security issues in Turkey. In accordance with this scope, monitoring and inspection studies are carried out on drinking-utility water, thermal spring water, packaged water, swimming water and swimming pools. By the relevant legislation, samples are collected in the field and sent to the laboratory, and the analysis results from the laboratory are followed. All these activities are monitored and evaluated electronically by the Environmental Health Information Management System (ÇSBYS) (Cevreonline, n.d.). The main challenges in water services provision and water management can be determined as the privatization of some cities and the growth in the packaged water sector in Turkey (Körbalta, 2019).

As similar to legal implications, there are also alternative implications by local governments and municipalities to use water sources efficiently. These implications can be categorized as deterrent, re-

*Table 11. The Amount of wastewater discharged from municipal sewerage by receiving bodies, 2012-2018*

| | 2012 | | 2014 | | 2016 | | 2018 | |
|---|---|---|---|---|---|---|---|---|
| | Amt. | % | Amt. | % | Amt. | % | Amt. | % |
| Amount of wastewater discharged (Total) | 4 072 563 | 100.0 | 4 296 851 | 100.0 | 4 499 145 | 100.0 | 4 795 130 | 100.0 |
| Treated (Total) | 3 260 396 | 80.1 | 3 483 846 | 81.1 | 3 842 350 | 85.4 | 4 236 419 | 88.3 |
| Untreated (Total) | 812 167 | 19.9 | 813 005 | 18.9 | 656 795 | 14.6 | 558 711 | 11.7 |
| Sea (Total) | 1 843 115 | 44.9 | 1 915 294 | 44.6 | 1 812 650 | 40.3 | 1 949 475 | 40.7 |
| -Treated | 1 718 588 | 93.2 | 1 759 461 | 91.9 | 1 724 792 | 95.2 | 1 883 205 | 96.6 |
| -Untreated | 124 528 | 6.8 | 155 833 | 8.1 | 87 858 | 4.8 | 66 270 | 3.4 |
| Lake/Artificial lake (Total) | 75 116 | 1.8 | 93 596 | 2.2 | 78 551 | 1.7 | 67 935 | 1.4 |
| -Treated | 36 748 | 48.9 | 47 893 | 51.2 | 53 262 | 67.8 | 53 363 | 78.6 |
| -Untreated | 38 368 | 51.1 | 45 703 | 48.8 | 25 289 | 32.2 | 14 571 | 21.4 |
| River (Total) | 1 817 352 | 44.3 | 1 898 895 | 44.2 | 2 153 123 | 47.9 | 2 248 589 | 46.9 |
| -Treated | 1 276 456 | 70.2 | 1 409 633 | 74.2 | 1 728 000 | 80.3 | 1 911 078 | 85.0 |
| -Untreated | 540 896 | 29.8 | 489 262 | 25.8 | 425 122 | 19.7 | 337 511 | 15.0 |
| Dam (Total) | 114 199 | 3.5 | 120 781 | 2.8 | 126 325 | 2.8 | 148 735 | 3.1 |
| -Treated | 63 296 | 55.3 | 61 843 | 51.2 | 76 660 | 60.7 | 104 292 | 70.1 |
| -Untreated | 50 903 | 44.7 | 58 938 | 48.8 | 49 665 | 39.3 | 44 443 | 29.9 |
| Land (Total) | 35 770 | 0.9 | 17 954 | 0.4 | 20 063 | 0.4 | 19 052 | 0.4 |
| -Treated | 8 999 | 25.2 | 8 367 | 46.6 | 14 036 | 70.0 | 13 173 | 69.1 |
| -Untreated | 26 771 | 74.8 | 9 587 | 53.4 | 6 027 | 30.0 | 5 878 | 30.9 |
| Other (Total) | 187 011 | 4.5 | 250 332 | 5.8 | 308 434 | 6.9[r] | 361 346 | 7.5 |
| -Treated | 156 309 | 83.3 | 196 649 | 78.6 | 245 601 | 79.6 | 271 307 | 75.1 |
| -Untreated | 30 701 | 16.7 | 53 683 | 21.4 | 62 833 | 20.4 | 90 038 | 24.9 |
| Amount (Thousand m3) / percent<br>Amt.:Amount | | | | | | | | |

Source: Adapted from TURKSTAT, (2019d).

warding and innovative. As a sample for deterrent implication, there are measures such as increasing costs due to the excessive water usage. Within the rewarding way, the application of a reduction in the environmental and sanitation taxes based on the conscious water consumption by citizens can be given as an example case. In an innovative way, the application of sponge city models to protect the rain water in the city is an important case. In addition, suggestions such as implementing Xeriscape in landscape arrangements, which are among the duties of municipalities, and accelerating afforestation works with the central government, are also undergoing innovative practices. The brief explanation for these innovative approaches is given in the solutions and recommendations section.

*Table 12. The Profile of Municipal Water Indicators, 2008-2018*

| Main Indicators for Water in Municipalities | Years | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 |
| The Numbers of municipality served by water supply network | 3.190 | 2.925 | 2 928 | 1 394 | 1 394 | 1 397 |
| Municipal population served by water supply network | 58 052 383 | 60 664 687 | 62 649 551 | 70 522 136 | 73 587 584 | 75 779 007 |
| The proportion of the population which served by water supply network in total municipal population (%) | 99 | 99 | 98 | 97 | 98 | 99 |
| Water abstraction for municipal water supply network | 4 546 574 | 4 784 734 | 4 936 342 | 5 237 407 | 5 838 561 | 6 193 158 |
| - Dam | 1 810 188 | 2 252 421 | 2 416 018 | 1 886 617 | 2 618 225 | 2 468 103 |
| - Well | 1 275 691 | 1 273 822 | 1 395 957 | 1 423 751 | 1 563 154 | 1 740 116 |
| - Spring | 1 060 963 | 1 015 865 | 948 133 | 984 869 | 1 000 205 | 1 138 388 |
| - River | 173 928 | 159 472 | 78 282 | 652 370 | 552 624 | 560 356 |
| - Lake - Artificial lake /sea | 225 805 | 83 154 | 97 953 | 289 800 | 104 354 | 286 196 |
| Fresh surface water abstraction for municipal water supply network | 2 209 921 | 2 495 047 | 2 592 253 | 2 828 787 | 3 275 202 | 3 314 654 |
| Fresh ground water abstraction for municipal water supply network | 2 336 654 | 2 289 687 | 2 344 090 | 2 408 620 | 2 563 359 | 2 878 503 |
| Water abstraction per capita in municipalities (liters/capita-day) | 215 | 216 | 216 | 203 | 217 | 224 |
| Water distribution by municipal water supply network | 2 400 522 | 2 579 676 | 2 801 939 | 3 394 545 | 3 732 875 | 4 045 486 |
| Number of drinking water treatment plants | 170 | 206 | 258 | 381 | 519 | 629 |
| - Physical | 71 | 77 | 79 | 69 | 54 | 22 |
| - Conventional | 84 | 96 | 132 | 165 | 197 | 197 |
| - Advanced | 15 | 33 | 47 | 147 | 268 | 410 |
| Total capacity of drinking water treatment plants | 4 422 745 | 4 499 508 | 4 629 842 | 5 346 014 | 5 558 307 | 6 023 791 |
| - Physical | 136 743 | 156 490 | 132 800 | 148 052 | 115 489 | 31 000 |
| - Conventional | 4 166 692 | 4 172 571 | 4 291 360 | 4 955 564 | 4 989 372 | 5 437 331 |
| - Advanced | 119 310 | 170 447 | 205 681 | 242 398[r] | 453 446[r] | 555 461 |
| Amount of drinking water treated | 2 120 561 | 2 520 085 | 2 729 430 | 2 995 001 | 3 350 389 | 3 574 058 |
| - Physical | 54 425 | 54 615 | 43 314 | 47 875 | 33 653 | 3 677 |
| - Conventional | 2 019 619 | 2 401 093 | 2 602 102 | 2 860 041 | 3 113 183 | 3 292 165 |
| - Advanced | 46 517 | 64 378 | 84 015 | 87 085 | 203 553 | 278 216 |
| The numbers of municipality giving a service with drinking water treatment plants | 434 | 346 | 411 | 436 | 436 | 443 |
| The population of municipality giving a service with drinking water treatment plants | 29 074 451 | 32 992 877 | 35 868 415 | 41 610 124 | 43 881 160 | 46 229 893 |
| The proportion of population served by drinking water treatment plants in total municipal population (%) | 50 | 54 | 56 | 58 | 59 | 60 |
| Turkey population | 70 586 256 | 73 722 988 | 75 627384 | 77 695904 | 79 814871 | 82 003 882 |
| Total number of municipalities | 3 225 | 2 950 | 2 950 | 1 396 | 1 397 | 1 399 |
| Total municipal population | 58 581 515 | 61 571 332 | 63 743047 | 72 505107 | 74 911343 | 76 888 607 |
| The amount: thousand m3/year | | | | | | |

Source: Adapted from TURKSTAT, (2019e).

*Table 13. The comparison of city-village population, 2007-2020 (Address Based Population Registration System)*

| Year | % of city population (Province and district centers) | % of village population (Towns and villages) |
|---|---|---|
| 2007 | 70.5 | 29.5 |
| 2008 | 75.0 | 25.0 |
| 2009 | 75.5 | 24.5 |
| 2010 | 76.3 | 23.7 |
| 2011 | 76.8 | 23.2 |
| 2012 | 77.3 | 22.7 |
| 2013 | 91.3 | 8.7 |
| 2014 | 91.8 | 8.2 |
| 2015 | 92.1 | 7.9 |
| 2016 | 92.3 | 7.7 |
| 2017 | 92.5 | 7.5 |
| 2018 | 92.3 | 7.7 |
| 2019 | 92.8 | 7.2 |
| 2020 | 93.0 | 7.0 |

Source: Adapted from TURKSTAT, (2021b).

## SOLUTIONS AND RECOMMENDATIONS

Municipalities create recreation areas where citizens can move comfortably through park and garden arrangements. Therefore, landscaping in urban areas is among the responsibilities and duties of municipalities. When protecting clean drinking water resources, "Xeriscape" applications give the opportunity of the least use (most efficient) of water in municipalities. "Xeriscape" can generally be defined as a "featured landscape arrangement" as aiming to protect water resources and the environment with the least usage of water. Arid landscaping does not necessarily mean zero water use (Çorbacı, et al, 2011). Recently, the advantages with having cost and benefit, encourage people to convert to xeric landscaping associated with Xeriscape" (Sovocool, et al., 2006). However, municipalities can contribute to less irrigation by making different visual arrangements in areas such as highway walls where people cannot perform recreational activities, while landscaping.

"The effects of deforestation on water availability, flash floods and dry season flows depend on what happens to these countervailing influences of infiltration and evapotranspiration-the sponge versus the fountain" (Chakravarty, et al., 2012). With afforestation activities, it may be possible for the arid land and agricultural areas of the cities to become productive again and to rain more in the city. In this respect, the realization of forestation activities in local administrations with the participation of the public is seen as an effective strategy for sustainable water management.

Sponge Cities is based on the practice of seizure-absorption so that the flood waters can be used for the benefit of the city. Creating a sponge city requires an infrastructure that enables the storage and use of rainwater, called gray water. Establishing a green infrastructure where roof plants, rain gardens and wetlands are designed will increase the success of these practices (Qiao, et al., 2020).

## FUTURE RESEARCH DIRECTIONS

The issue of water security, especially the fair distribution of water, is gaining importance day by day. Consequently, the number of publications conducted with interdisciplinary approaches in this field is increasing. One of these research areas is considered to be the role of local governments in water security.

In this study, the contributions and roles of municipalities on clean drinking water safety are discussed through investigating the case of Turkish municipalities. With this approach, which includes secondary data collection, future predictions using different statistical methods can be developed with this information in future studies. At the same time, with these data, the opinions of experts on water security issues can be learned through survey and interview techniques. Interviews and surveys on these issues can be conducted with experts in local government subsidiaries. Large surveys with citizen participation can also be organized to measure awareness in water consumption. Similar studies can be used to compare data from different countries.

## CONCLUSION

Turkey is classified as a high-risk country in terms of water stress in the long term due to the results from various national and international reports and statistical data. Therefore, the use and supply of clean drinking water resources are considered as an important research topic. The scope of this study is limited to municipality studies in water security. The findings obtained within the scope of the study created important indicators to draw attention to the critical importance of water security for Turkey. Although the possibility of water stress in the future is predicted for each country, applications for water safety come to the fore in countries with high water stress risk. In this respect, Turkey is an important case for water security studies with its immigration from countries experiencing water insecurity and its geopolitical position in the world.

Considering access to clean water resources as a security issue, predicting the social conflicts that may arise as a result of water scarcity is very important information for the sustainable future of cities and countries. In this respect, it is necessary for municipal administrations to keep their water security action plans ready. These plans should include possible conflict scenarios and strategies for resolving water disputes. In the future, water security will be the main indicator in distinguishing between resilient and fragile cities.

## REFERENCES

Acciona. (n.d.). *Ranking of countries with the highest water stress*. https://www.activesustainability.com/water/ranking-countries-highest-water-stress/

Allan, C., Xia, J., & Pahl-Wostl, C. (2013). Climate change and water security: Challenges for adaptive water management. *Current Opinion in Environmental Sustainability*, *5*(6), 625–632. doi:10.1016/j.cosust.2013.09.004

Bakker, K. (2012). Water security: Research challenges and opportunities. *Science*, *337*(6097), 914–915. doi:10.1126cience.1226337 PMID:22923564

BBC. (n.d.). *Resource management – water*. https://www.bbc.co.uk/bitesize/guides/zg2mycw/revision/6

Bostancı, S. H. (2015). Sustainability strategies and projects of Turkish municipalities. In K. Thomas (Ed.), *Handbook of research on sustainable development and economics* (pp. 56–71). IGI Global. doi:10.4018/978-1-4666-8433-1.ch004

Briscoe, J. (2009). Water security: Why it matters and what to do about it. *Innovations: Technology, Governance, Globalization*, *4*(3), 3–28. doi:10.1162/itgg.2009.4.3.3

Cevreonline. (n.d.). *Su güvenliği*. https://cevreonline.com/su-guvenligi/

Chakravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N., & Shukla, G. (2012). Deforestation: Causes, effects and control strategies. *Global Perspectives on Sustainable Forest Management*, *1*, 1–26.

Cook, C., & Bakker, K. (2012). Water security: Debating an emerging paradigm. *Global Environmental Change*, *22*(1), 94–102. doi:10.1016/j.gloenvcha.2011.10.011

Çorbacı, Ö. L., Özyavuz, M., & Yazgan, M. E. (2011). Peyzaj mimarlığında suyun akıllı kullanımı: Xeriscape [The smart use of water in landscape architecture: Xeriscape]. *International Journal of Agricultural and Natural Sciences*, *4*(1), 25–31.

Esen, Ö., Yıldırım, D. C., & Yıldırım, S. (2020). Threshold effects of economic growth on water stress in the Eurozone. *Environmental Science and Pollution Research International*, *27*(25), 31427–31438. doi:10.100711356-020-09383-y PMID:32488700

European Environment Agency. (2018). *Water in the city*. https://www.eea.europa.eu/signals/signals-2018-content-list/articles/close-up-2014-water-in

Gain, A. K., Giupponi, C., & Wada, Y. (2016). Measuring global water security towards sustainable development goals. *Environmental Research Letters*, *11*(12), 124015. doi:10.1088/1748-9326/11/12/124015

General Directorate of Environmental Impact Assessment, Permit and Inspection. (2020). Environmental Indicators. Author.

Hofste, R. W., Reig, P., & Schleifer, L. (2019). *17 Countries, Home to One-Quarter of the World's Population, Face Extremely High Water Stress*. https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress

İnsani Tüketim Amaçlı Sular Hakkında Yönetmelik [Regulation on Water for Human Consumption]. (n.d.). https://www.resmigazete.gov.tr/eskiler/2005/02/20050217-3.htm

Keleş, R., Hamamcı, C., & Çoban, A. (2012). *Çevre politikası*. İmge Kitapevi Yayınları.

Körbalta, H. (2019). Türkiye'de Yerel Su Güvenliği. *Güvenlik Bilimleri Dergisi*, *8*(1), 55–84. doi:10.28956/gbd.562965

Leichenko, R., & O'Brien, K. (2019). *Climate and society: Transforming the future*. John Wiley & Sons.

McMichael, A. J., Haines, J. A., Slooff, R., Sari Kovats, R., & World Health Organization. (1996). *Climate change and human health: an assessment* (No. WHO/EHG/96.7). World Health Organization.

McNutt, M. (2013). Climate change impacts. *Science*, *341*(6145), 435. doi:10.1126cience.1243256 PMID:23908191

Moumen, Z., El Idrissi, N. E. A., Tvaronavičienė, M., & Lahrach, A. (2019). Water security and sustainable development. *Insights into Regional Development*, *1*(4), 301–317. doi:10.9770/ird.2019.1.4(2)

Qiao, X. J., Liao, K. H., & Randrup, T. B. (2020). Sustainable stormwater management: A qualitative case study of the Sponge Cities initiative in China. *Sustainable Cities and Society*, *53*, 101963. doi:10.1016/j.scs.2019.101963

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.b). *2.4- Environmental Expenditures*. https://cevreselgostergeler.csb.gov.tr/cevre-koruma-harcamalari-i-85708

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.a). *6.7- Municipal Water Supply*. https://cevreselgostergeler.csb.gov.tr/belediye-icme-ve-kullanma-suyu-kaynaklari-i-85745

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.c). *6.8-Municipalities Served by Wastewater Treatment Plant*. https://cevreselgostergeler.csb.gov.tr/atiksu-aritma-tesisi-ile-hizmet-verilen-belediyeler-i-85746

Republic of Turkey Ministry of Foreign Affairs. (n.d.). *Turkey's Policy on Water Issues*. https://www.mfa.gov.tr/turkey_s-policy-on-water-issues.en.mfa#:~:text=Contrary%20to%20the%20general%20perception,North%20America%20and%20Western%20Europe

Sovocool, K. A., Morgan, M., & Bennett, D. (2006). An in-depth investigation of Xeriscape as a water conservation measure. *Journal - American Water Works Association*, *98*(2), 82–93. doi:10.1002/j.1551-8833.2006.tb07590.x

Staddon, C., & Scott, C. A. (2018). Putting water security to work: Addressing global challenges. *Water International*, *43*(8), 1017–1025. doi:10.1080/02508060.2018.1550353

Thuiller, W. (2007). Climate change and the ecologist. *Nature*, *448*(7153), 550–552. doi:10.1038/448550a PMID:17671497

TMMOB Cevre Mühendisleri Odasi. (2019). *Dünya Çevre Günü Türkiye Raporu, Haziran 2019*. https://www.cmo.org.tr/resimler/ekler/10504079d7e9ced_ek.pdf?tipi=72&turu=X&sube=0

TURKSTAT. (2018). *Environment and Energy, Environmental Expenditure of Municipalities*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1ÇevreselHarcamaları

TURKSTAT. (2019b). *Water Abstraction for Municipal Water Supply Network*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2019c). *Disposal/Recovery Methods and Amount of Municipal Waste*. Author.

TURKSTAT. (2019d). *Amount of Wastewater Discharged From Municipal Sewerage to Receiving Bodies*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2019e). *Water Indicators of Municipalities*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2021a). *The Results of Address Based Population Registration System, 2020, Press Release, Number: 37210*. https://data.tuik.gov.tr/Bulten/Index?p=The-Results-of-Address-Based-Population-Registration-System-2020-37210

TURKSTAT. (2021b). *Şehir-Köy Nüfus Oranı*. https://data.tuik.gov.tr/Kategori/GetKategori?p=nufus-ve-demografi-109&dil=1

TURKSTAT (Turkish Statistical Institute). (2019a). *Sectoral Water and Wastewater Statistics, 2018, Press Release, Number: 30673*. https://data.tuik.gov.tr/Bulten/Index?p=Sektorel-Su-ve-Atiksu-Istatistikleri-2018-30673

UNICEF. (n.d.). *Water scarcity, Addressing the growing lack of available water to meet children's needs*. https://www.unicef.org/wash/water-scarcity

World Resources Institute. (n.d.a). *Baseline Water Stress*. https://www.wri.org/applications/aqueduct/country-rankings/

World Resources Institute. (n.d.b). *Drought Risk*. https://www.wri.org/applications/aqueduct/country-rankings/?country=TUR&indicator=drr

World Resources Institute. (n.d.c). *Riverine Flood Risk*. https://www.wri.org/applications/aqueduct/country-rankings/?indicator=rfr

WWF. (n.d.). https://www.worldwildlife.org/threats/water-scarcity

Yıldırım, S., Bostancı, S. H., & Erdogan, S. (2017). Environmental sustainability in local governments: A case of Turkish municipalities. *Journal of Geography and Regional Planning*, *10*(12), 330–339. doi:10.5897/JGRP2017.0668

Yıldırım, S., & Kaplan, M. (2020). The profile of Turkey's sea and seafood in the context of sustainable development. *Gaziantep University Journal of Social Sciences*, *19*(3), 853–866.

Yıldırım, S., & Yıldırım, D. C. (2021). Achieving seafood security in the Mediterranean Region: A case of Turkey. In R. Castanho & J. Martín Gallardo (Eds.), *Management and Conservation of Mediterranean Environments* (pp. 173–193). IGI Global. doi:10.4018/978-1-7998-7391-4.ch011

## KEY TERMS AND DEFINITIONS

**Dryness:** Drought, which is generally a slowly developing climate event, is a water scarcity in the soil caused by moisture imbalance.

**Fresh Water Resources:** Fresh water can be expressed as water with potable chemical properties.

**Municipality:** Municipalities are the closest local administrations to the public, whose management styles and relations with the central government vary according to the countries.

**Sponge Cities:** It refers to a system that develops for the retention and reuse of rain water in accordance with the design in the city.

**Water Justice:** Drought causes soil inefficiency and poverty. Not having access to clean water creates serious health problems. Water-based inequalities bring the issue of water justice to the agenda.

**Water Scarcity:** It expresses the limitation and almost exhaustion of the water resources.
**Water Security:** It expresses the sufficient quantity and quality of water resources.
**Water Stress:** It expresses the pressure on freshwater resources.

# Section 2

# The COVID-19 Pandemic, Tourism, and New Technologies

# Chapter 18
# A Review of Alternative Economic Approaches to Achieve Sustainable Development:
## The Rising Digitalization and Degrowth Post COVID-19

**Seda Yildirim**
https://orcid.org/0000-0003-4367-6652
*Tekirdag Namık Kemal University, Turkey*

**Isil Demirtas**
*Giresun University, Turkey*

**Durmus Cagri Yildirim**
*Tekirdag Namık Kemal University, Turkey*

## ABSTRACT

*The COVID-19 pandemic has changed the progress in 2030 Sustainable Development Goals, and policymakers have been challenged with the implications of conventional economic system in the market. At this point, it can be said that the adoption of the best alternative economic and business model for the marketplace is the new phenomenon during the COVID-19 pandemic. Accordingly, alternative economic and business models can reduce the carbon emission, environmental pollution, and global warming, but there is a still dark point in solving social issues globally. This study aims to give a brief framework for alternative economic and business models in the context of sustainability. This study presents the links between 2030 Sustainable Development Goals, digital economy, and de-growth. In other words, this chapter focuses on digital economy (digitalization) and degrowth model (degrowing). Accordingly, it is thought to give an up-to-date work for achieving sustainable development after the COVID-19 pandemic in the long term.*

DOI: 10.4018/978-1-7998-8482-8.ch018

## INTRODUCTION

Sustainability and digitalization are seen as two popular phenomena in the 21th century. While sustainability is a vital principle in every kind of policies including health, education, economy, employment, energy etc., the need of digital transformation in government and business is getting higher (Yıldırım and Bostancı, 2021). When considering the effects of the Covid-19 pandemic globally, it can be said that it is the biggest global crises that ever happened. After the Covid-19 pandemic, economic, social and environmental issues have been re-designed due to the new normal conditions and the possible future. Especially, it is observed that the Covid-19 pandemic has accelerated the adoption of digital transformation in government and business model, globally (Öncü et.al., 2021; Yıldırım and Bostancı, 2021; Yıldırım et.al., 2021a). On the other side, the Covid-19 has affected the progress in 2030 Sustainable Development Goals (SDGs). However, there are already some troubles in achieving sustainable development and its goals. Brundtland Report (Our Common Future) (1987) emphasized the term of sustainable development formally and then, all countries who members of the United Nations accepted the importance of sustainable development by United Nations Conference on Environment and Development (UNCED)-Earth Summit (Demirtaş, 2021:332). In fact, Covid-19 pandemic has forced all countries to adopt alternative economic and business models in the way of sustainability. When struggling to achieve economic and social development, there are still big problems in environmental problems. At this point, the continuation of environmental problems has shown that sustainable growth is insufficient to meet expectations (Schneider et al., 2010: 511). According to Daly (2007: 15), the problem stems from the fact that the relationship between growth and development is not separated. In other words, while a sustainable economy stops growing at a certain level, it only needs to continue to develop. Therefore, it is necessary to focus on sustainable development, not on sustainable growth. Viktor (2020) similarly mentioned about the lack of economic growth in the long term. The continuation of economic growth as the main policy objective causes "factors directly related to welfare such as *leisure time, increase in quality of life, democratic participation, environment and happiness*", which we can define as the main welfare criterion. On the other hand, the aim of continuous growth by rich countries will increase "*resource scarcity and environmental problems*" (Viktor, 2020: 165-166).

Essentially, economic growth refers to an increase in GDP (Gross Domestic Product). GDP is also used as an indicator of social welfare. However, there is no theoretical basis for using GDP in this way. Although the use of GDP as a representation of welfare has been criticized since the 1960s, this approach has been widely maintained until today (Van den Bergh, 2009: 117-118). Recently, it has been observed that it has a weak relationship with desired outcomes such as GDP and life expectancy, literacy, democracy, justice, equality, health and happiness, and undesirable outcomes such as suicide, death, obesity, antidepressant use, and crimes. In this case, it is not certain whether economic growth is beneficial for people. In other words, it is not a successful indicator that countries stand behind this much (Paulson, 2017: 428). At this point, Neef (1995) explained with the threshold hypothesis that the growth of economies will not always increase the welfare level because it has a limit. For every society, economic growth increases the quality of life, but this increase occurs to a certain level. When the economy reaches or exceeds this threshold level, the quality of life may begin to deteriorate (Neef (1995: 117). Then, economies should focus on welfare-enhancing goals. Easterlin (1974) paradox, which deals with the relationship between happiness and GDP per capita, draws a similar conclusion. It has been observed that the relationship between the total happiness of individuals and high income level does not increase over time. Therefore, the relationship between happiness and income level is also not clear (Büchs and

Koch, 2019: 156). They continue to fall short of development. The Covid-19 crisis has proven that the world needs to undergo a major change in the way of economic and business implications. Accordingly, the main question is here:

- What would be the most sufficient sustainable economic and business model for countries in the long run?

This study aims to review alternative economic and business model in the context of sustainability and digitalization. This chapter focuses on examining the rising alternative economic and business models in the way of sustainability. So, the study preferred to review two main model as digital economy (digitalization) and degrowth model (degrowing). By giving recent progress for the alternative models, it is thought to provide a brief framework for the link between alternative models and sustainability during the Covid-19 pandemic. The main research questions can be listed as:

- How has Covid-19 affected the 2030 Sustainable Development Goals?
- What does digital economy model suggest in the long term?
- How can policy makers adapt degrowth model in the long term?
- What are the main issues of the link between 2030 Sustainable Development Goals, degrowth and digitalization?

Although the literature gives a comprehensive framework for the related models, this chapter focuses on primary models and presents a link between sustainability and the Covid-19 pandemic. The main contribution of this chapter can be explained as below:

- The recent progress in 2030 Sustainable Development Goals will be summarized.
- The recent progress in digital transformation in government model and business model will be explained through digital economy.
- Degrowth model will be explained based on recent progress.
- This study will provide a brief profile in recent approaches against sustainability and digitalization during the Covid-19 pandemic.

## SUSTAINABLE DEVELOPMENT AND COVID-19 PANDEMIC

Sustainable Development can be accepted as the new economic growth and development approach in general view. Sustainable development was introduced by the United Nations (UN) formally in 2000s. However, the need of sustainability in economic, social and environmental issues had been discussed in 1960s (Yildirim, 2020). The most important milestone can be determined as the UN Conference on Sustainable Development (Rio+20) in 2012 by launching sustainable development goals. When observing the historical progress in sustainable development goals, it can be said that universal goals to solve main problems in economic, social and environmental issues was created in the UN Conference on Sustainable Development in 2012 (UNDP Turkey, n.d.). On the other side, The United Nations Millennium Declaration which was signed in 2000, started the regular goals to be achieved until a specific period. Millennium Development Goals (MDGs) included 8 goals to be achieved until 2015 (WHO, 2018).

The MDGs can't be evaluated as so successful due to its achieved goals by 2015. But, the MDGs really achieved to get attention for sustainable development goals globally (International Labor Organization (ILO), n.d.). After the MDGs, 2030 Sustainable Development Goals (SDGs) has been launched to be achieved until 2030. There are 17 main goals in 2030 SDGs and every goal has its own sub-goals (United Nations, 2015). Table 1 presents a current profile for 2030 SDGs as:

While countries which accepted 2030 SDGs and have launched their new policies to achieve 17 goals until 2030, have challenged with the Covid-19 pandemic recently. At this point, the Sustainable Development Goals Report - 2020 includes the link between the covid-19 and 2030 SDGs when evaluating the achievement levels. We can summarize the main findings of Sustainable Development Goals Report 2020 as below (United Nations, 2020):

- **Goal 1: No Poverty:** According to Sustainable Development Goals Reports (2020), the Covid-19 pandemic had a negative effect on the achievement of Goal 1, globally. The millions will face the challenges with unemployment and poverty again since the Great Depression. It is estimated that the numbers of people living under poverty level in Southern Asia (additional 32 million people) and sub-Saharan African (additional 26 million people) will be increase rapidly. Women faced to inequality conditions during the Covid-19 pandemic. In 2019, it is seen that 12.8 percent of workers in the ages between 15 and 24 aged were found as living in poverty level. In addition, there are big gaps in "unemployed persons receiving unemployment cash benefits" between regions. For example, the half of unemployed people in Australia and New Zealand were found to be received unemployment payments and 44 percent of unemployed people in Europe and Northern America received unemployment cash benefits. On the other side, only 3 percent of unemployed people in sub-Saharan Africa 12 per cent in Latin America and the Caribbean received unemployment payments. The Covid-19 pandemic has worsened the level of poverty like as disasters, hurricanes, floods, earthquakes and wildfires. In 2018, it is seen that least developed countries (LDCs) had lost in economic, social and environmental development as a result of disasters.
- **Goal 2: Zero Hunger:** The Covid-19 pandemic increased the risk of food insecurity globally. In 2014, 22.4 percent of the population affected by the food insecurity but by 2019, this percentage increased to 25.9 percent. In addition, small-scale food producers fall into a financial crisis during the Covid-19 pandemic. In 2019, almost 690 million people were undernourished and 6.9 percent of children affected by insufficient nourishment. These children mostly lived in Central and Southern Asia. Government's incentives or investment can support agriculture. However, investments or supports decreased rapidly in last five years. Rising food price also caused food insecurity recently. Especially, people suffered from high cost food in Sub-Saharan Africa in 2019. It can be said that Africa is the worst in food security and the Covid-19 pandemic worsened food market in Africa. For example, bad weather conditions prevented transportation of food and reduced the production of agriculture in Eastern Africa. People in Western Africa affected higher food price as a result of insecure living conditions. Both of negative economic and environmental conditions also caused increased food price in Southern Africa.
- **Goal 3: Good Health and Well-being:** The Covid-19 pandemic mostly influenced the health policies globally. It is expected to see thousands of death of children with under 5 years old and mothers by 2020 as a result of the Covid-19 pandemic and insufficient health care services. If there is a decrease in food access and a long-time cut in routine health care services, there will be destructive numbers of deaths of mothers and children globally.

*Table 1. The Profile 2030 Sustainable Development Goals (SDGs)*

| 2030 SDGs | Aim | What have been done?* |
|---|---|---|
| **1. No Poverty:** | Poverty is a main issue for the world. Until 2030, countries aim to reduce the proportion of poverty in the society as much as possible. | 7 Targets<br>9 Publications<br>29 events<br>834 Actions |
| **2.Zero Hunger:** | Hunger threats the humanity in the long term. By 2030, it is aimed to provide sufficient quantity food for all people in the world. | 8 Targets<br>9 Publications<br>19 events<br>763 Actions |
| **3.Good Health and Well-Being:** | The sustainability of good health and well-being is important for the humanity. | 13 Targets<br>8 Publications<br>15 events<br>701 Actions |
| **4.Quality Education:** | Primary education should be accessed by every people in the world. Quality education is a main right for all people. | 10 Targets<br>6 Publications<br>11 events<br>1205 Actions |
| **5.Gender Equality:** | By 2030, every kinds of discrimination should be ended for all women | 9 Targets<br>7 Publications<br>16 events<br>930 Actions |
| **6.Clean Water and Sanitation:** | Safe, clean and affordable drinking water should be accessible for all people in the world. | 8 Targets<br>8 Publications<br>12 events<br>686 Actions |
| **7.Affordable and Clean Energy:** | By 2030, renewable energy systems should be adopted to keep energy efficiency. | 5 Targets<br>8 Publications<br>8 events<br>696 Actions |
| **8.Decent Work and Economic Growth:** | Without job or work, people can't keep their life with higher living standards. | 12 Targets<br>9 Publications<br>29 events<br>1231 Actions |
| **9.Industry, Innovation and Infrastructure:** | To keep economic growth, green innovative technology can be adopted. | 8 Targets<br>8 Publications<br>26 events<br>540 Actions |
| **10.Reduced Inequalities:** | Every kind of inequality situations should be reduced. | 10 Targets<br>6 Publications<br>19 events<br>503 Actions |
| **11.Sustainable Cities and Communities:** | Sustainable cities and communities can reduce the negative effects caused by urban life on environment | 10 Targets<br>11 Publications<br>14 events<br>697 Actions |
| **12.Responsible Consumption and Production:** | The rising population needs causes higher consumption and production that sustainable consumption patterns can reduce negative effects on environment as much as green production. | 11 Targets<br>11 Publications<br>8 events<br>895 Actions |
| **13.Climate Action:** | The climate change is a real issue globally and member countries firstly accept the United Nations Framework Convention on Climate Change. | 5 Targets<br>7 Publications<br>11 events<br>1094 Actions |
| **14.Life Below Water:** | Reducing negative environmental changes and pollution in seas and oceans is an important goal. | 10 Targets<br>9 Publications<br>26 events<br>2024 Actions |
| **15.Life on land:** | Areas of forests and biodiversity should be sustainable and negative effects to forest areas and biodiversity should be prevented. | 12 Targets<br>5 Publications<br>11 events<br>699 Actions |
| **16.Peace, Justice and Strong Institutions:** | To achieve social development, peace, justice and strong institutions are vital issues globally. | 12 Targets<br>7 Publications<br>13 events<br>630 Actions |
| **17.Partnerships for the goals:** | To fight against climate change globally, the coordination and partnerships between countries is the key to develop global sustainable policies | 19 Targets<br>30 Publications<br>75 events<br>1266 Actions |
| *The information was taken from United Nations Department of Economic and Social Affairs Sustainable Development, (n.d.) | | |

Source: (created by authors)

- **Goal 4: Quality Education:** The Covid-19 pandemic caused a huge impact on global education system. The lack down of schools, cancelled education programs (national and international), and transformation in remote education are main outcomes of this process. Missing education influences the behavior and perception of children and young negatively in the long term. During the Covid-19 pandemic, over 190 countries had to decide on shutdown of the schools and so almost 90 percent of students stayed at home without education. Although there are options as remote education, the most of the students (at least 500 million children/ young) can't access to remote education system. The slow progress in access to primary education in lower income and least developed countries has been worsened during the Covid-19 pandemic. When 87 percent of the European households can access to internet at home, only 18 percent of the African households can access to internet.
- **Goal 5: Gender Equality:** The violence and discrimination against women has been increased during the Covid-19 pandemic. Especially, lockdown at home caused higher bad conditions for women. In addition, the marriage of young women (age in 20-24) will be expected to increase after the Covid-19.
- **Goal 6: Clean Water and Sanitation:** The clean water is needed to reduce poverty, food insecurity and increase health and well-being of people in the long term. The pollution in water sources influence the biodiversity and sources of food in the Earth. The coordination between countries to protect water sources is a vital issue when observing that the most of the water sources are transboundary sources. By 2018, it was reported that 60 percent of 172 countries had been too low and low or middle-low level in implication and funding of water sanitation programs. The water stress levels were found above 70 percent in Northern Africa and Central and Southern Asia. Then, water stress levels were found 45 percent in Western Asia and 55 percent in Eastern Asia.
- **Goal 7: Affordable and Clean Energy:** The share of total renewable energy in the energy consumption increased from 17 percent (2015) to 17.3 percent in 2017. The biggest rise in renewable energy included solar-energy and wind-energy system. On the other side, most people (especially women and children) can't access to clean energy for their own needs.
- **Goal 8: Decent Work and Economic Growth:** The main finding is the slowdown of the progress in economic growth globally by 2019. The living standards of people decreased and the most of people lost their jobs during the Covid-19 pandemic. To sum up, the economic conditions of the world will be expected to worsen due to the impacts of the Covid-19 pandemic.
- **Goal 9: Industry, Innovation and Infrastructure:** The aviation industry which plays an important role in economic growth, has been suffered from the Covid-19 pandemic. In the first five months in 2020, the numbers of passengers fall deeply (51.1 percent) due to the comparison with the same period in 2020. The investment in R&D has increased and the need of internet access and usage has increased. However, people form the least developed countries are not so lucky to access to internet.
- **Goal 10: Reduced Inequalities:** The calculated GINI index decreased recently. The GINI index measures income inequality. The reports during the Covid-10 pandemic determined that the main disadvantaged groups were classified as "older persons, persons with disabilities, children, women, migrant and refugees". The Covid-19 pandemic mostly influenced these groups. It was determined that new migration policies should be planned for the future periods.
- **Goal 11: Sustainable Cities and Communities:** It is seen that urban areas and cities causes to spread of the Covid-19. In addition, the populated informal settlements and slums were mostly

influenced by the Covid-19. Accordingly, the urban design is an important issue to fight against natural disasters or viruses such as Covid-19, globally. By 2020 May, it was reported that 154 countries has a National City planning.

- **Goal 12: Responsible Consumption and Production:** It was seen that the global material footprint is not fall and it still keeps growing. The pandemic creates an opportunity to decrease ecological footprint globally. For example, shutdown at home, the fall in transportation including air, bus, car and a decrease in production make a little improvement. However, it is expected to increase in ecological footprint after the pandemic.
- **Goal 13: Climate Action:** The climate change can't be reduced when observing the recent data. For example, the warmest weather was reported in 2019 and this was the warmest year in the least ten years. The sufficient polies should be implemented to reduce carbon emission and slow down the fast of the warming weather or stop it as much as possible.
- **Goal 14: Life Below Water:** The Ocean plays a role in absorbing $CO_2$ emissions but the higher percentages of $CO_2$ causes higher acidification in the ocean. Higher acidification influences the life below water and biodiversity linking to food sources. On the other side, over-fishing activities threats the biodiversity in the long term.
- **Goal 15: Life on Land:** The fall in biodiversity from landing areas keeps going on recently. 10 Million hectares of forest were destroyed between 2015 and 2020. According to the achievement levels of 2030 Sustainable Development Goals, only a third of 113 countries were seen close to be successful in making sustainable policies to protect biodiversity.
- **Goal 16: Peace, Justice and Strong Institutions:** Achieving a peace and justice globally is too hard goal since decades. The Covid-19 pandemic increases the violence and unjust conditions for people. In addition, 60 percent of countries have prison overcrowding during the pandemic.
- **Goal 17: Partnerships for the Goals:** The Covid-19 pandemic revealed that the international coordination should be increased to achieve main issues of 2030 Sustainable Development Goals. On the other side, foreign investments are expected to decline in 2020.

Today, almost 55 percent of the population lives in urban areas and it is estimated that the population living in urban areas and cities will be doubled by 2050. Accordingly, people living in cities should participate in achieving 2030 Sustainable Development Goals. During the Covid-19 pandemic, it is also observed that cities caused higher spread of pandemics and threats the health and well-being of people. At this point, cities with higher population are in jeopardy in the world and achieving sustainable development is more challenge in these cities (The World Bank, 2020).

During the Covid-19 pandemic, the importance of sustainability principle in economic and social issues is recognized more clearly. The lack of some main public services including health, employment, education and equality decrease the level of social development in many countries during the Covid-19 pandemic (International Labor Organization (ILO) and The Organisation for Economic Co-operation and Development (OECD), 2020; International Labor Organization (ILO), 2020). On the other side, a decrease in production and transportation has decreased the proportion of $CO_2$ emissions temporary in countries with higher industry such as China (Le Quere et.al., 2020). The climate change is still increasing but some observations has showed that the proportion $CO_2$ emissions can be prevented or reduced by less production and transportation systems which are causing higher $CO_2$ emissions. Thus, it can be said that the Covid-19 pandemic gives a little clue for the way of reducing the global warming in practical (McGrath, 2020; Hale, 2020; Klueger, 2021). In other words, the Covid-19 pandemic just creates a picture for the possibility of reducing $CO_2$ emissions and global warming. If policy makers keep sustainable models for production, industry and energy, the climate change can be prevented in the long term.

## DIGITALIZATION AND DEGROWTH DURING THE COVID-19 PANDEMIC

The recent observation on the link between *industrial-economic development and environmental pollution* has proved that economic and business models promoting industrial-economic development have increased the global warming and environmental pollution (Yıldırım et.al., 2021b). Thus, the rising danger coming from the climate change and natural resource scarcity show that conventional economic growth models are not sustainable for the future (Alexander, 2012). At this point, the concept of growth has also begun to be discussed due to its negative outcomes in the long term. Assadourian (2012: 40-41) mentioned that developed countries are faced with a curse in terms of excessive consumption and production. The abundance and the development level in these countries have been separated from each other for a long time. In fact, the economy based on abundance and excessive consumption harms these countries. Problems such as obesity, depression, traffic, and stress disorders are the ones that stand out from the negative results faced by developed countries. On the other hand, the view that the increase in wealth does not increase the welfare in developed countries has started to be confirmed recently (Cosme et. al, 2017).

Sustainable development aims to keep sustainable balance between economic, social and environmental issues when monitoring the growth (Yıldırım and Yıldırım, 2020). Considering the truth that usual economic or business models can't achieve sustainable development goals or save the Earth in the long term, seeking alternative economic or business models has increased recently. It can be said that the green economy model is the first and most closely related model in terms of sustainable development and sustainable development goals. The United Nations Environment Program (UNEP) determines that the green economy offers a model that encourages social and economic development while minimizing environmental risks and dangers (UNEP, 2011). The World Green Economy Organization evaluated the green economy model in a practical way and defines this model as "low-carbon, climate-resistant social and economic development" (CISL, 2018). Sustainable economy model has emerged that will ensure economic growth on the one hand and the elimination of environmental problems on the other (Demirtaş, 2017: 111). However, the rapid depletion of natural resources pushed the sustainability limits of this model (Yıldırım et al., 2021c: 2).At this point, recent periods has showed that new alternative models can be more effective tool to achieve 2030 Sustainable Development Goals. Especially, the argument on new economic and business models has been growing in the way of sustainable development during the Covid-19 Pandemic. This chapter will explain digital economy and degrowth model as a new economic and business model recently.

### Digital Economy and Sustainability during the Covid-19 Pandemic

It is expected that new technologies will be used more in industry and business models and digital transformation will accelerate. At this point, it can be said that the Industry 4.0 trend will shift from large-scale enterprises to medium-sized enterprises. It is stated that digitalization in production technology will contribute to ecological development. Significant ecological contributions such as the efficient use of natural resources, increase in productivity, and efficient use of water resources arise with digitalization in the industry. For example; The Netherlands, Japan, Germany and the United Kingdom are among the countries that accelerate digitalization in industry and business models. (Martynenko and Vershinina, 2018).

The stagnation of digital transformation process in some countries or business models has been changed into rapid transformation process during the Covid-19 pandemic. The decrease in physical mobility and face-to-face communication in business models has highlighted the virtual environment in business processes. During the pandemic, activities of business areas have been moved to the virtual environment. With the pandemic crisis, the world has entered into a mandatory isolation. In this difficult period, countries and businesses which have reached a certain stage in digital transformation, have been able to continue their activities without slowing down (BDO, 2020). The contributions of the digital economy during the epidemic period can be summarized as in the Table 2.

*Table 2. The Digital Economy and The Covid-19*

| Factors | What happened |
|---|---|
| **Remote working model** | The most of workers are used to work remote. In addition, many businesses can keep their functions. |
| **Online shopping/trade channels** | Shopping behaviors and industrial buying process are moved to digital channels during the Covid-19 pandemic. Thus, consumers can buy products and services by online shopping channels. |
| **Digital Content Usage** | The Covid-19 pandemic creates a new area for enjoyment. For example, Netflix is the winner platform due to the lockdown period. |
| **Digital Platform management** | The number of online platforms increase |
| **Digital Healthcare services** | Some healthcare services have moved to digital platforms. |

Source: (adapted from BDO, 2020)

The rise of the digital economy may have affected countries and industries in different ways. For example; It has created a greater supply load for those who carry out their production activities with ICT technology. It has been determined that in developed countries such as the USA, England and Germany, the density of robots among the manufacturing sectors is higher than the developing economies of India, Brazil and South Africa (Banga and Velde, 2020).

Banga ve Velde (2020)'s study gives a model determining the influence of the Covid-19 pandemic on business model as table 3:

The digital economy offers an opportunity to experience a great change in terms of sustainability on a global scale. The digital economy makes significant contributions especially for countries that are disadvantaged in terms of achieving 2030 SDGs. For example; Reaching 2030 SDGs for the global South has become easier with digital economy. When 17 SDGs are considered, digital economy will increase cooperation, coordination and create a growth opportunity for small-scale economy and businesses. The 17 SDGs should be considered as a whole and work towards goals within the framework of the principle of "leaving no one behind". At this point, the digital economy can be seen as a powerful and effective tool (Besada, 2018).

The application of ICT (Information and Communication Technologies) to government and business models is a process that brings digital transformation to the agenda. In particular, the digital economy

*Table 3. The Influence of the Covid-19 pandemic on Business Model*

| Covid-19 shock to digital economy | Covid-19 shock to several sectors and policies |
|---|---|
| **Direct Effects** | **Indirect Effects** |
| **Demand: Increase demand for digital economy and digital business model** | Demand: When there is a decrease in some sectors, a demand in related industries or sectors decrease, too. As similar way, some shocks in supply side can increase the demand in the related areas. |
| **Demand: Increase business model including work at home, online marketing, online service management** | Demand: Face-to-face education or healthcare services declined during the Covid-19 pandemic and then, digital model of education and healthcare services increases. |
| **Supply: Investments of digitalization will increase** | Supply: Buying technologies of ICT and innovative tools and etc. can be delayed. |

Source: (adapted from Banga and Velde (2020):4-5)

model that has evolved as a new economic order has contributed to the growth rates of second-generation computing (Ivanov et al., 2021). In summary, with the rapid adoption of digital economy and business models on a global scale, the digitalization process of the economy can be an important driving force in the realization of the SDGs. Important digital tools such as the Internet, artificial intelligence, and sensors provide benefits in terms of reducing errors and increasing productivity in business models and policies. There may be some difficulties in adopting digital transformation and digital business models. When these challenges are overcome, accelerating factors can be used to achieve the 2030 SDGs. The use of "Bitcoin and Ethereum" application can be given as examples of the important developments that have come to the fore with the rise of the digital economy (Rielli, 2018).

In addition, digitalization in government also supports the efficiency in public service delivery and management during the Covid-19 pandemic. Especially, healthcare and education which are generally accepted as fundamental public service, are managed by digital platforms during the Covid-19 pandemic (Öncü et.al., 2021; Yıldırım et.al., 2021). Many countries have moved their public and government services into digital platforms. The most of higher education models has been transformed into remote education model recently (Recio and Colella, 2020).

The United Nations has recently presented findings on the relationship between the digital economy and the 2030 Sustainable Development Goals. In terms of achieving the 2030 SDGs, "global digital collaborations and opportunities offered by technology" point to digitalization as an important tool in achieving these goals. The United Nations is planning to appoint a technology representative responsible for establishing the link between sustainability and digitalization for the digital transformation process (The International Institute for Sustainable Development (IISD), 2020). The action should be started against to the climate change and achieving sustainable development goals has been recognized by governments, businesses and people due to the Paris Agreement on climate change. The way to the sustainability makes the adaptation of new and alternative economic and business model recently. At this point, digital technologies give a new opportunity to fight against to the climate change. For example, the Global e-Sustainability Initiative (GeSI) and Deloitte present significant findings for the link between digitalization and sustainability (Neves, 2019). According to GESI and Deloitte reports, the impacts of digital technologies on sustainable development can be summarized in Table 5.

*Table 4. The impacts of digital technologies on sustainability*

| Impacts | Contributions |
|---|---|
| **Connection** | Digital technologies create information, ideas and opportunities by helping to communicate. |
| **Monitor and watch** | Digital technologies help to monitor and follow the world. Transparency in information is provided. |
| **Information analysis, reporting** | Digital technologies provide convenience in terms of information analysis and reporting. |
| **Coordination** | Digital technologies coordinate between the physical and digital worlds. |

Source: (adapted from Neves, 2019)

## DeGrowth Model, Sustainability and Covid-19 Pandemic

Degrowth economy is one of the alternative approaches seeking a common solution to environmental, social and economic problems. It is easy to argue and justify degrowth, but the implementation of this economic system is quite challenging. However, it can be said that degrowth model can be a great solution for the future in the context of sustainable development. The concept of "*Decroissance-Degrowth*" was first born in France in the 1970s as a concept that drew attention to the fact that consumption was not sustainable. The rise of neo-liberal economics reduced the interest in the concept for a while and the concept of degrowth remained mostly in French literature. The concept, which was renewed as sustainable degrowth in the 2000s, became popular as an anti-global activist movement and spread outside France. It can be said that criticism against the concept of sustainable development played an important role as the widespread of degrowth model (Kallis et al., 2018; Khamara and Kronenberg, 2020).

The important progress that enabled the concept of degrowth to take attention in the World was the first international conference on socially sustainable economic degrowth for ecological sustainability and social equity in 18-19 April 2008 in Paris (Research & Degrowth, 2010; Khamara and Kronenberg, 2020; Kallis et al., 2018). The Degrowth Declaration which published by the conference participants, clearly stated the scope, purpose and need of the degrowth model. In the Declaration, the concept of degrowth was defined as a paradigm shift based on ecological sustainability, prioritizing human needs and increasing the quality of life, and saving human activities from dependence on economic activity. In other words, degrowth expresses as a stable economy in which more humanitarian concepts such as leisure time, unrequited activities, creativity, equality, and tolerance are respectful to human rights and cultural differences (Research & Degrowth, 2010:523). Degrowth economics focuses on qualitative development rather than a quantitative economic growth. Thus, the concept of welfare is separated from economic growth and it is considered together with more humanitarian characteristics (Assadourian, 2012: 62).

Degrowth model can give an alternative way to the sustainable development. However, there are some challenges for implementing this model universally. Table 6 can guide the readers about the implication method of degrowth model as below:

When analyzing the policies regarding degrowth, it is understood that these policies are more environmentally friendly. In fact, it is similar to the policies suggested by the green economy. Therefore, when we look at the whole of policies, degrowth is seen as a localization policy advocacy that prioritizes the environment. On the other hand, a stronger and more inclusive strategic roadmap to convince states is required to adopt the degrowth economy.

*Table 5. The views for the degrowth model*

| Researchers | View |
|---|---|
| Martinez- Alier et al. (2010) | As the concept of degrowth is considered as the opposite of the concept of economic growth, it creates a negative concept perception. Therefore, economic degrowth is not the opposite of economic growth and sustainable growth. |
| Schneider et al., (2010) | Degrowth model was expressed as a sustainable degrowth in the 2000s, and this model separated its scope from unsustainable problems coming from economic recession and depression. |
| Kallis et al. (2018) | Degrowth model expresses a type of renunciation against the growth. The researchers list fundamental elements of degrowth model as “sharing, simplicity, conviviality, care and commons” |
| Kallis (2011) | Degrowth economy emphasizes a smaller, newer and different social structure. It expresses sustainable degrowth as a radical project suggesting better living conditions are provided with less consumption while the institutional infrastructure is transformed into a suitable form to enable degrowthing in cultural and political. |
| Assadourian (2012) | Sustainable degrowth can be expressed as a radical project that ensuring better living conditions with less consumption. The degrowth model opposes all growth approaches including green growth. |
| Sekulova et al. (2013) | Sustainable degrowth helps to ensure that the business volume of the society is sustainable and it ensures that it is stabilized by reducing it equally. |
| Cosme et al, (2017) | Although degrowth economy includes the period of economic downsizing, this downsizing should be constructed with a systematic structure in a way that will not cause an economic shrinkage. |

Source: (created by authors)

*Table 6. Economic Degrowth Policies: How to achieve degrowth?*

| Researchers | The suggestion |
|---|---|
| Assadourian, (2012: 43-45) | The degrowth model suggests less consumption. Governments and businesses can guide people and society about less consumption patterns and sustainable implications. For example, states can make incentives for degrowth and sustainability. Such as subsidies to organic producers, incentives to rent and build small houses. Implementing many activities such as ensuring a fair distribution of income with taxes and sharing working hours more equally are appropriate policies for degrowth. |
| Kallis (2011: 876) | Implications including eco-villages, expansion of rural settlements, establishment of local cooperatives, dissemination of organic agriculture and realization of policies can be given as main examples of degrowth model. In addition, policies such as reducing working hours, guaranteeing minimum health conditions, and implementing policies that will ensure high welfare are also listed as policies in favor of degrowth. |
| Latouche (2006:3) | Degrowth policies suggest a more reformist transition process. It emphasizes that all types of activities should be reconsidered in a way to ensure downsizing. For example, policies such as return to small-scale agriculture, reducing transportation costs, promoting the expansion of maintenance services, imposing heavy taxes on advertising expenditures, and ensuring energy efficiency. |
| Mocca (2020: 79-80) | The regional-local scale is suitable for the degrowth theory. According to Mocca (2020), there is not much emphasis on local policy solutions in degrowth policies. It draws attention to the need to emphasize localism in ensuring ecology, democracy and fair distribution. At this point, decentralization should be achieved both by reallocating the production and consumption of goods and services at the local level and by re-localizing the policies in the decision-making process. |
| Kallis (2011:875) | Degrowth model proposes policies for the selective downsizing of man-made capital. |

Source: (created by authors)

## SOLUTIONS AND RECOMMENDATIONS

The 21th century has awakened to be careful about the future due to the climate change, global warming and related environmental problems (Yıldırım et.al., 2021c). When considering recent crises with the usual (conventional) economic models, the 2008 financial crisis led to the questioning of traditional economic models and the search for alternative economic policies. In this context, green and sustainable economic policies were implemented. However, the continuation of ecological-economic problems and the social and economic problems caused by the current covid-19 pandemic have shown that the policies implemented are not sufficient. In fact, although it is ignored, the covid-19 crisis has also emerged as a crisis caused by environmental damage. Later, it also increased many economic problems such as poverty, income distribution injustice and unemployment. Therefore, the economic, environmental and recently added health crisis is in interaction. There is a close causal relationship between the crises experienced. For this reason, alternative economic models are sought that can solve all these crises on a common ground.

Although economic growth has been criticized in many ways, it is debatable whether the downsizing is feasible. According to Alexander (2012:359), the capitalist system is dependent on growth. Therefore, the shrinkage of the economy causes unemployment, insecurity and many social and economic problems, as is experienced in times of crisis. However, the policies implemented to overcome the crisis are aimed at achieving economic growth. Because it is thought that when economic growth is restored, unemployment, poverty and social problems will be solved. But even if all this is true, ignoring environmental problems is a harbinger of bigger problems for the future. Therefore, it is necessary to abandon the traditional viewpoint of the present and perhaps the concept of downsizing should be taken a little more seriously for an alternative solution.

## FUTURE RESEARCH DIRECTIONS

This study gives a brief framework for alternative economic and business models in the way of sustainability during the Covid-19 pandemic. Thus, the main contribution of this study is presenting a recent progress to achieve 2030 Sustainable Development Goals. As reviewing digitalization and degrowing, this study is limited with two alternative models in the literature. On the other side, this study is thought to be useful by giving up-to-date information for the current literature.

The study can list some suggestions for the future studies as:

- The future studies can focus on explaining how alternative economics and business models can be implemented in the context sustainable development.
- Alternative sustainable economic models have some troubles during the implication and practices. Accordingly, the way of transformation in sustainable development should be explained more clearly for governments.
- Every societies or governments should adopt the best choice for sustainable development.
- During the periods in crises such as the Covid-19 pandemic, there should be new solutions for achieving sustainable development goals.
- Investigating sample cases can give useful clue for future implications of sustainable economic and business models in the long term.

## CONCLUSION

The Covid-19 pandemic has challenged the progress in achieving 2030 Sustainable Development Goals. The health crises point outs the huge gap between developed countries, developing countries and the least developed countries .When policy makers try to create new economic and business model to get a balance between environmental and economic issues, the challenge with social issues gives a new arguments.

The report, Digital with Purpose reveals that the United Nations can achieve 2030 Sustainable Development Goals by using digital technologies and innovative digital systems. The main findings of this report can be given as (GESI, n.d.):

- *"Digital access, faster internet, cloud, internet of things (IOT), cognitive, digital reality and blockchain*" are among the basic digital technologies. When considering 2030 SDGs, 103 of 169 SDG sub-targets are directly affected by these digital technology and its tools.
- If digital technologies can be used efficiently, there is a possible progress in SDGs by accelerating 22%.
- Digital technologies can provide a significant reduction in $CO_2$ emissions in the long term

The digital economy has some benefits in achieving most of 2030 SDGs. However, the level of digitalization can be varied by countries and governments. Accordingly, this level gap in digitalization can cause inequalities between countries and their development levels.

It can be said that degrowth model has been shining since the Covid-19 pandemic. Considering the big challenges of degrowth model, adopting degrowth model is thought to be impossible in a practice way. At this point, the Covid-19 pandemic showed that growing is not always a great choice.

*Table 7. Degrowth Model Suggestion during the Covid-19 pandemic*

| Who suggests degrowth model | Why? |
|---|---|
| The degrowth.info editorial team (2020) | Degrowth model aims to achieve growing by local production and keeping justice and equality. The Covid-19 pandemic showed the importance of ensuring equal living standards for all people in the world. |
| The open letter working group, (2020) | The Covid-19 pandemic points out why policy makers should change the growing perspective in the long term. Over 1.100 experts from several sixty countries and seventy organizations *calls for Degrowth* to fight against the Covid-19 pandemic and related issues. This call can be defined as The "Degrowth open letter". |
| Hendranastiti, N.D. (2021) | The recent outcomes of conventional growing theory have proved the impossibility of sustainability in the long term. Thus, new alternative growing models such as degrowth can give a solution for the society to achieve sustainable development. |
| Nelson & Liegey (2020) | The arguments toward conventional growing models have been proved during the Covid-19 pandemic. At this point, the perspective and approach for growing should be changed. |
| Dartnell & Kish (2020) | Degrowth model can be adaptable but it can be modified to give efficient economic and business model for the related economy. |

Source: (created by authors)

Accordingly, alternative economic and business model can reduce the carbon emission, environmental pollution and global warming but there is a still dark point in solving social issues globally. This chapter presents the recent progress and implications in digital economy model and degrowth economy model during the Covid-19 pandemic. When observing practical implications and literature, it can be said that digitalization and degrowth are both rising models to be adopted by the policy makers. However, these models can challenge governments due to their specific principles in the way of sustainability.

## REFERENCES

Alexander, S. (2012). Planned economic contraction: The emerging case for degrowth. *Environmental Politics*, *21*(3), 349–368. doi:10.1080/09644016.2012.671569

Assadourion, E. (2012). Fazla Gelişmiş Ülkelerde Küçülmenin Yolu [Lexical characteristics of Turkish language]. In L. Starke (Ed.), *Worldwatch Enstitüsü Dünyanın Durumu 2012 Sürdürülebilir Refaha Doğru* (pp. 37–66). Çev. Ayşe Başçı, İş Bankası.

Banga, K., & te Velde, D. W. (2020). Covid-19 and disruption of the digital economy; evidence from low and middle-income countries. Digital Pathways at Oxford Paper Series; no. 7.

BDO. (2020). *Covid-19 Is Accelerating The Rise Of The Digital Economy*. https://www.bdo.com/insights/business-financial-advisory/strategy,-technology-transformation/covid-19-is-accelerating-the-rise-of-the-digital-e

Besada, H. (2018). *Digital Economy and the Implementation of the 2030 Agenda for Sustainable Development*. https://www.unsouthsouth.org/wp-content/uploads/2018/12/Digital-Economy-and-the-Implementation-of-the-2030-Agenda-Hany-Besada.pdf

Büchs, M., & Koch, M. (2019). Challenges for the degrowth transition: The debate about wellbeing. *Futures*, *105*, 155–165. doi:10.1016/j.futures.2018.09.002

CISL (The University of Cambridge Institute for Sustainability Leadership). (2018). *Rewiring the Economy, Ten tasks, ten years*. https://www.cisl.cam.ac.uk/resources/publication-pdfs/rewiring-the-economy-report.pdf

Cosme, I., Santos, R., & O'Neill, D. W. (2017). Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals. *Journal of Cleaner Production*, *149*, 321–334. doi:10.1016/j.jclepro.2017.02.016

Daly, H. E. (2007). *Ecological Economics and Sustainable Development: Selected Essays of Herman Daly*. Edward Elgar Publishing. doi:10.4337/9781847206947

Dartnell, L. R., & Kish, K. (2021). Do responses to the COVID-19 pandemic anticipate a long-lasting shift towards peer-to-peer production or degrowth? *Sustainable Production and Consumption*. . doi:10.1016/j.spc.2021.05.018

Demirtaş, I. (2017). *Ekolojik ve Ekonomik Krizlere Alternatif Çözüm Olarak Yeşil Ekonomi Politikaları*. Alternatif Politika, İklim Değişikliği ve Enerji Özel Sayısı.

Demirtaş, I. (2021). Yeşil Ekonomi: Kavramsal Bir Tartışma. In Z. Savaşkan, Ç. Söker, & F. H. Yılmaz (Eds.), *Çevre Hukuku ve Politikaları Kavramlar, Teoriler ve Tartışmalar* [Lexical characteristics of Turkish language] (pp. 325–358). Seçkin Publishing.

GESI. (n.d.). *GESI Digital With Purpose (Full Report)*. https://gesi.org/research/gesi-digital-with-purpose-full-report

Hale, G. (2020). *The Effect of COVID-19 on CO2 Emissions*. https://econofact.org/the-effect-of-covid-19-on-co2-emissions

Hendranastiti, N. D. (2021). *COVID-19 and Degrowth: A Momentum to Restructure the System*. https://worldfinancialreview.com/covid-19-and-degrowth-a-momentum-to-restructure-the-system/

International Labor Organization (ILO). (2020). *A gender-responsive employment recovery: Building back fairer*. Policy Biref, Jluy 2020. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_751785.pdf

International Labor Organization (ILO). (n.d.). *Millennium Development Goals*. https://www.ilo.org/global/topics/millennium-development-goals/lang--en/index.htm

International Labor Organization (ILO) & The Organisation for Economic Co-operation and Development (OECD). (2020). *The impact of the COVID-19 pandemic on jobs and incomes in G20 economies*. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_756331.pdf

Ivanov, I., Orlova, L., & Vlasova, T. (2021). Digitalization as a Factor of Sustainable Development of Industrial Enterprises. *IOP Conference Series. Earth and Environmental Science*, *666*(6), 062047. doi:10.1088/1755-1315/666/6/062047

Kallis, G. (2011). In defence of degrowth. *Ecological Economics*, *70*(5), 873–880. doi:10.1016/j.ecolecon.2010.12.007

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research On Degrowth. *Annual Review of Environment and Resources*, *43*(1), 291–316. doi:10.1146/annurev-environ-102017-025941

Khmara, Y., & Kronenberg, J. (2020). Degrowth in the context of sustainability transitions: In search of a common ground. *Journal of Cleaner Production*, *267*(122072), 1–13. doi:10.1016/j.jclepro.2020.122072

Klueger, J. (2021). *The COVID-19 Pandemic's Impact on Global CO2 Emissions Didn't Last Very Long*. https://time.com/5943530/covid-19-co2-emissions-climate-change/

Latouche, S. (2006). *How do we learn to want less? The globe downshifted. Le Monde Diplomatique*. https://www.jussemper.org/Resources/Economic%20Data/Resources/The%20 globe%20downshifted,%20 by%20Serge%20Latouche.pdf

Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F., & Peters, G. P. (2020). Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(7), 647–653. doi:10.103841558-020-0797-x

Martínez-Alier, J., Pascual, U., Vivien, F. D., & Zaccai, E. (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics*, *69*(9), 1741–1747. doi:10.1016/j.ecolecon.2010.04.017

Martynenko, T. S., & Vershinina, I. A. (2018). Digital Economy: The Possibility of Sustainable Development and Overcoming Social and Environmental Inequality in Russia. *Revista ESPACIOS*, *39*(44). https://www.revistaespacios.com/a18v39n44/a18v39n44p12.pdf

McGrath, M. (2020). *Climate change: Covid pandemic has little impact on rise in CO2*. https://www.bbc.com/news/science-environment-55018581

Mocca, E. (2020). The local dimension in the degrowth literature. A critical discussion. *Journal of Political Ideologies*, *25*(1), 78–93. doi:10.1080/13569317.2019.1696926

Neef, M. M. (1995). Economic growth and quality of life: A threshold hypothesis. *Ecological Economics*, *15*(2), 115–118. doi:10.1016/0921-8009(95)00064-X

Nelson, A., & Liegey, V. (2020). *Coronavirus and degrowth*. https://theecologist.org/2020/apr/03/coronavirus-and-degrowth

Neves, L. (2019). *Going "Digital with Purpose" to Achieve Climate Goals and 2030 Agenda.* https://sdg.iisd.org/commentary/guest-articles/going-digital-with-purpose-to-achieve-climate-goals-and-2030-agenda/

Öncü, M., Yıldırım, S., Bostancı, S., & Erdoğan, F. (2021). The Effect of COVID-19 Pandemic on Health Management and Health Services: A Case of Turkey. *Duzce Medical Journal*, *23*(Special Issue), 61–70.

Paulson, S. (2017). Degrowth: culture, power and change. *Journal of Political Ecology, 24, 425-666*. doi:10.2458/v24i1.20882

Recio, S. G., & Colella, C. (2020). *The world of higher education after COVID-19. How COVID-19 has affected young universities*. YERUN. Available at: https://www.yerun.eu/wpcontent/uploads/2020/07/YERUN-Covid-VFinal-OnlineSpread.pdf

Research & Degrowth. (2010). Degrowth Declaration of the Paris 2008 conference. *Journal of Cleaner Production*, *18*(6), 523–524. doi:10.1016/j.jclepro.2010.01.012

Rielli, L. E. (2018). *Sustainable development and the digital economy: new opportunities for access to markets.* http://noviconsult.com.br/wp-content/uploads/2018/12/Sustainable-development-and-the-digital-economy-new-opportunities-for-access-to-markets.pdf

Schneider, F., Kallisa, G., & Martinez-Alier, J. (2010). Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. *Journal of Cleaner Production*, *18*(6), 511–518. doi:10.1016/j.jclepro.2010.01.014

Sekulova, F., Kallis, G., Rodríguez-Labajos, B., & Schneider, F. (2013). Degrowth: From theory to practice. *Journal of Cleaner Production*, *38*, 1–6. doi:10.1016/j.jclepro.2012.06.022

The degrowth.info editorial team. (2020). *A degrowth perspective on the coronavirus crisis*. https://www.degrowth.info/en/2020/03/a-degrowth-perspective-on-the-coronavirus-crisis/

The International Institute for Sustainable Development (IISD). (2020). *Digital Cooperation Must Connect, Respect, Protect*. UN Secretary-General. http://sdg.iisd.org/news/digital-cooperation-must-connect-respect-protect-un-secretary-general/

The open letter working group. (2020). *More than 1,000 experts call for Degrowth as post-COVID-19 path*. https://www.degrowth.info/en/2020/05/more-than-1000-experts-call-for-degrowth-as-post-covid-19-path/

The World Bank. 2020). *Urban Development.* (https://www.worldbank.org/en/topic/urbandevelopment/overview#)

UNDP Turkey. (n.d.). *Background on the goals*. https://www.tr.undp.org/content/turkey/en/home/sustainable-development-goals/background.html

United Nations. (2011). *The Green Economy: Trade And Sustainable Development Implications.* United Nations Conference on Trade and Development. https://unctad.org/en/Docs/ditcted2011d5_en.pdf

United Nations. (2020). *The Sustainable Development Goals Report 2020*. https://unstats.un.org/sdgs/report/2020/

United Nations Department of Economic and Social Affairs Sustainable Development. (n.d.). *The 17 Goals*. https://sdgs.un.org/goals

United Nations (UN). (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. General Assembly Seventieth session. Agenda items 15 and 116. A/RES/70/1.

Van den Bergh, J. C. J. M. (2009). The GDP paradox. *Journal of Economic Psychology*, *30*(2), 117–135. doi:10.1016/j.joep.2008.12.001

Victor, P. A. (2020). Büyüme. In Küçülme yeni bir çağ için kavram dağarcığı (pp. 162-166). Metis Publishing.

WHO. (2018). *Millennium Development Goals (MDGs)*. https://www.who.int/news-room/fact-sheets/detail/millennium-development-goals-(mdgs)

Yıldırım, D. Ç., Yıldırım, S., Erdoğan, S., Demirtaş, I., Couto, G., & Castanho, R. A. (2021c). Time-Varying Convergences of Environmental Footprint Levels Between European Countries. *Energies*, *2021*(14), 1813. doi:10.3390/en14071813

Yildirim, S. (2020). The Consumer Role for Sustainable Development: How Consumers Contribute Sustainable Development Goals. In V. Chkoniya, A. Madsen, & P. Bukhrashvili (Eds.), *Anthropological Approaches to Understanding Consumption Patterns and Consumer Behavior* (pp. 325–341). IGI Global. doi:10.4018/978-1-7998-3115-0.ch018

Yıldırım, S., & Bostancı, S.H. (2021), The efficiency of e-government portal management from a citizen perspective: evidences from Turkey. *World Journal of Science, Technology and Sustainable Development*. doi:10.1108/WJSTSD-04-2021-0049

Yıldırım, S., Bostancı, S. H., Yıldırım, D. C., & Erdogan, F. (2021a). *Rethinking mobility of international university students during COVID-19 pandemic*. Higher Education Evaluation and Development., doi:10.1108/HEED-01-2021-0014

Yıldırım, S., & Yıldırım, D. Ç. (2020). Achieving Sustainable Development Through a Green Economy Approach. In S. Patti & G. Trizzino (Eds.), *Advanced Integrated Approaches to Environmental Economics and Policy: Emerging Research and Opportunities* (pp. 1–22). IGI Global. doi:10.4018/978-1-5225-9562-5.ch001

Yıldırım, S., Yıldırım, D. Ç., Aydın, K., & Erdogan, F. (2021b). Regime-dependent effect of tourism on carbon emissions in the Mediterranean countries. *Environmental Science and Pollution Research International*. Advance online publication. doi:10.100711356-021-14391-7 PMID:34014485

## ADDITIONAL READING

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research On Degrowth. *Annual Review of Environment and Resources*, *43*(1), 291–316. doi:10.1146/annurev-environ-102017-025941

Öncü, M., Yıldırım, S., Bostancı, S., & Erdoğan, F. (2021). The Effect of COVID-19 Pandemic on Health Management and Health Services: A Case of Turkey. *Duzce Medical Journal*, *23*(Special Issue), 61–70. doi:10.18678/dtfd.860733

Yildirim, S. (2020). The Consumer Role for Sustainable Development: How Consumers Contribute Sustainable Development Goals. In V. Chkoniya, A. Madsen, & P. Bukhrashvili (Eds.), *Anthropological Approaches to Understanding Consumption Patterns and Consumer Behavior* (pp. 325–341). IGI Global. doi:10.4018/978-1-7998-3115-0.ch018

Yıldırım, S., & Yıldırım, D. Ç. (2020). Achieving Sustainable Development Through a Green Economy Approach. In S. Patti & G. Trizzino (Eds.), *Advanced Integrated Approaches to Environmental Economics and Policy: Emerging Research and Opportunities* (pp. 1–22). IGI Global. doi:10.4018/978-1-5225-9562-5.ch001

Yıldırım, S., Yıldırım, D. Ç., Aydın, K., & Erdogan, F. (2021). Regime-dependent effect of tourism on carbon emissions in the Mediterranean countries. *Environmental Science and Pollution Research International*. Advance online publication. doi:10.100711356-021-14391-7 PMID:34014485

## KEY TERMS AND DEFINITIONS

**2030 Sustainable Development Goals (2030 SDGs):** 2030 SDGs presents 17 main goals including main issues such as poverty, hunger, education, health, equality, gender equality, energy, water, sea life, forest land, climate change, employment, industry, sustainable city, peace-justice, sustainable consumption-production, and global partnership to be achieved until 2030.

**COVID-19 Pandemic:** The COVID-19 pandemic which influences the sustainability of the health issues is the worst global health crises in 21th century.

**Degrowth Economy:** This model presents a new model suggestion including sustainable development in the context of de-growing implications.

**Digital Economy:** This model presents digital transformation in economic model and business practices.

**Digitalization:** The digitalization expresses the transformation and adaptation of digital technology and tools in every kind of implications.

**Green Economy:** It is the closest sustainable economic model to sustainable development. Green economy aims to get sustainable balance between environmental, economic, and social issues.

**Sustainable Development:** The development aims to achieve economic development and social development by reducing the negative impacts on environment in the long term.

# Chapter 19
# The Role of the Government in Environmental Sustainability During the COVID-19 Pandemic

**Ayfer Gedikli**
*Duzce University, Turkey*

**Abdullah Kutalmış Yalçın**
*Duzce University, Turkey*

## ABSTRACT

*The COVID-19 outbreak and its global spread through human-to-human contact have made it even more important to analyze the environmental effects. The higher the population, the higher the energy usage, the higher amount of carbon emissions, and the faster the environmental degradation. Having a high-quality environment is important for people to protect themselves from infection. During the lockdowns, city residents could benefit from the environment. Shutdowns contributed not only to break the chain of infections but also to the development of the environment and ecosystems. Due to the great cuts in transportation and industrial sectors, air and water pollution levels have come down, and nature has started to reassert itself. In this process, governments have a great role to fight the pandemic and protect the environment. In this chapter, environmental sustainability and the role of governments during the pandemic will be analyzed. Also, the viable solutions for environmental sustainability that can be provided by the governments will be put forth.*

## INTRODUCTION

For many developing countries, development stands for urbanization and industrialization. Nevertheless, during the industrialization and urbanization processes, environment quality has been ignored and environmental degradation is thought as the trade-off of development. Air pollution, sanitation and hygiene, inadequate water supply, and hazardous wastes lead to harmful living conditions, fatal illnesses, and destroy ecosystems. Furthermore, increasing pollution exacerbates poverty and inequal-

DOI: 10.4018/978-1-7998-8482-8.ch019

ity, and slows down economic growth in both urban and rural areas. Environmental degradation may negatively impact the development process and competitiveness of developing countries. Particularly the countries that are highly dependent on their natural resources are at greater risk of environmental pollution. Degradation of forests, fisheries, contaminating freshwater, and air, and water pollution are the factors of poor human health ecosystem that affects both economic and daily life activities (Nazeer, Tabassum, and Alam, 2016:590).

Moreover, poor people suffer more from environmental degradation since they cannot afford to protect themselves from the negative impacts of air, land, and water pollution. Due to environmental pollution, there are 9 million premature deaths (16% of all deaths) which represent three times more deaths from AIDS, tuberculosis, and malaria combined and 15 times more than the deaths from all wars and other types of violence. The current researches found a close linkage between air pollution and the number of cases and deaths due to Covid-19. These dramatic data are highlighted during the pandemic period and pointed to the urgency to fight environmental problems (The World Bank, 2021).

The World Bank declared that the cost associated with health damage from air pollution is approximately $5,7 trillion and 4,8% of global GDP. Many developing countries such as China, Argentina, India, Mexico, Pakistan, Nigeria, Bangladesh, and Brazil suffer from the cost of pollution-related diseases due to noise pollution, inadequate water supply, and air pollution (The World Bank, 2021). Communities realized that climate change, water pollution, deforestation, and uncontrolled wildlife trade may increase the severity of the pandemics. Statistics showed that air pollution leads reduction in the environmental health of communities and 4,2 million premature deaths a year. Furthermore, poor sanitation systems and lack of access to clean water may increase the spread and exacerbate the impact of pandemics in many developing countries. These environmental factors impact the less well-off segment of societies. (OECD, 2020a:1-2).

Thus, it is crucial to address pollution as it has irreversible impacts on human health, human capital, and GDP losses. Due to the pandemic, global production, employment, and consumption levels shrunk that caused substantial economic and social shocks. Surprisingly, while lockdowns caused economic hibernations, they also caused short-term environmental quality improvements such as declines in air pollution and greenhouse. While people stayed home, air quality levels in big cities improved because of the reduction in factory and transport emissions of $CO_2$, nitrogen oxides, ozone formation, and particulate matter. $CO_2$ emission reduction encouraged the governments to hope to mitigate greenhouse emissions and climate change in the long term (Hamwey, 2020). The fast spread of the outbreak has also increased public awareness for the environmental quality and preparedness to deal with such unexpected diseases.

During the outbreak, all economies are derailed and deeply impacted. National governments had a trade-off between coping with the medical crisis and keeping the economy active. In such a problematic atmosphere, the active role of local governments reminded the importance of the state in the context of public administration and environmental quality (Sevin et al., 2020:19). According to the report prepared by Deloitte (2021:10-11), governments and public entities should have the highest concern for environmental protection and climate change problems. Besides, governments have the central roles to play in protecting the environment, and thus governments need to set sustainable strategies for the short and long term. Pollution management of governments should be wise and well-designed to alleviate poverty, improve the share of wealth and prosperity and bring healthier and more productive life standards with a quality environment. Pollution management should include better job creations, energy efficiency, more qualified transport, sustainable urbanization, mitigation of carbon emissions, and good governance (The World Bank, 2021).

On the contrary, the current studies indicated that the novel pandemic caused deregulations and weakening environmental protectionist policies. For example, Vale et al. (2021) analyzed the effects of the Covid-19 pandemic on environmental legislation and protectionist policies in Brazil. The authors indicated that although deforestation continued in Amazon during the pandemic period, there was a 72% reduction in environmental fines. In other words, the Covid-19 pandemic period and lockdowns were used as a tool to weaken the environmental protectionist policies in Brazil by the hand of the government. This has the potential to increase greenhouse gas emissions, loss of biodiversity, and the likelihood of similar zoonotic disease outbreaks.

The purpose of this chapter is to analyze how the Covid-19 outbreak affected the environment as well as to explore what kind of innovative solutions and alternative policies can be implemented by governments to overcome the pandemic and foster resilience. In this context, the questions to be answered are as follows:

- *How the pandemic affected the environment quality,*
- *The role of governments in fighting the pandemic*
- *How the pandemic changed the governments' decision making,*
- *Alternative policy suggestions for governments to alleviate environmental degradation.*

## CONCEPTUAL FRAMEWORK OF ENVIRONMENTAL POLLUTION

Basically, there are three major reasons for environmental pollution: Industrialization, urbanization, and globalization. These three basic factors affect the level of air, water, noise, and land pollution. As the industrial sector improves in an economy, it is necessary to consume more fossil fuels (oil, natural gas, and coal) that are the main sources of pollution. The manufacturing industry, industrial and agricultural production, power generation, road, rail, and air transport are primary pollution reasons. Industrial activities cause a higher level of pollution by emitting more waste gases such as carbon monoxide, sulfur oxides, and nitrogen oxides that threaten human life. *Urbanization* is the second most important reason for environmental pollution. There is a huge migration trend from rural areas to urban areas. Immigrants mostly settle in the suburbs and peripheral regions. Furthermore, mostly in developing and less developed countries, environmental degradation is ignored and there are many squatted settlements that do not offer good living standards. Besides, a higher population in big cities brings more economic activities and more environmental pollution. Therefore, increasing consumption, residential activities, increasing wastes escalate environmental pollution. *Globalization* is another important reason for environmental pollution. Since there is cheap labor in many developing countries, investors of dirty industries move their industries to these countries rather than establishing in more regulated countries. All these factors cause environmental pollution which results in obstacles to sustainable development. Furthermore, environmental degradation destroys the natural habitat that serves the basic needs of humans such as increasing water pollution leading to loss of marine output, deforestation causing low tree food production, and loss of crops. There is a striking discrepancy that while developed countries have high-quality environments although they have much greater economic activities, developing countries have a great environmental degradation despite having smaller economic performance. The high pollution level of developing countries is a result of low or no environmental regulations (Nazeer, Alam, and Tabassum, 2016:591-592). Increasing population, loose governmental regulation, poor public opinion, poor civilization, lack of environmental awareness, and growing polluting sectors in the economy such as mining, resource extracting, and construction sector are the other important reasons for environmental degradation.

## ECONOMIC SHUTDOWN AND ENVIRONMENT QUALITY

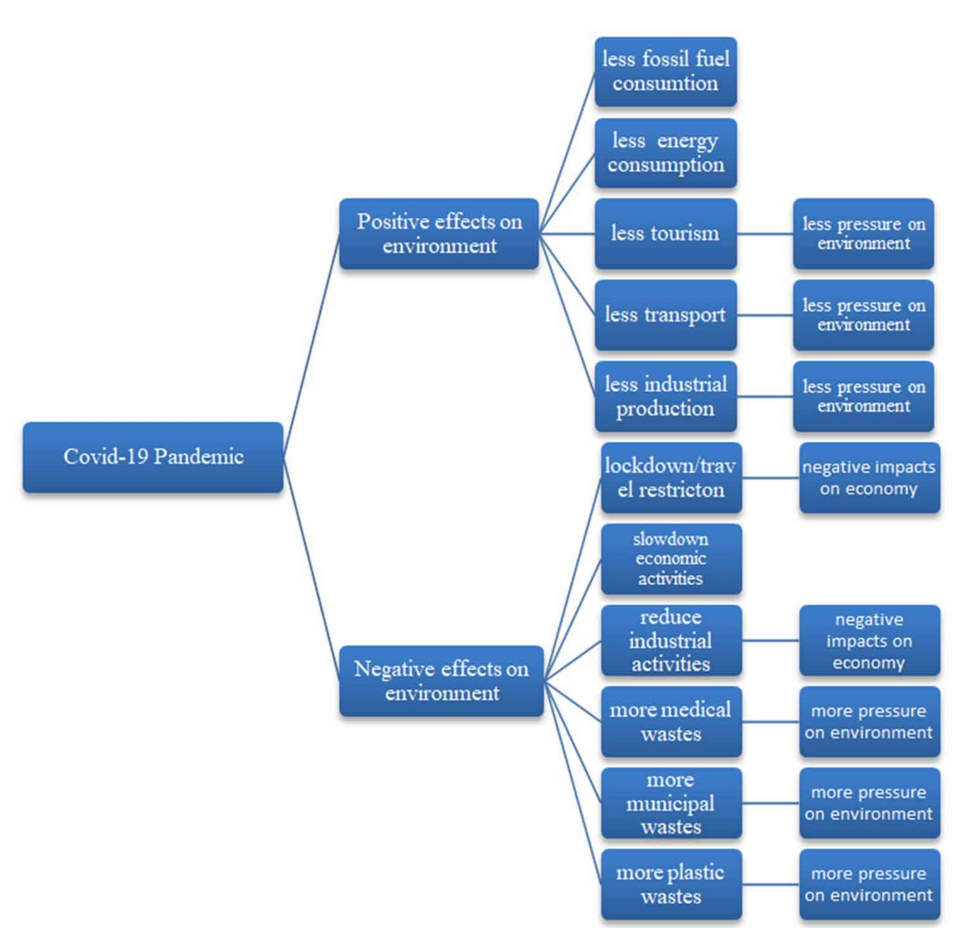
Since December 2019, the earth has been struggling with the Covid-19 outbreak. In the early periods of the pandemic, it was accepted as a global health crisis. Nevertheless, beyond the public health problem, it was a complex crisis with its devastating socio-economic, political, humanitarian, and security dimensions. Actually, the world had already been at great risk by climate change due to the vulnerability of human and natural systems. The global economy had also been fragile when it was caught to the disease. Particularly starting from the global financial crisis in 2008, there had been the recession and the contraction of per capita income in most of the countries. Furthermore, the pandemic brought a real challenge to the global goal of ending poverty by 2030. Unfortunately, because of the pandemic restrictions, the communities will be more marginalized without any support or safety net, and the number of hunger may rise from 135 million to more than 250 million people. Again, due to the strain of lockdown, the agricultural labor and almost 1,6 billion informal economy workers are badly affected. It is expected to have great shocks in commodity markets and deep food supply chain disruptions (UNCCD, 2020:3). These problems recalled the sensitivities on sustainability since ecological destruction, environmental degradation and climate change may accelerate the spread and emergence of pandemics. Thus, the new business models should take not only financial risks but also environmental and social risks into account. The fact that communities avoided long-distance flights, consumption of hazardous products, and environmental pollution has caused an opportunity to continue living in the same way. The pressure to act and live more responsibly increased the sensitivity of citizens, individuals, companies, and governments. Each of these actors is expected to focus on a more sustainable environment and carbon management (Sevin et al., 2020:31).

There is no doubt that the novel Covid-19 pandemic caused an opportunity to revisit the environmental degradation problems and work on reducing them. In order to reduce the transmission of the virus, millions of people have stayed in lockdown. These precautions caused improvement in the air quality and a drop in water pollutions (Saadat, Rawanti, and Hussain, 2020).

Figure-1 illustrates the positive and negative environmental effects of the outbreak. The implemented policies also contributed to either positive or negative impacts on the ecosystem. Due to the pandemic restrictions to slow down the spread of the pandemic, all means of transport are declined, local and international tourism was controlled, and most of the industrial activities were slowed down. These restrictions caused less energy consumption, less movement, and less aviation and road transport that brought less energy consumption and lower carbon emissions. These measures led less environmental pollution. However, all these precautions also caused great lockdowns on economies as well. Reduced industrial activities caused great job losses, increasing poverty and lack of production. On the contrary, there was a great increase in medical wastes and municipal wastes due to increasing take-home shipping and packaging. To decrease the risk of spread, people were encouraged to use more disposable products that may cause more environmental degradation.

Therefore, the positive and negative impacts of the Covid-19 pandemic should be explained in detail to put forth effective policy suggestions.

*Figure 1. The environmental effects of the Covid-19 pandemic*
**Source:** *Rume and Islam (2020:3) and authors' own explanations*




## a. Positive Environmental Effects of Covid-19 Pandemic

During the outbreak, big and small cities in the affected countries like the US, France, the UK, Spain, Turkey, Italy, Germany, Iran, and South Korea, were under partial or full lockdown for a long time. During this period, the sectors contributing to environmental pollution were all stopped. Aviation, transport, industries, power plants, biomass burning, and residential activities were all slowed down. Furthermore, restaurants, schools were closed. Under the nationwide lockdown, road, air, and rail transports were suspended. Even hospital services were suspended with the exception of urgency. As a result, air and water quality improvement have been realized in many countries. Non-functioning plants leaded less industrial waste emission. Besides, since vehicles were not on the roads, there were lower carbon emissions, lower greenhouse gases, and toxic tiny suspended particles in the environment (Ram and Prusty, 2020:2). Numerically, $CO_2$ emissions reduced by 6% (1,913 Mt $CO_2$) in 2020 compared to 2019. This is due to great declines in aviation and ground transport sectors as well as the lockdown between March and November. Just during the lockdown, $CO_2$ reduction was ranged between 10 and 15% causing a total of

1,366 Mt $CO_2$ emission decrease. Similarly, aviation and transportation sectors showed the greatest $CO_2$ emissions reduction by 33% and 16% respectively. Even after the lockdown was alleviated, there were still declines in $CO_2$ emissions because of the continuing restrictions on domestic aviation and transport. Developed countries plan to include green and sustainable targets. Accordingly, out of $13 trillion of recovery aid (up to December 2020), $4 trillion was planned to spend on reducing carbon emissions and nature-incentive sectors such as agriculture, industry, waste management, energy, and transport. Some of the developed countries such as Canada, the EU, the Republic of Korea, and the UK initiated recovery strategies for carbon reduction elements focusing on renewable energy, clean transport, and mobility and promoting a green industrial revolution. Similarly, China laid out recovery plans by stimulating supports for electric vehicles and related infrastructure investment and setting up China Green Development Fund. New Zealand also invested an NZD70 million fund for the decarbonization of industrial processes. However, those targets are not close to the Paris Agreement goals, yet (CCSA, 2021:38).

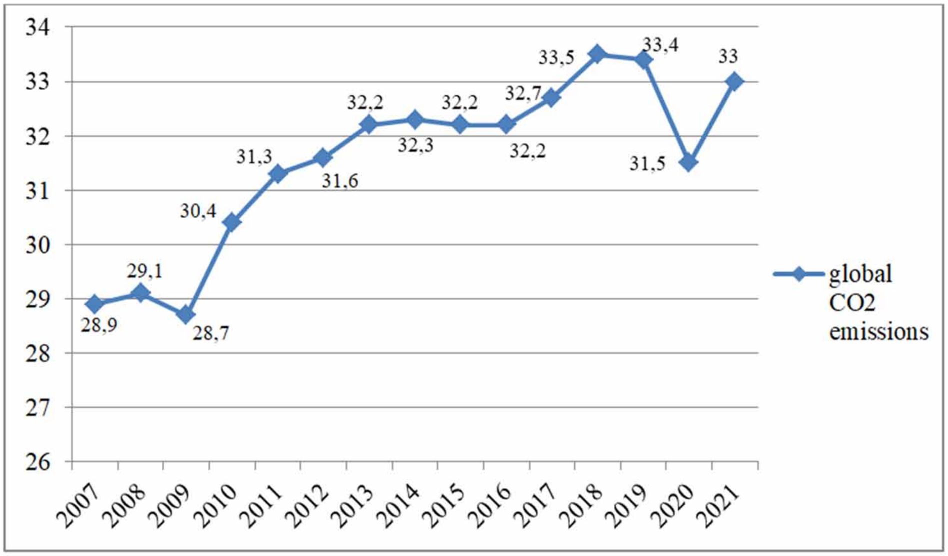
Figure-2 represents the global energy-related $CO_2$ emission during the 2007-2021 period. After the global financial crisis in 2008, there was a huge increase in global carbon emissions. While it was 29,1 Gt in 2008, it increased to 33,5 Gt in 2018. Global $CO_2$ emissions shrank by 5,8% in 2020 (almost 2 Gt) which was five times greater than the 2009 decline that was following the global financial crisis. Due to the pandemic, $CO_2$ emissions declined more than energy demand in 2020. In this period, while demand for oil and coal decreased, demand for renewables increased. Global energy-related $CO_2$ emissions were recorded as 31,5 Gt in 2020. This amount was the highest average annual concentration in the atmosphere of 412.5 parts/million. This rate is almost 50% greater than it was in the industrial revolution period. Global energy-related $CO_2$ emissions are expected to rebound and increase by 4,8%. Besides, emerging markets accounted for more than 2/3 of global $CO_2$ emissions in 2021 while emissions in developed countries are in structural decline. Among all emerging economies, China has a special place. China's carbon emissions are expected to increase by almost 500 Mt. Similarly, economic recovery in India pushed emissions 200 Mt more than 2020. The US is also expected to increase its carbon emissions in 2021 by more than 200 Mt to 4,46 Gt $CO_2$, yet 5,6% less than the 2019 level and 21% less than the 2005 level. The expected increase in the EU is 80 Mt $CO_2$. As a whole, $CO_2$ emissions from developed countries have dropped by 1,8 Gt $CO_2$ since 2000 and their share in global emissions had fallen by 20% (IEA, 2021).

Figure-3 illustrates the total energy consumption of the world, BRICS countries, the EU, OECD, and China. Comparing with the previous years, global energy consumption growth fell by 4% in 2020 during the pandemic, except in China. China is the world's largest energy consumer rapidly recovered from the outbreak and consumed 24% of the global energy. Stay-at-home measures and slowing economic activities dropped the energy consumption in 2020. It contracted by -7,6% in the US, 7% in the EU, Japan, and Canada, and by 4,8% in Russia. The decline was less (-3%) in India, South Korea, and Saudi Arabia, and -2% in Australia and Brazil. Energy consumption reduced in Africa and Middle East regions as well (Enerdata, 2021).

As illustrated in Figure-3, while China and BRICS have an increasing trend, G7 countries have negative trend in energy consumption.

As shown in Figure-4, G20 energy consumption dramatically declined by the pandemic. While there was a sharp decline in petroleum products and oil consumption, electricity consumption stands in vivid. As a whole, total energy consumption in G20 declined by 3,6% and decreased everywhere except in China, as a developing country with a steady growth trend, though at a slower rate than the pre-pandemic period (Enerdata, 2021). Less energy consumption and less demand for power in industries brought lower use of fossil fuels and other conventional energy sources. While people were lockdown, ecosystems started

*Figure 2. Global energy-related $CO_2$ Emissions (Gt) (2007-2021)*
**Source:** *IEA (2021)*




to recover themselves. Even the air became cleaner in big cities and pollution level declined in touristic spots such as beaches and forests. Thus, while the pandemic put great constraints on our daily habits, it has led a positive impact on the environment (Ram and Prusty, 2020:2).

*Figure 3. Total energy consumption (2007-2020) (Mtoe)*
**Source:** *Enerdata (2021)*

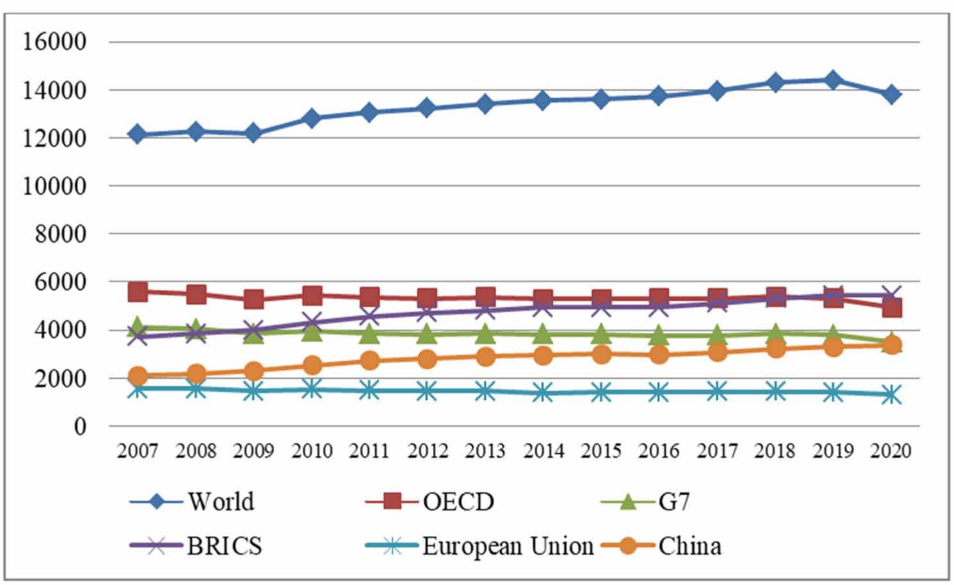
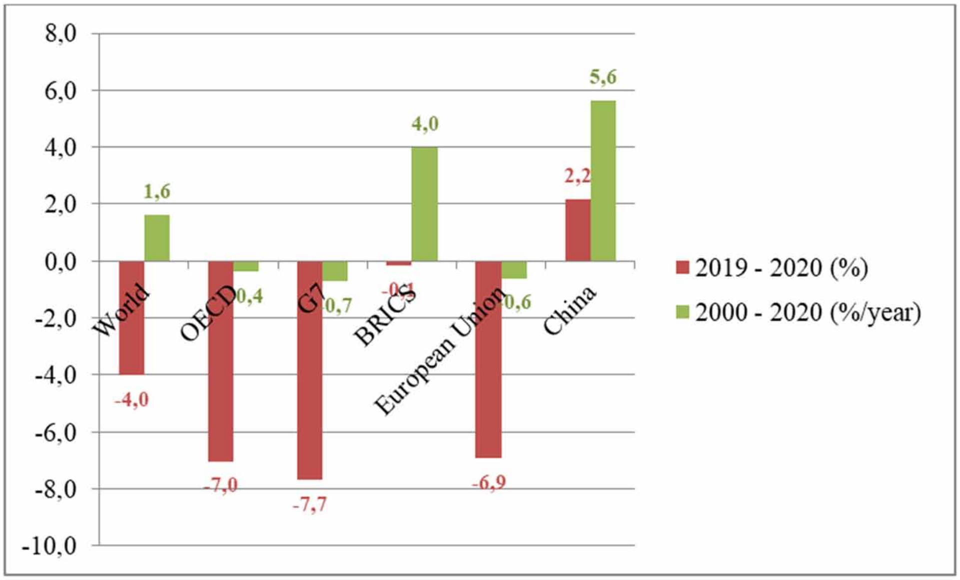


*Figure 4. Energy consumption change (2019-2020) and (2000-2020)*
**Source:** *Enerdata (2021)*




## b. Negative Environmental Effects of the Covid-19 Pandemic

The environmental consequences of the pandemic have not all been positive. The fact is that the pandemic caused a huge increase in medical waste generation. Sample collection of the suspected Covid-19 patients, diagnosis, treatment of patients, and infectious and biomedical wastes generated by the hospital increased dramatically. Infected wastes also have the risk of contamination of physical spaces like water and land (Zambrano-Monserrate et al., 2020). Due to the increasing usage of the mask and other necessary unrecyclable environmental pollution has risen. Increasing wastes caused fears of the virus. In addition, due to lockdown policies, many consumers increased their consumption takeaway delivery with single-use packaging. Quarantine policies and lockdowns caused an increase in the demand for online shopping for home delivery that increased the household wastes due to shipping package materials (Somani et al., 2020). In their research on Saadat et al. (2020) concluded that in Wuhan/China, medical wastes were 190 million tonnes more than in the pre-pandemic period. Due to increasing export restrictions and declines in cargo transportation services, the pandemic has increased the volume of unshippable agricultural and fishery products. This caused a dramatic increase in municipal solid wastes. Furthermore, in many countries, waste recycling programs are postponed to reduce the transmission of the virus infection. In the US, recycling programs dropped nearly 46% since the government was worried about the risks of the virus spread in recycling facilities (Somani et al., 2020). The severe cut in agricultural and fishery export levels increased organic waste. As the waste is left to decay, greenhouse gas and the level of methane emissions are expected to rise during and after the pandemic period. All these changes created acute problems for the waste management industry. In addition, tourism activities declined dramatically. This caused a deep decline in the income of the people from the tourism sector. Similarly, export declines in agricultural and fisheries products caused rising unemployment rates in this sector. People from these sectors are mostly low-income people in developing countries. They became more vulnerable to coronavirus due to the lack of social safety nets in these countries (Hamwey, 2020).

## ROLE OF GOVERNMENTS IN MANAGING ENVIRONMENTAL QUALITY DURING THE PANDEMIC

The primary duty of the state is to ensure the safety of individuals. Indeed, the security phenomenon is one of the key concepts of the reason for the establishment of the state. However, since the content of the security concept is getting more complicated due to the new conditions and necessities, it needs to be examined under different conditions (Haser, 2018: 6). In this context, a pandemic that threatens health can be considered as an element of the security need of society. Indeed, individuals create a reflex to fight against environmental hazards and epidemics that threaten their safety. Since this reflex forces the international community to take action, the concepts of health security and environmental security, which are the basic components of the concept of human security, gain importance in the work of international organizations as well as the state (Erdem, 2016: 261). In recent years, the term security, which is one of the vital needs for people, societies, and states, has radically changed the perspectives of states approaching global problems from the traditional national security concept with the current Covid-19 pandemic (Ateş, 2009: 18). Thus, the security role of the government can be enlarged and differentiated according to specific conditions. The pandemic process has led to a redefinition of the content of the state's security responsibility. While the previous definition of security was the safety of society and life, due to the current health crisis, health security is now among the primary responsibilities of the states.

To discuss how to manage the unexpected negative effects of the pandemic, the G7 countries met in Cornwall on 11-13 June 2021. They had a common agenda covering health, economic recovery and employment, free trade, future borders, climate and environment, gender equality, global responsibility, and international action. As a result of the summit, the report with 70 specifications was revealed. Health, climate changes, and environmental quality were expressed as important subjects for governments for fighting the Covid-19 pandemic. Summit participants have committed to a Green Revolution that will limit the rise in global temperatures to 1.5°C for sustainable environmental quality. In addition, it was declared that the aim of the governments should be to reach zero emissions by 2050 and to protect 30% of the sea and land. It was also stated that 1 billion doses of the Covid-19 vaccine would be supplied to countries in need of vaccine until next year in order to minimize the destructive effects caused by the Covid-19 pandemic. (Carbis Bay G7 Summit Communique, 2021).

Therefore, mitigating the spread of the Covid-19 pandemic is one of the pioneer roles of governments. The reason behind this is not solely public health but also social and economic concerns. To decrease the negative effects of the pandemic, most of the governments put containment measures that caused a sudden reduction in economic activities and social interactions. Therefore, government strategies to support economic recovery should also include policies to limit the threats from greenhouse effects and environmental degradation. Governments may combine economic stimulus with technological innovations to provide sustainable improvements in people's lives which are highly correlated with a healthy environment. Short-term and long-term measures should target to enhance economic prosperity by improving productivity, decarbonizing economic activities, better environmental quality, and higher life standards (OECD, 2020a:1-2). Consequently, states should take responsibility in well-being of air, water, and land quality to have a better living standard, higher economic prosperity with lower risk of virus spread.

## a. Government's Role in Air Quality

Regardless of the pandemic, air pollution has been one of the world's greatest environmental health risks. According to WHO (2019), there are approximately 4,2 million premature deaths per year due to outdoor pollution and 3,8 million deaths for indoor pollution. More dramatically, 9 out of 10 people breathe air with hazardous pollutants. Therefore, improving air quality may both decrease acute respiratory illnesses and provide social benefits. (OECD, 2020b:3).

The practitioners reported that there is a link between air pollution and mortality rates from Covid-19 and the higher indoor and outdoor air pollution, the more severe impacts of the pandemic. According to OECD (2020) report, a small increase in particulate matter ($PM_{2.5}$) leads to an increase in the Covid-19 death rate of 8-16% depending on the region. In addition, airborne transmission of the virus is faster in more polluted areas. The fact that socially disadvantaged groups are more exposed and vulnerable to air pollution, they are at higher risk of adverse cardiovascular and respiratory impacts (OECD, 2020c). During the pandemic period, air pollution reduced temporarily since transportation, aviation, tourism, and industrial activities were all curtailed. However, with the alleviation of the precautions, increasing air travel by the movements of people within and between cities, increasing production in factories air pollution start to rise again in many countries. Patients suffering from illnesses related to air pollution are more affected by the Covid-19 virus. By initiating measures, taxes, and other regulations, governments can take air pollution under control. The Covid-19 pandemic process can be a good opportunity to get public support in initiating these precautions. By taking the following precautions, governments can play a proactive role in protecting the environment:

- Suggesting energy-efficient energy consumption to households and manufacturing companies
- Providing incentives for environmental-friendly vehicles
- Urging to use less-pollutive fuel at transportation
- Discouraging to use the motor vehicle at downtowns (paying more for parking lots at downtown, paying to go downtown by motor vehicle, etc.)
- Suggesting environmental-friendly energy consumption to households and manufacturing companies
- Setting measurements and regulations for thermal isolation in buildings and factories
- Urging to use filters and clean the chimneys, and applying more effective environment taxes.
- Having more public opinion and public awareness

## b. Government's Role in Water Quality

Water can be contaminated by direct or indirect sources. Direct pollutants are factories, power plants, sewage systems, mines, and natural resource wells, etc. Indirect pollutants include rain, wind, and snow that carry pollutants from one area to another (Nazeer, Alam, and Tabassum, 2016:593).

The reduction in economic activities during the pandemic period caused an improvement in water quality in waterways, coastal zones, and beaches. Many countries and regions reported that there is less concentration of suspended particulate matter and other pollutants in the water. India and Bangladesh where domestic and industrial wastes are thrown into rivers without treatment reported that industrial sources of pollution shrunk during the lockdown period. The rivers Ganges, Yamuna, and Vembanad lake have reached a cleaner level as there was less industrial pollution during the pandemic precautions. In

Vembanad lake, particular matter concentration decreased by 15,9% (Yunus, Masago, and Hijioka, 2020). In addition, because of the curtailment of transportation and touristic activities, the number of people visiting wetlands and water activities was reduced in many regions. The decreasing number of tourists resulted in a remarkable change in the appearance of the beaches with cleaner and crystal water like Acapulco (Mexico) and Barcelona (Spain) (Zambrano-Monserrate, Ruano and Sanchez-Alcalde, 2000).

This temporary period is over with the resume of economic activities. Thus, governments should take the advantage of the pandemic precautions and set measures to protect the water lands. The countries that have great revenue from the tourism sector should review the policies and regulations to keep the lakes and sees clean. Those governments should create alternative sectors to get the revenue alongside of the tourism sector to preserve the environment and water areas. Domestic and industrial waste materials should be treated and filtered before thrown into rivers and seas. Besides, waste management strategies should be improved and some wastes should be used to generate biomass energy. This strategy will provide both less pollutive waste material and energy generation for production.

## c. Government's Role in the Solid Waste Disposal

Before the pandemic, organic and inorganic waste caused a wide range of environmental pollution. They caused soil erosion, deforestation, air, and water pollution. During the quarantine period, consumer habits had to change and their demand for home delivery increased. And consequently, wastes generated by households increased dramatically. Medical wastes were also increased during the pandemic period. Hospitals in Wuhan-China where the pandemic was initiated produced approximately 240 metric tonnes while it was less than 50 tonnes before the pandemic. The environment can be contaminated by solid wastes such as masks, disinfectants, and other wastes during the pandemic. Dirty masks can spread the virus. In many countries, local entities such as municipalities should be more proactive in keeping the environment clean from these wastes. The USA postponed the recycling programs in order to alleviate the risk of Covid-19 spread in recycling centers. Similarly, Italy prohibited the infected people from sorting their wastes (Zambrano-Monserrate, Ruano and Sanchez-Alcalde, 2000). In addition, people had to wear disposable masks and gloves to protect themselves from the spread of the virus. Massive waste of masks and other unrecyclable wastes caused an excessive burden on the environment. Therefore, governments should be more aware of keeping the environment clean and garbage disposal facilities should be more effective. People should be informed how to use and throw these wastes. There should be fines for violation of proper usage and throwing litter and masks. Government should work on increasing public awareness of this issue.

## d. Government's Role in the Noise Pollution

Noise pollution is the unwanted sound that is generated by industrial, social, and commercial activities of people, by engine motors, and the high volume of the music. Noise pollution is considered one of the most important environmental pollution factors that worsen the living conditions of human beings, plants, and animals. Due to the pandemic restrictions by most governments all over the world, people stayed home. There was limited noise of transport vehicles due to transportation restrictions. Besides, most of the commercial activities were stopped that caused a dramatic decline in noise pollution in crowded cities. Governments should keep the noise at lower levels. Accordingly, many governments initiated some restrictions. For example, the Turkish government imposed to end of music events by midnight to both controls the spread of the virus and limit noise pollution (Geybullayeva, 2021).

## What Else Should be Done?

The COVID-19 pandemic became one of the groundbreaking developments in global health, economic and international relations in global history such as the fall of the Berlin Wall, the September 11 attacks, and the Arab Spring. (Erşen, 2020: 58). In his call for solidarity, UN Secretary-General Guterres (2020) expressed that *"we are facing a global health crisis unlike any in the 75-year history of the UN. This is, above all, a human crisis that calls for solidarity. We must ensure that the lessons are learned and that the crisis provides a watershed moment for health emergency preparedness and investment in critical 21st-century public services and effective delivery of public goods. We have a framework for action; the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change."*. Accordingly, the economic development of local countries should be harmonized with environmental protectionist policies. Economic and social development strategies must be coordinated with the paradigm of the collective strategies to fight the pandemic and environmental degradation (Suryani, 2020:17). Figure-5 illustrates the major strategies to protect the environment. Among them, having international cooperation between the states and global institutions may provide a global protection of environment.

Most of the developed countries try to launch recovery packages for building back with a better environment, meeting the environmental quality targets, and reaching carbon-neutrality.

Besides, the Covid-19 pandemic has put the sovereignty of nation-states within their individual borders to a serious test by creating a serious challenge to the security structure of the international system in which nation-states are the main actors. (Gülboy, 2021: 11) The pandemic has forced nation-states to be more active in the economic and social field. In order to overcome the pandemic, states have closed their borders and reduced border crossings in the name of public health banned the export of medical supplies, and taken very drastic measures that limit the personal rights that citizens are born with. This situation strengthened the realist argument, which believes that the main actor in international relations is still the state (Valiyeva, 2020: 392) It is obvious that the main role played by states has been considerably strengthened during the pandemic. The main motivation of this policy is due to the protective role of the state over the country (Woods ET, Schertzer R, Greenfeld L, Hughes C, Miller-Idriss C, 2020: 15).

While launching short-term sector-specific policies, the government should be careful in following factors (OECD, 2020a:2):

- Governments should check the policy responses of short-term fiscal and tax provisions regarding their environmental impacts. Precise monitoring of the environmental effects of stimulus measures should avoid unexpected environmental consequences that may result in damages to the environmental health of societies.
- Existing environmental standards should not be sacrificed as a part of the recovery plan. While countries initiate urgent measures to overcome the negative impacts of the outbreak, they should not give up the pre-existing measures addressing environmental pollution, biodiversity loss, greenhouse gases, and other environmental problems.
- Governments should implement financial supports to the environmentally-friendly sectors and to the sectors that may cause environmental improvements. In addition, loan guarantees, tax abate-

*Figure 5. The basic strategies for environmental sustainability*
**Source:** *Rume and Islam (2020) and Authors' own explanations*


ments, and preferential loans can be used to support environmental commitments and performance in pollutive sectors.

- All measures should aim to enhance environmental quality to protect the communities since a quality environment will have a positive effect on human health. For example, cleaner air will decrease the vulnerability of urban populations that make people stronger to health risks.
- Transparency and communication with all parties about the benefits of improving the quality of the environment will bring more support from public opinion and success in the process. Transparency may increase public pressure on firms and public institutions. This will also discourage corruption and opposition by interest groups.
- The short-term and long-term environmental effects of stimulus packages should be evaluated before implementation.
- Leakages across regulatory borders are problematic if polluters are not stationary. Therefore, policymakers should be in full cooperation with neighboring jurisdictions to avoid pollutive actions.

Although the countries try to slow down the spread of the virus with effective responses and vaccination, there are weak signals of recovery. Currently, there are new variants of Covid-19 have been recognized. Therefore, to have an effective fight with the pandemic, governments should take some strong policy actions. They are (IRP, 2020:3-6; UNCCD, 2020:12; OECD, 2020b:7, 9-10, 12):

- *Evidence-based decision-making processes by the governments.* Evidence-based decision-making processes bring well-informed planning and decision-making through the use of the best information for short and long-term actions. Quality data can be used for infection prevention and control. Information management is crucial in tracing and tracking the movements and trends of risk groups.
- *Social protection as a government policy.* Most of the developing countries are lack safety nets for the majority of the population that requires government interventions to encourage sustainable economic growth with a sustainable environment. The timing and duration of social policies are critical decisions of governments to provide social protection are supported to vulnerable groups on time.
- *Initiating recovery during the response to the pandemic.* While having a response and early measures are implemented by the governments, some further environmental development programs should be initiated. This will allow governments to begin creating a recovery framework that sets strategies, policies, and priorities as well as to develop institutional structures and determine sources of financing the environmental strategies. Building early actions may bring no-regrets options that may generate positive outcomes for the long term.
- *Investing in more R&D on environmental quality researches.* Particularly the studies on the environment and health nexus may provide a better understanding of the importance of nature. It is a fact that environmental change may affect by climate change and biodiversity loss.
- *Innovation and technology transfer.* The use of technology allows governments to make informed decisions and apply scientific and targeted policies. Predictive analysis can be also included in information management through the use of technology. Since fast-advancing technologies lead not only production and consumption but also drive patterns of land use and territorial ecosystems, innovative technologies can be applied to improve the quality of the environment.
- *Implementing innovative financial instruments.* The Covid-19 pandemic forced governments to reallocate tight budgets and to get supplementary funding since government revenues were shrinking due to lack of economic activities with low productivity, increasing inflation, constrained trade, and lower purchasing power. Alternative funds that can be transferred from local and international sources can be allocated on recovery priorities and strategies to be implemented for environmental protection. Implementing innovative financial instruments and involvement of citizens, public opinion, and business in policymaking for environmental protection may provide more support to the strategies to be implemented. Creating land-based green bonds, sovereign and pension funds to be implemented for decarbonization
- *Collaboration and cooperation between the governments.* International collaboration, coordinated efforts, and coalitions should be taken on recovery in the environment. New models of governance can be adopted between local, national, and international levels and across the sectors. Technical measures, spatial planning, and risk aversion policies can be combined with conventional engineering and production policies. There should be more natural-based solutions that are highly

efficient and cost-effective with multiple benefits such as building city parks that cool cities in the summer and boost human well-being and contribute to biodiversity conservation.

- *The full involvement of all parties.* All strategies should be implemented by all parties such as government, private sector entities, households (women, children, young and elderly people), and NGOs.
- *Solidarity, protective, collective, and watchful attitudes.* It is critical to have permanent solidarity, protective and watchful attitudes to have sustainable protection of the environment. In most cases, for the pure profit-oriented approaches, environment protective policies are non-tradable and non-profitable. However, there are alternative policies to be implemented to have a more environmentally friendly and more inclusive approach that cares more about the negative externalities of industrial wastes. To reach such a sustainable environment, it is necessary to change the social life, trade, educational system, and social interactions. In this process, innovation would be the key element for emerging needs (Sevin et al., 2020:15).
- *Following Sustainable Development Goals.* It is estimated that 20% of the earth's territorial cover was polluted and degraded. Furthermore, land degradation is responsible for a quarter of global $CO_2$ emissions (3,6-4,4 billion tonnes). Land-based actions can contribute to around 25-50% of climate change solutions.
- *Guidance and training on how to collect hazardous waste from different sectors and how to dispose of them.*
- *Effective management of biomedical and hospital wastes.* Collection, separation, transportation, storage, and disposal of healthcare wastes should be done in accordance with the minimization of negative impacts on human health and the environment.
- *Implement strategies to maintain plastic and recycling measures.*
- *Governments should develop strategies to have better air quality.* Strategies should include transport and environment quality, planning better quality land use, and less pollutive instruments usage (transport vehicles, filters for factories, etc.)
- *Related institutions should keep records and data collection for monitoring.*
- *Governments should support public transportation, but by focusing on promoting cleaner facilities and reducing crowds.*
- *Encouraging the companies to implement cleaner production methods*
- *Governments should provide safe and reliable water and sanitation services.* Public fountains and public water taps can be good services for vulnerable groups.
- *By the measures and subventions, households should afford clean water.* Water infrastructure should be improved and modernized if necessary.
- *Governments should initiate reforms for harmful subsidies in agricultural, manufacturing, and industrial sectors to protect human health and biodiversity.*
- As Khan, Li, and Zhao (2015) indicated in their study on China, central governments can play a crucial role by providing incentives to the regions to control pollution spillovers. In addition, market incentives and monitoring policies can be supportive. While taxes and permits are cost-effective, setting performance standards can be easier to execute.
- *Imposing zoning restrictions.* Policymakers can set restrictions and regulations regarding zones and regions. Zoning restrictions can provide that emissions are concentrated in certain areas with lower population densities. This policy may mitigate the pollution spillovers to more crowded areas (Oliva, Alexianu, and Nasir, 2019:5).

## CONCLUSION

The global lockdown due to the Covid-19 pandemic has brought a good opportunity to assess our devastating impacts on the environment. While staying at home, people witnessed clean air, water, and growing plants. Nature reminded the importance of a livable environment to humanity. Therefore, policymakers from all countries should make a commitment to instilling the principles of sustainable development with sustainable and clean environment strategies, lifestyle, and public policies. All the stakeholders including governments, international institutions, and individuals need to fight the environmental degradation which causes loss of life and biodiversity. A fresh perspective is required to address some key issues that we learned from this pandemic. All countries need to find alternative methods to achieve the targets of environmental sustainability in order to fight the pandemic, protect lives and the environment. To do so, there should be more emphasis on adopting international cooperation and regulations as well as comprehensive measures for the protection of the natural environment. Rethinking holistic approaches for improving our relationship with the environment that will lead us towards sustainability, agricultural sustainability, and increasing renewable and environment-friendly energy consumption are some of the important strategies in this process.

## REFERENCES

Ateş, D. (2009). Uluslararası İlişkiler Disiplininin Oluşumu, İdealizm/Realizm Tartışması Ve Disiplinin Özerkliği. *Doğuş Üniversitesi Dergisi*, *10*(1), 11–25.

Bay, C. (2021). *G7 Summit Communique*. Our Shared Agenda For Global Action To Build Back Better.

CCSA. (2021). *How Covid-19 is changing the world: a statistic perspective* (Vol. 3). The World Bank's Development Data Group, UN DESA, and UNCTAD.

Delloitte. (2021). *2021 climate check: Business' views on environmental sustainability-Distruptive 2020 slows climate action, but executives determined to act*. https://www2.deloitte.com/global/en/pages/risk/articles/2021-climate-check-business-views-on-environmental-sustainability.html

Enerdata. (2021). *Total energy consumption*. https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html

Erşen, E. (2020). *Koranavirüs, Küreselleşme ve Uluslararası Sistem Covid-19 Sonrası Uluslararası Sistem: Eski Sorunlar Yeni Trendler*. SAM Publishing.

Geybullayeva, A. (2021). *Turkey: Pandemic restrictions out, new restrictions*. Globalvoices. https://globalvoices.org/2021/06/24/turkey-pandemic-restrictions-out-new-restrictions-in/

Gülboy, B. S. (2021). Covid 19 Pandemisinin Uluslararası Yapı ve Ulus Devlet Boyutunda Güvenlik Kavramına Etkileri, Covid 19 Pandemisinin Küresel Siyasette Ulusal Ve Uluslararası Ölçekte Güvenlik Algısı Ve Pratiklerine. İstanbul University Center of Political Science and International Relations.

Guterres, A. (2020). *Video speech*. https://www.un.org/en/un-coronavirus-communications-team/above-all-human-crisis-calls-solidarity

Hamwey, R. (2020). *Environmental impacts of coronavirus crisis, challenges ahead*. UNCTAD. https://unctad.org/news/environmental-impacts-coronavirus-crisis-challenges-ahead

Haser, D., & Uluslararası, İ. G. K. (2018). *Soğuk Savaş Sonrası Dönemde Güvenlik*. İstanbul University Institute of Social Sciences.

IEA. (2021). *CO2 emissions*. https://www.iea.org/reports/global-energy-review-2021/co2-emissions

IRP. (2020). Practical lessons for recovery from the Covid-19 pandemic-principles for recovery. International Recovery Platform, Japan, December 2020. Kamala Valiyeva, Kovid-19 İle Ulus Devleti Yeniden Düşünmek. *İstanbul Ticaret University Journal of Social Sciences, 19*(37), 390-403.

Khan, M. E., Li, P., & Zhao, D. (2015). Water pollution progress at borders: The role of changes in China's political promotion incentives. *American Economic Journal. Economic Policy*, *7*(4), 223–242. doi:10.1257/pol.20130367

Nazeer, M. Tabassum, U., & Alam, S. (2016). Environmental pollution and sustainable development in developing countries. *The Pakistan Development Review*, *55*(4), 589-604.

OECD. (2020a). *From containment to recovery: Environmental responses to the COVID-19 pandemic*. https://unece.org/DAM/RCM_Website/OECD_Covid_env_responses_brief_April_2020.pdf

OECD. (2020b). *Environmental health and strengthening resilience to pandemics*. https://unece.org/DAM/RCM_Website/OECD_Covid_env_health_brief_April_2020.pdf

OECD. (2020c). *Making the green recovery work for jobs, income and growth. OECD Policy Responses to Coronavirus (Covid-19).* https://www.oecd.org/coronavirus/policy-responses/making-the-green-recovery-work-for-jobs-income-and-growth-a505f3e7/

Oliva, P., Alexianu, M., & Nasir, R. (2019, December). Suffocating prosperity: Air pollution and economic growth in developing countries. IGC, Growth Brief. *Energy*.

Ram, S.C.V.S., & Prusty, S.A.K. (2020). *Covid-19 and its impact on environment*. Members Reference Service LARRDIS, No. 25/RN/Ref./May/2020.

Rume, T., & Islam, S. M. D.-U. (2020). Environmental effects of Covid-19 pandemic and potential strategies. *Heliyon*, *6*(9), e04965. doi:10.1016/j.heliyon.2020.e04965 PMID:32964165

Saadat, S., Rawtani, D., & Hussain, C. M. (2020, August 1). Environmental perspective of Covid-19. *The Science of the Total Environment*, *728*, 138870. doi:10.1016/j.scitotenv.2020.138870 PMID:32335408

Sevin, A.E., Bektaş Otman, B., Çelen, E., Kozikoğlu, E., Oğuz, K.B., Kavak, K., Bitlis, M., Şalgam, S., & Çınar, Ş. (2020). *Covid-19 pandemic as an ecosocial crisis and sustainability*. ESCARUS, TSKB.

Somani, M., Srivastava, A. N., Gummadivalli, S. K., & Sharma, A. (2020, September). Indirect implications of Covid-19 towards sustainable environment: An investigation in Indian context. *Bioresource Technology Reports*, *11*, 100491. doi:10.1016/j.biteb.2020.100491 PMID:33521605

Suryani, A. S. (2020, July). The impact of Covid-19 pandemic on the global environment. *Info Sinkat*, *XII*(13), 13–18.

The World Bank. (2021). *Pollution*. https://www.worldbank.org/en/topic/pollution

UNCCD. (2020). *Supporting the global response to the Covid-19 pandemic: Land-based solutons for healthy people and healthy planet*. UNCCD.

Vale, M. M., Berenguer, E., de Menezes, M. A., de Castro, E. B. V., & de Siqueira, L. P. (2021). The Covid-19 pandemic as an opportunity to weaken environmental protection in Brazil. *Biological Conservation*, *255*, 108994. doi:10.1016/j.biocon.2021.108994 PMID:33568834

WHO. (2019). *Air pollution*. https://www.who.int/health-topics/air-pollution#tab=tab_1

Woods, E. T., Schertzer, R., Greenfeld, L., Hughes, C., & Miller-Idriss, C. (2020). COVID-19, Nationalism, And The Politics Of Crisis: A Scholarly Exchange. *Nations and Nationalism*, 1–19. PMID:32837223

Yunus, A. P., Masago, Y., & Hijikoka, Y. (2020, August 20). Covid-19 and surface water quality: Improved lake water quality during the lockdown. *The Science of the Total Environment*, *731*, 139012. doi:10.1016/j.scitotenv.2020.139012 PMID:32388159

Zambrano-Monserrate, M. A., Ruanob, M. A., & Sanchez-Alcalde, L. (2020). Indirect effects of Covid-19 on the environment. *The Science of the Total Environment*, *728*, 138813. doi:10.1016/j.scitotenv.2020.138813 PMID:32334159

# Chapter 20

# The Sustainable Development Goals From a Social Work Perspective in the COVID-19 Pandemic Period

**Hatice Öztürk**
https://orcid.org/0000-0002-4982-3257
*Aksaray University, Turkey*

**Bilge Abukan**
https://orcid.org/0000-0002-6690-9351
*Ondokuz Mayis University, Turkey*

**Filiz Yıldırım**
*Ankara University, Turkey*

## ABSTRACT

*The COVID-19 pandemic is an ecosocial and global crisis caused by human actions. With the pandemic, poverty and inequalities have gradually deepened; in particular, the acceleration of digitalization in the pandemic period has revealed digital inequalities. In addition, problems such as poverty, climate change, global warming, and social and environmental sustainability concerns constitute obstacles to achieving sustainable development goals. Social workers play an active role in the achievement of sustainable development goals; as such, they should also be able to critically evaluate the associated processes and results. In such an evaluation, it is important that social workers adopt an ecosocial approach that centers on people and nature. Based on this, in this study, sustainable development and related goals are evaluated from a critical point of view, discussing them in light of the COVID-19 pandemic. As a result of this analysis, the degrowth approach is recommended as an alternative to sustainable development.*

DOI: 10.4018/978-1-7998-8482-8.ch020

## INTRODUCTION

In *Ecology, Revised and Expanded: A Pocket Guide*, the law of ecology is expressed as: *"All things are interconnected. Everything goes somewhere. There's no such thing as a free lunch. Nature bats last." (Callenbach, 2008, p.6).* This passage points to the negative effects of human actions; for example, as a result of human actions, increasing consumption of natural resources has become exploitation, which constitutes environmental injustice. The relationship of injustice between man and nature is the cause of many environmental problems, such as pollution, global warming, depletion of natural resources, loss of biodiversity, and climate change (Singh & Singh, 2017).

The Covid-19 pandemic has similarly emerged as a result of the negative effects of human actions, and poses a threat to the social, economic, and political systems of all countries, and the well-being of all people, due to the risk of transmission and death. During the Covid-19 pandemic period, changes and transformations have been experienced in many areas, such as health, education, the economy, and social services. These changes differ depending on the socio-economic level and the development situations within different countries, but the importance of sustainability is increasingly being recognized in the development policies and programs of countries around the world.

Sustainable development goals, also known as global goals, are important for both protecting the environment and in developing solutions to global problems. However, there is debate as to whether sustainable development goals are functional in practice, because, given the inequalities and poverty that exist, it is clear that progress toward these goals has not been sufficient (Winkler & Williams, 2017).

The social work profession, which is closely related to the well-being of humans and the environment, is involved in micro, meso, and macro level interventions to reduce inequalities and poverty. Within the social work profession, the ecosocial approach is at the center of sustainable development discussions, as it highlights the importance of adopting the principles of social and environmental justice (Dominelli, 2018).

In this chapter, with a focus on the Covid-19 pandemic, we will discuss the sustainable development goals from a social work perspective and suggest the degrowth approach in planning as an alternative to sustainable development. The study comprises two main sections: in the first, sustainable development goals are discussed with a focus on the impact of the Covid-19 pandemic; in the second part, the growth and degrowth approach is discussed from a social work perspective, and the importance of the degrowth approach in development plans is emphasized.

## BACKGROUND

Throughout the course of the "Covid-19 pandemic", the protective measures adopted worldwide, such as quarantining and social distancing, have reduced people's interventions in nature. As a result, decreases in energy consumption and air pollution levels were observed, as well as increases in water quality (Ali et al., 2021; Ju et al., 2021; Kim et al., 2020). Positioning itself at the top of the pyramid of life, humanity causes irreversible damage to nature in order to maintain its existence and comfort. However, the Covid-19 pandemic caused people to stay at home, and this detrimental impact was temporarily diminished. In all countries affected by the Covid-19 pandemic, various adverse effects have emerged at the individual, family, society, and country levels, and across sectors such as health, the economy, education, tourism, and transportation (Atri et al., 2020; Bashir et al., 2020). Thus, the Covid-19 pandemic can be described as an ecosocial and global crisis.

As of April 2021, more than 3 million people worldwide had died due to the pandemic (Worldometer, 2021) and it is predicted that the effects on the global economy will be intense and long-lasting (Behravesh & Rocha, 2020). Such global problems have a direct impact on countries' policies and development goals and, as such, sustainable development goals need to be reconsidered, as they include a commitment to the solutions of social and environmental problems that arise on a global scale. Sustainable development goals are based on the principle of 'leaving no one behind', globally, with the aims of eradicating poverty, protecting the planet, and ensuring that all people can lead peaceful and prosperous lives (United Nations Development Program, 2020). Considering the effects of the Covid-19 pandemic, it is clear that the achievement of the sustainable development goals and ensuring the sustainability of prosperity will be more challenging (Leal Filho et al., 2020), due to the uncertainty of the pandemic and the rapid spread of the virus all over the world that has threatened the global economic order (Karakas, 2020). Increasing poverty and unemployment, especially during the pandemic period, constitutes an obstacle to development, and progress toward achieving sustainable development goals related to people, the planet, prosperity, peace, and partnership does not seem possible (Winkler & Williams, 2017).

Even prior to the pandemic, several discussions had been raised regarding the possibility of achieving sustainable development goals. The first of these discussions relates to the problems of participation and accountability in the process of achieving and measuring progress toward the sustainable development goals. In this context, the emphasis has been on the importance of strengthening the quality, conceptual, and methodological aspects of measurement rather than producing new social, economic, and environmental statistics on country basis in regard to the implementation, monitoring, and evaluation of the objectives (Hák et al., 2016). Another argument is that sustainable development is not a rights-based approach affording each stakeholder the opportunity to have free, active and meaningful participation in development processes that affect their lives. However, the participation of local citizens in particular is not sufficient. In other words, local citizens cannot take an active role in the development process. In addition, development actors and stakeholders have been criticized for not adequately fulfilling their responsibilities in this regard (de Man, 2019). Moreover, excessive consumption, an anthropocentric approach and economic growth are at the fore in the sustainable development approach. At the heart of this approach, these focuses are associated with ecological crises or problems. All development actors and stakeholders adopted on the are criticized for failing to fulfil their responsibilities to meet the well-being requirements of both humans and the natural world.

The environmental problems that have arisen due to this excessive consumption are reflected in different areas of life, and climate change is arguably the most important example (Winkler & Williams, 2017). In addition, global ecological problems such as climate change cause new inequalities and injustices to emerge and existing inequalities to become more severe. In this context, countries' policies based on economic growth negatively affect both social and environmental well-being (Alston, 2015; Powers & Peeters, 2019), creating difficulties in achieving sustainable development goals.

In order to overcome these social and environmental problems, in this study the degrowth approach is suggested as an alternative to the economic growth, excessive consumption, and anthropocentric approach. The degrowth approach, which supports sustainable life, involves downsizing of the production and consumption-based system that focuses only on people (Schneider et al., 2010). In this respect, the degrowth approach is compatible with the ecosocial approach of social work, which is based on social and environmental justice and aims to reduce inequalities and poverty.

## Sustainable Development Goals in the Covid-19 Pandemic

In the historical past, the negative effects of economic crises (e.g., the 1997 Asian Crisis, the 1998 Russian Crisis) caused by neo-liberal policies and increased infectious diseases, natural disasters, inequalities, especially poverty, triggered discussions on development. In these discussions, economic growth as a goal in itself has been questioned. Therefore, alternative approaches have emerged that recognize economic growth as a tool for human development (Dogru, 2016). It has been accepted that countries should attach importance to poverty reduction as well as economic growth and that as well as the economic, the social, cultural, and environmental dimensions of development should be considered. To this end, the United Nations Millennium Summit was held in New York in 2000 with the aim of to reducing the percentage of the extremely poor population by half by 2015 (Eskinat, 2016). At the summit, eight goals were set, named the 'Millennium Development Goals', by the member states of the United Nations, to be achieved by 2015. These goals are as follows *(Dogru, 2016, p.6):*

1) Eradicate extreme poverty and hunger
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

According to the report prepared by the United Nations on the evaluation of these development goals (MDGs Report, 2015), more than 1 billion people have escaped extreme poverty since 1990. Furthermore, worldwide, from 2000 to 2015, the number of primary school-age children out of school has decreased by almost half and gender equality has been achieved in primary education in approximately two thirds of developing countries. Globally, there have been reductions in the under-5 and maternal mortality rates, and there was a 40% decrease in the number of HIV/AIDS cases between 2000 and 2013. In studies aimed at the prevention of malaria and tuberculosis, life-saving results have been obtained, especially for children under 5 years of age. Environmentally, there have been improvements in the ozone layer, and access to improved sanitation has been increased. There has also been an increase in the development assistance of developed countries and, as of 2015, mobile cellular signal has reached 95% of the globe (MDGs Report, 2015).

However, despite the positive developments toward achieving the Millennium Development Goals noted in the report, millions of people have still been left behind due to sex, age, disability, ethnicity, or geographic location, and it is reported that inequalities (gender, employment, rich–poor, rural–urban, etc.), conflicts, poverty and inadequacy, climate change and environmental losses, continue in many countries (Eskinat, 2016; MDGs Report, 2015). Development approaches based on increasing economic growth and consumption of resources directly contribute to climate change, environmental sustainability problems, and social inequalities because economic growth-oriented approaches necessitate an anthropocentric approach.

The concept of sustainable development was first set out in an official context in the Brundtland report prepared by the World Environment and Development Commission in 1987. According to this report, *"Humanity has the ability to make development sustainable to ensure that it 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, p.16).* The inclusion of environmental sustainability in the Millennium Development Goals indicates that development is not only based on economic growth. However, central to these goals, human well-being is focused, and the achievement of goals is measured according to quantity. In this respect, the Millennium Development Goals laid the groundwork for the Sustainable Development Goals, which were to be achieved between 2015 and 2030. The Sustainable Development Goals are based on the idea that environmental and social sustainability is fundamental to human development and development (Dogru, 2016). The goals are listed as:

*…no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth; industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land; peace, justice and strong institutions, partnerships on the goals. (United Nations Development Program, 2020).*

In achieving global goals, it is emphasized that balance should be achieved about, within, and among countries in terms of inclusive and sustainable economic growth and fostering social inclusion and environmental protection (United Nations, 2015). Whether the sustainable development goals will contribute to achieving this balance is debatable. The social, environmental, and economic problems faced by humanity support the idea that understandings of sustainable development differ, creating gaps in practice and shortfalls in terms of measurement and evaluation (del Río Castro et al., 2020).

According to the Sustainable Development Report 2020, the pandemic may have negative effects on the "no poverty, zero hunger, good health and well-being and decent work and economic growth" goals in the short term. However, during the pandemic, countries have been made vulnerable in many ways, and inequalities, especially income inequality, have increased significantly increased, causing suffering for poor individuals and vulnerable groups (Sachs et al., 2020).

On the other hand, the pandemic has given governments significant experience in how to respond to an emergency health crisis and the revealed the adequacy (or not) of countries' public health systems (Sachs et al., 2020). The uncertainties that emerged with the Covid-19 pandemic and the conditions of prolonged isolation endured by many have also negatively affected individuals in psychological and mental health terms (Cyrus et al., 2020). As a result of the pandemic, it is estimated that the number of individuals living in poverty will reach 150 million by the end of 2021 (World Bank, 2021), and the number of individuals affected by hunger will exceed 840 million by 2030 (United Nations, 2020a). In addition, the more than 91% of students were affected by the temporary interruption of their education in 2020 (United Nations, 2020b). Although there has been limited progress toward achieving the development goals of gender equality, many women have been particularly vulnerable in terms of social security during the pandemic and have also been exposed to inequality and violence (United Nations, 2020c). Indicators for access to clean water around the world are also not positive, as billions of people still lack clean water sanitation (United Nations, 2020d). Furthermore, the COVID-19 pandemic has caused record levels of deprivation and unemployment triggering a historic recession. Thus, it has created an unparalleled human crisis that most affects the poorest (United Nations, 2020e). The use of information and communication technologies in many areas, such as health, the economy, and education has increased, due to isolation and social distancing requirements; this has created a new form of inequality:

digital inequality. A ‘digital divide’ has emerged for 3.6 billion people due to lack of digital access to education, employment, and health (United Nations, 2020f). In addition to all of these negative indicators, the world is increasingly urbanizing and air pollution, climate change, coastal water degradation, deforestation, and desertification continue to threaten environmental sustainability (United Nations, 2020g). It is estimated that there will be a 6% decrease in greenhouse gas emissions over the course of the pandemic, but it is emphasized that this will be temporary (United Nations, 2020h).

It is clear from the above that the pandemic represents an important obstacle to the realization of the Sustainable Development Goals. It has been suggested that, in dealing with the Covid-19 pandemic, the goals can be achieved through six basic social transformations: “education and skills, health and wellbeing, clean energy and industry, sustainable land use, sustainable cities, and digital technologies” (Sachs et al., 2020). Government ministries, businesses, and civil society play an important role in the realization of these social transformations (Sachs et al., 2020). The pandemic obliges all humanity to change production and consumption patterns, to ensure environmental and social justice, and to take new steps towards sustainable living. The inadequacy of implementations aimed at achieving the 17 goals determined since 2015 highlight the gaps in implementation (del Río Castro et al., 2020; Sachs et al., 2020) revealing the need for a review of economic growth-oriented policies to ensure a more sustainable society. The actions and discourses of countries based on solidarity and cooperation are important for the achievement of global goals and for the struggle against poverty and efforts to achieve equality and peace in the world.

## The Degrowth Approach as an Alternative to Sustainable Development

In the 21st century, the use of digital technologies has increased due to the need for social isolation during the pandemic period. Accordingly, the inequalities in access to the internet and digital technologies and the difference in digital literacy among individuals have deepened the inequality in societies (Beaunoyer et al., 2020). The potential of digital technologies plays an important role in dealing with the pandemic, but digital inequality creates a digital divide among individuals in their ability to meet basic and social needs (United Nations, 2020f). Nevertheless, the Covid-19 pandemic has accelerated digitalization and provides the groundwork for the building of the digital society of the future. On the one hand, the world is discussing the violations of and threats to human rights and freedoms posed by artificial intelligence-supported algorithms that provide increasingly personalized experiences. On the other hand, it witnesses the struggles against poverty and inequality of individuals with limited access to digital technologies. In order to combat these inequalities, the human actions that cause these inequalities should be focused on. Focusing on the relationships between local, regional, and global people and living beings in their physical environments, and the well-being of people and the planet, ‘green’ social work builds a new discourse for a sustainable life (Dominelli, 2018). Green social work adopts a holistic perspective based on many environments, including physical, social, economic, and cultural, and their effects on human behavior. This approach puts marginalization, structural inequalities, human rights, and active citizenship on the agenda of the social work profession, with the main goal of protecting the planet. In addition, green social work encourages the development of new intervention models for this purpose (Dominelli, 2018).

Undoubtedly, the technological developments, human actions, and consumption patterns that emerge with digitalization play an important role in achieving the Sustainable Development Goals. Digital technologies are used in many systems (health, work, education, etc.) (Vargo et al., 2021). However, during the Covid-19 pandemic period, it has been observed that systems are inadequate in the provision of basic and social services in some countries. As part of the measures taken to mitigate the transmission risk of the virus, the digitalization process has accelerated further, particularly in education and working life, where virtual meetings and online training have been held via digital platforms (Ho et al., 2020), and in the health system where tele-health services have been used utilizing artificial intelligence applications (Bokolo, 2020).

Considering the accelerated digitalization during the Covid-19 pandemic period, it can be said that technological developments are progressing in a "growth-oriented" (Kallis et al., 2018) manner and that the extent of inequality between countries and within societies has created a digital divide. This growth-oriented progress of technology, which provides the main tools of production and consumption, will result in ecological and global crises if proper planning is not carried out. Although the consequences of such crises pose a risk for both rich and poor countries, the direction of consumption (a growth-oriented approach, exploitation of resources) is an important factor in sharing responsibility among both groups.

The pandemic, forest fires, wildlife losses, and climate change, all of which have resulted from the excessive use of resources, as well as production and consumption patterns of societies, cause both ecological and global crises. According to the 2020 Living Planet Report, the populations of vertebrate species have decreased by 68% in the last 50 years due to human actions (World Wide Fund for Nature, 2020). The effects of the Covid-19 pandemic, which have been felt all over the world, demonstrate the need for an ecosocial approach in order to protect biodiversity and ecosystems, address climate change, and support a sustainable lifestyle (Boetto et al., 2018; Powers et al., 2019). Such an ecosocial approach would encourage the adoption of sustainable lifestyles; support the green social work model that focuses on social and environmental justice in the social work profession; aim to reduce poverty and inequalities; advocate equal distribution of power and social resources; and respect the socio-cultural and physical environments of all living things (Dominelli, 2018).

Considering the ecological and biophysical limits of the planet, the increasing growth demands of countries will worsen the impact of the crises that may occur in the future (Matthey, 2010). In line with neoliberal policies, reducing public spending and state intervention in welfare states has led to an increase in poverty and inequality (Diop-Christensen, 2018; Holden, 2003; Matthies et al., 2020). Countries with particularly low economic growth suffer more from the consequences of global warming than other countries (Diffenbaugh & Burke, 2019; Matthies et al., 2020). According to the Poverty and Shared Prosperity 2020 report published by the World Bank, it is estimated that the global poverty rate will reach 7% by 2030. The report highlighted that the group that has suffered most from conflict and climate change around the world is those whose incomes are around or below the poverty threshold (World Bank, 2020). While inequality and injustice is increasing, the negative effects of the global and ecological crises pose a particular threat for countries with populations living on the poverty line.

The social work profession is important for the realization of social and environmental justice and development at local, national, and international levels (Teixeira & Krings, 2015). The growth-oriented priorities of capitalism have caused spatial inequality of development, in a process that creates social and environmental injustice in societies (D'Alisa et al., 2020). According to the growth paradigm, new technologies result in greater production and consumption, waste accumulation, and resource extraction (D'Alisa et al., 2020; Latouche, 2009), which in turn causes more natural resources to be used (Latouche, 2009). Accordingly, it does not seem possible to achieve both economic growth and sustainability simultaneously in pursuing the Sustainable Development Goals. Thus, a new perspective is needed in all processes, from the preparation of the national and international development plans to their implementation. The social work profession offers the ‘degrowth’ approach, an ecosocial approach that embraces the observance of the rights of not only humans but also all living things in the ecosystem on the planet, as an alternative (Powers & Peeters, 2019; Rinkel & Powers, 2019). The degrowth approach offers a critical perspective on growth, arguing that it is costly, leads to injustice, and is ecologically unsustainable. It also criticizes capitalism as a social system that requires and sustains growth. In addition, the degrowth approach criticizes the focus on gross domestic product and commodification *(conversion of social products and socio-economic services and relations into commodities with monetary value)* (D’Alisa et al., 2020, p.22). The degrowth approach questions the economic growth paradigm of sustainable development, which rests on an anthropogenic and growth ideology and calls instead for an ecosocial approach. As a collective and deliberative process, ‘degrowth’ aims at an equitable downscaling of production and consumption capacity that increases human well-being and enhances ecological conditions (Schneider et al., 2010; Sekulova et al., 2013). However, the degrowth approach should not be perceived as an anti-growth; rather, it opposes placing growth at the center as a success criterion or goal. In addition, it prepares the ground for social transformation by proposing to strengthen relations between people and their environment (Rinkel & Powers, 2019). In other words, the degrowth approach allows people to regain control of what they do and how they do it, and to reorganize their lives, despite the domination of capitalism over the lives of individuals (D’Alisa et al., 2020). Taking an ecosocial approach, the degrowth approach does not consider natural resources as commodities and capital, and considers well-being not only in economic terms, but in terms of meaning and quality (Rinkel & Powers, 2019). Thus, a sustainable degrowth approach is important for the resolution of ecological and social conflicts (Sekulova et al., 2013). Social work interventions have an important role in combating many global and ecological crises at the micro, meso, and macro dimensions (climate change, global warming, pandemics, etc.). The practices of social workers adopting an ecosocial approach, who work with individuals, families, groups, and communities, are considered important in terms of ensuring social and environmental justice, coping with poverty and inequality, and promoting sustainable living (Powers et al., 2019). The degrowth approach can create a new beginning as a mechanism for social transformation and the realization of global goals. In this respect, the professional interventions of social workers focused on green social work and the degrowth approach open the door to initiatives for sustainable living.

## SOLUTIONS AND RECOMMENDATIONS

The short- and long-term effects of the Covid-19 pandemic have revealed that anthropocentric perspectives, and governments’ approaches to development based on economic growth must be addressed. In particular, an approach focused on economic growth ignores the well-being of other living things in the ecosystem, placing humans and their well-being alone at the center. This leads to environmental injustices and the neglect of other living things’ right to life. This anthropocentric view and the pursuit of solely economic growth aim paves the way for humans to have unlimited rights and to exploit resources. Where the rights of man are unlimited, his domination of nature endangers both his own well-being and the well-being of the entire ecosystem in the long term. It is important to maintain a balance and harmonious order between man and nature, so that they can be mutually supportive on a horizontal plane, rather than a hierarchical order on the vertical plane, and to eliminate the distinction between man and nature. Bookchin states that hierarchy and domination cause inequalities in society, and that the vertical plane characterized by exploitation in the human–nature relationship causes ecological crises (Bookchin, 1996). Ensuring social and environmental justice and placing human–nature relations on a horizontal plane requires a new approach. In all of these discussions, the degrowth approach, which expresses the beginning of people's self-limitation, encourages downsizing for social and environmental sustainability. On this point, autonomy is not the (external) limits or imperative towards growth that protects nature or avoids disaster. It emphasizes collective self-limitations prioritizes factors regarding social choice, such as simplicity, festivity, and thrift. The degrowth approach questions the domination of the capitalist philosophy and system based on economic growth, and the social and environmental injustices and inequalities caused by it (D'Alisa et al., 2020; Schneider et al., 2010). Adopting this approach can bring about a philosophical transformation. For this reason, it is important for all countries to be included in national and international plans. In addition, the holistic approach to human–nature relations of the social work profession has an important place in reducing social and environmental injustices and structural inequalities, which is the focus of the degrowth approach (Powers et al., 2019).

With the Covid-19 pandemic, inequalities around the world, including digital inequalities, have disrupted the realization of the Sustainable Development Goals in many countries. This creates an opportunity for discussion of the functionality of these goals. Social workers are struggling with different dimensions of inequality, particularly in light of the Covid-19 pandemic. Social workers are able to drive social transformation by promoting the green economy, sustainable living, and social-environmental justice in achieving global goals by adopting the degrowth approach, as social work can contribute to community development, community organization, community planning, and community education, especially through macro-level interventions. Furthermore, social workers can carry out various interventions involving advocacy, social action, and directing social policies, again by adopting the degrowth approach. The profession can also function to encourage the participation of all individuals in development processes with a rights-based approach in micro, meso, and macro dimensions.

## FUTURE RESEARCH DIRECTIONS

The overarching mission of the social work profession is to tackle global problems such as poverty, inequality, and injustice. These global problems are reflected in the Sustainable Development Goals. Social workers support the achievement of these goals through their professional knowledge, skills, and interventions. The ecosocial approach of social work views the growth-based approach to achieving development goals as unsustainable and unjust. In the current situation, a degrowth approach to planning, as an alternative to sustainable development, is an important debate on the social work agenda. Studies on the degrowth approach to sustainable development and sustainability are limited in the social work literature (Powers et al., 2019; Powers & Peeters, 2019; Ramsay, 2020; Rinkel & Powers, 2019) and the degrowth approach is a fairly new topic in the field. A book edited by Rinkel and Powers critically discusses the goals of sustainable development from a social work perspective (Rinkel & Powers, 2019). As stated in the book, social workers work with communities around the world that are exposed to the effects of ecosocial and global problems; thus, social workers should adopt advocacy, action, and education roles, as well as participate in debates on sustainable development. The Green/EcoSocial Work Collaborative Network is an international collaborative network that enables the sharing of ideas and resources as a way to participate in these discussions. The participation of social workers in this network can make it easier for them to be aware of these discussions and to take an active role in planning towards green economy and sustainable living globally (Rinkel & Powers, 2019).

As yet, no studies in the social work literature have discussed this issue with a focus on the Covid-19 pandemic, in the context of which inequalities are getting deeper and poverty and injustice are increasing. The climate crisis has also become even more pressing. This situation requires questioning the functionality of the Sustainable Development Goals in terms of the well-being of both humans and nature and the adoption of an ecosocial approach. The global impacts of the Covid-19 pandemic reveal that the functionality of these goals should be critically discussed, and future research should focus on these issues.

## CONCLUSION

With the Covid-19 pandemic, poverty and inequality have worsened, and new inequalities have emerged. The social work profession, which focuses on human rights and social justice, have taken an active role in the fight against poverty and inequality during the pandemic period. Social workers have ensured that many services such as health, education, social services, and psycho-social support could be accessed by all individuals, and that services have been offered in a digital environment not to be interrupted. In addition, they have provided preventive services and information against the risk of contamination. They have taken on action, consultancy, advocacy, and resource management roles, particularly in supporting individuals who have experienced loss (i.e., a wife, relatives, close friends, socioeconomic status or employment). In this context, it can be stated that the roles of social workers at micro, mezzo, and macro levels are essential in achieving sustainable development goals. However, independent of the pandemic, it is impossible to achieve these goals by adopting anthropocentric and economic growth-oriented approaches. To achieve sustainable development goals, it is necessary to adopt an ecosocial approach instead of an anthropocentric approach. This is important not only for human well-being but also for the well-being of nature. In addition, in achieving sustainable development goals, social workers are focused on developing local, regional, and global solidarity and cooperation and the promotion of a green economy. As an alternative to sustainable development, the degrowth approach can be an essential step in focusing on the well-being of both people and nature and their transition into a sustainable life.

## REFERENCES

Ali, G., Abbas, S., Qamer, F. M., Wong, M. S., Rasul, G., Irteza, S. M., & Shahzad, N. (2021). Environmental impacts of shifts in energy, emissions, and urban heat island during the COVID-19 lockdown across Pakistan. *Journal of Cleaner Production*, *291*, 125806. doi:10.1016/j.jclepro.2021.125806

Alston, M. (2015). Social work, climate change and global cooperation. *International Social Work*, *58*(3), 355–363. doi:10.1177/0020872814556824

Atri, D., Siddiqi, H. K., Lang, J., Nauffal, V., Morrow, D. A., & Bohula, E. A. (2020). COVID-19 for the cardiologist: A current review of the virology, clinical epidemiology, cardiac and other clinical manifestations and potential therapeutic strategies. *JACC. Basic to Translational Science*, *5*(5), 518–536. doi:10.1016/j.jacbts.2020.04.002 PMID:32292848

Bashir, M. F., Ma, B., Komal, B., Bashir, M. A., Tan, D., & Bashir, M. (2020). Correlation between climate indicators and COVID-19 pandemic in New York, USA. *The Science of the Total Environment*, *728*, 138835. doi:10.1016/j.scitotenv.2020.138835 PMID:32334162

Beaunoyer, E., Dupéré, S., & Guitton, M. J. (2020). COVID-19 and digital inequalities: Reciprocal impacts and mitigation strategies. *Computers in Human Behavior*, *111*, 106424. doi:10.1016/j.chb.2020.106424 PMID:32398890

Behravesh, N., & Rocha, E. W. (2020). *Interim global economic forecast*. IHS Markit.

Boetto, H., Bell, K., & Kime, K. (2018). Holistic ecosocial work: A model for transformative change through being, knowing and doing. In M. Powers & M. Rinkel (Eds.), Social work promoting community and environmental sustainability: A workbook for social work practitioners and educators (pp. 46–57). International Federation of Social Workers (IFSW).

Bokolo, A. J. (2020). Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic. *Irish Journal of Medical Science*, *1971*(1), 1–10. doi:10.100711845-020-02299-z PMID:32642981

Bookchin, M. (1996). *Toplumsal ekolojinin felsefesi: Diyalektik doğalcılık üzerine denemeler* (R. G. Öğdül, Çev.). Kabalcı Yayınları.

Callenbach, E. (2008). *Ecology: A pocket guide, revised and expanded*. University of California Press. doi:10.1525/9780520942226

Cyrus, S. H. H., Cornelia, Y. I. C., & Roger, C. M. H. (2020). Mental Health Strategies to Combat the Psychological Impact of COVID-19 Beyond Paranoia and Panic. *Academic Medicine*, *49*(3), 155–160. PMID:32200399

D’Alisa, G., Demaria, F., & Kallis, G. (Eds.). (2020). Küçülme: Yeni bir çağ için kavram dağarcığı (A. C. Sarı, B. Öktem, B. Gürden, Y. Kurtsal, Çev.). Metis Yayıncılık.

de Man, A. (2019). The Sustainable Development Goals and the rights-based approach to development: Compatible or missing the point? *African Human Rights Law Journal*, *19*(1), 445–469. doi:10.17159/1996-2096/2019/v19n1a21

del Río Castro, G., Fernández, M. C. G., & Colsa, Á. U. (2020). Unleashing the convergence amid digitalization and sustainability towards pursuing the Sustainable Development Goals (SDGs): A holistic review. *Journal of Cleaner Production*, *122204*. Advance online publication. doi:10.1016/j.jclepro.2020.122204

Diffenbaugh, N. S., & Burke, M. (2019). Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(20), 9808–9813. doi:10.1073/pnas.1816020116 PMID:31010922

Diop-Christensen, A. (2018). Beating the ‘unemployable’ with a stick? How Danish street-leel workers transformed a Danish work-first policy. In M. Kamali & J. Jönsson (Eds.), *Neoliberalism, Nordic welfare states and social work: Current and future challenges* (pp. 205–215). Routledge. doi:10.4324/9781315111834-18

Dogru, B. (2016). *100 Maddede sürdürülebilirlik rehberi*. SKD-Türkiye Yayınları.

Dominelli, L. (2018). *Yeşil sosyal hizmet* (A. İ. Çoban, Çev.). Nika Yayınevi.

Eskinat, R. (2016). Binyıl kalkınma hedeflerinden sürdürülebilir kalkınma hedeflerine. *Anadolu Üniversitesi Hukuk Fakültesi Dergisi*, *2*(3), 267–282.

Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators*, *60*, 565–573. doi:10.1016/j.ecolind.2015.08.003

Ho, C. W. L., Caals, K., & Zhang, H. (2020). Heralding the digitalization of life in post-pandemic east asian societies. *Journal of Bioethical Inquiry*, *17*(4), 657–661. doi:10.100711673-020-10050-7 PMID:33169256

Holden, C. (2003). Decommodification and the Workfare State. *Political Studies Review*, *1*(3), 303–316. doi:10.1111/1478-9299.t01-2-00001

Ju, M. J., Oh, J., & Choi, Y. H. (2021). Changes in air pollution levels after COVID-19 outbreak in Korea. *The Science of the Total Environment*, *750*, 141521. doi:10.1016/j.scitotenv.2020.141521 PMID:32829258

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research on degrowth. *Annual Review of Environment and Resources*, *43*(1), 291–316. doi:10.1146/annurev-environ-102017-025941

Karakas, M. (2020). Covid-19 salgınının çok boyutlu sosyolojisi ve yeni normal meselesi. *İstanbul Üniversitesi Sosyoloji Dergisi, 40*(1), 541-573. doi:10.26650/SJ.2020.40.1.0048

Kim, J., Jeong, U., Ahn, M.-H., Kim, J. H., Park, R. J., Lee, H., Song, C. H., Choi, Y.-S., Lee, K.-H., Yoo, J.-M., Jeong, M.-J., Park, S. K., Lee, K.-M., Song, C.-H., Kim, S.-W., Kim, Y. J., Kim, S.-W., Kim, M., Go, S., ... Liu, X. (2020). New era of air quality monitoring from space: Geostationary environment monitoring spectrometer (GEMS). *Bulletin of the American Meteorological Society*, *101*(1), E1–E22. doi:10.1175/BAMS-D-18-0013.1

Latouche, S. (2009). *Farewell to Growth*. Polity Press.

Leal Filho, W., Brandli, L. L., Lange Salvia, A., Rayman-Bacchus, L., & Platje, J. (2020). COVID-19 and the UN sustainable development goals: Threat to solidarity or an opportunity? *Sustainability*, *12*(13), 5343. doi:10.3390u12135343

Matthey, A. (2010). Less is more: The influence of aspirations and priming on well-being. *Journal of Cleaner Production*, *18*(6), 567–57. doi:10.1016/j.jclepro.2009.03.024

Matthies, A. L., Peeters, J., Hirvilammi, T., & Stamm, I. (2020). Ecosocial innovations enabling social work to promote new forms of sustainable economy. *International Journal of Social Welfare*, *29*(4), 378–389. doi:10.1111/ijsw.12423

MDGs Report. (2015, March 24). *The Millennium Development Goals Report.* https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf

Powers, M. C., Rambaree, K., & Peeters, J. (2019). Degrowth for transformational alternatives as radical social work practice. *Critical and Radical Social Work*, *7*(3), 417–433. doi:10.1332/20498601 9X15688881497178

Powers, M. C. F., & Peeters, J. (2019). Sharing to flourish: A degrowth approach to provisioning for prosperity. In M. Rinkel & M. Powers (Eds.), Social work promoting community and environmental sustainability: A workbook for social work practitioners and educators (pp.172-193). International Federation of Social Workers (IFSW).

Ramsay, S. (2020). Let's not return to business as usual: Integrating environmental and social well-being through hybrid business models post COVID-19. *International Social Work*, *63*(6), 798–802. doi:10.1177/0020872820944996

Rinkel, M., & Powers, M. (Eds.). (2019). Social work promoting community and environmental sustainability: A workbook for global social workers and educators. International Federation of Social Workers (IFSW).

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., & Woelm, F. (2020). *The Sustainable Development Goals and COVID-19. Sustainable Development Report 2020*. Cambridge University Press. https://s3.amazonaws.com/sustainabledevelopment.report/2020/2020_sustainable_development_report.pdf

Schneider, F., Kallis, G., & Martinez-Alier, J. (2010). Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. *Journal of Cleaner Production*, *18*(6), 511–518. doi:10.1016/j.jclepro.2010.01.014

Sekulova, F., Kallis, G., Rodríguez-Labajos, B., & Schneider, F. (2013). Degrowth: From theory to practice. *Journal of Cleaner Production*, *38*, 1–6. doi:10.1016/j.jclepro.2012.06.022

Singh, R. L., & Singh, P. K. (2017). Global environmental problems. In R. Singh (Ed.), Principles and applications of environmental biotechnology for a sustainable future. Applied Environmental Science and Engineering for a Sustainable Future. Springer. doi:10.1007/978-981-10-1866-4_2

Teixeira, S., & Krings, A. (2015). Sustainable social work: An environmental justice framework for social work education. *Social Work Education*, *34*(5), 513–527. doi:10.1080/02615479.2015.1063601

United Nations. (2015, March 24). *Transforming our world: The 2030 agenda for Sustainable Development*. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

United Nations. (2020a, March 24). *Goal 2: Zero hunger*. https://www.un.org/sustainabledevelopment/hunger/

United Nations. (2020b, March 24). *Goal 4: Quality education*. https://www.un.org/sustainabledevelopment/education/

United Nations. (2020c, March 24). *Goal 5: Achieve gender equality and empower all women and girls.* https://www.un.org/sustainabledevelopment/gender-equality/

United Nations. (2020d, March 24). *Goal 6: Ensure access to water and sanitation for all.* https://www.un.org/sustainabledevelopment/water-and-sanitation/

United Nations. (2020e, March 24). *Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all.* https://www.un.org/sustainabledevelopment/economic-growth/

United Nations. (2020f, March 24). *Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation.* https://www.un.org/sustainabledevelopment/infrastructure-industrialization/

United Nations. (2020g, March 24). *Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.* https://www.un.org/sustainabledevelopment/biodiversity/

United Nations. (2020h, March 24). *Goal 13: Take urgent action to combat climate change and its impacts.* https://www.un.org/sustainabledevelopment/climate-change/

United Nations Development Program. (2020, March 25). *What are the Sustainable Development Goals?* https://www.tr.undp.org/content/turkey/en/home/sustainable-development-goals.html

Vargo, D., Zhu, L., Benwell, B., & Yan, Z. (2021). Digital technology use during COVID-19 pandemic: A rapid review. *Human Behavior and Emerging Technologies*, *3*(1), 13–24. doi:10.1002/hbe2.242

Winkler, I., & Williams, C. (2017). The sustainable development goals and human rights: A critical early review. *International Journal of Human Rights*, *21*(8), 1023–1028. doi:10.1080/13642987.2017.1348695

World Bank. (2020, March 23). *Poverty and shared prosperity.* https://www.worldbank.org/en/publication/poverty-and-shared-prosperity

World Bank. (2021, April 20). *Poverty.* https://www.worldbank.org/en/topic/poverty/overview#1

World Commission on Environment and Development. (1987). *Our common future, Chapter 2: Towards sustainable development.* https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

World Wide Fund for Nature. (2020, March 23). *Dünya liderleri, 2030'a kadar biyolojik çeşitlilik kaybını tersine çevirmeyi taahhüt etti*. https://www.wwf.org.tr/?10260/dunya-liderleri-2030a-kadar-biyolojik-cesitlilik-kaybini-tersine-cevirmeyi-taahhut-etti

Worldometer. (2021, April 20). *Covid-19 coronavirüs pandemic.* https://www.worldometers.info/coronavirus/

## ADDITIONAL READING

Dhakal, S. P., & Burgess, J. (2021). Decent work for sustainable development in post-crisis Nepal: Social policy challenges and a way forward. *Social Policy and Administration*, *55*(1), 128–142. doi:10.1111pol.12619

Dominelli, L. (2021). A green social work perspective on social work during the time of COVID-19. *International Journal of Social Welfare*, *30*(1), 7–16. doi:10.1111/ijsw.12469 PMID:33362429

Kallis, G. (2018). *Degrowth*. Agenda Publishing. doi:10.2307/j.ctv5cg82g

Nesmith, A. A., Schmitz, C. L., Machado-Escudero, Y., Billiot, S., Forbes, R. A., Powers, M. C., Buckhoy, N., & Lawrence, L. A. (2021). Pathways to change: Community and environmental transformation. In *The intersection of environmental justice, climate change, community, and the ecology of life* (pp. 83–104). Springer. doi:10.1007/978-3-030-55951-9_7

Peeters, J. (2017). Thinking about commons: A post-capitalist perspective for social work. In A. Matthies & K. Närhi (Eds.), *Ecosocial transition of societies: Contribution of social work and social policy* (pp. 71–88). Routledge.

Powers, M., Schmitz, C., & Beckwith Moritz, M. (2019). Preparing social workers for ecosocial work practice and community building. *Journal of Community Practice*, *27*(3-4), 446–459. doi:10.1080/10705422.2019.1657217

Powers, M. C., & Engstrom, S. (2020). Radical self-care for social workers in the global climate crisis. *Social Work*, *65*(1), 29–37. doi:10.1093wwz043 PMID:31828329

Rambaree, K. (2013). Social work and sustainable development: Local voices from Mauritius. *Australian Social Work*, *66*(2), 261–276. doi:10.1080/0312407X.2013.784793

Ramsay, S., & Boddy, J. (2016). Environmental social work: A concept analysis. *British Journal of Social Work*, *47*(1), 68–86. doi:10.1093/bjsw/bcw078

## KEY TERMS AND DEFINITIONS

**COVID-19 Pandemic:** It is a pandemic that has been announced due to the worldwide spread of the COVID-19 virus, which is a type of coronavirus families such as MERS and SARS and causes severe respiratory problems.

**Degrowth Approach:** It is an approach that based on the fair reduction of production and consumption capacity, social transformation for a sustainable life, and provision of social and environmental justice.

**Ecosocial Approach:** It is an approach that promotes the equitable and sustainable use of resources for the well-being of human and nature, recognizing that human beings are a part of nature.

**Environmental Justice:** It is a fair protection of all individuals from the consequences of environmental damage, regardless of race, ethnicity, culture, socio-economic level, and so on.

**Green Social Work:** In the social work profession, it is an approach that deals with people and their relationships with their physical environment in a holistic manner, and takes care of the well-being of the planet and human.

**Neoliberal Policies:** It is the policies towards the privatization of public spaces and the reduction of public expenditures as a result of neoliberalism based on free market economy and individual freedom.

**Social Justice:** It is a rights-based approach that enables all individuals in a society to have fundamental rights and obligations and to actively participate in decision-making process.

**Social Services:** These are the services provided by public, private or non-profit organizations for the well-being of individuals, families, groups, and communities in systems such as education, health, social security, and accommodation.

**Sustainability:** It is the coexistence process of human and other living things in the ecosystem.

**Sustainable Development Goals:** Based on the principle of leaving no one behind, they are global goals that address social and environmental problems such as poverty, inequality, and climate change.

# Chapter 21
# Tourism, Entrepreneurship, and Sustainability:
## Critical Questions

**Mariana Nóbrega**
*University of Aveiro, Portugal*

**Mariana Sousa**
*University of Aveiro, Portugal*

**João do Vale Ribeiro**
*University of Aveiro, Portugal*

**Nina Szczygiel**
https://orcid.org/0000-0001-5026-1629
*University of Aveiro, Portugal*

## ABSTRACT

*The new global economy and its branches need to be both sustainable and entrepreneurial. In the world where finitude of resources can be eye-witnessed, decisions that lay upon the principles of people, profit, and planet have the ability to preserve the quality of life of present and future generations. Tourism is one of those sectors which have largely expanded over the past decades and whose development affects countries, economies, and natural resources. Sustainable tourism appears to be a natural fit for entrepreneurs wishing to establish new ventures and pursue business opportunities in today's dynamic yet complex business climate. This chapter examines the nexus between entrepreneurship and sustainable tourism. On the basis of theoretical framework and the review of relevant global environmental and tourism-specific tendencies, an online empirical study was conducted to understand how young adults perceive entrepreneurship and sustainability in tourism and the contribution of the two to sustainable development.*

DOI: 10.4018/978-1-7998-8482-8.ch021

## INTRODUCTION

Over the last years, sustainability and its facets have gained an increasing attention worldwide. Human activity has been harmful to the planet for centuries and, if maintained this way, it constitutes a real danger to life on the planet. The United Nations (UN) has recognized these tendencies and translated them into seventeen Sustainable Development Goals (SDGs) for the period 2016-2030 (United Nations, 2018). The SDG framework is a "blueprint to achieve a better and more sustainable future for all" (United Nations, 2017) and is used as a call for action to promote economic growth while protecting the planet. Sustainable development is now regarded as the main concept of the future (Carley & Christie, 2017).

When looking closer at the SDGs, some of them, such as "decent work and economic growth" or "industry, innovation and infrastructure" are directly related to entrepreneurship venturing. Moreover, there is a number of others, associated to the entrepreneurship role and potential, pointing out the prospective outcomes of well-succeeded entrepreneurial activity in the micro, meso and macro dimensions. Despite its economic and social importance and being an object of unceasing attention, entrepreneurship does not have one generally accepted definition. Hisrich (1986) regards entrepreneurship as a process in which risk seems to be a necessary component. More specifically, he suggests that through a combination of effort, time and a variety of risks entrepreneurship can result in something valuable and different (Hisrich, 1986). People have a need to create (Murray, 1938) and entrepreneurship can be one of the means to express it. New generations bring new ideas and tend to invest in providing new solutions. Creating new ventures allows for development of people, economy and society.

Tourism is an interesting branch to consider when it comes to entrepreneurship and sustainability. Over the last decades, the tourism sector has witnessed a continuous and exponential growth. The tourism industry is responsible for 4.4% of GDP, 6.9% of employment and 21.5% of service exports in OECD countries (OECD, 2020), and has registered a continuous growth. In Portugal, the contribution of travel and tourism to GDP was 17.3% in 2017 and is forecast to rise up to 20.5% in 2028 (World Travel & Tourism Council, 2018) playing an important role in the national economy. Changes in demographic and lifestyle patterns together with holiday/work preferences reflect the need for innovation in tourism and give companies an opportunity to respond to the increase in tourist demand resulting from these changes (Crnogaj et al., 2014). Increased demand, diversification of tourism products and services, and the development of sustainable businesses are necessary to meet the needs of new types of tourists (Lordkipanidze, Brezet, & Backman, 2005).

Despite its strategic role to countries, investors and entrepreneurs (Nikraftar & Hosseini, 2016), the concept of tourism entrepreneurship has not been yet properly understood (Nikraftar & Hosseini, 2016; Zhang et al., 2020). Crnogaj and colleagues (2014) add to that the linkage between tourism, entrepreneurship and sustainability have not received so far much consideration whether in research or policymaking regardless of their unquestionable interdependence. At the same time, tourism cannot survive in the long run if it is not both, sustainable and entrepreneurial (Crnogaj, 2014).

The aim of this chapter is to examine the nexus between entrepreneurship and sustainable tourism. More specifically, the work investigates how young adults perceive entrepreneurship and sustainability in tourism and it discusses the contribution of the two to sustainable development. For the purpose of the study, the researchers carried out an online survey was in December 2020 that examined some aspects that might be specifically relevant to that age group. The interest in the younger generation, currently university students and recent graduates (generation Z), has to do with the role they will soon play in companies and organizations. We are living in unprecedented times, eye-witnessing the consequences of long-lasting overuse of natural resources and harmful behaviors. This generation soon will occupy the decision-making roles concerning economies, societies and the environment. The youth matters and their perceptions and attitudes will be critical in determining the future of Earth.

## MAIN FOCUS OF THE CHAPTER

### Tourism as a Theoretical Concept

Leiper's (1979) definition is often used to define tourism. The author refers to tourism as to a system of which the main building blocks are tourists, tourism generating areas, transit regions, destination areas and the associated tourism industry. This system exists because of the movement of people out of their usual area of residence for a period exceeding one night. The exception are the trips made with the objective of obtaining remuneration in the visited areas and/or transit regions. The elements of the system are spatially and functionally interconnected and, as it happens with any open system, one needs to take into account the surrounding environment (human, sociological, economic, technological, physical, political, among others) in its analysis as well. In this understanding, tourism is a subset of travel and tourists are a subset of travelers (Leiper, 1979). According to the UNWTO (2014), tourism comprises activities performed by individuals during their travels and stay in places located outside their usual living environment undertaken for a variety of reasons, such as: leisure, business, visiting family and friends, education and training, or health, among others. Specifically, four types of individuals who practice tourism can be distinguished: excursionist (stay at the destination for a period of less than 24 hours, not staying overnight), tourist (stays at the destination for at least 24 hours, staying overnight), visitor (includes excursionists and tourists) and traveler (includes visitors and some individuals who are not considered tourists, such as refugees, nomads and border workers) (UNWTO, 2014). The distinction between tourist and "same-day visitors" was done mainly for the purpose of statistical analysis (Suvantola, 2002).

### Global Trends in Tourism: Environmental Tendencies

Environmental concern has been on the rise even in countries and groups skeptical about the idea of climate change. With reaching the whole world weather anomalies and natural disasters that affect individual safety, general well-being and countries' economic stability, more and more people acknowledge the need to sustainably manage the planet's resources and ecosystems. The debates on climate change come with the issues of protection of biodiversity, which is vital for the life on Earth. Current environmental trends include the changes in energy production, namely the focus on renewable energy at the expense of fossil fuel use; the reduction of energy consumption, for example in transportation (electric vehicles) and in lighting (LED lights); and the increased demand for plant-based food, that is, opting for a vegetarian or vegan diet (EnergyWatch, 2020). The concern with sustainable consumption is accompanied by the ongoing change in consumer behavior (ERM Group, 2021; Schneider Electric, 2021). Circular solutions with the purpose of making the most of existing resources, such as food and clothing, that is, to monetize what already exists, are in place. The "anti-plastic" quest is increasingly present in the society. People prefer now more environmentally friendly solutions and tend to avoid plastic items for instance in packaging. The technology sector has also shown to be committed to sustainability what is important as technology can often act as a lever to drive sustainable practices (EnergyWatch, 2020; ERM Group, 2021; Schneider Electric, 2021).

Sustainability is very present in the UNWTO tourism policies, all of which refer to sustainability as an objective, while 67% refer to the efficient use of resources, 64% refer sustainability to competitiveness and 55% refer to sustainability exhaustively. These policies typically last for 10 years (UNWTO, 2019). Tourists travel nowadays mainly for leisure, recreation and vacation reasons (56%); visiting family and friends, health, religion and others (27%); business and professionals (13%); and other unspecified reasons (4%) (UNWTO, 2019). According to the UNWTO (2019), the main specific consumer trends in tourism are: (i) traveling "to change"; (ii) traveling "to show"; (iii) search for a healthy life; (iv) increase in the "accessible" economy; (v) traveling alone and multigenerational travel; and, finally, (vi) raising awareness of sustainability. The trend traveling "to change" reflects the desire to live as a place, actively participating in the culture, and to seek out unique and authentic experiences. The tendency to travel "to show" emphasizes the dependence of individuals on social networks and the need to share their life, in this sense, the moments they experience and the destinations they visit must be "instagramable". The search for a healthy life and lifestyle are related to the practice of outdoor activities, also those of a sporting nature, and which promote well-being (Resonance, 2019; UNWTO, 2019).

## Global Trends in Tourism: Tourism and the Covid-19 Pandemic

The Covid-19 pandemic has severely affected the tourism sector (INE, 2021). The expected annual growth did not materialize. The number of international arrivals decreased by 70% in just eight months (UNWTO, 2020). This decrease represents a loss of revenue in the amount of 730 billion US dollars in international exports, a loss with an impact eight times that of the 2009 global economic crisis (UNWTO, 2020). Such situation has further implications at various levels and inevitably influences trends in tourist activity. Four trends are expected to lead the way in tourism recovery: (i) demand evolution, (ii) health and hygiene, (iii) innovation and digitalization and (iv) sustainability (WTTC & Wyman, 2020). The first trend is related to the preference for the familiar, predictable, reliable and low risk (WTTC & Wyman, 2020). In this sense, trips within the country and the region will be valued, as well as the practice of outdoor activities, and the planning of trips will be done more carefully (WTTC & Wyman, 2020). Tourist destinations such as rural areas, small towns and beaches will be the most sought after and the stay of tourists will be longer (WTTC & Wyman, 2020). Health and hygiene are key aspects, the tourist need to feel safe and protected. In this regard, the World Travel and Tourism Council and Wyman (2020, p.3) argue that the travel and tourism sector "has a unique opportunity to rethink prevailing business models and co-create with local communities as it considers its most valuable asset: its people. Innovation and digitization have gained even more importance as the pandemic has forced the increased use of digital tools (videoconferences, contactless payments, online identification documents, among others) (Wyman & WTTC, 2020) and the increased demand for virtual tourism illustrates the potential for technological advances in the sector. In regard to the last trend, the sustainability, that must be not only environmental, but also social and institutional (Wyman & WTTC, 2020). In this sense, together with the increased concern with the environmental impact and the preservation of wildlife the tourism industry should take into account the respect for equality and human rights (Wyman & WTTC, 2020). In turn, marketing and promotion should be sued for developing communication and digital promotion campaigns, through the investment in social networks (UNWTO, 2020a).

In sum, the identified travel and mobility trends related to the Covid-19 pandemic are: (i) travel within the country itself, close to the place of residence; (ii) interest in nature and outdoor activities; (iii) concern with safety; (iv) development of safe and inclusive destinations; (v) recognition of technological and digital facilities; and (vi) greater concern with travel planning. Both categories of the global trends closely relate to one type of tourism, a sustainable tourism. It is believed that sustainable tourism can benefit from the aforementioned global trends and that it represents an interesting opportunity for entrepreneurs who aspire to start their own business.

## Nexus Between Tourism, Sustainability and Entrepreneurship

The idea of sustainability has spread significantly since the publication of the Brundtland Commission report in 1987. The Brundtland Commission, formerly the World Commission on Environment and Development, approached sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" and emphasized two concepts: that of the needs and basic needs in particular to which the priority should be given, and that of the limitations as a general characteristic of the modern world (United Nations World Commission on Environment and Development, 1987).

Sustainable tourism has been regarded as a kind of tourism that enjoys an organic vision toward its potential impacts in all dimensions and on all stakeholders. The impacts could be for instance of economic, social or environmental nature, both positive and negative, and the stakeholder group could comprise visitors, local communities and the industry (World Tourism Organization and United Nations Development Programme, 2017). According to UNWTO (2013), sustainable tourism refers to the need to:

- Make the best use of environmental resources that are a key element in the development of tourism, maintaining essential ecological processes and helping to maintain the existing natural heritage and biodiversity;
- Respect the sociocultural image and authenticity of host communities, keep their living environment and built cultural heritage and traditional values, and to contribute to intercultural understanding and tolerance;
- Assure feasible long-term economic operations, providing to all stakeholders fairly distributed socio-economic benefits including stable employment and income-generating opportunities and social services for host communities, and contributing to poverty reduction.

A 2017 publication of *Tourism and the Sustainable Development Goals – Journey to 2030* focused on the importance of tourism and sustainable development and discussed how the tourism industry could contribute to the achievement of the sustainable development goals. The year 2017 was actually designated by the 70th UN General Assembly as the International Year of Sustainable Tourism for Development. In the context of the 2030 Agenda for Sustainable Development and the SDGs, the International Year supported changing policies, business practices and consumer behavior in order to achieve a more sustainable tourism sector that would contribute to the SDGs in five main areas: (i) sustainable economic growth; (ii) social inclusion, employment and poverty reduction; (iii) resource efficiency, environmental protection and climate change; (iv) cultural values, diversity and heritage; and (v) mutual understanding, peace and security (World Tourism Organization and United Nations Development Programme, 2017). However, thanks to its wide reach and impact, the sector can and should contribute directly or indirectly to the achievement of the seventeen Sustainable Development Goals (World Tourism Organization and United Nations Development Programme, 2017).

Crnogaj et al. (2014) argue that the idea of sustainable tourism can and should be used as a basic indicator of the extent to which economic, social and aesthetic goals have been achieved while protecting biological diversity, key ecological processes, social integrity and cultural values. It is essential that the tourism industry becomes more sustainable (De Lange & Dodds, 2017), and, in this sense, tourism should be well planned and managed (UNWTO, 2013) as a process in its all phases. Sustainability is a central element of the competitiveness of tourist destinations and the guidelines and management practices for sustainable tourism development are applicable to all forms of tourism, in all types of destinations (OECD, 2016).

Tourism characteristics make it therefore a potential development agent. On the one hand, an economic activity stimulates production, trade and job creation, thanks to its large value chain. On the other hand, it is an economic activity that causes major environmental impact by using scarce resources and therefore can be a factor of negative changes in the society (UNWTO, 2013). Thus, tourism should be developed in a sustainable way.

The principles of sustainable development are increasingly important for tourism service providers (entrepreneurs and tourism companies), tourists and the local community (Crnogaj et al., 2014) and as a matter of fact, in order to achieve sustainable tourism, tourism enterprises must be responsible for their actions in relation to the environment, their employees and the local community (UNWTO, 2013). Sustainable development of a territory can be achieved through the voluntary contribution of the population, the choice of environmental priorities and effective management (Muzyka et al., 2019). The collaboration of the local community for the sustainable development of tourism has been pointed out by several authors, such as Crnogaj et al. (2014), Eusebio et al. (2014), Muzyka et al. (2019) or Nooripoor et al. (2020). Moreover, Ateljevic and Li (2009) have highlighted the importance of the participation of other, numerous stakeholders in the decision-making process for tourism development.

For tourism to contribute to the sustainable development of destinations, it should provide a high-quality experience for visitors, encourage the use of locals in activities related to tourism, optimize local economic benefits, create long-term economic links between local communities and industries, consider the limits of the environmental load capacity, protect the natural heritage, and improve the quality of life of residents (Eusébio et al., 2014). Abranja (2017) emphasizes the importance of destinations having favorable minimum conditions in terms of communications, infrastructure and resources so that they were able to stimulate entrepreneurship. Only in this way, and with the help of entrepreneurs as the main agents of economic and social change, responsible for the generation, dissemination and application of creativity and proactivity and of execution of innovation, can entrepreneurship create positive impacts on the development of sustainable tourism (Abranja, 2017). Of course, there are opinions that entrepreneurs in the tourism industry have little business and innovation skills (Crnogaj et al., 2014), but contrary evidence also exists (Bascavusoglu-Moreau et al., 2013; Omerzel, 2016). Lordkipanidze et al. (2005) reinforce the idea that education and training for those involved in tourism entrepreneurship are of great importance. Specific skills and knowledge in a given area can be a significant advantage, with knowledge being the most important source of innovation for companies (Nikraftar & Hosseini, 2016) and a fundamental requirement in the development of destinations (Aberg, 2014, cited by Nikraftar & Hosseini, 2016).

Small and medium enterprises (SMEs) are the main building blocks of many modern economies (Karadag, 2015). They account for are a large proportion of all businesses in the country (Gherghina et al., 2020; Hansen & Bogh, 2021) and are responsible for production of goods and services and employment generation stimulating the country's well-being and quality of life (Erdin & Ozkaya, 2020) and economic development (Sinclair, 1998; Neagu, 2016). The SMEs operating in the tourism industry have the ability to analyze market opportunities and develop new products or services that respond to market needs. In addition to being a source of employment for the economy (Lordkipanidze et al., 2005), especially in countries for which the tourism and tourism-related service sector highly contribute to the national GDP, they play an important role in innovation. Although such companies are important in the context of regional development, sustainable development and economic diversification, some authors argue that only a small percentage of small tourist companies are truly entrepreneurial (Ateljevic & Li, 2009).

In a general understanding however prevails the belief that development of tourist activity enables economic development and fosters local entrepreneurship. This, together with current tendencies in production and consumption patterns, results in encouraging further tourism-related entrepreneurial ventures and developing new forms of sustainable tourism. Both of these dimensions are central areas for political support and financing (Ateljevic & Li, 2009).

Therefore, entrepreneurship and local innovation allow tourism to optimize the potential of the local economy and promote the development of local businesses (Carlisle et al., 2013). Tourism can be a driving and rejuvenating activity in a region; however, heritage and tourist resources are not enough to guarantee the attractiveness of these spaces. This way, entrepreneurship opens space for innovative entrepreneurial applications through definition of strategies for combining specific characteristics of the region and creative aspects (Abranja, 2017). Entrepreneurship and innovation can contribute to a competitive advantage, adding value and quality to the tourism sector (Triantafillidou & Tsiaras, 2020), and supporting the development of the tourism industry reputation and advancement at the international level (Carlisle et al., 2013).

## METHODOLOGY

The aim of this research was to investigate the relationship between sustainability, tourism and entrepreneurship. For this purpose, a quantitative approach was used. The researchers built a questionnaire which they later shared via social networks (Facebook and Instagram). The questionnaire was directed to young adults (generation Z) and aimed to gather their perceptions about entrepreneurship, sustainable tourism and the importance of entrepreneurship in sustainable tourism. The body of the questionnaire comprised four sections: the first section contained items regarding entrepreneurship, the second section contained items regarding sustainable tourism and the items in the third section referred to sustainable tourism and entrepreneurship together. The last part of the questionnaire contained socio-demographic information.

The questionnaire was administered in Portuguese. It was anonymous, and the participants were ensured of confidentiality of all information they would provide.

Data collection occurred in 2020 and the data were pre-analyzed twice during the data collection phase in order to determine the first signals of redundancy. Data saturation, whether in quantitative or in qualitative research, refers to the phase in research when new observations do not provide any additional information and is a sign that data collection should terminate (Faulkner & Trotter, 2017).

Data were analyzed with the IBM SPSS v.27 software.

## RESULTS

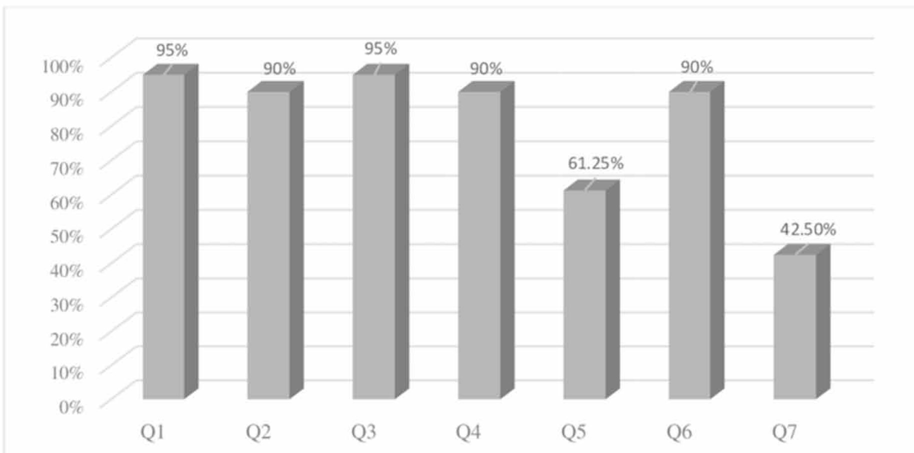
The data collection resulted in 80 valid responses. The respondents were mostly female (80%), aged between 18 and 25 (72.5%), of Portuguese nationality (97.5%) with a small percentage of Brazilian nationality (2.5%) and full-time higher education students (73.8%) which was to be expected because of the age group under analysis. The remaining part of the respondents were either working students or workers.

Regarding the first section of the questionnaire, most respondents (77.5%) affirmed that they had already had contact with entrepreneurship during their academic training and/or had been following entrepreneurs on social networks. When asked about the characteristics they considered most important in an entrepreneur, the most selected were: (i) leadership spirit (68.8%); (ii) spirit of initiative (85%); (iii) team spirit (75%); (iv) dedication to work (72.5%); (v) good communication skills (81.3%); (vi) strategic vision (81.3%); and (vii) proactivity (61.3%). The last question in this section intended to assess in a Likert scale from 1 to 5 (1 - "not at all important" and 5 - "very important"), the perceptions of the importance of entrepreneurship for sustainable development. Most respondents rated this importance with 4 (37.5%) or 5 (57.5%), indicating that the respondents in the study found entrepreneurship important for sustainable development.

The second section of the questionnaire related to the perceptions about sustainable tourism. The first question aimed to identify the most important aspects in considering a tourism company as sustainable. The aspects found most important were: (i) the use of sustainable materials in the construction of the company's infrastructures (52.5%); (ii) the use of renewable energy sources (67.5%); (iii) the conscientious use of resources (73.75%); (iv) social concern (56.25%); and (v) making commitments to the environment in order to reduce its environmental impact (56.25%). About half of the respondents said they were able to provide an example of a sustainable tourism company, with the majority of these companies being tourist accommodation or catering establishments. The research intended also to assess the importance of tourism for sustainable development, what was done using a Likert scale from 1 to 5 (1 - "not at all important" and 5 - "very important"). In that question, 71.3% of respondents considered tourism very important for the sustainable development. Still, when purchasing a certain tourism product/service, 70% of respondents said they did not bear in mind whether the supplier company followed the sustainability principles.

When questioned about the importance of individuals linked to the tourism sector having an entrepreneurial attitude, 95% of respondents provided an affirmative answer while the remaining 5% disagreed. For the majority (75.6%), sustainable tourism was perceived as a good area for an entrepreneur to develop their business and 6.3% considered that it was not, at least not at the moment, due to the Covid-19 pandemic. The other 17.5% of respondents were not convinced in that matter. It is noteworthy that no individual answered "no". Finally, respondents were provided a series of statements in which they were asked to say the extent to which they agreed with in a Likert scale from 1 to 5 (1 - "totally disagree" and 5 - "totally agree"). The statements were: (1) Entrepreneurships is important for the creation of sustainable products and services; (2) Entrepreneurships contributes to the planning of tourism activities and tourism destinations; (3) Entrepreneurships contributes to a sustainable development of tourism activities; (4) Innovation is an important factor in sustainable tourism entrepreneurship; (5) Sustainable tourism depends on entrepreneurship; (6) It is important that the entrepreneurs working in the tourism activities have skills and knowledge in both, entrepreneurship and tourism; (7) All tourism companies are entrepreneurial. Of those, the ones with the highest share of respondents who completely agreed with the provided statement were: (i) Entrepreneurships is important for the creation of sustainable products and services (56.25%); (ii) Innovation is an important factor in sustainable tourism entrepreneurship (67.5%); and (iii) It is important that the entrepreneurs working in the tourism activities have skills and knowledge in both, entrepreneurship and tourism (57.5%). Figure 1 shows the number of respondents who strongly agreed (4 on the Likert scale) and totally agreed (5 on the Likert scale) with in the seven statements.

*Figure 1. Number of respondents who strongly and completely agreed with the statement (in %)*
*Source: Authors' elaboration*




## SOLUTIONS AND RECOMMENDATIONS

The results of the applied questionnaire suggest that there is a general awareness of entrepreneurship and sustainable tourism among the young generation (more specifically, generation Z) and that they recognize the contribution of both to sustainable development. Respondents consider sustainable tourism to be an interesting business area for young entrepreneurs who are looking to start own business. Contrary to what was expected, only few respondents actually choose sustainable tourism businesses when making their market decisions.

Generation Z will soon occupy the political, economic and organizational areas and will be responsible for the direction in which they will go. It seems that the greatest challenge ahead resides in the decision-making the young people do and will do. That is, it seems the young generation is aware, but this awareness does not yet translate into conscious decision making yet. Therefore, "knowing" should be accompanied by "doing".

## FUTURE RESEARCH DIRECTIONS

A still limited amount of research and published papers on tourism entrepreneurship and entrepreneurship associated with sustainable tourism could be explored in further studies. One suggestion is to extend the study and comprise the youth from some regions, the whole country or perform a cross-country analysis. Another, broader, possibility is to approach the problem from a multi-generational perspective. A cross-generational analysis could be conducted to test previously defined study hypotheses or a model that reflects specific generation's motivations or consumer behaviors could be developed.

## CONCLUSION

Sustainable tourism responds to current international environmental and tourism-specific trends, presenting itself as a solution to concerns about sustainability. This way, entrepreneurs have the opportunity to innovate and provide value to different dimensions of sustainable development. As a central force of socioeconomic development entrepreneurship contributes to the development of individual industries and the country as a whole in key areas such as GDP, exportation, standard of living and quality of life, and community development. Entrepreneurial approach in the tourism activities may contribute to innovation, sustainable development of tourist destinations, job creation and integration of the local community.

Sustainability is a topic of growing importance for individuals, economies, societies and the future of the planet. It is also an essential factor when creating a business/company in the present days. The tourism sector, like the other ones, needs to take into account sustainability in the provision of goods and services. In this sense, entrepreneurship plays an important role in sustainable tourism. The relationship between these activities can be beneficial for all: tourism, entrepreneurship and sustainability.

## ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## REFERENCES

Abranja, N. (2017). O empreendedorismo como base do turismo sustentável: Proposta de modelo conceptual. *Observatório de Inovação do Turismo*, *9*(2). Advance online publication. doi:10.17648/raoit.v11n2.4464

Ateljevic, J., & Li, L. (2009). Tourism entrepreneurship – concepts and issues. In J. Ateljevic & S. J. Page (Eds.), *Tourism and Entrepreneurship* (pp. 9–32). Routledge. doi:10.1016/B978-0-7506-8635-8.00002-2

Bascavusoglu-Moreau, E., Kopera, S., & Wszendybył-Skulska, E. (2013). The role of creativity in development of innovation in tourism. Journal of Entrepreneurship. *Management and Innovation*, *9*(1), 5–15. doi:10.7341/2013911

Carley, M., & Christie, I. (2017). *Managing Sustainable Development*. Routledge. doi:10.4324/9781315091525

Carlisle, S., Kunc, M., Jones, E., & Tiffin, S. (2013). Supporting innovation for tourism development through multi-stakeholder approaches: Experiences from Africa. *Tourism Management*, *35*, 59–69. doi:10.1016/j.tourman.2012.05.010

Crnogaj, K., Rebernik, M., Bradac Hojnik, B., & Omerzel Gomezelj, D. (2014). Building a model of researching the sustainable entrepreneurship in the tourism sector. *Kybernetes*, *43*(3-4), 377–393. doi:10.1108/K-07-2013-0155

EnergyWatch. (2020). *The top 10 sustainability trends to watch in 2020*. Retrieved from https://energywatch-inc.com/

Erdin, C., & Ozkaya, G. (2020). Contribution of small and medium enterprises to economic development and quality of life in Turkey. *Heliyon*, *6*(2), e03215. doi:10.1016/j.heliyon.2020.e03215 PMID:32055722

Eusébio, C., Kastenholz, E., & Breda, Z. (2014). Tourism and sustainable development of rural destinations: A stakeholders' view. *Revista Portuguesa de Estudos Regionais*, *36*, 13–21.

Faulkner, S. L., & Trotter, S. P. (2017). Data saturation. In J. Matthes, S. C. Davis, & R. F. Potter (Eds.), The International Encyclopedia of Communication Research Methods (pp. 1–2). doi:10.1002/9781118901731.iecrm0060

Gherghina, Ș. C., Botezatu, M. A., Hosszu, A., & Simionescu, L. N. (2020). Small and medium-sized enterprises (SMEs): The engine of economic growth through investments and innovation. *Sustainability*, *12*(1), 347. doi:10.3390u12010347

ERM Group. (2021). *Sustainability Report*. Author.

Hansen, E. B., & Bøgh, S. (2021). Artificial intelligence and internet of things in small and medium-sized enterprises: A survey. *Journal of Manufacturing Systems*, *58*, 362–372. doi:10.1016/j.jmsy.2020.08.009

Hisrich, R. D. (1986). The woman entrepreneur: characteristics, skills, problems and prescriptions for success. In D. L. Sexton & R. W. Smilor (Eds.), *The Art and Science of Entrepreneurship* (pp. 61–86). Ballinger Publishing Company.

INE. (2021, April 30). *Tourist activity with a very negative year-on-year change but less pronounced, reflecting the comparison with a month already affected by the pandemic*. Press release. Retrieved from https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=471119801&DESTAQUESmodo=2&xlang=en

Karadag, H. (2015). The role and challenges of small and medium-sized enterprises (smes) in emerging economies: An analysis from turkey. *Business and Management Studies*, *1*(2), 179–188. doi:10.11114/bms.v1i2.1049

Lordkipanidze, M., Brezet, H., & Backman, M. (2005). The entrepreneurship factor in sustainable tourism development. *Journal of Cleaner Production*, *13*(8), 787–798. doi:10.1016/j.jclepro.2004.02.043

Murray, H. A. (1938). *Explorations in Personality*. Oxford University Press.

Muzyka, S. M., Vinober, A. V., Shvetsova, S. V., Bondarenko, O. V., & Kozlova, S. A. (2019). Potential of rural tourism in the Tunkinsky National Park (Baikal region): Synergy of environmental and economic factors. *IOP Conference Series. Earth and Environmental Science*, *341*(1), 012016. Advance online publication. doi:10.1088/1755-1315/341/1/012016

Neagu, C. (2016). The importance and role of small and medium-sized businesses. *Theoretical and Applied Economics*, *23*(3), 331–338.

Nikraftar, T., & Hosseini, E. (2016). Factors affecting entrepreneurial opportunities recognition in tourism small and medium sized enterprises. *Tourism Review*, *71*(1), 6–17. doi:10.1108/TR-09-2015-0042

Nooripoor, M., Khosrowjerdi, M., Rastegari, H., Sharifi, Z., & Bijani, M. (2020). The role of tourism in rural development: Evidence from Iran. *GeoJournal*. Advance online publication. doi:10.100710708-020-10153-z

OECD. (2016). OECD Tourism Trends and Policies 2016. *Tourism Trends and Policies*, *2016*. Advance online publication. doi:10.1787/tour-2016-en

OECD. (2020). *OECD Tourism Trends and Policies 2020*. OECD Publishing. Retrieved from http://www.oecd.org

Omerzel, D. G. (2015). Innovativeness in tourism: Model development. *Procedia Economics and Finance*, *23*, 750–756. doi:10.1016/S2212-5671(15)00550-X

Resonance Consultancy. (2019). *World's Best Cities 2019. A Ranking of Global Place Equity*. Retrieved from https://media.resonanceco.com/uploads/2018/11/Resonance-2019-Worlds-Best-Cities-Report.pdf

Schneider Electric. (2021). *Bridging progress and sustainability for all*. 2021 -2025 Sustainability Report. Retrieved from: https://download.schneider-electric.com/files?p_Doc_Ref=SustainabilityReport2020EN

Sinclair, M. T. (1998). Tourism and economic development: A survey. *The Journal of Development Studies*, *34*(5), 1–51. doi:10.1080/00220389808422535

Suvantola, J. (2002). *Tourist's Experience of Place*. Ashgate Publishing Limited.

Triantafillidou, E., & Tsiaras, S. (2020). Exploring entrepreneurship, innovation and tourism development from a sustainable perspective: Evidence from Greece. *Journal for International Business and Entrepreneurship Development*, *86*(1), 53–64. doi:10.1504/JIBED.2018.090020

United Nations. (2017). *UN resolution A/RES/71/313. Resolution adopted by the General Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development*. Author.

United Nations. (2018). *Goals for Sustainable Development*. Retrieved from https://www.un.org/sustainabledevelopment/ru/about/development-agenda/

United Nations World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Oxford University Press. Retrieved from https://www.environmentandsociety.org/mml/un-world-commission-environment-and-development-ed-report-world-commission-environment-and

World Tourism Organization (UNWTO). (2013). *Sustainable Tourism for Development Guidebook - Enhancing capacities for Sustainable Tourism for development in developing countries*. Madrid: UNWTO. doi:10.18111/9789284415496

World Tourism Organization (UNWTO). (2019). *International Tourism Highlights. 2019 Edition.* World Tourism Organization. doi:10.18111/9789284421152

World Tourism Organization (UNWTO). (2020). *World Tourism Barometer*. Retrieved from https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2020-01/UNWTO_Barom20_01_January_excerpt_0.pdf

World Tourism Organization and United Nations Development Programme. (2017). *Tourism and the Sustainable Development Goals – Journey to 2030, Highlights*. UNWTO. doi:10.18111/9789284419340

World Travel & Tourism Council. (2018). *Travel & Tourism Economic Impact. 2018 Portugal.* Author.

World Travel & Tourism Council (WTTC) & Wyman, O. (2020). *To Recovery & Beyond: The Future of Travel & Tourism in the Wake of COVID-19.* Retrieved from https://wttc.org/Portals/0/Documents/Reports/2020/To%20Recovery%20and%20Beyond-The%20Future%20of%20Travel%20Tourism%20in%20the%20Wake%20of%20COVID-19.pdf

Zhang, H., Lu, L., & Sun, F. (2020). Changing role of lifestyle in tourism entrepreneurship: Case study of Naked Retreats Enterprise. *Tourism Management*, *84*, 104259. Advance online publication. doi:10.1016/j.tourman.2020.104259

## ADDITIONAL READING

Badulescu, A., Badulescu, D., Bac, D., & Sipos-Gug, S. (2014). Attitudes and intentions of business master students towards sustainable tourism and entrepreneurship. *Amfiteatru Economic Journal, 16*(8), 1110-1124.

Bakas, F. E., Duxbury, N., & de Castro, T. V. (2019). Creative tourism: Catalysing artisan entrepreneur networks in rural Portugal. *International Journal of Entrepreneurial Behaviour & Research*, *25*(4), 731–752. doi:10.1108/IJEBR-03-2018-0177

Carr, A., Ruhanen, L., & Whitford, M. (2016). Indigenous peoples and tourism: The challenges and opportunities for sustainable tourism. *Journal of Sustainable Tourism*, *24*(8-9), 1067–1079. doi:10.1080/09669582.2016.1206112

De Lange, D., & Dodds, R. (2017). Increasing sustainable tourism through social entrepreneurship. *International Journal of Contemporary Hospitality Management*, *29*(7), 1977–2002. doi:10.1108/IJCHM-02-2016-0096

Ertac, M., & Tanova, C. (2020). Flourishing women through sustainable tourism entrepreneurship. *Sustainability*, *12*(14), 5643. doi:10.3390u12145643

Hall, J., Matos, S., Sheehan, L., & Silvestre, B. (2012). Entrepreneurship and innovation at the base of the pyramid: A recipe for inclusive growth or social exclusion? *Journal of Management Studies*, *49*(4), 785–812. doi:10.1111/j.1467-6486.2012.01044.x

Panzer-Krause, S. (2019). Networking towards sustainable tourism: Innovations between green growth and degrowth strategies. *Regional Studies*, *53*(7), 927–938. doi:10.1080/00343404.2018.1508873

Porter, B. A., Orams, M. B., & Lück, M. (2018). Sustainable entrepreneurship tourism: An alternative development approach for remote coastal communities where awareness of tourism is low. *Tourism Planning & Development*, *15*(2), 149–165. doi:10.1080/21568316.2017.1312507

Sun, X., & Xu, H. (2020). Role shifting between entrepreneur and tourist: A case study on Dali and Lijiang, China. *Journal of Travel & Tourism Marketing*, *37*(5), 547–561. doi:10.1080/10548408.2019.1598535

Swanson, K. K., & DeVereaux, C. (2017). A theoretical framework for sustaining culture: Culturally sustainable entrepreneurship. *Annals of Tourism Research*, *62*, 78–88. doi:10.1016/j.annals.2016.12.003

Valdés, R. M. T., Álvarez, C. L., Spila, J. C., & Santa Soriano, A. (2019). Relational university, learning and entrepreneurship ecosystems for sustainable tourism. *Journal of Science and Technology Policy Management*, *10*(4), 905–926. doi:10.1108/JSTPM-03-2018-0032

## KEY TERMS AND DEFINITIONS

**Generation Z:** Generation of people born between 1995-2015 (this estimate is approximate as no generally accepted time frames exist) and who are sometimes referred to as first digital natives or ‘zoomers’.

**Innovation:** Process of creation, development and practical implementation of a new product, service or process by which it is expected to relace or improve the existing solution, contribute to efficiency and effectiveness and create value.

**Nomad:** Individual with no strongly developed sense of belonging. Moving from a place to place is his way of living.

**Quality of Life:** Subjective perception that an individual holds about their life in the context of present conditions, circumstances, and values. A multidimensional concept that measures a person’s well-being.

**Standard of Living:** Construct describing the quantity and quality of goods and services available to an individual, group, socio-economic class, or the entire population. Refers to the level of wealth and lived comfort.

**Sustainability:** In general terms, feature, condition, or characteristic of an object or a system that allow it to endure over time.

**Sustainable Development Goals:** Objectives adopted by the United Nations in 2015 as a universal call to action addressing peace, prosperity, and protection of the planet. The Sustainable Development Goals are holistic, multidimensional, and integrated so that an action (and change) in one will affect outcomes in others.

**Sustainable Tourism:** Tourism of which planning and development pay attention to the present and future potential impacts on people and life on the planet in social, economic, and environmental dimensions.

# Chapter 22
# Sustainable Socio-Intercultural Development

**José G. Vargas-Hernández**
https://orcid.org/0000-0003-0938-4197
*Posgraduate and Research Department, Tecnológico Mario Molina, Unidad Zapopan, Mexico*

## ABSTRACT

*This chapter has the objective to explain and analyze the issues, problems, concerns, and tendencies related to the sustainable socio-intercultural development. The analysis departs from the assumption that the nature of a sustainable socio-intercultural development system should be based on the common socio-cultural values and public understanding to strengthen the sustaining practices of governance. The method employed is the reflective approach based on an analytical review of the theoretical literature and empirically derived current practices in communities, governments, and organizations. The analysis concludes that the implementation of a sustainable socio-intercultural socioeconomic and environmental development needs to be supported by a well-designed institutional governance. To achieve this, a commitment on the practice of effective community economic growth and socio-environmental sustainable development is required.*

## INTRODUCTION

Socio-interculturality is supported by socio ecological bio diversity focusing on sustainable development capacities influenced by the shift governance toward a greater roles of local communities under the pressures of global governance structures over time.

The concept of good governance is an issue that comes from the area of international development and has been adopted by the policy making field in corporate management, and challenged the capacities of national states bureaucracies and local indigenous territorial governments. Organizations can develop corporate governance capital as a valuable reserve to sustain a transitional change towards the socioeconomic development. Good governance is understood as the organization of a living together in which everybody participates beyond the state.

DOI: 10.4018/978-1-7998-8482-8.ch022

Local governance roles and derived community responsibilities may treat power inequalities through networks of support aimed to overcome its governance, economic, social, environmental and management problems. Good local governance is an imperative to economic development and poverty reduction (Grindle 2004: 525). This dominant proposition in the development and governance literature has been theoretical and empirically examined (Cornell and Kalt 1995).

Local indigenous communities must be familiar with the economic development and business cycles supported by strong governance capacities (Hunt and Smith 2006, 2007). The community governance interactions with the business organizations tend to design and develop contradictory strategies which are operationalized within the institutional environment and organizational governance. One of the biggest challenge for the governance arrangements of indigenous communities are the mediation of conflicts, tensions, myths, expectations of the economic development.

The institutional frameworks, governance representation and decision-making and the forms of organizational culture facilitate the economic development of the community. Community is the special-demographic unit for inclusive and legitimate governance form and generation of economic development. The relevant community actors in the governance of business and economic development initiatives reflect in their actions the cultural values, their power, leadership, authority and relationships systems.

The concept of governance is related to government approach to law from pyramid to network (Ost & van de Kerchove 2002). This notion of good governance and sustainable development leaves people with no hope outside (Campbell 1997, Parthasarahty 2005, Rahnema 1997).

Governance schemes supported by the Millennium Development Goals are modelled on the organizational orientation towards transnational rule-making organizations while adopting complex governance structures (Bäckstrand, 2006; Hale and Mauzerall, 2004). However, the capacity of people, groups, organizations and communities to design, create, develop and transform their own institutional structures and policies to fit the environmental changes and the state efforts to achieve a governance of local culture.

## ENVIRONMENTAL AND SUSTAINABLE DEVELOPMENT

A sustainable development framework must encourage the value of alternative divergent thinking with respect of pluralism of worldviews, cultural diversity and recovery of local community environmental culture to recover the traditional systems of natural resources management and include all these concerns in the construction of environmental policy responses to sustainable development issues. The development of principles for good natural resources management and development governance can be supported by the contribution of the literature review by a panel de experts who may refine and test these principles (Linstone and Turoff 1975).

The dynamic aspects of local communities in collaboration strategy developed to engage with residents, organizations and leaders are related to the complexities of local history, politics, social organizations, business development, and so on, leading all to governance culture.

The practice of socio-intercultural sustainable leadership requires to be sustained by the development of socio-intercultural sustainable systems and their implications with their respective implications to sustain leadership development at communities, institutions, organizations and individual levels. Leadership plays an important role when operating in increasingly socio-intercultural environments. In socio intercultural environments it is required more perceptive, skillful and experience-oriented approaches for a governance related exercise.

Indigenous leadership may instigate strategies to design an organizational model for the construction of an socio-intercultural governance and the institutional environment to support the economic development. Socio-intercultural governance is a relational and heterogeneous field encapsulating environment in the interplay of agency, relationships and practices among local communities, organizations and the state. Indigenous governance and leadership are positioned within a wider local community environment of systemic forms of socio-intercultural domains.

Institutional environment and legal factors have an impact on contract governance mechanism (Handley and Angst 2015) such as reducing the inter-organization conflicts. The strategic local institutional environment of a community shared by members generates institutional capital and governance which become the vehicle for collective action and socio economic development. Institutional environment, culture and legal factors affect the long-term contract governance effectiveness reducing the inter-organization conflicts (Handley and Angst 2015).

Sustainable development issues and challenges can be contextually framed within the socio-intercultural dialogue and cultural diversity, inextricably linked to knowledge, human values, creativity, etc. Cultural diversity is a source of innovation for sustainable development theory, social and community experiences and knowledge and as a means for building a culture of peace, human fulfillment, tolerance and non-violence (United Nations Educational, Scientific and Cultural Organization UNESCO, 2004). Cultural diversity as an alive, continuous and evolving element of cultural societies that shapes human aspirations to be promoted for better economic, social, political and environmental opportunities (Stenou, 2004).

Cultural diversity and socio-intercultural dialogue promoted by creativity and partnerships are relevant sources of traditional knowledge and learning for capacity building of sustainable development strategies and policies. The lack of resources and documents to support the sustainable development practices connected to socio-intercultural dialogue and cultural diversity to guide policy level and other interests of the stakeholders, require some initiatives to fill this existing gap by creating the opportunities for research and innovation engagement to develop these materials and resources.

Systemic thinking, problem-solving and cause-effects are limited approaches when empowering people through socio-intercultural partnerships to take action in decision-making processes and building capacities in sustainable development. Decision making and representation are processes of negotiation among the diverse cultural values and views about the community needs to building the governance legitimacy and support the economic development and business.

Indigenous community cultural values and relationships are excluded from the governance arrangements and economic development practices. The social field and the institutional systems field of indigenous community governance tend to endure, develop and function depending of the increasing complexity of environmental conditions. These organizational and institutional arrangements are the expression in which socio-political actors and economic agents enact the community governance system.

Cultural diversity and socio-intercultural dialogue is in a relationship integrated to sustainable development policies where the socio-intercultural partnerships interact though learning experiences as the objective to learn for sustainable development. Changes on cultural diversity as the evolving worldviews to develop a strategy based on shaping sustainable development.

Public-private partnerships are relevant for sustainable development where cultures are involved representing the complexity of socio-intercultural relationships and contacts among the partners and the stakeholders involved. Cultural diversity and socio-intercultural dialogue can be integrated into knowledge and learning perspectives linking economic, social, cultural and environmental opportunities for sustainable development.

Cultural diversity and socio-intercultural dialogue are vehicles to support as the culture dimension to be articulated in the relationship with sustainable development posing a challenge to policy-making, strategies and practices. Socio-intercultural has a relationship to sustainable development is a critical source for the policy-making as well as the relationships with the stakeholder groups, which can build upon other resources, materials and documents and inform the strategic and policy formulation and implementation.

Cultural diversity and socio-interculturality are weak, narrowly defined and complex notions in relation to be integrating components of implementing sustainable development to facilitate the creation of inclusive pathways for more sustainable societies. A more inclusive community socio-intercultural governance and participation balance the decision making processes about the services and benefits provided by the social institutions of family, community and organizations required to support and provide governance solutions to the economic development and business success.

Cultural diversity policies determine the issues of sustainable development and collective learning based on socio-intercultural dialogue in different socio-economic, cultural and environmental regional contexts. Learning to live together is a principle to be applied for existent relationships between socio-intercultural diversity and the sustainable development future (Nurse, 2006; United Nations Educational, Scientific and Cultural Organization UNESCO, 2005b; Hawkes, 2001).

The principles of socio-intercultural dialogue and cultural diversity are challenged by the sustainable development initiatives and practices strengthened by participative strategies to promote integration of actors, stakeholders, communities, etc. Principles of cultural diversity and socio-intercultural dialogue embedded within frameworks must be responsive and integrated to policy-making in sustainable development to assess representation and interpretation of culture and the impacts.

Integration of theoretical and practical principles of sustainable development into areas of knowledge and learning strategies and increase participation to benefit from a societal transformation in terms of values, behaviors and lifestyles. Sustainable development poses global strategic learning challenges to design frameworks underpinning economic, social, cultural and environmental contexts of regional territories focusing on the delimitation of different priorities depending of the issues and realities. There are some gaps in the integration in the policy making of cultural diversity and socio-intercultural dialogue dimensions to add learning value for sustainable development and identify opportunities and contributions.

Environmental and sustainable development can assess traditional indigenous knowledge and practices which may be linked to scientific knowledge and learning for wider creativity applications enabling to construct different alternative pathways for a sustainable society. Native languages and multilingualism terminologies are a vehicle of indigenous knowledge exchange and learning sustainable practices and traditions to explore potential applications and to design and implement promotion of strategies and policies on sustainable development in local indigenous communities linking to scientific knowledge.

Indigenous sustainable development governance structures are identified with several issues such as spatial planning and working on the ground with local communities in flexible time and using feedback on socio-intercultural competencies (Moorcroft *et al.*, 2012). The framework of natural resource management and development governance is based on learning and experimentation interdependencies in environmental sectors that are vulnerable to complexities and uncertainties.

Sustainability problems in terms of natural resource management and governance has ethical foundations based on notions of responsibility, participation, institutional demands and policy (Dovers 2005). The interdependency among community people and their cross-boundary concerns and issues related the nature of environmental challenges and the coordination across the natural resources management governance levels, and other policy and spatial domains. Cross-scale structure of natural resources management governance challenges the interactions imposed by the complexity and uncertainty levels of environmental governance.

Development of socio-intercultural competencies becomes an element of a new globalized environment and plural societies providing opportunities and abilities for aspirations to all forms of socio-intercultural character of human life. Indigenous communities need an institutional and normative framework to enable opportunities participate in planning and decision making processes to build local and regional capacities and partnerships for sustained community governance through community development. Institutional environment and legal factors have an impact on contract governance mechanism (Handley and Angst 2015) such as reducing the inter-organization conflicts.

Local governance structures can be modeled by the State´s Constitution based on the mandatory institutional set for core local public community services delivery and decisions about the organizational structure, authority´s governance, planning for sustainability, administrative processes and system arrangements, etc. Socio-intercultural spaces can coexistence between local community indigenous and state domains and regulations in territories where the planning agencies can develop the socio-intercultural capacities of projects and land use planning zoning and practices of resource allocation subject to planning and development controls.

Socio-intercultural sustainable city planning practice is based on principles such as the equality, equitable and fair, just treatment, in which individuals and communities respond to more demanding and changing environments with dynamic, hybrid and multiple evolving identities (Wood 2012). The increasing number in interdependencies among the diverse stakeholders and actors from different spaces and territories necessitate greater interactions in horizontal distribution of power at multiple sustainable community and organizational governance scales related with environmental problems.

The governance statements can open spaces to find resources for a range of issues and time constraints. When these spaces are more oriented toward socio intercultural environment may include the operation dynamics of ongoing policy shifts and the corresponding ongoing processes.

Socio-intercultural diverse urban spaces can promote plural contacts and interactions through various events and activities aimed tom strengthen the confidence of ethnic groups enable them equal opportunities for economic, social, political, cultural and environmental development. Global citizenship is linked to sustainable environmental development and both are supported by knowledge, values, skills and attitudes development such as critical thinking, cooperative work, etc.

Cultural diversity policies may reorient current practices of sustainable development for the creation of alternative futures and confronting challenges (United Nations Educational, Scientific and Cultural Organization, UNESCO, 2008a, 2008b) to retain traditions in a mono-culture and to enhance the coexistence of culturally plural societies in a more open and global framework.

Building capacity for sustainable development requires to reinforce education and face the challenges of cultural learning processes through initiatives and challenges related to influence the actors and stakeholders involved in a changing sustainable society. An international socio-intercultural education research and development project can promote sustainable development based on an approach learning by doing and action through the participation and empowerment of students and encouraging local communities and local school governance (SANTAG, 2000)

People engaged in future thinking is necessary to envisioning sustainable futures, imaging visions and having meaningful interpretations of sustainable development leading them to take responsibility and ownership. People in communities should engage in defining the vision of their futures for sustainable development (Tilbury and Wortman, 2004). Sustainable community development learning and embedded culture approaches are a major challenge for environmental policy-making that require resources and guidelines.

The broadest sense of sustainable development is relevant and integral to reach sustainable community development. To achieve these goals and resolving the community and organizational issues is required to crate, acquire and develop skills in governance, resolving compliances, allocate and manage the resources to the community and meet requirements for infrastructure to deliver public services.

People engaged in future thinking is necessary to envisioning sustainable futures, imaging visions and having meaningful interpretations of sustainable development leading them to take responsibility and ownership. Socio-intercultural dialogue between communities is a critical component of sustainable development contributing to facilitate and combine knowledge exchange in more sustainable practices as a means for sustainable visions for the future.

## GOVERNANCE DEVELOPMENT

Governance issues really matter and become priority when undertaking organizational community diagnostic assessments and consultations externally driven for strategic planning development (Gillespie 1999). The debate between governance and sustainable development, according to Eberhard (2008) has problems tom accept the socio-intercultural dialogue challenges under frameworks such as good governance which calls for an socio-intercultural theory of law.

Governance institutions, structures and processes can collapse and can be dismantled struggling with dramatic changes in local development strategies (Dodson and Smith 2003).

Recent developments on uncertainty in indigenous community governance bodies and organizational issues have combined with the self-determination on policy shifts and changes of state and territory jurisdictions.

Lack of community governance leads to several social responsibility issues related to problems and tensions, which may require immediate attention and solution, particularly regarding to decision making processes, planning and management of natural and public resources. Community governance face many problems and difficulties faced by adverse events that poses a threat to its ongoing stability and attributed to management, decision making and implementation of decisions to ensure its socio economic and environmental development.

Indigenous and community governance arrangements have been examined in relation to the balance of power relationships under the institutional and government policies, after the post-colonial struggles and under the institutional. Social and cultural capital are imperatives that require strategic management and balanced through governance arrangements, otherwise they may be problematic for indigenous community governance to generate business and economic development. Community governance in remote locations require a shifting on policy and funding economic environment because they usually lack continuity of services provided poorly-funded organizations.

Organizational and community capacity building support may enable the community to regain control over the development of governance skills and tools for strengthening self-governance. Finding the pathways to community self-governance environment encompasses finding the governance concepts, values and structures to be more compatible with the local community which is essentially socio-intercultural in nature between local people and their organizations and state institutions (Hinkson and Smith 2005; Merlan 1998).

Decision making powers involving all the communities to design and implement initiatives of development is the base to reshape legitimate and capable good socio-intercultural governance arrangements. Governance socio-interculturality is complex by the cultural and linguistic diversity and further complicated by the organizational scale, history and transformations of its indigenous constituency to more diverse organizations and development agencies.

Creation, development and transformation of governance institutions requires innovation, creativity, containment and constation by communities and government officials and bureaucrats alike. This process of re-imaging their governance based on the creation and development of culture of governance values, institutions and organizations have to be a solution according to their community needs.

In periods of rapid increase in membership participation in formal governance issues, management bureaucrats may be reluctant to embrace the capacity building of formal community governance and to tamper with an organizational development model. The capacity building of sustainable organizational governance requires training and monitoring into the design and delivery of resources and programs focused on conformity and compliance to the regulations as well as on decision making for community development (Willis 2004: 17).

The lack of clarity in the term organizational governance has implications for change, development and empowerment of the community. Organizational complexity, ambiguity and uncertainty have effects on the realistic and unrealistic expectations generated around the organizational governance issues and capacity building. This organizational governance capacity building leads toward the development of flexible open spaces for all the stakeholders, organizations and communities involved to address concerns and make decisions.

Indigenous local culture is viewed as inherited that inevitably undermines western standards of good governance, but if considered enables to design more culturally appropriate government and community programs securing service development and policy governments. The development of good governance is a priority concern issue for any community government managing resources and projects.

The governance development of governments in relation to Indigenous local affairs has failed to make advances (Dillon and Westbury 2007: 208) in developments. The viability and feasibility of community governance development project should be assessed and the results should be known by the community members who may consider and decide introduce reforms to their current governance arrangements and their affiliated organizations.

Local indigenous governance offers greater self-determination gradually being recognized by the state and the official policy aimed to generate socioeconomic development and community wellbeing. Community organizations and institutions may provide a positive or negative basis for local indigenous governance and its relationships with socioeconomic development. Indigenous governance is challenging in cross-cultural multidimensional complexities of the environments because the of ideology, politics, institutions and agents involved in arrangements and processes across different rural and urban settings.

The organizational governance model for membership and representation aimed to community socio economic development initiatives is related to the core of extended families. However, this model of organizational and corporate governance should be more inclusive focusing on a wider community constituency in community populations that can benefit from the services provided. Local indigenous populations may have dysfunctional governments due to poor community governance capacities caused by relevant disadvantaged socio economic and environmental factors. However, they may be determined to build their capacities and increase their authority over their own natural resources, public affairs and their own future destiny.

It is also questioned that indigenous family relationships may contribute positive or negative for good organizational governance and its relationships with the socioeconomic development outcomes. Legitimate and effective organizational governance operating in a community environment, local, regional, state and national context, is critical for sustainable business and corporate governance and economic development.

Organizational and corporative good governance codes have been extended to the public sphere and civil society encouraging local governments to privatize some of the public responsibilities in diverse sector where more efficiency is sought and to involve nongovernmental and social organizations to get into policymaking. Some of these good codes of governance are the established by the World Bank (Kaufmann et al. 2003), and other international organizations such as the United Nations Development Programme (UNDP 1997), the European Commission (EC 2001), etc.

It is considered, maybe wrongly, that the involvement of family on governance arrangements and development initiatives operate deficiently as a cultural institution. Given the expectations, problems, tensions and misunderstandings of group families play a relevant role as a representative model in community and organizational governance by maintaining a strategic balance between economic, social and cultural goals. On the other hand, this representative model of governance based on the relevant role of the community groups have the relevant role in addressing the pressures for more community participation to manage the negative impacts in socioeconomic development.

Indigenous people need to find their own self-determination and self-control in community governance independent from government to promote the development they value (Hunt and Smith 2007). The institutional and organizational development of local indigenous governance meet the specific socio-political and cultural requirements in complex and sometimes contested environments (Sanders, 2004). The foundation of institutional and governance capital invested with practical capacity, resilience and flexibility aiming to achieve a development dividend.

The design of a set of governance principles alongside some examples of governance principles usage across a range of scales is required to improve organizational and community governance systems recognized by the corporate sector followed by the upheavals of economic liberalization and internationalization. Other relevant changes that have contributed to the development of corporate and organizational governance are the increasing of privatization in ownership structures, institutional investor growth and shareholder activism, introduction of good practice codes which have led to the improvement of accountancy practices, legitimacy and effectiveness (Aguilera and Cuervo-Cazurra 2004).

Policies designed under the principles of Indigenous community self-determination and self-management are the base for the organizational development to support community governance arrangements (Moreton-Robinson 2007). The changing roles and functions of organizational development may be based on the representation locus for homelands and the government improvement of governance capabilities and structures

Regional and local governance frameworks can be legitimate and effective foundations to design and implement a long term strategy for regional development (Ah Kit 2003). In the context of economic development initiatives, the concepts and assumptions of family and community are close related, either fundamental or antithetical to good indigenous local governance.

Local and community governance have to be re-imagined. Local and community inhabitants have to stay engaged and use all the opportunities to reshape and reinsert strategically goal priorities on institutional governance processes and cultural values of governance. Institutional governance transformation may arise from the environmental changes in the form of embedded initiatives from the institutional state power exercising financial, jurisdictional and institutional powers through the governing of its culture of governance.

These assumptions and expectations may contribute to develop an evolving indigenous local governance able to support the organizational and community development goals. Indigenous local systems of governance remain located the post-colonial and socio-intercultural frameworks. Indigenous governance is analyzed as relationships of negotiation and contestation between and among governments and local Indigenous groups over the institutional frameworks, funding sources and self-determination policy implementation in an environment of post-colonial struggles.

Any community development generates a new set of governance challenges that may require adaptive management and balance of community tensions between incorporated western form and aboriginal customary form of governance. A successful mediation between these two different governance approaches may offer balanced operations and opportunities for local people.

The growing relevance of strengthening organizational development contribute to the emergence of formal community governance. In turn, the indigenous community requires of a strong policy changes to facilitate the implementation and performance of this emerging community socio-intercultural governance in such a way that meet the aspirations and expectations of indigenous and non-indigenous populations (Rowse 2002).

Organizational governance development is the consequence of governance values related to governance ate local domains of action and values bringing them into the organizations. Sustainable local organizations have several economic and strategic implications to develop governance for business enterprise, community environment and cultural identity development based on the management of their constraints and benefits from legal and structural demarcation and from governance representation.

The community and organizational governance history is reflected in the key factors that have more influence in the governance arrangements structure and the socio-economic development role model as an agency for the economic independence for the families, organizations and businesses. Organizational governance factors facilitate and strengthen the indigenous business and economic development (Dodson and Smith 2003). The management of mundane and ceremonial relationships between individuals and human groups articulated at local and regional levels are the domain of governance (Williams 1986, 1987).

The history of sustainable organizational governance development has passed through community self-determination in the complexity of socio-intercultural environment as an official government policy to manage some governance tensions. These governance conflicts and tensions among the indigenous and non-indigenous populations requires the socio-intercultural transformations and developments of governance. Business and economic development can be easily eroded by political conflicts and demands from governments who hold their own ideological vision on the role that should play the community. Therefore, it is important to identify the factors that contribute to these governance transformations and development aimed to manage the tensions in a market-based economies and indigenous community-based social norms.

Governance institutions can be imposed and receive external coercion to have little traction in changing behaviors to build responsibilities and commitments in enabling governance policies aimed to facilitate community development. The ongoing co-evolution change under environmental conditions requires of governance institutions that should have a sustainable vision, anticipated and oriented to the long term aimed to foster learning cultures and experimentation in the development of adaptive capacities (Kemp et al. 2005; Allan and Curtis 2005). The community sustainable governance institutions considered as a system that creates the conditions in the institutional context of the organizational environment developing institutional capital which contributes to the economic development, creation of competitive advantages and the formation of sustained business and commerce.

Organizations involved in governance and collaborating on learning and projects activities and cooperate with stakeholders, officials from international organizations, national and local governments and civil society must care more on sustainable development and low carbon policies and actions in favor of improving the climate change.

## SUSTAINABLE DEVELOPMENT GOVERNANCE

The governance system is the result of trends that require participation and consultation in the agenda for sustainable development based on shifts in the balance between individual and collective interests to build civic and ecological capacities for greening production, distribution and consumption. The development of territorial regions strengthens both regional identities that can meet and engage in new forms of socio-intercultural governance and dialogue among the different socio -economic partners, stakeholders, political and social actors, economic agents regional and local authorities, etc. The dominant land use and development planning systems centered on natural resources management takes the form of a top-down approach in which the public interest is hostile to any expression of socio-intercultural governance based on local indigenous values.

The cultural diversity, socio-intercultural dialogue and socio-interculturality dimensions intrinsic to local societies is considered in terms of cultural heritage of local sustainable development. socio-interculturality frame practice and innovation in institutional governance grounded in the pre-existing meanings hold on community and people´s values and behaviors and not imposed from outside.

The development of local indigenous governance structures to facilitate indigenization processes to develop the institutional governance arrangements (Gluckman 1968: 223). The declining development of natural resources has prompted the design and implementation of diverse collaborative governance arrangements aimed for managing, planning and investing on natural resources programs.

The mode of new governance addresses the solution of problems in complex, uncertain, interdependent environments and with deficiencies in resources, knowledge, expertise, etc. New governance arrangements for environmental and natural resource management and policy regimes requires integration and coordination at the level of temporal and spatial multiscale (Lemos and Agrawal 2006). The governance of natural resources management acknowledges the principle of adaptability in environments of complexity and uncertainty to develop management capacities and provides a framework of adaptive governance and flexibility to respond to contextual threats and opportunities.

Sustainable development, governance and participation are legal, socio-economic and political notions attached to interdisciplinary and socio-intercultural challenges. To tackle socio-economic, cultural and environmental concerns and issues of sustainable development is necessary to approach from different perspectives such as among other challenges, the cultural diversity, socio-intercultural governance, citizenship and democracy, participatory decision making, human rights, etc.

The governance mechanism is a factor affecting collaboration leading to the long-term sustainable development of business practices and improvement of social performance. In the collaborative relationship the meta-cognitive dimension of cultural intelligence is likely the one that most influence have in socio-intercultural confidence development moderating contract governance related to collaboration.

Formal indigenous community governance is based on population groups with various identities and involved in political action through the development of socio-intercultural governance field and state political formations. In this environment of aboriginal socio-political life between the aboriginal groups is enacted in a dynamic process of autonomy and relatedness (Martin 1993; Myers 1986). Keen (1989: 21) considers that the aboriginal governance distinguishes the aboriginal domain in a wider political and social environment. This concept of indigenous community governance is linked to the concept of extended family in local economic development and social systems (Finlayson 1991; Macdonald 2000; Smith 2000; Sutton 1998).

The indigenous community economic development is related to governance. Indigenous community governance is concerned for the improvement of the socioeconomic wellbeing of the local community people with the attached economic dividend to good governance (Kaufmann 2005; Cornell and Kalt 1990; Kaufmann, Kraay and Mastruzzi 2005.

Development of partnerships involving indigenous communities are critical to achieve socio-intercultural governance aimed to use indigenous and scientific knowledge to protect, maintain and manage biodiversity ecosystems and natural resources outcomes (Howitt *et al*. 2013; Muller 2014). Ecosystems are characterized by dynamic emergent properties and interpenetration that generate environmental uncertainty and complexity (Dryzek 1987). As such, processes and tools to monitor and evaluate (M&E) (Convention on Biological Diversity 2011; Gorenflo *et al*. 2012; Maffi & Woodley 2012; Porter-Bolland *et al*. 2012; Gomez-Baggethun *et al*. 2013; Kothari *et al*. 2013; Poe *et al*. 2014; Smyth 2015).

The planned organizational devolution is a strategy to demarcate the economic development partnerships to community cultural and service delivery. In system of environmental devolved governance, responsibilities, resources and financial autonomy may be allocated to lower tiers with the flexibility of governance capacity to deliver outcomes (Lawrence 2005).

Local aboriginal communities define their own socio-intercultural skills to develop relationships in a created space geographically grounded where its institutions, culture and values take place and assume their capacities for challenging opportunities in sustainable development governance. Any sustainable development project has to be supported by building socio-intercultural governance capacities and structures to facilitate trust relationships bringing together the different peoples under the sharing and participation of a common agenda.

The global governance provides a framework to promote synergies between research, policy-making and training to generate creative ideas and innovative solutions. The component of sustainable governance training usually encompasses the focus on compliance to present a bundle of tools to be used in planning proposals for the community development.

Global governance is an imposed ideal of participatory development and ideology getting people to participate solving global problems in a set agenda into a de facto imposed model of good governance set in a socio-legal-political vacuum but not in the shaping of the agendas. A democratic and participatory ethos of institutional sustainable development underpins the governance of organizations concerning a democracy sustained by a governance process based on the participation of all the stakeholder involved in decision making processes, and not solely with representative democracy (Beane & Apple, 1999).

Multilevel governance linkages of any system can address and target policy gaps supported by a social learning model (Leys and Vanclay, 2011: 574) confronting the socio-intercultural capacity of institutional deficits of socio-intercultural competencies processes and knowledge systems, socio-intercultural dialogue and cultural diversity policy making process and frameworks must ensure awareness and understanding of sustainable development, to identify gaps, opportunities, best practices, proposals and recommendations (UNESCO, 2008a).

A regional and local sustainable development requires a strategic connectivity in a multilevel governance environment (Roberts 2000). The socio-intercultural nature of organizational membership takes for granted the homelands for a cultural match with the governance arrangements in accordance with a wider governance environment. Besides, any organization has a wider governance environment as the site of social engagements and political struggles between power and governance arrangements, objectives, values, etc.

The community governance environment conceptualization and analysis are more focused on government strategy and policy, budgeting, funding and service delivery frameworks implemented by different levels of government. Governance histories of communities and governance environment elucidate the cultures of governance and local government arrangements and processes (Hunt and Smith 2006, 2007; Smith 2005). The significant inter-influence between different inter cultures of governance shape contemporary local practices which can be negotiates or contested (Merlan 1998, 2005).

Local indigenous institutions and organizations are expressions of community governance as the multi nodal networked form of governance including families and groups, which is embedded in the governance environment including bureaucratic governments, policy networks, business and voluntary organizations, and so on. The governance environment trespasses these boundaries and goes into considering the nature.

## CONCLUDING REMARKS

Local governments must have a clear understanding of governance and accountability structures and systems of organizations as socio-intercultural institutions, where the different types of accountability systems have to reconciled. Design of governance institutions requires of normative standards that enable governing in the uncertainty and complexity contexts thorough the multilevel governance of a sustainable environmental biodiversity and ecosystems through the coordination of the diverse interest of the stakeholders among the public, private and voluntary organizations.

The multilevel environmental governance has implications for accountability and inclusiveness as an essential input to ensure more innovative solutions to uncertain and complex problems. The institution building for community sustainable governance is supported by a well-designed governance for sustainable socioeconomic and environmental development. To achieve this, it is required a commitment on the practice of effective organizational development inserted in a flexible and resilient institutional environment to promote collective performance.

Learning opportunities of nature and ecosystem environments should focus on changing mind sets, behaviors, values, lifestyles, decisions and choices to develop collective knowledge for sustainable futures. In fact, training for governance development may be required to be upward accountable within the government framework requirements. A governance training parallel process may highlight the deficiencies and provide opportunities for development encouraging greater management participation in the overall strategy for formal change of governance to ensure greater membership participation.

A transparent community governance strategy designed by governments may put some pressure to business organizations for the diverse services delivery contributing to economic socio-development of the whole community which is equated as good governance. An organizational incubation strategy facilitates more diversification of its structure and operational flexibility to respond to changes of socio-economic development conditions leading to the strengthening of community governance.

This situation requires to review the strategic direction of the structure and leadership of governance to integrate into the functions of the organizational structure Leadership is a critical factor and the catalyst for building the organization's institutional capital and community governance culture for economic development. Institutional capital and governance culture are critical factors to mobilize other form of capitals for the sustained economic organizational development of organization. The institutional environment of organizations progressively built up reserves of cognitive, normative and regulative forms of capital for managing economic development.

The emergence of socio-intercultural community interacting with businesses and relational style of aboriginal politics and local leadership may undermine the representative democratic politics system and thus some institutions and organizations can be enabled or disabled depending of this governance environment (Hunt and Smith 2006). To achieve these goals, leadership must be qualified and have expertise on representative organizations strong links into the local community and strong networks into the regional, state and national leaderships. Community and organizational leadership succession is a critical factor to preserve the strategic institutional capital and the resilience of governance culture.

A trend towards to create regional institutional governance, the organizations and authorities need to resolve the issues of funding opportunities and the inclusion of community history peoples within the organizational structures to be resolved by legislative laws and government policies. It may be necessary a local government development and reform agenda centered on regional governance issues related to service delivery functions. The organizational governance functions must address community government priorities beyond financial management and despite that had in-built imbalances and tensions which are historically inherent to the organizations and community development and closely involved in in the governance structures.

Local governance capacity building should be based on the development of a culturally-based constitution aimed to develop legitimate governance to promote economic, social and environmentally safe communities. Community organizations may be attuned to the environmental governance in relation to their role and their assimilation in government policy. The capacity building in socio-intercultural natural resource management systems should be engaged on the development of knowledge and skills of local agents, stakeholders and participants.

## REFERENCES

Aguilera, R. V., & Cuervo-Cazurra, A. (2004). Codes of good governance worldwide: What is the trigger? *Organization Studies*, *25*(3), 415–443. doi:10.1177/0170840604040669

Ah Kit, J. (2003). Building Stronger Regions—Stronger Futures Strategy, Minister for Community Stronger Futures Strategy. Minister for Community Stronger Futures Strategy Development, Sports, Culture and Arts, Northern Territory Government, Darwin.

Allan, C., & Curtis, A. (2005). Nipped in the bud: Why regional scale adaptive management is not blooming. *Environmental Management*, *36*(3), 414–425. doi:10.100700267-004-0244-1 PMID:16132442

Bäckstrand, K. (2006). Democratizing Global Environmental Governance? Stakeholder Democracy after the World Summit on Sustainable Development. *European Journal of International Relations*, *12*(4), 467–498. doi:10.1177/1354066106069321

Beane, J. A., & Apple, M. W. (1999). The case for democratic schools. In M. W. Apple & J. A. Beane (Eds.), *Democratic schools: lessons from the chalk face*. Open University Press.

Campbell, B. (1997). Reconceptualisation de l'État au Sud – Participationdémocratique ou managérialisme populiste. In *Crépeau François, Mondialisation deséchanges et fonctions de l'État* (pp. 163–231). Bruylant.

Convention on Biological Diversity. (2011). *Aichibiodiversity targets*. https://www.cbd.int/sp/targets/

Cornell, S., & Kalt, J. P. (1990). Pathways from poverty: development and institution-building on American Indian reservations. *American Indian Culture and Research Journal*, *14*(1), 89–125. https://www.hks.harvard.edu/hpaied/pubs/pub_016.htm

Cornell, S., & Kalt, J. P. (1995). Successful economic development and heterogeneity of government form on Aboriginal Indian reservations, PRS 95-4. Harvard Project on American Indian Economic Development, Malcolm Weiner Center for Social Policy, John F. Kennedy School of Government, Harvard University.

Dodson, M., & Smith, D. E. (2003). *Governance for sustainable development: strategic issues and principles for Indigenous Australian communities.* CAEPR Discussion Paper No. 250, CAEPR. http://www.anu.edu.au/caepr/discussion.php

Dovers, S. (2005). *Environment and sustainability policy: Creation, implementation, evaluation*. Federation Press.

Dryzek, J. (1987). *Rational ecology: Environment and political economy*. Blackwell.

Eberhard, Ch. (2008). *Law in a Globalizing World: Towards 'Good Governance' Through socio-intercultural Dialogue? Revista Direito, Estado e Sociedade, 33*.

European Commission. (2001). *White paper on governance*. Brussels, Belgium: European Commission.

Finlayson, J. (1991). *Don't Depend on Me: Autonomy and Dependence in an Aboriginal Community in North Queensland* (PhD Thesis). Anthropology Department, ANU, Canberra.

Gillespie, D. (1999). *Report to Bawinanga Aboriginal Corporation, Maningrida NT—Strategic Planning Issues for the Corporation*. Unpublished report, Tallagella Pty Ltd.

Gluckman, M. (1968). The utility of the equilibrium model in the study of social change. *American Anthropologist*, *70*(2), 219–237. doi:10.1525/aa.1968.70.2.02a00010

Gomez-Baggethun, E., Corbera, E., & Reyes-Gar-cia, V. (2013). Traditional ecological knowledge and global environmental change: Research findings and policy implications. *Ecology and Society*, *18*(4), 72. doi:10.5751/ES-06288-180472 PMID:26097492

Gorenflo, L. J., Romaine, S., & Mittermeier, R. A. (2012). Co-occurrence oflinguistic and biological diversity in biodiver-sity hotspots and high biodiversity wilderness areas. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 8032–8037.

Grindle, M. S. (2004). Good enough governance: Poverty reduction and reform in developing countries. *Governance: An International Journal of Policy, Administration and Institutions*, *17*(4), 525–548. doi:10.1111/j.0952-1895.2004.00256.x

Hale, T. N., & Mauzerall, D. L. (2004). Thinking Globally and Acting Locally: Can the Johannesburg Partnerships Coordinate Action on Sustainable Development? *Journal of Environment & Development*, *13*(3), 220–239. doi:10.1177/1070496504268699

Handley, S. M., & Angst, C. M. (2015). The impact of culture on the relationship between governance and opportunism in outsourcing relationships. *Strategic Management Journal*, *2015*(36), 1412–1434. doi:10.1002mj.2300

Hawkes, J. (2001). The Fourth Pillar of Sustainability: Culture's Essential Role in Public Planning. Melbourne: Common Ground P/L.

Howitt, R., Doohan, K., Suchet-Pearson, S., Cross, S., Lawrence, R., Lunkapis, G. J., Muller, S., Prout, S., & Veland, S. (2013). Socio-intercultural capacity deficits: Con-tested geographies of coexistence in natural resource management. *Asia Pacific Viewpoint*, *54*(2), 126–140. doi:10.1111/apv.12014

Hunt, J., & Smith, D. E. (2006). *Building Indigenous community governance in Australia: preliminary research findings.* CAEPR Working Paper No. 31, CAEPR, CASS, ANU.

Hunt, J., & Smith, D. E. (2007). *Indigenous Community Governance Project: Year two research findings.* CAEPR Working Paper No. 36, CAEPR, CASS, ANU.

Kaufmann, D. (2005). Back to basics: Ten myths about governance and corruption. *Finance & Development*, *42*(3). http://www.imf.org/external/pubs/ft/ fandd/2005/09/index.htm

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2003). *Governance matters III: Governance indicators for 1996–2002*. The World Bank. doi:10.1596/1813-9450-3106

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2005). *Governance matters IV: governance indicators for 1996–2004.* World Bank Policy Research Working Paper 3237. Available at https://worldbank.org/wbi/governance/pubs/govmatters4.html

Keen, I. (1989). Aboriginal governance. In J. C. Altman (Ed.), Emergent Inequalities in Aboriginal Australia. University of Sydney.

Kemp, R., Parto, S., & Gibson, R. B. (2005). Governance for sustainable development: Moving from theory to practice. *International Journal of Sustainable Development*, *8*(1/2), 12–30. doi:10.1504/IJSD.2005.007372

Kothari, A., Camill, P., & Brown, J. (2013). Conservation as if people also mattered: Policy and practice of community-based conservation. *Conservation & Society*, *11*(1), 1–15. doi:10.4103/0972-4923.110937

Lawrence, G. (2005). Promoting sustainable development: The question of governance. In F. H. Buttel & P. McMichael (Eds.), *New directions in the sociology of global development* (pp. 145–174). Elsevier.

Lemos, M. C., & Agrawal, A. (2006). Environmental governance. *Annual Review of Environment and Resources*, *31*(1), 297–325. doi:10.1146/annurev.energy.31.042605.135621

Leys, A. J., & Vanclay, J. K. (2011). Social learning: A knowledge and capacity building approach for adaptive co-management of contested landscapes. *Land Use Policy*, *28*(3), 574–584. doi:10.1016/j.landusepol.2010.11.006

Linstone, H. A., & Turoff, M. (1975). *The Delphi method: Techniques and applications*. Addison-Wesley.

Macdonald, G. (2000). Economies and personhood: demand sharing among the Wiradjuri of New South Wales. In G. W. Wenzel, G. Hovelsrud-Borda, & N. Kishigami (Eds.), The Social Economy of Sharing: Resource Allocation and Modern Hunter-Gatherers. National Museum of Ethnology.

Maffi, L., & Woodley, E. (2012). *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan. doi:10.4324/9781849774697

Martin, D. F. (1993). *Autonomy and Relatedness: An Ethnography of the Wik People of Western Cape York Peninsula* (PhD Thesis). ANU, Canberra.

Merlan, F. (1998). *Caging the Rainbow: Places, Politics and Aborigines in a North Australian Town*. University of Hawai'i Press. doi:10.1515/9780824861742

Merlan, F. (2005). Explorations towards intercultural accounts of socio-cultural reproduction and changes. *Oceania*, *75*(3), 167–182. doi:10.1002/j.1834-4461.2005.tb02878.x

Moorcroft, H., Ignjic, E., Cowell, S., Goonack, J., Mangolomara, S., Oobagooma, J., Karadada, R., Williams, D., & Waina, N. (2012). Conservation planning in a cross-cultural context: The Wunambal Gaambera Healthy Country Project in the Kimberley, Western Australia. *Ecological Management & Restoration*, *13*(1), 16–25. doi:10.1111/j.1442-8903.2011.00629.x

Moreton-Robinson, A. (2007). Introduction. In *Sovereign Subjects: Indigenous Sovereignty Matters*. Allen & Unwin.

Muller, S. (2014). Co-motion: Making space to carefor country. *Geoforum*, *54*, 132–141. doi:10.1016/j.geoforum.2014.04.011

Myers, F. (1986). *Pintupi Country, Pintupi Self: Sentiment, Place and Politics Among Western Desert Aborigines*. University of California Press.

Nurse, K. (2006). Culture as the fourth pillar of sustainable development. Paper prepared for the Commonwealth Secretariat.

Ost, F., & van de Kerchove, M. (2002). *De la pyramide au réseau? Pour unethéorie dialectique du droit*. Facultés Universitaires Saint Louis.

Parthasarahty, D. (2005). Taking Participation Seriously. A Critique of Good Governance. In Droit, gouvernance et développement durable,numéro spécial des Cahiers d'Anthropologie du Droit. Karthala.

Poe, M. R., Norman, K. C., & Levin, P. S. (2014). Cultural dimensions of socioecological systems: Key connections and guiding principles for conservation in coastal environments. *Conservation Letters*, *7*(3), 166–175. doi:10.1111/conl.12068

Porter-Bolland, L., Ellis, E. A., Guariguata, M. R., Ruiz-Mallen, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, *268*, 6–17. doi:10.1016/j.foreco.2011.05.034

Rahnema, M. (1997). Participation. In *The Development Dictionary. A Guide to Knowledge as Power*. Zed Books.

Roberts, P. (2000). Strategic connectivity. In *The new regionalism: Strategies and governance*. Centre for Local Economic Strategies.

Rowse, T. (2001). Democratic systems are an alien thing to Aboriginal culture.... In M. Sawer & G. Zappala (Eds.), *Speaking for the People: Representation in Australian Politics*. Melbourne University Press.

Sanders, W. (2004). *Thinking about Indigenous community governance.* CAEPR Discussion Paper No. 262, CAEPR, ANU.

SANTAG (Kwazulu-Natal Sanitation Task Group). (2000). ELET: An NGO in school and sanitation education. *OUTLET Newsletter for SANTAG, 32*.

Smith, D. E. (Ed.). 2000. Indigenous Families and the Welfare System: Two Community Case Studies. CAEPR Research Monograph No. 17, CAEPR, ANU.

Smith, D. E. (2005). *Researching Australian Indigenous governance: a methodological and conceptual framework*. CAEPR Working Paper No. 29, CAEPR, ANU.

Smyth, D. (2015). Indigenous protected areas andICCAs: Commonalities, contrasts and confusions. *Parks*, *21*(2), 73–84. doi:10.2305/IUCN.CH.2014.PARKS-21-2DS.en

Stenou, K. (2004). Cultural diversity and dialogue: an interface. In *Cultural Diversity and Globalization –The Arab-Japanese Experience*. UNESCO Publishing.

Sutton, P. (1998). Families of polity: post-classical Aboriginal society and native title. In *Native Title and the Descent of Rights. National Native Title Tribunal, Perth. Yarnteen Aboriginal and Torres Strait Islanders Corporation (YATSIC) 2005. Annual Report*. YATSIC.

Tilbury, D., & Wortman, D. (2004). Engaging people in sustainability. Commission on Education and Communication, IUCN.

United Nations Development Programme. (1997). *Good governance for sustainable human development*. http://magnet.undp.org/policy/chapter1.htm

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2004). *The UN Decade of Education for Sustainable Development (2005-2014): International Implementation Scheme*. UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2004). *The UN Decade of Education for Sustainable Development (2005-2014): International Implementation Scheme*. UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2005a). Convention of the Protection and Promotion of the Diversity of Cultural Expressions. Paris: UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2008a). Background Note. A Review of Education for Sustainable Development (ESD) Policies from a Cultural Diversity and SOCIO-INTERCULTURAL Dialogue Perspective. Unpublished document. UNESCO/CLT/CPD/CPO20/11/2008. Paris: UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2008b). UNESCO Concept Note. Towards a New Cultural Policy Profile. UNESCO/CLT/CPD 01/08/2008. Paris: UNESCO.

Westbury, N. & Dillon, M. (2006, Dec. 8). Australia's institutionalised second class. *The Australian Financial Review*.

Williams, N. M. (1986). *The Yolngu and Their Land: A System of Land Tenure and Its Fight for Recognition*. Australian Institute of Aboriginal Studies Press.

Williams, N. M. (1987). *Two Laws: Managing Disputes in a Contemporary Aboriginal Community*. Australian Institute of Aboriginal Studies.

Willis, C. (2004). *Review of Governance Training for Indigenous Organisations and Communities in the Northern Territory: Final Report to the Department of Community Development, Sport and Cultural Affairs*. NT Government.

Wood, P. (2012). *Socio-intercultural Placemaking, socio-intercultural cities.* www.coe.int/socio-interculturalcities

# Chapter 23
# UNESCO, Idanha-a-Nova, and the UNESCO Creative Cities Network:
## A Multilevel Approach to the Local Implementation of the SDGs

**Julijana Nicha Andrade**
*Federal University of Minas Gerais, Brazil*

## ABSTRACT

*The chapter's main objective is to study the city's rising role as a driver for implementing the 2030 SDGs and UNESCO Creative Cities Network's part as UNESCO's mechanism to support cities in the effort. The results show that there is a changing nature of authority in the policy cycle on a more holistic level, where alongside the nation-state, international organizations and cities play a vital role in the problem definition, decision-making, agenda-setting, transfer, and implementation of policies. The increasing importance of cities internationally stretches the municipal policy cycle from the local to regional, national, and international levels. Orchestration complemented with an inter-organizational relations framework is used to study the case of Idanha-a-Nova UNESCO Creative City of Music. The case study shows that Idanha-a-Nova drove the implementation of the SDGs locally with the Portuguese state's support. However, because it lacked expertise and mechanisms of implementing the goals, it reached out to private consultancy and individual experts.*

## INTRODUCTION

The local implementation of the Sustainable Development Goals (SDGs) has proven to be the biggest challenge on the international level (Harris, 2020; Fischer, 2020). For the effective implementation of the Goals, local municipalities and actors need to be heavily involved in the process, one that was for-

DOI: 10.4018/978-1-7998-8482-8.ch023

mulated and adopted on the UN level. So, how a decision that was taken on the international level can be actioned on the local level?

The public policy literature has taken a nation-state approach to the policy process, assuming that the nation-state is the only actor that can formulate and implement public policies (Reinicke, 1998; Baltodano, 1997; Lerner & Lasswell, 1951). The new governance model of development goes beyond the nation-state and adopts a non-hierarchical way of policymaking where the nation-state is not the only actor, as is the case with the Sustainable Development Goals. The decision was made on the international level, but the transfer and implementation are done on a municipal level. Hence, alongside the state, IOs and cities play an active role in the policy process (Bulkeley & Schroeder, 2011; Stone, 2008; Faria, 2018). These three-fold relations pave the way for new governance mechanisms, such as orchestration, that allow for steering state behavior through intermediary actors (Abbott et al., 2015).

In that context, the UN acts through its institutions in the UN System to promote, diffuse and implement the SDGs. Nation-states are still the central actors that approved and adopted the SDGs. However, as Kamau, Chasek, and O'Connor (2018) show, the negotiation process was not the simplest. The Goals' implementation on a state level is more coordinative by providing the institutional mechanisms rather than executive (OECD, 2017). As the 2030 Sustainable Development Goals focus on endogenous development and stress the crucial role of culture towards achieving it, the UN agency for culture, UNESCO, has taken an active role in promoting the Goals. UNESCO then supports the Goals through various programs, but the most prominent one is the UNESCO Creative Cities Network (UCCN). The UCCN's primary mission is to implement the Sustainable Development Agenda via policymaking and promotion of standardized policies by sharing best practices for urban development (UNESCO, 2019). The UNESCO Creative Cities Network is a platform where cities share best practices for cultural and urban policies and support each other functionally.

In the orchestration framework, cities act as intermediaries to UNESCO, which is their orchestrator, and cities steer the state's behavior towards implementing policies supporting SDGs on a local level (Figure 1). Cities are becoming drivers of the SDGs' implementation because they have UNESCO's ideational support and the local governance mechanisms to act upon the SDGs. The orchestration framework is complemented with the literature on inter-organizational relations to dig deeper into the multilevel governance arrangements among UNESCO, the city, and the nation-state. The inter-organizational relations address relations on the international, national, individual, bureaucratic, and inter-institutional levels. Particular importance is given to the individual and inter-institutional levels as those where the interaction on different levels occurs. This framework explains how the city acts as an intermediary in implementing the SDGs locally without compromising the national policymaking process. The data gathering and analysis are done via document analysis, in-depth case study, and informative interviews with the key stakeholders when data from the document analysis was missing. The theoretical framework is applied to the city of Idanha-a-Nova in Portugal. After setting the theoretical framework and gathering the data, the information collected was put within the research framework.

Idanha-a-Nova is an insightful case study as a territory rich with cultural heritage and the actor's interaction on multiple governance levels to make the territory and the cultural heritage the backbone of its development. Idanha-a-Nova became UNESCO Creative City of Music in 2015. Idanha-a-Nova is also one of the smallest city members at UCCN. Its focus is on sustainable rural development, a relatively new topic to UCCN as previously only bigger cities focusing on urban development were members. The Title has given the town greater authority to act as a cultural expert on the international level and attract further national and international funding and tourists.

*Figure 1. Causal relationship: The city as an intervening mechanism to implement UN`s SDGs nationally*
*Source: Personal elaboration*


This chapter's main objective is to study cities' rising role as drivers for implementing the 2030 SDGs and UNESCO Creative Cities Network's (UCCN) part as UNESCO's mechanism to support cities in the effort. Furthermore, the chapter aims to discuss the changing nature of authority in the policy cycle on a more holistic level. Alongside the nation-state, International Organizations (IOs) and sub-national entities play a vital role in the problem definition decision-making, agenda-setting, transfer, and implementation of policies. The increasing importance of cities and city-regions internationally stretches the municipal policy cycle from the local to regional, national, and international levels.

The chapter is organized in the following manner. The first section gives a high-level overview of the current literature on the SDGs and UNESCO and UCCN's role in attaining them. Moreover, it elaborates on global cities' literature, orchestration, and inter-organizational relations on multilevel governance among cities, nation-states, and International Organizations. It then focuses on the cities' role in global public policies and their shift to more active participation in implementing the SDGs via the UNESCO Creative Cities Network. The second section covers the inter-organizational relations among UNESCO, the UNESCO Creative Cities Network, Idanha-a-Nova, and Portugal. Their relations are studied on the international, national, regional, individual, bureaucratic, and inter-institutional levels. The following section offers some solutions and recommendations of how the UCCN can overcome its urban and Eurocentric approach to creative city membership. The final section opens the floor for further research and concludes. The concluding remarks are in terms of the city's role in the different governance levels, particularly its role as a leading global policy actor that promotes and implements the SDGs.

## BACKGROUND

The intensification of globalization and multilateralism made once state-specific challenges global. Issues such as climate change, hunger, unemployment, poverty are not unique to one place. These global challenges were to be addressed on an international level via the Millennium Development Goals. They were the first attempt for global public policies for development. However, due to their exogenous approach to development and numerous other shortcomings (Awortwi & Musahara, 2016; Fehling et al., 2013; Kamau, Chasek & O'Connor, 2018), they failed to offer sustainable solutions for the shared problems. The Sustainable Development Goals were created to fill in those gaps. They were unanimously adopted at the UN General Assembly and expected to be implemented at all levels and government spheres (Kamau, Chasek & O'Connor, 2018).

The SDGs consist of 17 Goals and 163 Targets. They are interdisciplinary and universally applicable, regardless of the country's level of development. Besides their universality, the UN recognizes the national priorities and challenges for achieving them. The SDGs are voluntary and non-legally binding, but all UN member states are expected to implement them via national frameworks for sustainability. The Sustainable Development Goals take a whole government approach covering all aspects of sustainability – environmental, cultural, and human. They represent a new paradigm for development because they stress the importance of the environment and urbanization and highlight the means of attaining sustainable societies (explained in Goal 17). They are unique because they emphasize that culture, creativity, and innovation can change the urbanization ideas from the traditional high-waste approach to an inclusive, environmentally friendly, and user-centered approach.

The monitoring of SDGs is on voluntary self-reporting to the United Nations High-level Political Forum[1] . However, as the Goals and National review reports are not binding, the UN relies on the goodwill of the country's representatives to deliver them.

UNESCO is the UN specialized agency for Education, Science, and Culture. It is also the oldest and most active international organization that perpetuates cultural initiatives, mostly on heritage and traditional arts. Most recently, following the global trend on innovation and creativity, UNESCO has become one of the most active actors supporting these kinds of initiatives (Duedahl, 2016). Moreover, UNESCO is the only IO with an operational reach to each member state via the UNESCO National Commissions. The National Commissions execute on UNESCO's mandate and promote and support its programs on national and local levels (UNESCO, 2012). They collaborate closely with governmental and non-governmental institutions, and through the Commissions, UNESCO has enabled a free flow of information and expert knowledge (Duedahl, 2016).

As mentioned above, UNESCO has modified the UNESCO Creative Cities Network (UCCN) mission to accommodate the promotion and implementation of the SDGs locally. The UCCN emerged in 2002 to foster partnerships in cultural industries for development in developing countries. In 2004 the first city became its member, the city of Edinburgh as a City of Literature. Currently, 246 cities from more than 80 countries that are UN member-states are UCCN members (UNESCO, 2020). Regardless of its size, a city can apply for one of the following categories: crafts and folk art, design, film, gastronomy, literature, media arts, and music by presenting an implementation plan. After the acceptance, the city receives ideational assistance to implement the plan and participates in the respectful thematic sub-network.

The UCCN has become very popular, and membership at the Network has become more competitive because as members, cities get to use the UNESCO logo and their cultural-specific title. As a cultural expert, UNESCO transfers its legitimacy to the cities through the Creative City Title's endorsement and the right to use UNESCO's logo. Via the formal UNESCO recognition, the IO also validates the cultural activities of cities nationally and internationally. The Title is important for cities because they can introduce policies and lobby for high-level institutional changes, and increase cities' social role to attract support from the local civil and private sectors (Matovic et al., 2018).

The UCCN has been criticized for its week oversight of the SDGs implementation. Cities run the risk of gentrification, i.e., changing traditional spaces by bringing in affluent businesses and residents and increasing the cost and standard of living in the area (Lee, 2018). Moreover, as UCCN members are primarily concentrated in Europe, sharing best practices runs the risk of being Eurocentric and not directly applicable to the different local structures. Therefore, the knowledge sharing among cities could run towards uniformity. That would also lead to a lack of flexibility and inclusion of cultural diversities into mainstream cultural policies. (Matovic et al., 2018).

## The Rise of the City as a Policy Actor

Most of the world's population lives or seeks migration to urban areas. The UN estimates that by 2050, 66% of the world's population will live in cities (UNESA, 2018). The future economic, social and territorial development of countries will be determined by the type of development cities implement (Vaz & Reis, 2017). Problems caused by industrialization (such as over-urbanization, unequal development, uncontrolled gentrification, urban bias, and regional inequalities) have triggered the implementation of urban development strategies to find solutions (Pires et al., 2017; UNESA, 2018).

Creative Cities are cities or towns where the economy and urban development actively rely on culture, creativity, and innovation. Moreover, the 2008 financial crisis opened new opportunities for cities and city-regions to become more active actors in multilevel governance (Le Galès & Harding, 1998). Cities could not merely rely on government funding; hence they started reaching regional and international funds. The creative city model considers cultural policies in entrepreneurial turn (Vieira de Jesus, 2017); such examples are local incentives for socio-cultural entrepreneurship, start-up companies in culture and the arts, local and indigenous communities, usage of sustainable materials, etc. The creative cities create networks among themselves and share best or good practices, norms, and ideas, diffusing the global policies.

The literature refers to world cities or global cities to the ones that are: centers of large commercial enterprises, multinational corporations, hubs of advanced services, and places that are generally marked with deeply segmented social spaces, with extremes of poverty, wealth, social life, and division of labor (Hall, 1966; Castells, 1996; Friedmann & Wolff, 1982; Sassen, 1991; Knox, 1995). Although size-terms definitions are conflicting, they all agree that global cities dominate world affairs (Potter & Lloyd-Evans, 1998). White (2010) argues that the economic, cultural, and creative development of small and medium-sized cities has been understudied in the world cities literature. The European Union has been at the forefront of recognizing rural development based on the same development principles. As part of the strategy for regional development, the EU considers small and medium cities to be "centers for public and private services, as well as for local and regional knowledge production, innovation and infrastructure (…) essential for avoiding rural depopulation and urban drift, and are indispensable for the balanced regional development, cohesion and sustainability of the European territory" (European Commission, 2011, pp. 4).

Cities as administrative loci mean that they are part of the nation state's territory and the complex structural positions. These positions are multiple and overlapping networks of regulation and governance, in which nation-state power is embedded (Brenner, 1998). The city operates in the institutional structure of the nation-state. Furthermore, the city facilitates intergovernmental and intragovernmental relations, but it does not challenge the nation-state's authority (Lipschutz, 1997). The city provides the institutional arrangements for the policy transfer and implementation through the decentralization of administrative, fiscal, and political processes on the municipal level (Biela et al., 2012, Moisio & Paasi, 2013; Salet et al., 2003).

Cities can sign treaties and contracts without involving the central state. With that, cities can influence the nation-state's external relations (affecting regional or general trade, investment, and other policies) from within (Duchacek, 1990). Cities engage in international relations primarily via paradiplomacy. Vieira de Jesus (2016) argues that economic and cultural paradiplomacy should not be understood in terms of division but in promoting the local cultural diversity to attain competency in the global market. He shows that creative cities benefit from practicing cultural paradiplomacy by attracting foreign investment by promoting the local cultural attractiveness and tourism, technical cooperation for the development of their cultural and creative industries, and program partnerships that create the basis for them to compete as a creative city. Moreover, cities use the IO's influence to enter the global market of cultural and creative goods (Vieira de Jesus, 2016).

Some scholars argue that there is a decline of the nation-state (e.g., Ohmae & Ōmae, 1995) because it loses its bargaining power from international organizations and corporations. A more productive line of thinking argues that what occurs is a restructuring of intergovernmental relations. The transfer of powers and responsibilities is diffused among different governmental and international levels (e.g., Scholte, 2000; Brenner, 1999). Territorial organization of power goes beyond the nation-state (Jessop, 2005; Haas, 1992; Stone, 2008). The state remains a central institutional matrix of political power and territorial organization. The presentation of a dualistic choice between the life and death of the state's role in multilevel governance disregards the qualitative reshaping of territoriality and sovereignty (Anderson, 1996) and its fluid nature (Branner, 1998).

Koops (2017) argues that the nation-states' design and influence still matter because they are the central actors in international politics by facilitating negotiations, providing resources, etc. All these processes occur on the national level, which set the foundation for developing global public policies and inter-organizational relations on multiple levels. Nation-states are still key actors locally and internationally, and a group of other actors is as well. The nation-state can delegate responsibilities and authority in the mode of interactive participation rather than opposing forces (Lipschutz, 1997).

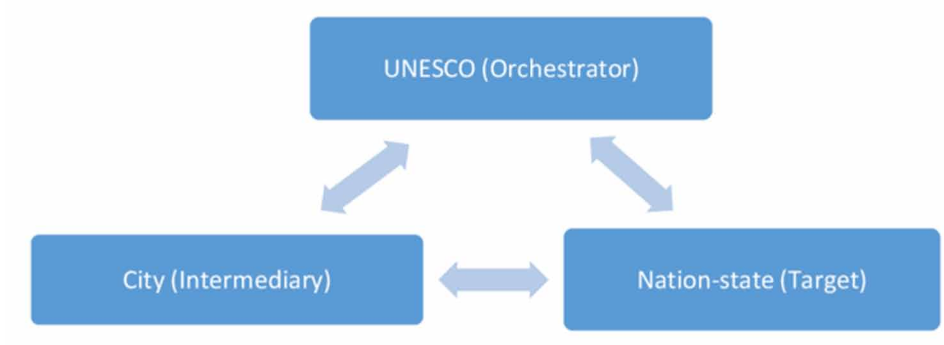
The current turn of globalization that promotes city development is reconfiguring the nation-state, but it does not create a new city-centric economic model. Nation-states and cities operate simultaneously, and the cities are the ones that push and implement the global trends on the nation-state level. Nation-states promote cities as nodes of transnational capital (Jessop, 1990; Haas, 1992). IOs then engage directly with sub-national units to transfer and implement the global public policies on local or national levels.

Bulkeley (2005) argues that the complex interconnection among the different scales of governance has been ignored by scholars who have followed the classic, independent decision-making process (cascaded decisions from international to national and finally local institutions). IOs and cities' role as dynamic actors in the policy process has been understudied in the literature. Instead, their interconnection lies in hybrid governing arrangements that operate in networks on multiple levels (Bulkeley & Betsill, 2005).

Koops and Biermann (2017) argue that the relations among International Organizations, member-states, and other actors should be seen as a multilevel phenomenon involving various actors and players at different levels of analysis. Furthermore, they argue that while the literature on International Relations has focused on the three units of research – the international system, the nation-state, and the individual – the relation amongst the actors should study the bureaucratic and the inter-institutional levels to comprehend the inter-organizational relations (Koops & Biermann, 2017).

The international level refers to the processes, dynamics, ideas, and opportunities in the international system that directly affect the cooperation or competition between the organizations. The member-state level refers to the influence of national key decision-makers, processes, and interests on the national level. The individual level refers to the impact of critical decision-makers or officials negotiating inter-organizational relations, such as ambassadors, officials, policy advisors, etc. Here we need to add the importance of transnational actors and experts who are not necessarily part of the institutions but affect the decision-makers and the policies shape (Oliveira & Pal, 2018; Koops, 2017). The bureaucratic level stresses the importance of actors working in the administration and the international organization's established structures. Finally, the inter-institutional or inter-secretariat level refers to the jointly estab-

*Figure 2. Relations between UNESCO, nation-state, and the city in the orchestration framework*
*Source: Personal elaboration.*




lished institutions, systems, and processes among the organizations created to facilitate their relations, such as steering committees, liaison offices, and other institutions that exchange formal and informal processes and influences.

The literature on inter-organizational relations is helpful, but it still adopts a nation-state approach. In other words, it hasn't considered sub-national units as independent decision-making bodies and the bureaucratic and inter-institutional level of actors operating on the municipal and international level, as in the case of UNESCO's engagement of cities. Moreover, the literature has not even studied UNESCO besides the fact that it has established inter-organizational relations (Biermann & Koops, 2017). Orchestration theory is then beneficial when trying to better understand the power relations among the three actors (Figure 2).

UNESCO's legitimacy as an orchestrator is in its expertise. UNESCO is the first International Organization to publish reports and promote the creative economy and creativity-related policies globally and locally. UNESCO has a strong orchestrator focality because it is a governance leader in culture and the creative industries (Kozymka, 2014). UNESCO has differentiated itself from other IOs by stressing the importance of culture, creativity, and innovation for achieving the SDA. Jørgensen refers to differentiation as "to an organization's active effort to build up its own image, identity and reputation" (2009, pp. 174). This explains why the UNESCO Creative Cities Network has expanded very rapidly since 2004 – its focality has allowed attracting a large number of municipalities, which has further helped the Network to maintain and enhance its central role in cultural policies and the creative industries.

As an orchestrator, UNESCO and the UN have limited capabilities to implement the SDGs on a national level because they strictly follow the principle of sovereignty. For that reason, it is a feasible strategy for UNESCO to engage cities as intermediaries. Intermediaries are engaged voluntarily and are key players in orchestration because they have governance capabilities, such as local information, technical expertise, enforcement capacity, material resources, legitimacy, and direct access to the targets that IOs lack. As a result of this relationship, IOs gain and further straighten their expertise and legitimacy. UNESCO has limited direct involvement on the local level but instead supplies ideational assistance to municipalities to implement and manage policies and programs for creativity and innovation to achieve the SDGs.

The intermediary is crucial for the policy implementation stage because its effectiveness depends on the local institutions, resources, and authorities (Caplan, 2005). Cities are suited intermediaries because they manage the policy transfer by identifying the local vulnerabilities, implementing plans and programs, and mobilizing the local actors (private, public and mixed partnerships). As an intermediary, the city strengthens its paradiplomatic activities (Duchacek, 1990), promotes itself internationally, and gains ideational assistance from UNESCO (Abbott et al., 2015). The city gets access to the pool of resources available in the UCCN and expert knowledge directly from UNESCO to implement the SDGs.

The role of individual actors is not to be undermined as institutions are made up of people. Mayors, local experts, artists, academics are all international actors that interact in physical and virtual spaces and act as policy diffusers.

The nation-state then accepts the orchestration and its role as a target because it doesn't need to invest resources in the SDG's implementation because it lacks the overall necessary expertise that UNESCO has, and it is institutionally distant from NGOs or other entities on local levels to implement the SDGs effectively. Moreover, nation-states do not oppose UNESCO orchestration because they have ratified the SDGs and committed to their international achievement. UNESCO then collaborates with the city and indirectly with the nation-state to manage their behavior. Due to the nature of the Goals, there is a broader goal convergence among the three actors. These relations straighten UNESCO's role and authority as a global governance actor and a leading IO for cultural and creative policies.

The next section of the chapter elaborates on the case of Idanha-a-Nova UNESCO Creative City of Music. It expands on UNESCO's detailed interaction as the orchestrator, Idanha-a-Nova as an intermediary, and Portugal as the target by studying the inter-organizational relations between the different actors involved in the application for the Bid and the gaining of the Title.

## The case of Idanha-a-Nova, UNESCO Creative City of Music

Idanha-a-Nova is one of the biggest Portuguese municipalities, which has 13 parishes. The district of Idanha-a-Nova is a territory of historical significance, founded in 1$^{st}$-century b.c. and has been governed by the Romans, the Germanic tribe, the Visigoths, the Muslims, the Christians, etc. The municipality organizes touristic tours around the remaining of the rich history and a walk in the rich nature, which is the first Portuguese municipality to take part in the International Network of Bio Regions (History, 2018). Idanha-a-Nova is rich in material and immaterial cultural heritage and natural reserves such as the Biosphere Reserve of the International Tagus and the UNESCO Naturtejo Geopark. Idanha-a- Nova is also famous for the Cultural Center Raiano, the region's most prominent music venue.

The town has strong historical ties with culture and music. The municipality's logo is based on the local percussion instrument called Adufe, traditionally played by women. Besides the rich history, the district has faced large migration towards the cities or abroad, and only the elderly population stayed. This demographic change caused social and economic stagnation.

Recently, however, it has become an attractive place for young families and people who seek a more sustainable lifestyle. The city's membership to the UNESCO Creative Cities Network and its independent events such as the Boom festival and numerous other festivals for food, beverages, eco-consciousness has made it a vibrant hub for culture, creativity, and innovation.

*Table 1. Detailed list of actors and programs involved in the inter-organizational relations between UNESCO, the Municipality of Idanha-a-Nova, and the Portuguese government*

| Inter-organizational level of interaction | Orchestrator – UNESCO | Intermediary- Idanha-a-Nova | Target – Portugal |
|---|---|---|---|
| **International** | UN Global Compact Network | National Association of Portuguese Municipalities; twinning; bilateral relations | Ministry of Foreign Affairs; The Interministerial Commission for Foreign Policy; Ministry of Planning and Infrastructures; Camões Institute |
| **Regional** | Education 2030 Framework for Action; Creative Europe | European Regional Development programs | Creative Europe; Strategy Europe 2020; Summer Academy on Cultural and Creative Industries and Local Development |
| **National** | 15 UNESCO Sites; "United Nations Decade of Education for Sustainable Development- Contributions to its implementation in Portugal" | CCI in Rural Spaces Program | Ministry of Culture; Regional Cultural Directories; Major Options for the Plan; National Strategy for SD |
| **Municipal** | Capacity-building programs in education and heritage. | Municipal Centre for Culture and Development | Whole of government approach of the SDGs on a national level |
| **Individual** | Clara Cabral (UNESCO National Commission) | Paulo Longo dos Santos (Head of the Department of Culture, Municipality of Idanha); Armindo Jucinto (mayor) | Augusto Santos Silva (Minister of Foreign Affairs);António Nóvoa (permanent delegate); Jose Cabral (chairman National Commission) |
| **Bureaucratic** | UCCN administration in Paris | Department of Culture at the Municipality of Idanha-a-Nova, Commission Candidacy | UNESCO field office staff |
| **Inter-institutional** | UNESCO National Commission | UCCN Steering Group | UNESCO National Commission at the Ministry of Foreign Affairs |

Source: personal elaboration

## Inter-Organizational Relations during Idanha-a-Nova's UNESCO Creative City Bid and Title

The study of the application process for the Bid of the UNESCO Title and the involvement of actors from different levels present an in-depth understanding of the role of Idanha-a-Nova in implementing the SDGs and its regional and international stretch (Table 1).

Idanha-a-Nova's Municipal Center for Culture and Development closely worked with civil society and private consulting companies to complete the UNESCO Creative Cities Network Bid application. The application for membership of the Municipality Idanha-a-Nova was partly motivated to solve the migration problem and re-branding of Idanha-a-Nova as a creative hub (Silva, Babo & Guerra, 2015). Idanha-a-Nova is UNESCO City of Music since 2015. That year, 47 cities from 33 countries joined the network, where Idanha-a-Nova was the first Portuguese city of music. Currently, 26 international cities of music are sharing best practices via the UNESCO sub-network of Music.

The Municipality of Idanha-a-Nova took the initiation for the Bid. The Bid arguments were based on previous cultural and creative activities that the Title would later straighten. Additionally, the region's strong music tradition and music events were also used to construct the argument.

The leading applicant team was composed of a Commission Candidacy made of the private consultancy IPI Consulting Network and a Working Group. They advised the members of Idanha-a-Nova's Municipality on the application process. IPI Consulting Network holds know-how in various areas, heritage, culture, creative industries, regional and local development, micro-businesses and entrepreneurship, environmentalism, etc., expertise that the municipality laked. IPI Consulting Network enjoys a wide range of clients, primarily local and regional Portuguese government institutions (IPI Consulting Network, 2019). The Working Group was composed of national and international consultants from the music sector and the creative industries.

The Portuguese National Commission for UNESCO is part of the Ministry of Foreign Affairs. In an interview, they state that they didn't act as consultants because they didn't accompany the application for candidacy but just gave their letter of support. Interestingly, all employees at the National Commission are part of the Portuguese bureaucracy. All are Portuguese nationals who need to oversee UNESCO Conventions, programs, projects, and ideas in Portugal. The National Commission thus is the joint body through which the direct interaction between UNESCO and Portugal occurs. In an interview with Clara Bertnard Cabral from the Culture Sector of the Portuguese National Commission for UNESCO, she informs that the candidacy of Idanha-a-Nova at UCCN was the first one from a Portuguese city, so the Commission was pleased to endorse Idanha with a support letter. Besides the endorsement letter, the Portuguese National Commission did not offer any other ideational or material assistance (Cabral, personal communication, September 2019).

After the successful gain of the Title, the person who took the lead for the coordination and management of the Idanha-a-Nova UNESCO Creative City of Music Title is Paulo Longo dos Santos (Image 1). He is the Head of the Department of Culture at the Municipality of Idanha-a-Nova. In an interview with him, he didn't seem comfortable sharing the team's name and contacts that supported the office or the team responsible for writing the candidacy (Santos, personal communication, November 2019). Longo mentioned that it was the municipality's initiative to apply for membership at UCCN. Since 2015, they see the membership benefits, but how he didn't want to comment (personal communication, October 2019).

Moreover, Longo argued that the application for candidacy is an internal document, and thus he wouldn't share it (personal communication, October 2019). Overall, there is a lack of transparency because as the application for candidacy is not publicly available (as it is in most UCCN members), there is no way of knowing the complete list of people involved. From newspaper articles and public statements, we can find out the names of some people involved in the candidacy process. Among them were the Director of the National Music Conservatory Ana Pernão, the ex-Ministers of Education Marçal Grilo and Guilherme de Oliveira Martins, the ex-minister of Culture Pedro Roseta, and the ex-President of the Republic Jorge Sampaio (Lusa, 2014). However, what was their specific involvement is difficult to know.

Other actors indirectly involved with the achievement of UCCN objectives but aligned with the municipal plan is The Municipal Centre for Culture and Development (Centro Municipal Cultura e Desenvolvimento). Moreover, the Association for Local Development supports start-ups and entrepreneurship in culture and innovation for regional development by offering courses, project coordination, and other services (CMCD, 2019). Other entities were the Portuguese Association of Music Education, The Music Syndicate, the Professionals of Spectacles and Audio-visual, the Portuguese Commission for UNESCO, and the UNESCO Cities of Music Mannheim, Bologna, Sevilha, and Hamamatsu (Lusa, 2015).

The UCCN Title was legalized by being integrated into Portugal's national law, and locally, the municipality of Idanha-a-Nova altered the municipal mission. As commitments to the change, there are broad statements, such as technical follow-up agreements, joint evaluations, lessons learned, action plans,

*Figure 3. Idanha-a-Nova's logo as UNESCO City of Music*
*Source: Cities of Music. Retrieved from: https://citiesofmusic.net/city/idanha-a-nova/*


etc. However, besides the fact that Goal 11 stresses the direct link between urbanization and cultural policies, there hasn't been an actual intersection among the Ministries in Portugal.

As a Network member, Idanha-a-Nova's objective is to brand the city and invest in increasing audiences and further investing in music education through building infrastructures and offering entrepreneurial support. As mentioned above, the Idanha-a-Nova UNESCO City of Music Office is headed by the Department of Culture at the Municipality of Idanha-a-Nova, and the municipal bureaucrats coordinate the Title. After winning the membership, the existing bureaucrats took on the additional task to accommodate the new needs of coordinating the UCCN objectives locally (Longo, 2019).

In an interview for a newspaper, the president of the City Hall of Idanha-a-Nova Armindo Jacinto, the Mayor of Idanha-a-Nova at the time, says that the application for UCCN membership was challenging because, in Portugal, there isn't much information on how to fill in the UCCN applications in Portugal (Lagoisa, 2015). Additionally, the UCCN's approach to development was urban, and until then, it didn't support many rural development plans. Besides the lack of experts on how to fill in the application, the application team's challenge was writing a Bid that uses urban-style development to a rural area.

Since 2015, most cultural activities are joined under the UNESCO City of Music Title, including the projects: Idanha Green Valley[2], Idanha Experimenta, Idanha Vive, and Idanha Made In. The program RESTART (RECOMECAR) is a mid-term strategy (2015-2025) that includes all the projects and the initiative to apply for membership at the UCCN. RESTART is a city-branding and regional development program formulated with the consultancy agency International Bloom Consulting and 52 local stakeholders. It aims to attract people who seek alternative and more sustainable lifestyles to move to or open their business in Idanha-a-Nova and encourage the diaspora's return (Municipio de Idanha, 2021). An evaluation study of the strategy conducted in 2018 shows that 348 business projects were initiated that resulted in 312 new working spaces and a direct investment of 30 million Euros. This initiative ties into the quest for creating sustainable production and consumption and embed healthy habits in the local population. As Yildirim (2020) argues, consumer's contribution towards sustainable development is critical. The municipality supports green markets, second-hand shops, and the production of bio-friendly products to create a truly sustainable cycle of local production and consumption.

Idanha-a-Nova invests in city-branding, cultural tourism via gastronomic, natural, and heritage sites and for those reasons has established the following programs: the Commercial Centre of Idanha-a-Nova, Support Pavilion for small and medium enterprises, Rural Incubator, Creative Industries Incubator, and i-Danha Food Lab (Municipio de Idanha, 2021).

The municipality of Idanha-a-Nova publishes its mid-term strategy and budget allocation in the Plan of Major Options. In 2018, this plan stated that sustainable development, the attraction of creative talent, and investment in the cultural industries is the top priority (Municipio de Idanha, 2021). In the 2019 publication, the municipality has further narrowed its focus on the investment in heritage, culture, and science, favoring easier access to culture, entertainment, and leisure. The plan's key guidelines try to balance the region's urbanization and preserve the natural environment via policies for a circular economy, low commercialization, water-based energy, investment in agriculture, and biological products promotion.

Idanha-a-Nova paradiplomacy has been most active in the last ten years. Idanha-a-Nova has created direct cultural activities through 'twinning' with Petres (Spain), Vert-le-Grand (France) and Condeixa-a-Nova (Portugal) (Associação Nacional de Municípios Portugueses, 2019). Moreover, Idanha-a-Nova has cross-national policies with Spain on sustainability and culture, including Naturtejo Geo Park, Por Terras Rayanas, Oralities Common Heritage, Alliance of Euro-Mediterranean Cultural Cities (AVEC), Portuguese Historical Sites, etc. (Municipio de Idanha-A-Nova, 2021). In terms of infrastructure, it promotes regional cohesion via the integration of the Transeuropean Network of Transports (Ibid).

Idanha-a-Nova has won numerous international recognitions and awards. In 2018, Idanha-a-Nova won a second-place competition for the category "Place Brand of the Year" with Barcelona, Edinburgh, and Tallinn. The City/Nation/Place Awards, sponsored by the New York Times, gave the award. At the same event, Idanha-a-Nova was given a special award by the city of Eindhoven recognizing the importance of the program "Restart in Idanha" (Recomeçar em Idanha) (City/Nation/Place Awards, 2018).

On a national level, the SDGs implementation is an action point on Major Options' Plan (Grandes Opções do Plano). The Plan blends national, economic, and social planning structures and underpins economic and social development policy's strategic orientation. The Plan is also formulated by the European Strategy of Sustainable Development and the National Strategy for Sustainable Development (Camara Municipal, 2018). Portugal has taken an active role in the coordination and drafting of the 2030 Agenda. However, its implementation at the national level brings new challenges which require some reshaping of institutional models to reflect and meet the inherent cross-sectorial coordination requirements. Accordingly, the Council of Ministers has adopted the first intra-governmental guidelines for the 2030 Agenda in 2016. The Inter-ministerial Commission for Foreign Policy acts as the headquarters and forum for inter-ministerial coordination, both for implementing the SDA and preparing the reports that will support national, regional, and global monitoring processes. The National Statistics Institute also plays a key role in monitoring the progress made in fulfilling Agenda 2030 by overseeing and producing the data for the monitoring progress. Considering the need for close alignment between the internal and external coordination and the mandatory component of a structured dialogue with the United Nations bodies, the Ministry of Foreign Affairs took on a general coordination role and the Ministry of Planning and Infrastructures (SDGs, 2017). The Voluntary National report on the implementation of Agenda 2030 for Sustainable Development was issued by the Ministry of Foreign Affairs and presented at the United Nations High-Level Political Forum in 2017. There it is highlighted that the Portuguese SGDs strategic priorities Golas 4, 5, 9, 10, 13, and 14.

Concerning the contribution to the UCCN Global Management, Idanha-a-Nova has taken part in all UCCN annual meetings. Paulo Longo (Longo, 2019) stresses the importance of sharing best practices for sustainable development among rural regions. Also, he highlights the vital role small and medium cities play in the development process and considers them crucial stakeholders in the regional and global networks for development. He quotes the cases of Boom Festival and Festival Save the Planet as the most effective best practices about sustainable development and creativity (Longo, 2019).

Portugal's membership in the European Union heavily influences the push for rural development. Portugal takes part in the Culture Programme (2007-2013) and Creative Europe (2014-2020), offering funds and prices related to heritage, the cultural and creative industries, and the arts. The Portuguese regional development is in line with Strategy Europe 2020, promoting inclusive, sustainable, and intelligent growth[3]. The "Portugal 2020- Reviving the Economy with EU's Help" is a project funded by the European Fund for Regional Development, which informs the general public about European funds in agriculture, culture, social inclusion, etc. The four-pillar program is based on smartness and competitiveness, sustainability and efficiency, inclusion and human capital, and place-based approach and governance (Cavaco et al., 2015). The main aim of Portugal 2020 is to encourage regional cooperation within and outside Portugal (Portugal 2020, 2019).

The URBACT program, part of the European Regional Development Fund, has been the European Territorial Cooperation program to foster sustainable integrated urban development in cities across Europe. It is an instrument of the Cohesion Policy, co-financed by the European Regional Development Fund. URBACT's mission is to enable cities to work together and develop integrated solutions to common urban challenges by networking, learning from one another's experiences, drawing lessons, and identifying good practices to improve urban policies (Cavaco et al., 2015; Cavavo, 2015). Idanha-a-Nova also benefits from the EU's material assistance for local development and implementation of the SDGs. The municipality has directly benefited from the EU Fund for Rural Development and EU's structural funds (Ibid). A project example that benefited from these funds is the Technological Park Vale do Tejo, which joins professionals from different areas that contribute towards developing the creative ecosystem, promotes cultural events, and generates employment opportunities and a positive impact on the regional economy.

Portuguese municipalities are pretty active in communicating among themselves and with cities and regions from other countries. The National Association of Portuguese Municipalities, founded in 1984, facilitates these relations by promoting, defending, and representing the Local Governments and Municipal Associations within the country and abroad. The institution represents the Portuguese municipalities at the Council of Europe and promotes the European Regional Development programs, decentralization, and greater autonomy nationally (NAPM, 2021). Moreover, Portuguese cities have organized themselves regionally via the Forum of Cities (Forum das Cidades), which is formed as part of the Strategy for Sustainable Cities 2020 to make cities more sustainable. To achieve the SDGs, small and medium-sized cities have connected via the Strategic Program of the Creative Cities Network to share best practices. This is a network of Portuguese self-declared creative towns, inspired by the UNESCO Creative Cities Network, where Idanha-a-Nova is also part (Forum das Cidades, 2016). It aims to foster cooperation between local authorities for knowledge and experiences on innovative and good practices to improve municipalities' economic and social efficiency (Ibid).

## SOLUTIONS AND RECOMMENDATIONS

UCCN Eurocentric approach and lack of support for rural areas in the application process was a challenge for Idanha-a-Nova, which was overcome by the joined effort of different individual actors across the public and private sector. It is interesting to note that Portugal is an EU member state, but it still lacked the expertise to fill in the application independently. UCCN's effort to encompass a larger pool of diverse cities is very recent. It still has a long way to go, working with experts from rural and developing countries to create a suitable format for their local structures. UCCN could create a cross-functional sub-group of cities and towns working on rural development that can share best practices and support other rural areas that want to become part of UCCN.

## FUTURE RESEARCH DIRECTIONS

This chapter opens few fronts for further research.

Firstly, private actors and individual experts' role in implementing the SDGs in Idanha-a-Nova needs to be further explored. Due to the limited access to publicly available documents and the limit to interview other actors, this chapter falls short of digging even deeper and identifying transnational actors' roles as experts who spread international ideas.

Secondly, it is not only the EU that influences Portugal's regional development. The involvement of other international actors such as OECD also needs to be investigated. OECD has also established plans for the creative industries, which is tied to Portuguese universities and individual scholars. Hence, further exploration of the OECD's assistance towards implementing the SDGs and their interaction with UCCN is needed.

Thirdly, further research on UCCN city members that focus on sustainable rural development is needed. This chapter only touched upon this topic while covering the case study of Idanha-a-Nova, but further, deeper comparative analysis among the UCCN city members that focus on sustainable rural development is needed.

Fourthly, the UCCN membership's impact on the local development needs to be assessed and Idanha-a-Nova's progress in achieving the SDGs. This chapter focused on the institutional path of the local implementation of the SDGs, but it did not measure the impact of the SDGs-related programs on the local development. Additionally, inter-ministerial cooperation on the Goals needs to be further investigated even though there isn't a central way of measuring the Goals' success (see Risse, 2017).

## CONCLUSION

The chapter takes an interdisciplinary approach by merging the literature on public policy, institutionalism, and international relations. The need for bridging the distances among the scholars lies in the fact that the international and the local are coming close very rapidly, but the literature has not caught up with these fast processes. Institutions and processes on all levels have expanded the internationalization of global public policies and trends, and the idea of creative cities has spread very rapidly due to that. Those relationships produce a different form of authority outside of the traditional sovereign state model (Stone, 2008; Faria, 2018).

This chapter's main objective was to address the rising role of cities as drivers for implementing the 2030 SDGs and the UNESCO Creative Cities Network as UNESCO's mechanism to support cities in the effort. From Idanha-a-Nova's case, we have seen that Idanha was at the forefront of rural development and an inspiration for other cities to follow suit. Even though Idanha had always had some central government support, the local public sector's initiatives and the local civil society and private actors drove the SDGs' implementation locally. As a UCCN member, Idanha-a-Nova helped the central Portuguese state to get a step closer towards implementing the SDGs and served as a poster child for rural development. Idanha-a-Nova's Reviver program is an example of an initiative that uses cultural and creative industries to attract the creative capital into Idanha-a-Nova, promote a sustainable lifestyle and capitalize on its rich cultural traditions. These findings support the orchestration theory as Idanha-a-Nova did have the local know-how and resources to implement policies and programs related to the SDGs, abilities that UNESCO, as an International Organization with a small office in Paris, would have. What this case study also shows us is that the target, or the Portuguese nation-state, in this case, was not opposed but supportive of the orchestration to occur.

We can conclude from the inter-organizational relations that the Portuguese government adopted the SDGs, and it is a voiced supporter. However, locally in the rural context, it could not support the municipal authorities for their implementation. What happened, in reality, is that the municipality of Idanha-a-Nova reached out to a private consultancy group to assist them in the bid process. Hence, even though the Portuguese state is supportive of the Goals, it lacks expertise and mechanisms of implementing them, and the cities (local actors from different sectors) are the drivers for their implementation.

From Idanha-a-Nova's case, we can notice a change in authority in the policy cycle because alongside Portugal, Idanha-a-Nova, and UNESCO, as an extension of the UN (Table 2). Idanha-a-Nova's international presence did not compromise the national policy process. The SDGs were defined and decided on an international level, and even though Portugal did have a say, it was a collective decision on an international level. The state's transfer and implementation were facilitated by the state via laws and statements but were effectively implemented by the municipality and the local actors. Even though the Portuguese representation at the UN voted the Goals, the problem definition and decision making were taken on an international level, the agenda-setting, the transfer, and policy implementation were done locally. Locally though, the city of Idanha-a-Nova was the one that set the priorities on the agenda (rural development, migration, sustainability), and the local level influenced Portugal's unique approach to sustainability and development with a focus on rural development and the blend of traditional knowledge with modern practices. This change has motivated Idanha-a-Nova's paradiplomatic activities and has put the city on the international map of creative and sustainable cities.

The transfer and implementation phase of the policy cycle has been until recently almost ignored by the literature. These phases allow new actors or straighten old ones' roles to be effective agents of international agreements' execution. Alongside the city, transfer agents (Stone, 2004), such as consultants, speakers, the private sector, and those organizing or funding an event, are the "new frontier" of policy transfer and diffusion because they provide the scientific justification of the policy formulation (Oliveira & Pall, 2018). It is difficult to draw the line if they are private or public actors because they fluctuate in between. They operate in networks, such as epistemic communities that share intellectual and scientific discourse (Stone, 2004; Haas, 1992). The same goes for mayors who attend international conferences, participate in paradiplomatic activities, and learn about best practices. The local administration's political aspect should be considered besides the commitment to implement the goals on a national level. The political will on the municipal level matter because they can enable or block the SDA implementation

*Table 2. Global policy cycle for cultural policies specific to innovation and creativity orchestrated by UNESCO*

| Policy cycle | Actors | | |
|---|---|---|---|
| | **UNESCO** | **City** | **Member-state** |
| **Problem definition /** | x | | x |
| **agenda-setting** | | x | x |
| **Formal decision-making /** | x | x | x |
| **policy transfer** | | x | x |
| **Policy implementation** | | x | x |
| **Monitoring and evaluation** | x | | |

Source: Personal elaboration

(Oliveira & Pall, 2018). The role of cities in global public policy and the global path towards sustainable development matters, and their role needs to be further stressed in the academic literature.

## REFERENCES


Abbott, K. (2015). *International Organizations as Orchestrators*. Cambridge University Press.

Anderson, B. (1991). *Imagined Communities: Reflections on the Origin and Spread of Nationalism*. Verso.

ANMP. (2021). Available at https://www.anmp.pt/

Awortwi, N., & Musahara, H. (2016). *Implementation of the Millennium Development Goals. Progresses and Challenges in Some African Countries*. Engelska.

Baltodano, A. P. (1997). The Study of Public Administration in Times of Global Interpenetration: A Historical Rationale for a Theoretical Model. *Journal of Public Administration: Research and Theory*, *7*(4), 615–638. doi:10.1093/oxfordjournals.jpart.a024368

Biela, J., Hennl, A., & Kaiser, A. (2012). Combining Federalism and Decentralization: Comparative Case Studies on Regional Development Policies in Switzerland, Austria, Denmark, and Ireland. *Comparative Political Studies*, *45*(4), 447–476. doi:10.1177/0010414011421767

Brenner, N. (1998). Global Cities, Glocal States: Global City Formation and State Territorial Restructuring in Contemporary Europe. *Review of International Political Economy*, *5*(1), 1–37. doi:10.1080/096922998347633

Bulkeley, H., & Betsill, M. (2005). Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change. *Environmental Politics*, *14*(1), 42–63. doi:10.1080/0964401042000310178

Bulkeley, H., & Schroeder, H. (2011). Beyond state/non-state divides: Global cities and the governing of climate change. *Climate Change and Governance.*, *18*(4), 743–766.

Caplan, R. (2005). *International Governance and War-Torn Territories. Rule and Reconstruction*. Oxford University Press. doi:10.1093/0199263450.001.0001

Castells, M. (1996). The Rise of the Network Society. Volume 1 of The Information Age: Economy, Society and Culture. Blackwell.

Cavaco, C. (2015). *Cidades Sustentáveis 2020*. DGT.

Cavaco, C. (2015). *Urban Analytics: Accelerating the Development of Smart cities in Portugal*. GDT. Available at: https://www.dgterritorio.pt/urbananalytics2015

City/Nation/Place Awards. (2018). *Finalists announced*. Available at: http://cityofmusic.cm-idanhanova.pt/noticias-e-agenda/city-nation-place-awards.aspx

CMCD. (2019). *Centro empresarial*. Available at: http://www.cmcd.pt/empreendedorismo/centro-empresarial/

Duchacek, I. D. (1990). Perforated sovereignties: toward a typology of new actors in international relations. In H. J. Michelmann & P. Soldatos (Eds.), *Federalism and international relations: the role of subnationalunits* (pp. 1–33). Oxford University Press.

Duedahl, P. (2016). A History of UNESCO: Global Actions and Impacts. Palgrave Macmillan UK. doi:10.1007/978-1-137-58120-4

European Commission. (2011). *Cities of tomorrow - Challenges, visions, ways forward*. Available at: https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/citiesoftomorrow/citiesoftomorrow_final.pdf

Faria, C. A. P. de. (2003). Idéias, conhecimento e políticas públicas: um inventáriosucinto das principais vertentes analíticas recentes. *Revista Brasileira de Ciencias Sociais*, *18*(51), 21-30.

Fehling, M., Nelson, B. D., & Venkatapuram, S. (2013). Limitations of the Millennium Development Goals: A literature review. *Global Public Health: An International Journal for Research, Policy and Practice*, *8*(10), 1109–1122. doi:10.1080/17441692.2013.845676 PMID:24266508

Fischer, D. (2020). *The challenges of implementing the Sustainable Development Goals in Asia*. EU. Available at: ttps://europa.eu/capacity4dev/articles/challenges-implementing-sustainable-development-goals-

Forum das Cidades. (2016). *Rede De Cidades Criativas*. Available at: https://www.forumdascidades.pt/content/rede-de-cidades-criativas

Friedmann, J., & Wolff, G. (1982). World city formation: An agenda for research and action. *International Journal of Urban and Regional Research*, *6*(3), 309–344. doi:10.1111/j.1468-2427.1982.tb00384.x

Haas, P. (1992). Introduction: Epistemic communities and international policy coordination. *International Organization*, *46*(1), 1–35. doi:10.1017/S0020818300001442

Hall, P. (1966). *The World Cities*. Heinemann.

Harris, E. (2020). *The Changing Global Context for SDG Implementation – Challenges and Opportunities.* UN. Available at: https://www.un.org/en/desa/changing-global-context-sdg-implementation-%E2%80%93-challenges-and-opportunities

History. (2018). The Goths and Visgoths. *The History Channel*. Available at: https://www.history.com/topics/ancient-rome/goths-and-visigoths

IPI Consulting Network. (2019). Available at: http://www.ipiconsultingnetwork.com/en/domains-of-activity/economy-of-culture-creative-industries-and-tourism

Jessop, B. (2005). Critical Realism and the Strategic-Relational Approach. *New Formations: A Journal of Culture*. *Theory and Politics*, (56), 40–53.

Jørgensen, K. E. (2009). *The European Union and International Organizations*. Routledge. doi:10.4324/9780203884416

Kamau, M., Chasek, P., & O'Connor, D. (2018). *Transforming Multilateral Diplomacy: The Inside Story of the Sustainable Development Goals*. Avalon Publishing. doi:10.4324/9780429491276

Knox, P. (1995). World cities in a world-system. In P. Knox & P. Taylor (Eds.), *World Cities in a World-System* (pp. 3–20). Cambridge University Press. doi:10.1017/CBO9780511522192.002

Koops, J., & Biermann, R. (Eds.). (2017). *Palgrave Handbook of Inter-Organizational Relations in World Politics*. Palgrave Macmillan. doi:10.1057/978-1-137-36039-7

Koops J. A. (2011). *The European Union an Integrative Power: Assessing the EU's Effective Multilateralism Towards NATO and the United Nations*. Brussels: VUBPress.

Kozymka, I. (2014). *The Diplomacy of Culture: The role of UNESCO in Sustaining Cultural Diversity*. Palgrave Macmillian. doi:10.1057/9781137366269

Lagiosa, J. (2015). *Idanha-a-Nova formaliza candidatura a Cidade da Música da UNESCO*. Beiranews. Available at: https://beiranews.pt/2015/07/idanha-a-nova-formaliza-candidatura-a-cidade-da-musica-da-unesco/

Le Galès, P., & Harding, A. (1998). Cities and states in Europe. *West European Politics*, *21*(3), 120–145. doi:10.1080/01402389808425260

Lee, K. (2018). *GENTRIFICATION: Changing Neighbourhoods for Better or Worse*. Available at: https://www.democratsabroad.org/bc_gentrification_changing_neighborhoods_for_better_or_worse

Lerner, H., & Lasswell, D. (1951). *The Policy Sciences: Recent Developments in Scope and Method*. Stanford University Press.

Lipschutz, R. D. (1997). From Place to Planet: Local Knowledge and Global Environmental Governance. *Global Governance*, *3*(1), 83–102. doi:10.1163/19426720-00301005

Lusa. (2014). *Idanha-a-Nova candidata-se a Cidade da Música da UNESCO*. Publico.pt. Available at: https://www.publico.pt/2014/11/19/culturaipsilon/noticia/idanhaanova-candidatase-a-cidade-da-musica-da-unesco-1676776

Lusa. (2015). *Óbidos e Idanha-a-Nova entram na rede de cidades criativas da UNESCO*. Publico.pt. Available at: https://www.publico.pt/2015/12/11/culturaipsilon/noticia/obidos-entra-nas-cidades-da-literatura-da-unesco-1717150

Matovic. (2018). *Creative Cities Mapping Creativity Driven Cities. 12 Good Practices from UNESCO Creative Cities Network*. Deusto Cities Lab Katedra.

Moisio, S., & Paasi, A. (2013). Beyond State-Centricity: Geopolitics of Changing State Spaces. *Journal of Geopolitics*, *18*(2), 255–266. doi:10.1080/14650045.2012.738729

Municipal, C. (2018). *Orçamento e Grandes Opções do Plano 2018*. Available at: https://www.cm-idanhanova.pt/institucional/financas-locais/documentos-previsionais/2018.aspx

Municipio de Idanha. (2021). *Official website*. Available at: https://www.cm-idanhanova.pt/

OECD. (2017). *Getting Governments Organised to Deliver on the Sustainable Development Goals*. Available at: https://www.oecd.org/gov/SDGs-Summary-Report-WEB.pdf

Oliveira, O., & Pal, L. (2018). New frontiers and directions in policy transfer, diffusion and circulation research: Agents spaces, resistance, and translations. *Brazilian Journal of Public Administration*, *52*(2), 199–220. doi:10.1590/0034-761220180078

Pires, R. (2017). Cidades Criativas de Pequena Dimensão e Contextos Rurais: A Perspectiva da Cidade de Ponte de Sor. *V CongresoInternacional de Ciudades Creativas*. Available at: https://www.researchgate.net/publication/311401396_Cidades_Criativas_de_Pequena_Dimensao_e_Contextos_Rurais_A_Perspectiva_da_Cidade_de_Ponte_de_Sor/stats

Portugal 2020. (2019). Available at: https://www.portugal2020.pt/

Potter, R., & Lloyd-Evans, S. (1998). *The City in the Developing World*. Routledge.

Reinicke, W. (1998). *Global Public Policy- Governing without Government?* Brookings Institution Press.

Risse, N. (2017). *Getting up to speed with to implement the SDGs: Facing the Challenges*. SDG Knowledge Hub. Available at: http://sdg.iisd.org/commentary/policy-briefs/getting-up-to-speed-to-implement-the-sdgs-facing-the-challenges/

Salet. (2003). *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions*. Spon Press.

Sassen, S. (1991). *The Global City*. Princeton University Press.

SDGs- Inter-Agency and Expert Group on SDG Indicators. (2017). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. United Nations Statistical Commission.

Silva, A. S., Babo, E. P., & Guerra, P. (2013). Cultural policies and local development: The Portuguese case. *Portuguese Journal of Social Science*, *12*(2), 113–132. doi:10.1386/pjss.12.2.113_1

Stone, D. (2008). Global Public Policy, Transnational Policy Communities, and their Networks. *Policy Studies Journal: the Journal of the Policy Studies Organization*, *36*(1), 19–38. doi:10.1111/j.1541-0072.2007.00251.x

UNESA. (2018). *68% of the world population projected to live in urban areas by 2050, says UN.* Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UNESCO. (2012). *Directories of National Commissions*. Available at: https://en.unesco.org/countries/national-commissions#:~:text=Presently%2C%20there%20are%20199%20National,within%20the%20United%20Nations%20system

UNESCO. (2019). *What does it mean to be a UNESCO Creative City?* Available at: https://en.unesco.org/creative-cities/sites/creative-cities/files/uccn_faq-en.pdf

UNESCO. (2020). *Creative Cities Network*. Available at: https://en.unesco.org/creative-cities/home

Vaz, D., & Reis, L. (2017). From City-States to Global Cities: The Role of Cities in Global Governance. *E-Journal of International Relations.* Available at: https://www.redalyc.org/html/4135/413553386002/

Vieira de Jesus, D. S. (2017). A arte do encontro: A paradiplomacia e a internacionalização das cidades criativas. *Revista de Sociologia e Politica*, *25*(61), 51–76. doi:10.1590/1678-987317256104

White, P. (2010). Creative industries in a rural region: *Creative West:* The creative sector in the Western Region of Ireland. *Creative Industries Journal*, *3*(1), 79–88. doi:10.1386/cij.3.1.79_1

Yildirim, S. (2020). The Consumer Role for Sustainable Development: How Consumers Contribute Sustainable Development Goals. In V. Chkoniya, A. O. Madsen, & P. Bukhrashvili (Eds.), *Anthropological Approaches to Understanding Consumption Patterns and Consumer Behavior* (pp. 325–341). IGI Global. doi:10.4018/978-1-7998-3115-0.ch018

## KEY TERMS AND DEFINITIONS

**Global Public Policy:** Multilevel global processes of flows and networks involving national, international and transnational actors.

**Inter-Organizational Relations:** The study of complex formal and/or informal interconnections between and among organizations involving various actors on multiple governance levels.

**Orchestration:** Coming from a constructivist perspective, the orchestration framework complements the Principle/Agent model. Orchestrators are entities that have ideational or material resources but lack enforcement capacities. For that reason, they operate via intermediaries who do have enforcement capacities for the end goal of steering or changing the behavior of a specific target.

**UNESCO Creative Cities Network:** UNESCO membership-based network of cities whose sustainable urban development is heavily dependant on a specific cultural area.

## ENDNOTES

1. High Level Political Forum on Sustainable Development which is a subsidiary body of the United Nations General Assembly and the United Nations Economic and Social Council responsible for the entire organization's policy on sustainable development.

2 Idanha Green Valley is a project linked to knowledge and innovation in rural areas and to its global positioning; Idanha Made In supports everything that is produced locally; Idanha Experimenta allows interested parties to get to know and experience the municipality of Idanha-a-Nova; Idanha Vive provides conditions of quality of life for those who live or intend to live in Idanha-a-Nova.

3 Portuguese government relies on European funds for regional development: (i) the European Structural and Investment Funds, which cover investment in infrastructure, energy, research and innovation and direct and indirect financing of small and medium-sized enterprises; (ii) the Investment Plan for Europe, which covers strategic investments in key areas such as infrastructure, energy, research, innovation and risk financing for small and medium-sized enterprises; (iii) the Connecting Europe Facility, to finance resilient networks and infrastructure in the transport, telecommunications and energy sectors; and (iv) Horizon 2020, which funds research and innovation for the implementation of all SDGs.

# Chapter 24
# The Digital Brand Marketing in the Azores Archipelago: New Paths for the Enhancement of Sustainable Regional Development

**Gaulter Couto**
*Universidade dos Açores, Portugal & CEEAplA, Portugal*

**Pedro Pimentel**
*Universidade dos Açores, Portugal & CEEAplA, Portugal*

**Sérgio António Neves Lousada**
https://orcid.org/0000-0002-8429-2164
*Universidade da Madeira, Portugal*

**Rui Alexandre Castanho**
https://orcid.org/0000-0003-1882-4801
*WSB University, Poland*

## ABSTRACT

*The ultra-peripheral Portuguese region of Azores is considered one of the EU outermost regions. This insular region is widely recognized as a sustainable nature-based destination. Its remoteness and breathtaking landscape attributed the region a label of adventure tourism by global references as Bloomberg, Departures, BBC, Forbes, GeekyExplorer, Lonely Planet, among others. In this regard, this type of tourism incorporated with the digital marketing generated around it is seen as a vital channel for inspiring sustainable regional development. Consequently, it is possible to verify that the digital marketing created around this new typology of tourism along with the Azores' singularity as a destination could significantly influence the local socio-economy base to the sustained development growth of the region. Furthermore, it was identified that the most reasonable opportunities for slow and nature-based tourism were located in rural tourism.*

DOI: 10.4018/978-1-7998-8482-8.ch024

## INTRODUCTION

The Global Sustainable Tourism Council (GSTC), based on the Sustainable Development Goals (SDGs), defines a *sustainable tourism destination* as achieving a multi-year destination strategy that is fully available. Also, this destination should be suited to its scale, and respect environmental, economic, social, cultural, quality, health, safety, as well as aesthetic issues, enabling a development based on public participation (Couto *et al.*, 2020).

In this context, the Insular Portuguese Region of Azores matches several of those principles. The Azores Archipelago is considered by the European Union (EU) one of the Ultra-peripheral territories or Outermost Regions (OR). Also, if there are numerous barriers to overcome in this ultra-peripheral Region, the Azores' strategic location has conferred extraordinary regional growth and development possibilities - i.e., the potential for Slow development and Nature-Tourism in the Region (Pimentel *et al*., 2020).

Besides, this type of tourism venture is an indispensable channel for achieving the so-desired regional sustainable growth and territorial sustainability. Consequently, the current preliminary research intends to provide additional knowledge of the ongoing multidisciplinary strategies and projects to achieve sustainable development in the Azores Archipelago through investment in digital brand marketing.

So, in the first stage, this study will be based on a literature review about brand marketing, destination, digitalization, sustainable development, and regional growth. After, an empirical approach will take place regarding the implications of the Azores Archipelago future if investments in digital brand marketing will be considered.

## THE BRAND MARKETING CONCEPT: A BRIEF OVERVIEW

Brand marketing, generally speaking, is the enterprise's product-specific image through a means of a profound reflection into the hearts of consumers (Malhotra, 2012). Also, brand marketing refers to the enterprise through the use of consumer demand for products, and then use the product quality, culture, and unique publicity to create a brand in the hearts of users to recognize the value of the final form of brand effectiveness marketing strategy and process (Wang, 2015). Thus, it uses various marketing strategies to make the target customer form the cognition-recognition-recognition of enterprise brand and product and service through marketing (DaCunha, 2014, Talpau, 2012). Moreover, according to Khedher (2015): "(...) *brand marketing from the high level is the image of the enterprise, visibility, good reputation, and so on display to consumers or customers in the eyes of customers and consumers to form a product or service brand image of the enterprise, this is brand marketing*".

The fundamental point of brand marketing is to find a differentiated personality for the brand - which can profoundly affect the core of the brand value of consumers. Also, it allows consumers to quickly identify and remember the interests of the brand and personality, drive consumer identity, even love a brand's main strength (Lub, 2015). The premise of brand marketing is the quality of products to ensure that consumers are recognized (Chaffey, 2012). Brands are based on tangible products and intangible services. Visible refers to the new packaging product, unique design, and the name of the rich symbolic attraction (Aaker, 2013).

The service is in the sales process or after-sales service to the customer satisfaction feeling, letting them experience real "God" happiness. It is based on the idea: "Let them always feel that the choice to buy this product is the right decision" - buy happy, with ease (Keller, 2013). Looking at the market, with the current technical means to promote the view, the current quality of the product is almost, from the standpoint of consumers, they are often the value of businesses can provide services and how effective (Cooper, 2013).

From the long-term competition, the establishment of brand marketing is necessary for the long-term development of enterprises. For enterprises, to meet their interests and consider customer satisfaction, pay attention to win, win lifelong customers (Yudkin,2014).

A brand identifies enterprises, products, and services and a kind of intangible assets reflecting the comprehensive strength and management level of enterprises, which plays a vital role in the commercial war. (Porter, 2005). For an enterprise, only the use of brands, operating brands, to win the market. Under the global commodity market, the competition of the product has transited to brand competition. Therefore, actively carry out brand marketing for all enterprises are urgent (Tan, 2014).

## The Seven Brand Marketing Elements

(i) **Quality is uppermost** - Any product, long-lasting, vigorous vitality comes from stable, reliable quality. We take drugs that are closely related to the life of the public to illustrate that, like a particular product, the consumer's expectation of quality (curative effect) is relatively high, thus leading to a high degree of loyalty and abandonment of the brand. Once the patient is approved of a drug, its purchase and use of the behavior will likely be long-term, such as well-known safflower oil, Bao Ji pill, and other traditional brands with a long history. On the contrary, even if only one failure of the experience, the patient may henceforth "into some league, never to use" (Zhang, 2014).

(ii) **Honesty first** - People without faith, the same brand loss of integrity, will eventually go far. In addition to product-market attributes and life cycle factors, the more important reason is that the former relies on down-to-earth, integrity-based, the latter relies on flashy advertising and virtual concept hype, time is to test the integrity of the ruler (Zhang, 2014).

(iii) **Accurate positioning** - Market positioning is the heart of the whole marketing. Indeed, successful brands have a feature, that is, in a consistent form of the brand's function and the psychological needs of consumers to connect, and the brand positioning of the information accurately conveyed to consumers. Market positioning is not the action of the product itself but the creative thinking of the existing products and the psychological action of the potential consumers. Consequently, the extraction of the most interesting competitive points for the target population and a specific means to convey to consumers, and then into the emotional understanding of consumers, brand marketing is a crucial link (Guo, 2015).

(iv) **Specific character -** A successful brand will never exaggerate its role and effect. Moreover, like personality, distinctive, and unique appeal, it is easier to get consumer identity. Brand image is accompanied by these catchy slogans and quickly established (Zhang, 2014).

(v) **Ingenious communication** - Focusing on the market competition, only communication can produce a differentiated brand competitive advantage. In the 80s, simple advertising is enough to build a brand. In the 90s, the overwhelming amount of advertising investment can also prop up a brand. Today, the creation of the brand is far from so simple, in addition to the above four aspects as a solid base, unique product design, excellent advertising creativity, Reasonable forms of expression, appropriate media, the best time to invest, perfect promotional mix, and so on many aspects are inseparable. Contextually, the leading cause is the absence of careful integration of marketing planning ideas; nature will not fully experience the effect of market communication (Zhang, 2014).

(vi) **Set up a brand -** A brand is a symbol; in fact, it is a symbol that combines multiple essential information of an enterprise. The enterprise's reliability, culture, products, quality, science and technology, potential, and other relevant information condensed into a brand symbol, and attempt to shape its broad social perceptibility and reputation, branded to the public heart, therefore, that products with brand symbols into the heart of consumers. The method is to build a brand. The brand's alphanumeric substance is not calculated according to its investment. Strong brand, low input, high income. The resulting high profits, many times more than the market average. The brand is the image, is the prestige, is the asset. A brand is a yardstick to measure the social credibility of enterprises and their products. Brand competitiveness is the core competitiveness of enterprises. Global economic integration, market competition depends on brand competition. (Zhang, 2014)

(vii) **The brand marketing significance** - the durability of enterprises, should be tight throughout the corporate brand advertising strategy, no matter what kind of marketing, are to their brand of implant communication, brand promotion, shape the corporate brand image, brand marketing (Lindsey, 2013).

So, the establishment of a good brand to have higher perceptibility and have a more reliable reputation. The realization of brand marketing has a special significance, concretely manifests in which aspect: the strength maximization, through the sharing, lets each participant become the stakeholder, no longer is indifferent, the armchair, from the past brand holder exerting power independently to become the stakeholder to work together, the marketing thrust and the demand-pull direction is consistent, according to the principle of mechanical synthesis, the ultimate force is the most natural (Solomon, 2013).

Contextually, the efficiency maximization, due to the past interest, does not care about sales transfer into the current common concern. Thus, that passive marketing into active marketing, stakeholders, can be the more favorable treatment of work, natural labor is the most provincial, more efficient. Particularly in the past, consumers who are indifferent to brands convert into brand stakeholders, and the research, investigation, and marketing industry are no longer anywhere near, and efficiency is naturally exceptional (Laws, 2012).

Furthermore, the risk minimization, by stakeholders to share the market risk, the risk of their respective natural minimum, especially the active participation of consumers interaction, commercial product development is the easiest to achieve. At the same time, everyone's benefits are relatively uniform, easy to united, the coefficient of internal friction risk will be considerably reduced; also, in each marketing node, the cost minimization, from the original brand holders to pay costs to the various stakeholders to pay their costs, from the past brand operators to control costs alone into the various stakeholders to control costs. Thus, it enables the stakeholders to obtain more plausible profits (Armstrong, 2014).

## DIGITALIZATION AND BRAND DESTINATION

Technological progress and the emergence of the empowered tourist/traveler imply that in the future, the most prosperous destinations will be those that leave the traditional top-down path in support of bottom-up and co-created branding approaches. Accordingly, a simple tourist or traveler is an influential creator of the destination brand. Moutinho *et al*. (2013) state that: "*the advancement of technology can, without doubt, be viewed as a threat to tourist destinations and their branding process.*" Also, developments on the Internet and social media have enabled the addition of immeasurable quantities of information, from landscape descriptions to pricing, accommodation rating, and scandals, with an impact on the image of destinations (Moutinho, 2013). It is widely accepted that digital destination branding has enhanced more complex and challenging (Munro, 2011). Thereby, nowadays, it is necessary to distinguish between a traveler and a tourist. According to the World Tourism Organization (WTO), a traveler goes between different geographic locations for any purpose and any duration. On the other hand, a visitor is a particular type of traveler, and subsequently, tourism is a subset of travel. In this regard, a tourist is classified as a tourist (or overnight visitor) if his/her trip includes an overnight stay in a particular place.

Travelers and tourists of all ages increasingly use digital technologies to research, explore, interact, plan, book, and ultimately share their travel experiences. There is an extensive array of online channels available to use for this purpose. Together with the shift towards traveler empowerment, these channels are demanding new strategies in destination branding initiatives. According to Pan et al. (2007), the impact of word of mouth on tourists'/travellers' decision-making process is uncertain and needs to be investigated through new methods. In addition, digital communities and traveler-generated content are creating significant opportunities to unobtrusively obtain data to investigate the realm of tourists'/ travellers' experiences and sentiments (Volo, 2010).

Tourism planners and destination managers now have the opportunity to connect with customers at many more communications and experience touchpoints than ever before to influence visitor satisfaction, loyalty, and word of mouth. A *destination brand* can be defined as the sum of all narratives and experiences.

Although the approach to destination branding did not appear in the literature until the end of the 90s (Pike, 2004); it has become increasingly valuable, which is due not only to the need for destinations to create an identity unique to differentiate themselves from their competitors (Hudson, 2009). Instead, it shows changes in consumer behavior (Baker, 2008).

The significance of branding for tourist organizations or destinations is highlighted through the following (Baker, 2008): a) tourism involves complex purchasing decisions and is highly involved by consumers so that the brand can reduce the choices available to consumers; b) branding can help offset the intangibility effects of the tourism product, especially if combined with a positive experience; c) branding can communicate consistency in a sector that is sensitive to variation in experience; d) branding can act as a risk reduction mechanism for choosing a "weak" destination; e) given the intimate nature of the tourist product, the brand can help ensure tourist satisfaction and thus facilitate the segmentation process; f) from the viewpoint of supply, branding can contribute to greater motivation and teamwork among stakeholders since the results to be achieved are common and attempt to benefit all parties involved.

Thereby, the branding of the tourist destination is a complex concept that is based on different products, services, and experiences and that relies on the management of different stakeholders - i.e., tourism industry, public sector, government, DMO's (Destination Management Organizations), and the local population (Konecnik, 2008).

To be successful, a destination's brand must be credible, differentiating, transmitting powerful ideas, involving the stakeholders and partners of the destination, and interacting with visitors (Cooper, 2008; Morgan, 2004).

According to Pike (2005):

*"(…) the positioning of branding through the DMO's represents a complex challenge in several aspects: destinations have a more dimensional character than consumer goods and other types of services; they have to take into account the different interests of the stakeholders, the DMO's are targeting different*

*geographic markets seeking to attract different segments that may be interested in the different types of products in the destination (…) decision-making policies are challenging to manage, since the destination encompasses both public and private organizations; an attempt is made to reach a consensus between the resident population and branding theories, given that the DMO's do not have complete control over the destination, with the involvement of residents in the image of the destination being crucial, since they also interact with tourists (…) fidelity to the destination is another aspect to be taken into account, this can be measured through the repetition of the view to the destination, monitored by the DMO (…) finally, financing is often a problem for the DMO."*

Therefore, the concept of destination branding is crucial for the destination to be identified and differentiated from the other alternatives present in the target market's mind (Qu, 2011). Destination branding, in addition to other stakeholders, seeks to interact with the destination's residents. Also, taking into account receptivity is an essential element. It seeks to reach tourists who receive information from different sources because when they visit the destination, they interact with products and services and evaluate the destination brand (Cooper, 2008).

## REGIONAL DEVELOPMNET AND SUSTAINABILITY

The term 'sustainable development' was firstly presented in the global policy discussion by the World Strategy for Nature. In fact, it was instituted as a new world model after 'Our Common Future,' the final report of the Brundtland Commission (Spangenberg, 1995, 2000; Amado, 2009; Castanho, Couto, and Santos, 2021).

This development is often defined as the process of satisfying the requirements of today without risking the necessities of future generations without limiting their possibilities to plan the territory in their own way (Castanho *et al.,* 2017; Ulucak, Yücel and Koçak, 2019; Castanho, Couto, and Pimentel, 2020).

According to Castanho, Couto, and Santos (2021), the sustainable development is *"(…) no longer a choice, but a necessity of us all. In fact, if we look to prosper as a society, and probably as a specie, there is no alternative instead of opting for a typology based on a sustainable development and growth*".

The idea of sustainable development is extensive and wide and is sustained on three fundamental pillars economic, social, and environmental (Loures, Santos, and Panagopoulos, 2007). The effects of these pillars are very dynamic and multifaceted (Castanho, Couto, and Santos, 2021; Castanho *et al*., 2021). Additionally, to its versatility, sustainable development's continuous nature makes it challenging to comprehend and evaluate the problem in full. Hence, sustainable development should be measured with sufficient economic, social, and environmental indicators and indices applying suitable techniques (Amado, 2009; Castanho, 2017).

In this regard, we emphasize the three main pillars of sustainable development: economic, social, and environmental.

Thus, according to Spangenberg (2000), the economic pillar could be seen as "(…) *a particular subsystem of society, which due to its features such as the specific logic of efficiency along with the short-term time frames, permits us to understand human beings as a profit-maximizing individual*". Thus, sustainability demands an economic system that meets the requirements of its populations, endeavoring enough employment and rejuvenating its population to address these services in the long term (Spangenberg, 2000). Therefore, to satisfy these requirements, the economic system's competitiveness must be a fundamental part of the concept of sustainability and for regional development (Spangenberg, 1995; Couto et al., 2021). Furthermore, it can be extrapolated away from this classification and incorporate regional and local economic development paradigms, such as land-uses and land covers, the real estate market, and numerous others (Castanho *et al.,* 2018; Codosero Rodas *et al*., 2020).

The social sphere usually refers to public policies that support social challenges. Social problems are related to our shared well-being and prosperity, including healthcare, education, housing, or employment, just a few examples (Loures, 2011; Lousada et al., 2018). They guarantee that individuals do have access to social assistance; they do not be affected by the lack of knowledge of their rights and practice a responsible contribution to social services and policies, as on a local scale as in a national (EU, 2020). Besides, many authors affirm that the institutional dimension should be strongly considered. For example, Jörg Spangenberg (2000) declares that:

*"Institutions are the success of the social interactions, along with established rules over the society, by the decision-making processes and their tools to apply such policies. So, the institutional dimension includes groups from civil society and the policy-makers, from the administrative system, and technicians".*

Accordingly, if we focus on a sustainable development attitude, it becomes apparent the importance of public participation, equality opportunities, no social discrimination, and stable political responsibility and transparency (Spangenberg, 2000; Castanho, 2020). The environmental pillar is described as the sum of all the bio-geological processes along with their constituents. Hence, it needs the preservation and conservation of the ecological systems as a natural basis to support the Anthropological sphere (Yigitcanlar, Dur, and Dizdarogluc, 2015; Kaletová et al., 2019).

Subsequently, through well-designed and accomplished planning strategies, the organization and interaction within societies and the environment may provide diverse advantages for cities and territories in different contexts. Additionally, the before-mentioned synergies support green areas with ecological and cultural heritage values, as is the preservation of biodiversity, prevention of the formation of heat islands in urban areas, amid various additional advantages (Labrianidis et al., 2003; Raposo et al., 2018).

## IMPLICATIONS OVER THE FUTURE OF THE AZORES ARCHIPLEAGO

An Intelligent Tourist Destination (ITD), according to Aenor (2016), is an:

*"innovative tourist space, accessible to all, consolidated on a state-of-the-art technological infrastructure that guarantees the sustainable development of the territory, facilitates the interaction and integration of the visitor with the surrounding environment, and increases the quality of their experience in the destination and the residents' quality of life."*

Reaching the ITD level requires work with some complexity, comprehensive, participatory, and properly structured. The detailed diagnostic process of the Azores in the search to identify the existing potential for its transformation into ITD revealed a long preparation work.

Based on extensive document analysis, namely the analysis of good practices, interviews with stakeholders in the sector, a technical process of self-diagnosis, and the construction of a SWOT matrix (Fundo de Maneio e Observatório do Turismo dos Açores, 2018), the following were demonstrated:

structural needs of the critical axes of the ITD, as defined by Segittur (2015): sustainability, innovation, technology, and accessibility.

Focusing on Sustainability, we found that it is the axis with the greatest maturity and degree of consolidation. The Azores have high rates of tourist sustainability, as demonstrated by several international awards, supported by multiple territorial management mechanisms and instruments, such as POTRAA (DRTur, 2019). However, there are still significant gaps, especially in the business sphere. Additionally, the increase in tourist pressure in recent years has caused new challenges to the sustainable management of the territory. It is critical to maintaining the integrity of natural resources, given the positioning of the Azores as a nature destination, in addition to the requirements imposed by the certification process as a ‘Sustainable Destination’ through the Global Sustainable Tourism Council (GSCT). The spatial planning itself faces some dilemmas, in a phase in which POTRAA (DRTur, 2019) is under review, needing to find sustained solutions to increase the tourist load in some places and attractions. This increase in activity in tourism has also brought other concerns, namely in the management of the balance in the coexistence between tourists and the local population and the territorial cohesion of the archipelago, and in the spread of the economic effects to all the islands.

In terms of innovation, consolidation is already lower, mainly due to the difficulty in transferring and incorporating new knowledge. The same happens with the introduction of new solutions in business activity but also in public administration. Technical difficulties arising from the lack of know-how and preparation are associated with the low qualification of the population and the lack and sensitivity to increasing performance, efficiency, and competitiveness. Thus, a low capacity for creating added value and presenting disruptive solutions or representing a significant degree of utility for the tourist, companies in the sector, and even the destination managers is continued.

Regarding technology, there was also a lack of maturity and preparation in several areas and the slow adoption of new technologies, both in public and private. In addition, there is no ‘base system’ that includes a technological infrastructure, optimized information system, and smart tools that enhance its use. This prevents the consummation of critical elements in smart tourist destinations, such as sensorization and permanent connectivity, as well as the collection, integration, and placement of big data (big data) at the disposal of the decision-making process and improving the tourist experience.

The Accessibility axis recorded the worst performance in the diagnostic process. It appears that the development of the Azores until recently did not include universal accessibility in the territory. There is, of course, an inadequate urban configuration, which results from development processes, constructive aspects, and even from the natural configuration of the territory itself. However, there are also relevant limitations on access to and enjoyment of natural spaces and several tourist attractions. Additionally, there is a lack of preparation of human resources to work with audiences with special needs, in a transversal way to all activities of the tourism sector, including catering, accommodation, tourist entertainment, public transport, and traditional commercial. In addition, there is inadequate preparation and availability of information, namely by digital means, which does not enhance the inclusion process.

As expected, the degree of consolidation of each of these axes has implications for developing the Azores as a tourist destination, affecting the preparation of a strategy to convert it into an ITD. There is, therefore, a need to carry out essential work in the construction of a structured value chain, which includes the basic infrastructure, the collection of data, the production of information, the generation of knowledge, the application of that knowledge in the system, educational and training, the transposition of cutting-edge know-how, and innovative practices for the destination decision, planning and management process, which in turn is adapted to the regional territorial and social reality and the consumption and enjoyment need tourist experience of visitors.

Adopting a reference model should be the first step towards the realization and operationalization of a DTI (Invat.tur, 2015). This essential principle was, in some way, introduced in the SMARDEST project, selecting the Segittur matrix (2015) as a source of guidance for the transformation process of the Azores. With the deepening of the work and the preparation of the self-diagnosis process, another possibility was explored, with the adoption of the model used by Invat.tur (2015) with the Valencian Community, given its greater operational focus. However, the overall results of the diagnostic analysis demonstrated the urgent need to define a specific model for the reality of the Autonomous Region of the Azores, mainly due to the immaturity and lack of preparation of the destination (Fundo de Maneio and Observatório do Turismo dos Açores, 2018).

For the idealization of a reference model leading to the transformation of the Azores into an ITD, several factors were considered, including the state of maturity of the Region as a tourist destination; its ability to generate and integrate intelligence; the resources available; and the potential that already exists for this process. There was a need to do some groundwork to directly respond to the challenges of the fundamental axes of ITD: sustainability, innovation, technology, and accessibility. In addition, it was considered pertinent to highlight the role of governance, given the evident need to mobilize stakeholders, adding the influence of the quadruple helix in this system as a factor of consolidation of the governance model. In this sense, to emphasize the regional reality, the whole process was framed in the tourism strategy of the Azores, namely through PEMTA (IPDT, 2016), POTRAA (DRTur, 2019), and RIS3 (SPI, 2014). Furthermore, standing out the interaction with the tutelage of the regional science and technology services, understood as an ideal mechanism to involve in avant-garde, technological, and scientific spirit issues as the one that underlies the concept of ITD. The action for materialization and practical implementation was also assumed, given the recurring difficulty of transposing strategic formulations to reality. Finally, the central role of the smart tourist as an information user and data generator was reinforced, without forgetting the intervention of companies and public administration in the entire system.

Thereby, the model defined for the Azores arises from a mixture between the fundamental base of Segittur (2015), the operational vocation of Invat.tur (2015), and the Region's paradigm. The proposed modeling thus defines the matrix on which the work of transforming the Azores into an ITD will be based on characterizing the optimal functioning of the system to be reached. Simplifying, it manages to reflect the application of the fundamental pillars of the ITD to the Region. However, it is duly guided by the reality and regional specificities and by leveraging existing mechanisms. It also reveals the essential line of the governance model, allocated to a specific entity, which should develop collaborative work with the various links of the quadruple helix of the tourism sector. Finally, it allows the perception of the most superficial layer of the action plan that will lead to the materialization of the strategy.

The strategy defined in the study of the *Fundo de Maneio and Observatório do Turismo dos Açores* (2018) was to assume the Azores as a destination of Nature per excellence and a living laboratory where technology and intelligence are placed at the service of the quality of the tourist experience and the efficiency of resources - enhancing the balance between the environment, competitive development, and internal cohesion.

To pursue the strategy, five strategic objectives were defined: to catalyze the process of transforming the Azores into ITD, enhancing the qualification of public agents and the active participation of private individuals; intensify the incorporation of innovative practices in companies and regional public administration, based on collaborative interaction with the Azores Science and Technology Service; optimize the integrated management of the territory and endogenous resources, contributing to their preservation and valorization, as well as to the cohesion of the islands; develop resources and inclusive practices that overcome the current service gaps and the conditions of the territory, facilitating greater accessibility to enjoy the Azores tourist experience; and to reinforce the use of cutting-edge technological resources to provide the Azores tourism sector with an adequate infrastructure for data management and its incorporation into decision processes of destination managers and tourists.

## FINAL CONSIDERATIONS

The proposal to convert the Azores into an ITD is based on a long-term vision. Also, the before mentioned is appropriately aligned with the regional strategy for the tourism sector. The aim is to prepare the destination and provide the internal equipment that responds to major international trends and the needs of smart tourists, consolidating the quality of the tourist experience without compromising the sustainability of regional resources. Contextually, in line with the strategic vision based on these principles, each of the central axes of the reference model, to which governance is added, supports the definition of five strategic objectives. In turn, these are supported by specific measures geared towards a consequent action plan.

## ACKOWLEDGMENT

This research is financed by the project GREAT—Genuine Rural Experiences in the Azores Tourism with the code: ACORES-01-0145-FEDER-000089.

## REFERENCES

Aaker, D. A., & Biel, A. (2013). *Brand equity & advertising: Advertising's role in building strong brands*. Psychology Press. doi:10.4324/9781315799537

AENOR. (2016). *Sistema de gestión de los destinos turísticos inteligentes*. Requisitos. Norma espanhola UNE 178501 elaborada pelo comité técnico AEN/CTN 178 - Cidades Inteligentes.

Amado, M. (2009). Planeamento Urbano Sustentável. Academic Press.

Armstrong, G., Adam, S., Denize, S., & Kotler, P. (2014). Principles of marketing (6th ed.). Melbourne: Pearson Australia.

Baker, M., & Cameron, E. (2008). Critical success factors in destination marketing. *Tourism and Hospitality Research*, *8*(2), 79–97. doi:10.1057/thr.2008.9

Castanho, R. A. (2017). *Sustainable Urban Planning in Transboundary Areas: Analysis of Critical Factors for Territorial Success* (Doctoral Thesis). University of Extremadura (UEx), Department of Vegetal Biology, Ecology and Earth Sciences.

Castanho, R.A. (2020). The Relevance of Political Engagement and Transparency in Cross-Border Cooperation (CBC) Environments. Analyzing Border cities in Europe. *Lex Localis - Journal of Local Self-Government, 18*(3), 487 – 502. . doi:10.4335/18.3.487-502(2020)

Castanho, R.A., Cabezas, J., Loures, L., & Fernández-Pozo, L. (2017). Evolution of Urban Planning Process in the Iberian Peninsula and his Footprints in Cityscape. New Challenges. *Monfragüe Resiliente – Scientific Journal, 8*(2).

Castanho, R. A., & Couto, G. (2020). Principles of Sustainable Tourism and Cultural Management in Rural and Ultra-peripheral Territories: Extracting Guidelines for its application in the Azores Archipelago. *Cultural Management: Science and Education*. doi:10.30819/cmse.4-1.01

Castanho, R. A., Couto, G., Pimentel, P., Carvalho, C., Sousa, Á., Graça Batista, M., & Garrido-Velarde, J. (2021). Os impactos da crise sanitária de COVID-19 sobre os Territórios Ultraperiféricos: O caso de estudo do Arquipélago dos Açores (Portugal) [The impacts of the COVID-19 health crisis on the Outermost Territories: The case study of the Azores Archipelago]. *Espacios, 42*(6), 104-116. doi:10.48082/espacios-a21v42n06p08

Castanho, R.A., Couto, G. & Santos, R. (2021). *Introductory Chapter: Rural Tourism as a Catalyst for Sustainable Regional Development of Peripheral Territories*. doi:10.5772/intechopen.96651

Castanho, R.A., Lousada, S., Naranjo Gómez, J.M., Escórcio, P., Cabezas, J. Fernández-Pozo, L. & Loures, L. (2018). *Dynamics of the Land Use Changes and the Associated Barriers and Opportunities for Sustainable Development on Peripheral and Insular Territories: The Madeira Island (Portugal)* [Working Title]. IntechOpen. doi:10.5772/intechopen.80827

Chaffey, D., & Bosomworth, D. (2012). *What is emotional branding? Smart Insights Digital Marketing Advice.* Available at: https://www.smartinsights.com/online-brand-strategy/emotionalbranding-means-customers-stay-loyal-for-the-long-haul/

Codosero Rodas, J., Castanho, R. A., Cabezas, J., & Naranjo Gómez, J. (2020). Sustainable valuation of land for development. Adding value with urban planning progress. A Spanish case study. *Land Use Policy*, *92*, 104456. doi:10.1016/j.landusepol.2019.104456

Cooper, B. B. (2013). *10 Surprising Social Media Statistics That Will Make You Rethink Your Social Strategy*. Fast Company, Business + Innovation. Available at: https://www.fastcompany.com/3021749/work-smart/10-surprising-social-media-statistics-that-willmake-you-rethink-your-social-stra

Cooper, C., & Hall, C. (2008). *Contemporary Tourism Marketing*. ButterworthHeinemann. doi:10.1016/B978-0-7506-6350-2.50006-6

Couto, G., Castanho, R. A., Santos, C., Pimentel, P., Sousa, Á., Faria, S., & Graça Batista, M. (2021). Determining Good Practices for Tourism Sustainability in Ultra-Peripheral Territories: A Research-Based on the Azores Region's Touristic Companies' Analysis. *Sustainability*, *2021*(13), 3895. doi:10.3390u13073895

Couto, G., Castanho, R. A., Sousa, A., Pimentel, P., Santos, C., & Carvalho, C. (2020). The Impacts of COVID-19 Crisis over the Tourism Expectations of the Azores Archipelago Residents. *Sustainability*, *2020*(12), 7612. doi:10.3390u12187612

DaCunha, M. (2014). *6 Social Media Marketing Strategies to Improve Your Efforts in 2014*. WordStream. Available at: https://www.wordstream.com/blog/ws/2014/01/09/social-mediamarketing-strategies

Fundo de Maneio e Observatório do Turismo dos Açores. (2018). *Proposta de Plano para Tornar os Açores num Destino Turístico Inteligente - Diagnóstico*. Elaborado para o Fundo Regional para a Ciência e Tecnologia.

Direção Regional do Turismo. (2019). *Revisão do Programa de Ordenamento Turístico da Região Autónoma dos Açores*. Relatório POTRAA Intermédio. Versão Consulta Pública.

European Union (EU). (2020). *Policy Forum on Development*. Working Group: Social Pillar of Sustainable Development. www. europa.eu

Guo, L. (2015). Inequity Aversion and Fair Selling. *JMR, Journal of Marketing Research*, *52*(1), 77–89. doi:10.1509/jmr.12.0175

Hudson, S., & Ritchie, J. (2009). Branding a Memorable Destination Experience. The Case of 'Brand Canada'. *International Journal of Tourism Research*, *11*(2), 217–228. doi:10.1002/jtr.720

Invat.tur. (2015). *Destinos turísticos inteligentes. Manual Operativo para la configuración de Destinos Turísticos Inteligentes.* Em parceria com o Instituto Universitário de Investigações Turísticas da Universidade de Alicante. Obtido de https://www.thinktur.org/media/Manual-de-destinos-tur%C3%ADsticos-inteligentes.pdf

IPDT. (2016). *Plano Estratégico e de Marketing do Turismo dos Açores*. Elaborado para o Governo Regional dos Açores. Obtido de http://www.azores.gov.pt/PortalAzoresgov/external/portal/misc/PEM_ACORES2.pdf

Kaletová, T., Loures, L., Castanho, R. A., Aydin, E., Gama, J., Loures, A., & Truchy, A. (2019). Relevance of Intermittent Rivers and Streams in Agricultural Landscape and Their Impact on Provided Ecosystem Services—A Mediterranean Case Study. *International Journal of Environmental Research and Public Health*, *2019*(16), 2693. doi:10.3390/ijerph16152693 PMID:31357719

Keller, K. L. (2013). Strategic brand management: building, measuring, and managing brand equity (4th ed.). Pearson Education.

Khedher, M. (2015). A Brand for Everyone: Guidelines for Personal Brand Managing. *The Journal of Global Business Issues*, *9*, 19–27.

Konecnik, M., & Go, F. (2008). Tourism destination brand identity: The case of Slovenia. *Journal of Brand Management*, *15*(3), 177–189. doi:10.1057/palgrave.bm.2550114

Labrianidis, L., Ferrão, J., Hertzina, K., Kalantaridis, C., Piasecki, B., & Smallbone, D. (2003). The Future of Europe's Rural Periphery; Final Report. In *5th Framework Programme of the European Community*. Routledge.

Laws, E., & Thyne, M. (2012). *Hospitality, tourism and lifestyle concepts: Implications for quality management and customer satisfaction*. Routledge. doi:10.4324/9780203051177

Lindsey, A. (2013). *What is Online Marketing?* TN Media. Available at: http://www.tnmedia.com/what-is-online-marketing/

Loures, L. (2011). *Planning and Design in Post-industrial Land Transformation: East bank Arade river, Lagoa - case study* (Doctoral thesis). Faculdade de Ciências e Tecnologia, Universidade do Algarve, Faro, Portugal.

Loures, L., Santos, R., & Panagopoulos, T. (2007). Urban Parks and Sustainable Development – The Case Study of Portimão City, Portugal. In A. Stamou, T. Panagopoulos, E. Stamatiou, A. Hatzopoulou, & D. Antunes (Eds.), *Energy, Environment, Ecosystems & Sustainable Development* (pp. 127–131). WSEAS Press.

Lousada, S., Escórcio, P., Castanho, R., Loures, L., Naranjo Gómez, J. M., Fernández-Pozo, L., Mora Aliseda, J., & Cabezas, J. (2018). A Multi-variated Analysis on Ultra-peripheral Territories. A Case Study Approach: Sustainability Indicators Proposal for Madeira Island. In T. R. Aranzadi (Ed.), Planeamiento Sectorial: Recursos Hídricos, Espacio Rural y Fronteras (pp. 293–303). Academic Press.

Lub, X. D., Rijnders, R., Caceres, L. N., & Bosman, J. (2015). The future of hotels: The Lifestyle Hub. A design-thinking approach for developing future hospitality concepts. *Journal of Vacation Marketing*, 1–16.

Malhotra, N. K., Birks, D. F., & Wills, P. A. (2012). Marketing research: An applied orientation (4th ed.). London: Pearson.

Morgan, N., & Pritchard, A. (2004). Meeting the destination branding challenge. In Destination Branding: Creating the unique destination proposition. Butterworth-Heinemann.

Moutinho, L., Rate, S., & Ballantyne, R. (2013). Futurecast: an exploration of key emerging megatrends in the tourism arena. In C. Costa, E. Panyik, & D. Buhalis (Eds.), *Trends in European Tourism Planning and Organisation* (pp. 313–325). Channel View Publications. doi:10.21832/9781845414122-026

Munro, J., & Richards, B. (2011). Destination brand challenges: the digital challenge. In Y. Wang & A. Pizam (Eds.), *Destination Marketing and Management, Theories and Applications* (pp. 141–154). CAB International.

Pan, B., MacLaurin, T., & Crott, J. C. (2007). Travel blogs and the implication for destination marketing. *Journal of Travel Research*, *46*(1), 35–45. doi:10.1177/0047287507302378

Pike, S. (2004). *Destination Marketing Organisations*. Elsevier.

Pimentel, P., Oliveira, A., Couto, G., Crispim Ponte, J., & Castanho, R. A. (2020). *The Azores Archipelago as a Region with Vast Potential for the Development of Adventure and Slow Tourism*. IntechOpen. doi:10.5772/intechopen.94411

Porter, M. E. (2005). *Estratégia Competitiva*. Campus.

Qu, H., Kim, L. H., & Im, H. H. (2011). A model of destination branding: Integrating the concepts of the branding and destination image. *Tourism Management*, *32*(3), 465–476. doi:10.1016/j.tourman.2010.03.014

Raposo, M., Castanho, R. A., Machado, M., Castro, C., Santos, P., & Pinto-Gomes, C. (2018). The Relevance of Vegetation Series on the Maintenance and Sustainability of Public Spaces in the South-west Iberian Peninsula. In Landscape Architecture: The Sense of Places, Models and Applications. InTech.

Segittur. (2015). *Smart Destination Report: building the future*. A pedido da Secretaria de Estado das Telecomunicações de Espanha. Obtido de https://www.segittur.es/opencms/export/sites/segitur/.content/galerias/descargas/documentos-en/Smart-Destination.pdf

Solomon, M. R. (2013). Consumer behavior: Buying, having and being (10th ed.). Pearson Education.

Spangenberg, J. (1995). Towards Sustainable Europe, A Study from the Wuppertal Institute for Friends of the Earth Europe. Luton.

Spangenberg, J. (2000). *Sustainable Development – Concepts and Indicators*. Colonia.

SPI. (2014). *Estratégia de Investigação e Inovação para a Especialização Inteligente da Região Autónoma dos Açores – RIS3 Açores*. Governo Regional dos Açores.

Talpau, A., & Vierasu, T. (2012). Online Marketing Strategies - UK and Romania. *Bulletin of the Transilvania University of Brasov, 5*(2), 31-34. Available at: http://ezproxy.snhu.edu/login?url=http://search.proquest.com/docview/1418210443?accountid=3783

Tan, D. (2014). *Fla Singapore*. Available at: http://www.flasingapore.org/info_branding.php

Ulucak, R., Yücel, A., & Koçak, E. (2019). *The process of sustainability: From past to present. Environmental Kuznets Curve*. EKC. doi:10.1016/B978-0-12-816797-7.00005-9

Volo, S. (2010). Bloggers' reported tourist experiences: Their utility as a tourism data source and their effect on prospective tourists. *Journal of Vacation Marketing*, *16*(4), 297–311. doi:10.1177/1356766710380884

Wang, H. J. (2015). A new approach to network analysis for brand positioning. *International Journal of Market Research*, *57*(5), 727–742. doi:10.2501/IJMR-2015-060

Yigitcanlar, T., Dur, F., & Dizdarogluc, D. (2015). Towards prosperous sustainable cities: A multiscalar urban sustainability assessment approach. *Habitat International: A Journal for the Study of Human Settlements,* 36-46.

Yudkin, M., & Stork, H. (2014). *The Benefits of Branding*. Available at: http://www.namedatlast.com/branding3.htm

Zhang, K. Z. K., Wang, S., & Zhao, S. J. (2014). Effect of brand pereffect of brand personality on brand loyalty in companies' microblogs. *PACIS 2014 Proceedings*. Available at: https://aisel.aisnet.org/pacis2014/203

# Chapter 25
# SmartDest:
## Converting the Azores Into a Smart Tourist Destination

**Gualter Couto**
*Universidade dos Açores, Portugal & CEEAplA, Portugal*

**Pedro Pimentel**
*Universidade dos Açores, Portugal & CEEAplA, Portugal*

**André Oliveira**
https://orcid.org/0000-0002-9517-1528
*Universidade dos Açores, Portugal & Fundo de Maneio, Portugal*

**João Crispim Ponte**
*Fundo de Maneio, Portugal*

**Carlos Santos**
*Universidade dos Açores, Portugal & OTA, Portugal*

**Deborah Estima**
*FRCT, Portugal & DRCTD, Portugal*

**Rui Castanho**
https://orcid.org/0000-0003-1882-4801
*WSB University, Poland*

## ABSTRACT

*The Azores are an increasingly attractive tourist destination. The excellence of endogenous resources has allowed it to consolidate its position as nature and adventure destination. Consequently, the regional strategy seeks to base this sector's growth on the principles of sustainable development. The potential granted by the new technologies is combined in an excellent opportunity to pursue this objective and convert the Azores into a smart tourist destination. Thus, according to this vision, a conversion plan was elaborated that can guide the performance of the destination management bodies and other stakeholders. In methodological terms, different techniques were applied, including the identification of good local practices and case studies for benchmarking, a self-diagnosis, interviews with stakeholders, and a SWOT analysis. The plan was concluded with the definition of measures, actions, and pilot projects to be implemented in the region following a structure based on the smart destinations development axes proposed in 2015 by Segittur.*

DOI: 10.4018/978-1-7998-8482-8.ch025

## INTRODUCTION

Until the COVID-19 pandemic, tourism assumed itself as one of the economic sectors with the greatest vitality and prosperity in the international context (Castanho *et al*., 2021; Couto et al, 2020; 2021). Tourist destinations faced the need to increase the quality of the offer of products and services to provide experiences with high added value and meet other highly competitive destinations. Besides, new technological trends, new behaviors of digital tourists, and concern for the sustainability of territories are increasingly important variables in tourist destinations' development models.

In this environment, the concept of Smart Destination emerges, with an ambitious vision of transforming tourist destinations into innovative, technological, accessible, and sustainable spaces capable of providing high-value experiences to visitors and a better quality of life for their inhabitants. It is about integrating and consolidating policies, equipment, and infrastructures that allow the collection and analysis of data in real-time, with essential rational decision-making factors. They must improve the governance of the tourist destination and the competitiveness of the sector and qualify the territory. At the same time, they must qualitatively increase tourism activities and resources to enhance tourist experiences, taking into account the new trends in tourist behavior, encouraging satisfaction, and the propensity for repetition.

The Azores is an increasingly attractive destination, with several awards and distinctions in recent years. Until the COVID-19 pandemic, there have been marked increases in tourist flows since the partial liberalization of regional airspace on routes with the Portuguese mainland, which occurred in 2015, reducing travel costs. According to the sector's strategy, the excellence of endogenous resources, especially natural ones, has allowed it to consolidate its positioning as nature and adventure destination according to its strategy (Ponte, Couto, Pimentel, Sousa, & Oliveira, 2019; Castanho *et al*., 2020; Pimentel *et al*., 2020). At the same time, it seeks to sustain the growth of tourism and other economic activities in the principles of sustainable development (Ponte, Couto, Pimentel, & Oliveira, 2018). According to the criteria of the Earth Check and the Global Sustainable Tourism Council, the Region has already been certified as a Sustainable Tourist Destination, an unprecedented situation in terms of archipelagic destinations in this area.

The opportunities afforded by new technologies, in line with the current paradigm of the information and knowledge society and the digital and technological era, make it possible to convert the Azores into a Smart Destination. The elaboration of a plan for the conversion will guide the performance of the destination management bodies and other stakeholders.

For elaborating the conversion plan, an extensive diagnosis was carried out to ascertain the Azores intelligence degree and identify the areas that present the most significant intervention needs for the implementation phase (Invat.tur, 2015; Segittur, 2015). In methodological terms, a set of techniques was used, which included identifying good practices already implemented locally, analysis of benchmarking case studies, a self-diagnosis according to the methodology of Invat.tur (2015), interviews, and analysis SWOT.

A strategic orientation was defined based on the diagnosis made, establishing a long-term vision and strategic objectives. Then, an action plan was elaborated, duly supported by a monitoring and evaluation plan.

## SMART TOURISM DESTINATIONS

The concept of Smart Tourism Destination has been gaining influence within the planning and promotion of tourist destinations to foster greater competitiveness and efficiency in the sector. It derives from the concept of Smart City, but it presents some relevant differences, both for a greater territorial scope and a greater specificity of performance.

### Definition

The concept of Smart Destination emerges as a new way of looking at tourism development, favoring the harmony between sustainability, accessibility, knowledge, innovation, and technology, in search of greater competitiveness, through the current and new resources, of increasing the efficiency of production and commercialization processes, and implementing environmental preservation practices and consolidated use of renewable energies (Muñoz and Sánchez, 2013). One of the most widespread definitions of Smart Destination is the following:

*"Innovative tourist space, accessible to all, consolidated on a state-of-the-art technological infrastructure that guarantees the sustainable development of the territory, facilitates the interaction and integration of the visitor with the surrounding environment and increases the quality of your experience at the destination and the quality of residents' life" (AENOR, 2018).*

This definition, along with other authors, highlights the structural importance of technology for a Smart Destination. Technological developments and the recurrent adoption of innovative processes have produced significant changes in tourists' behavior (Corte, D'Andrea, Savastano, & Zamparelli, 2017). Travelers are increasingly well informed, permanently connected, and interacting with multiple channels at the same time. The advent of Web 2.0, the affirmation of mobile, the proliferation of social media, and the implementation of functional Internet of Things systems are mechanisms that contributed to this new reality and that are inducing new business models, new forms of tourism planning, faster changes in development processes and, therefore, greater competitiveness in the entire tourism market, in terms of product structuring, promotion and marketing, destination management and increasing the quality of experiences for each visitor. Therefore, the technological system is a fundamental factor in the development of intelligent tourist destinations, which expands the traditional concept of a tourist destination (Jovicic, 2019).

Tourism is one of the sectors where the adoption of technology has been faster and more profound, contributing to its development (Carvalho & Carvalho, 2019). The predisposition for innovation is reflected in paradigmatic changes in the relationship between supply and demand and the presentation of new forms of consumption of tourist products. As explained by Huang, Goo, Nam, and Yoo (2017), the use of technologies for travel planning by tourists has been pervasive and proliferating.

According to Segittur (2015), Smart Destinations have to mobilize the necessary tools for the orderly collection, generation, and exploitation of information (intelligence), in order to be able to analyze events in real-time and to understand, immediately, the evolution of the relationship between supply and demand. All of this aims to satisfy the objectives of facilitating tourist interaction with the surroundings, streamlining decision-making by destination managers, and incorporating information into the companies' value chain, producing positive effects on destinations' competitiveness and sustainability.

## Development Axis

With the tourist at the center of structuring this new tourism development paradigm, Smart Destination's definition reveals four primary development axes: innovation, technology, accessibility, and sustainability (Segittur, 2015). This has been the foundation of the procedures applied in pioneering countries in applying the Smart Destination concept, such as Spain.

### Technology

Smart Destinations are associated with adopting and implementing new technologies across the entire value chain in the sector. Nevertheless, technology cannot be seen as an end in itself but as the entire system's structural basis. It should allow visitors, destination managers, and companies immediate access to information anytime, anywhere, playing a vital role in the tourist's experimentation and the planning and decision-making process of the remaining stakeholders. Technology has gained central importance as a catalyst for Smart Destination since the intensity of internet use in the entire sector (tourists and companies) has made connectivity an essential element for the tourist experience, the competitiveness of destinations, and improved management practices. It is used as a lever for innovation and creating disruptive solutions in the various links of the value chain, across the public administration and the private service.

### Innovation

Innovation in tourism is a continuous process of permanent reinvention of destinations, questioning and rethinking the entire value chain, the very functioning of the sector, and the natural order of all its components, in order to keep up with market developments, transform the and generate more great economic, social, and environmental value. A Smart Destination is, by definition, innovative, adding the ability to produce added value through the transformation of the information it manages to generate, collect, store, and analyze. Smart Destinations use innovation to explore new opportunities, reinforcing its differentiating and competitive matrix, which allows it to satisfy the needs of demand more fully. They benefit from an entrepreneurial and creative environment, from the emergence of new business models and tools to support efficiency, constantly feeding on small increments or disruptive solutions.

### Accessibility

Total accessibility is a growing concern in various social progress dimensions, being an integral part of the concept of sustainable development. In terms of tourism, it is reflected in the effort to adapt to the needs of anyone, regardless of having temporary or permanent limitations, in order to circulate, access, or enjoy places, products, services, or tourist experiences, as well as to contact, collect or interpret tourist information. It is intended that any visitor has the possibility and the freedom to travel in an agile and quiet way in a destination of their choice, doing what interests and desires, with total autonomy, pleasure, and easy access. It is not just about physical accessibility but also about digital accessibility.

## Sustainability

Smart Destinations seeks to implement development and management policies and models based on sustainability principles, which encourage sustainable business models conducive to the generation of wealth, the fair distribution of the value created by local communities, the preservation of resources, and the enhancement of local traditions and culture. It implies the introduction of information management mechanisms, as well as technological and procedural innovations, which streamline the processes of adapting to different tourist pressures during the year, combating seasonality, harmonized distribution of tourists across different locations/regions, from the measurement of carrying capacity and quantification of resource limits, prioritization of projects, adoption of risk management methodologies, promotion of inclusive processes and participatory decision-making and long-term protection of the global interests of the destination and its stakeholders. It is a structuring intervention encompassing specific contexts and interventions at an environmental, economic, and socio-cultural level.

# Smart Destinations *vs* Smart Cities

The emergence and growing importance of Smart Destinations are related to smart cities. Smart cities have their origin in developing smart solutions to allocate resources in urban centers with a high population density and continuous growth (Khan, Woo, Nam, & Chathoth, 2017). The notion of Smart Destination is an evolution of Smart City but within its specificity.

Despite the similarities, the two concepts are not synonymous and present different realities, with two substantial differences. These are related to the geographical limits and the target. Smart cities have defined their political, administrative, and geographical limits and intend, in essence, to improve the governance and quality of life of their inhabitants. Regarding Smart Destinations, the limits can coincide with the limits of a city or with a network of cities, aiming to guarantee an experience of added value to its visitors. However, they must ensure that the benefits are also extended to the resident population. Furthermore, as Gretzel (2018) argues, there may be problems with scaling projects from cities to regions.

According to Segittur (2015), the following differences must also be taken into account:

- Smart Destinations are mainly driven by the tourism sector. Thus, governance must be shared by entities that have representatives from all stakeholders. In smart cities, governance is assumed by city councils;
- Smart Destinations need to take into account multilingualism, cultural idiosyncrasies, gastronomic customs or seasonality;
- The interaction with the tourist is greater than just during the stay in the city. It starts before the trip and continues after your departure;
- Smart Destinations are closely linked to increasing competitiveness and improving the quality of tourist experiences.

Despite dealing with different realities, points of connection are evident, namely, in the importance they attach to information and communication technologies, connectivity and sensing, and sustainable development (Khan *et al*., 2017).

Boes, Buhalis, and Inversini (2015) refer that Smart Destinations are built from smart cities, combining and enhancing their tourist products to improve the tourist experience and the competitiveness of the destination. The authors conclude that, by leveraging the intelligence of cities at the level of people, living conditions, accessibility, the environment, the economy, and governance, cities are already creating conditions to support the construction of Smart Destination, where everything is interconnected, co-created and value-oriented through the implementation of technologies and infrastructures.

However, it is essential to highlight the work of Khomsi (2016). The author presents Montreal's case, which successfully adopted Smart City's concept, but failed to mobilize the tourism sector, limiting the full adoption of the concept of Smart Destination. The city's tourist authorities had little relevance in constructing the Smart City concept. However, they were pioneers in adopting practices and technologies to bring Montreal to a Smart Destination.

Human capital is the main component of intelligence in cities and tourist destinations since it is people who explore dimensions such as leadership, entrepreneurship, innovation, and social capital (Boes et al., 2015). For example, despite Barcelona's smart vocation, Femenia-Serra (2018) reports that there is an inadequacy of study plans in higher education in the tourism area, mainly due to the lack of integration of knowledge in ICTs, in the impact of tourism in the societies and the development of soft skills.

Invat.tur (2015) refers that the origin of the concept of Smart Destination is not only linked to the paradigm of Smart Cities. Corte et al. (2017) state that technologies are necessary to match the new tourist's consumption habits - the smart tourist.

## Smart Tourist - The Forefront of Tourism

New consumption habits are emerging concerning tourists' interests and expectations and the way they plan their trip, how they seek and compare information, how they choose their destination, how they make reservations, and how they experience and share experiences.

Driven by technological and digital tools and an internet connection, tourists seek a personalized experience and updated digital information adapted to the various devices about the destination's attractions, activities, and services (Xiang, Tussyadiah, & Buhalis, 2015). They also intend to share this experience as soon as possible on social networks. Tourists are increasingly independent and better informed. They seek new emotions and various experiences, which induces a more significant number of trips, but of shorter duration. They instantly have all the information they need about products, services, itineraries, deadlines, prices, availability, among others. They organize their travels and demand a broader range of digital services at the destination, the same services that they have access to in the country of origin (connectivity, social networks, use of proximity-based applications, among others), according to Segittur (2015).

Additionally, they seek to experience local traditions, values, and customs and understand the identity, context, and characteristics of the community and the destination (Saber Hospitality Solutions, 2016).

In a study on the communication capacity of Spanish municipalities with online tourists, López (2017) pointed out three fundamental characteristics that must be considered with regard to the new digital tourist:

- **Proactivity:** tourists are no longer just consumers of information but also producers of it. The information produced, mainly on social networks, becomes an excellent vehicle to promote the destination and, above all, in the purchase decision. It is a new word-of-mouth paradigm.
- **The use of various devices:** in addition to the use in the phases before (planning) and after (sharing and commenting) on the trip, mobile devices are also essential. They are used for communica-

tion between individuals, managing information in real-time, communication with objects, and communication of objects (Internet of Things).

- **Personalization:** mass communication, little segmented, does not create a connection with the tourist. The tourist wants informal, direct communication that takes into account their specific needs. It implies a change in communication, which must combine word-of-mouth characteristics in terms of empathy and content, and mass communication, in terms of the reach of the message.

This new paradigm constitutes a disruptive force to the *status quo* and has led to a change in how the tourism industry operates. Products and services are increasingly complete, integrating, flexible and personalized, which has only been possible to explore new technologies. These technologies have created new business models that accompany the consumer in all stages of the trip. Destinations are now more concerned with the needs of demand and the development of tourism products.

It is not enough to promote endogenous resources statically or to provide non-emotional experiences.

Segittur (2015) reinforces this idea when stating that the tourist becomes at the center of the tourist development of the destinations and that the creation of intelligent systems oriented to the integration and interaction of the tourist with the destination is vital, being necessary to develop tools that allow the interpretation of the destination's surroundings, speed up rational decision-making and effectively improve the quality of tourist experiences according to the needs of the tourist. Tavitiyaman, Qu, Tsang, and Lam (2021) state that suppliers to the tourism sector should provide new intelligent information systems to improve the tourist experience, improve satisfaction and increase return intentions.

## CONVERSION PLAN OF THE AZORES IN SMART DESTINATION

To start the conversion process for Smart Destination, Segittur (2015) recommends that the diagnosis of the destination be developed, identifying the needs of the destination and assessing the areas that need intervention. Strategic planning will depend on its degree of maturity since there may already be projects and actions implemented under other plans or initiatives. Invat.tur (2015) states that a self-diagnosis should be carried out to compare the destination's current situation with a base model of Smart Destination.

The next phase concerns strategic planning. In this phase, the strategic objectives that will allow to fill the identified flaws and design the destination as Smart Destination, according to the model adopted, and the region's positioning as a tourist destination, must be outlined. The strategy defined for the conversion process must be integrated into the region's development strategy (Invat.tur, 2015). There must be coordination with the plans implemented at the municipal and regional level, whether at the tourist level or in the other areas affected by the process, such as urbanism, the environment, the economy, finance, among others (Segittur, 2015). The action plan must identify the set of projects and actions that will enable the defined strategic objectives to be achieved. It is necessary to have permanent monitoring of the projects and actions developed. There must be a system for measuring the degree of implementation and the conversion process's success so that, reliably and objectively, it can be critically analyzed and evaluated the path followed and, when necessary, proceed to the appropriate adjustments, reviews, and improvements.

## Diagnostic

For the diagnosis, a set of techniques was used in the literature. In the following, a summary of the main results of the different techniques implemented is shown.

### The Evolution of Tourism

The Azores' archipelago is located in the middle of the Atlantic Ocean, dispersing along a southeast-northwest axis slightly greater than 600 km and covering a total area of 2,322 km2. It consists of nine islands of very heterogeneous and relatively small dimensions, just over 3,300 km from Boston (United States of America) and roughly 1,400 km from Lisbon (Portuguese capital city).

The projection of the economic development of the Azores defines *tourism* as one of its strategic pillars. The islands' natural characteristics, the existing comparative gains, and the growing tertiary of the economy made this decision an easily understandable option (Ponte, Couto, Pimentel, Sousa & Oliveira, 2020).

The evolution recorded until the pandemic of COVID-19 demonstrated the great potential of creating value for this sector and leveraging the regional economy. This trend was evident, especially since 2015, after implementing the new area accessibility model, which favored a considerable increase in the flow of passengers, as shown in Figure 1.

### Analysis of the Critical Factors for the Development of a Smart Destination

*Considering the review study carried out, an analysis was made of the critical factors for Smart Destination development, especially about the four axes of development proposed by Segittur (2015). This analysis can be taken as the first summary of all the information collected and analyzed on the Azores' Autonomous Region, which will provide input for the remaining diagnostic techniques.*

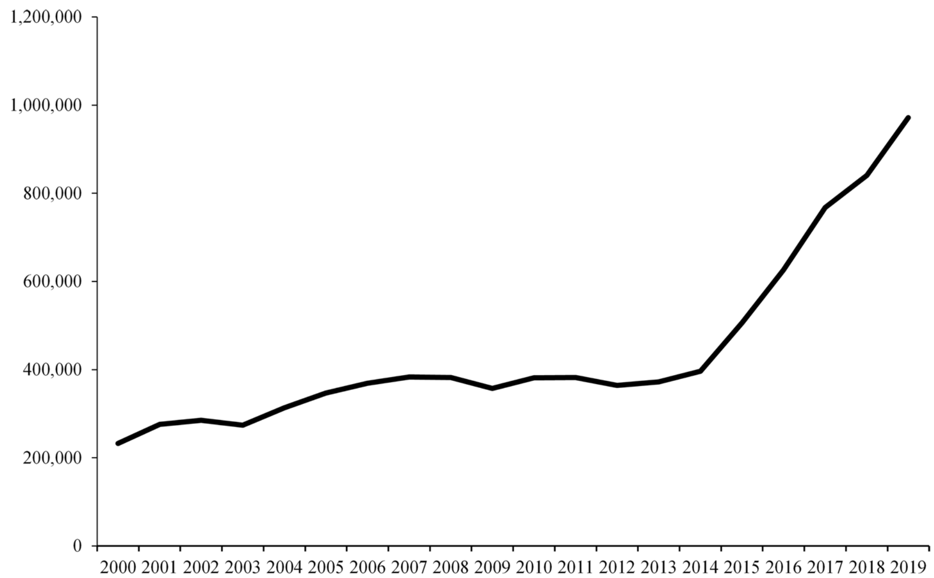
#### *Technology and Innovation*

The integration of technology and innovation in the various sectors of activity has been a bet on regional development strategies. The competitiveness of a large number of regional production units has been gradually improving. The need to deal with extraordinarily competitive products and players has led to the modernization of the processes of creation, transformation, and commercialization of products in agriculture, livestock, agribusiness, fisheries, sea, and tourism. As a result, there is an improvement in the quality of products and services and added value, which also results in a greater capacity to differentiate goods of regional origin.

The developments recorded in these areas and these companies and businesses are also due to factors associated with regional development and the influence of insertion in the community space. It is worth highlighting the implementation of some incentive measures, such as support for entrepreneurship and investment, the adoption of measures of an immaterial nature in the field of facilitating innovation and fostering demanding environments in terms of quality and certification, alongside the implementation and improvement of other instruments inserted in the community programming periods.

Nevertheless, resistance to change and the status quo is high. Innovation is seen as a solution to the most challenging situations, not constituting a fundamental principle in improving the value chain and

*Figure 1. Guests in the Autonomous Region of the Azores from 2000 to 2019*
*Source: SREA, 2000-2020*




increasing its value. The integration of innovative processes based on new technologies generally entails high-value investments that constitute barriers to their adoption, especially if it is not accompanied by a vision and a strategy that will support its application (e.g., changing behaviors and practices; training of staff; changes in functional structures) and obtaining an economic return. It is also necessary to consider the effects of insularity, the distance from large decision-making centers, the small size and geographical dispersion, resistance to change, volatile climatic and geological conditions, and socioeconomic characteristics, high-risk aversion, and low levels of purchasing power and training.

Despite the ambition to develop the Azores technologically and its innovation potential, the Region still lacks more relevant interventions in this regard. Concerning the tourism sector directly, the application of technologies is not at the ideal level. Many of the existing projects result from municipal initiatives in projects to convert their territories into smart cities. They are not integrated into a comprehensive process of enhancing the tourist destination. Additionally, it is noted that there are gaps that will need to be filled: tourist information posts with little equipment that can be used or rented by tourists; apps that, despite being increasingly appealing and helpful for disseminating resources and territory, make little use of the potential of augmented reality and QR codes; low connectivity to the Internet in more remote locations; the low sensing of public spaces and buildings, making it difficult to understand the movement of tourist flows and impairing the efficiency in the use of energy and water resources; Internet of things resource.

### *Sustainability and Accessibility*

The Azores are recognized as one of the most beautiful and sustainable tourist destinations in the world. According to the criteria of Earth Check and the Global Sustainable Tourism Council, this region is certified as a sustainable destination, an unprecedented certification in terms of archipelagic destinations.

The partial liberalization of airspace between the Region and the Portuguese mainland had a positive impact on the dynamization of the tourism sector and on the entire Azorean economy. However, attention should be paid to the risk of massification, which could jeopardize the sustainability of the destination.

In the light of the concepts presented by Butler (1980) and Buhalis (2000) regarding the life cycle of tourist destinations, the Azores are framed in the growth phase. The medium and long term perspective is critical because, after a rapid development and with good results, one must continue developing and structuring the competitive advantages of the destination, following the market evolutions and trends, and preparing it for the competitive challenges of the future. It is also necessary to take into account the carrying capacities of tourist resources to not jeopardize their present and future integrity and an unbearable economic and social cost.

New technologies should be seen as facilitators of improving sustainability. Practical efforts should be made in the use, management, and planning of public resources.

The low qualification of the population presents structural challenges for the sustainable development of the sector. Tourists are looking for an emotional, immersive, and cultural experience and intend to feel temporarily part of the society they visit. This requires a solid personal inter-relationship with tour operators and complimentary services. Specific markets, with a preponderance to spend at the destination, demand a high quality of services. Before making the trip, tourists develop a mental image about a destination and create a set of expectations (Buhalis, 2000) which, if the perceived value in "consumption" is lower than the expected value, will generate dissatisfaction (Chen & Chen, 2010). The destination will be in a less competitive position (Mihalic, 2000).

Accessibility for people with disabilities or special needs is not well developed. The surveys carried out within the scope of strategic tourism plans in the region demonstrate that this is one factor that generates the most significant dissatisfaction among tourists. In terms of the exploration of inclusive tourism, the Strategic and Marketing Plan for Tourism of the Azores (IPDT, 2016) only states that the tourism offer's organization will allow the definition of an accessibility strategy adjusted to mobility needs both for visitors and visitors or residents. Inclusive and accessible tourism is not part of the destination's communication strategy.

Despite the current legislation putting an end to basic principles of the inclusion of the population and visitors, there are still many challenges to be overcome, namely in the adaptation of existing spaces and buildings and people's public transport.

New technologies should contribute to the Azores' qualification as an inclusive and accessible destination, especially in terms of communication. Tourist information posts and tourist resources must be equipped with technological mechanisms that facilitate communication and interaction without difficulties with special needs visitors. In terms of digital accessibility, the vast majority of websites and apps in the tourism sector do not refer to adopting the principles outlined in the good practice manuals.

## Identification of Good Practices Already Implemented

Since the conversion to Smart Destination does not start from scratch and must seek to create synergies or improve the already installed capacity, existing projects and reference actions were identified.

Fifty-eight good practices were flagged in the Azores, framed in one or more smart destination development axes. The main contributions and features of each one were also identified, and suggestions to increase their impact.

In addition to improving the smart surroundings of the destination, it should be noted that some of the actions already fall under the concept of "smart tourism tools" - the smart tools (Smith, 2015). These are tools that correspond to the needs of the "smart" tourist, that is, those that, due to the way they are imbued in the destination environment, provide information technologically and digitally, in user-friendly interfaces and total convenience for the tourist—increasing the value of the experience and, consequently, the competitiveness of the destination.

## Organizational Diagnosis

For a destination to have the structural conditions to become a Smart Destination, effective and active public-private collaboration is required to strategically plan, coordinate, and implement the conversion process.

Twenty-three public and private organizations were identified that, for their know-how, for the responsibilities they have in governance and for the products and services available, will have an essential role in the validation and dissemination of the conversion plan, contributing with solutions and suggestions for the needs and identified interventions and in the interconnection with all intervening agents. These agents were mapped according to their potential for intervention and contribution to the proposed objectives.

## Interviews

The collection of information directly from the players that operate in the market, both in the public and private sectors, allows an in-depth knowledge of the regional reality. It allows the construction of a strategy and an action plan based on a realistic diagnosis and by the *praxis*.

Twenty face-to-face interviews were conducted with public and private agents, carefully selected according to their area of expertise. An interview guide was constructed, with semi-open questions measured on Likert scales (1-5) and with space for argument. We sought to collect information on the degree of maturity of the Azores as a Smart Destination in the various axes of development, the respective development potential, and the assessment of public policies, tourism resources, and stakeholders directly influencing this theme.

According to the interviewees, sustainability is the axis with the best chance of being developed. Next, innovation and technology share similar positions. The accessibility axis presents the least optimism in terms of development potential, as shown below.

## Innovation

Respondents report that, in general, there is a low capacity for innovation in institutions in the Azores. The financing difficulties and the use of traditional tools instead of new technologies have contributed to this situation, both in terms of equipment and promotion and marketing. However, the effort to promote the "Azores" destination in international markets is praised.

At the business level, the interviewees' view is more optimistic, especially concerning new products and services. However, the existence of many companies with minor differentiating factors is highlighted. Nevertheless, it is said that there have been improvements in these fields in comparison with the reality of a few years ago.

## Technology

More than half of the interviewees consider that there is little integration of technologies and facilitating processes in the tourism value chain, capable of improving the tourist experience and increasing its value. There are some technological and digital tools, mainly in tourist information and services, but with low penetration. The interviewees also mentioned the low integration of structured research and development processes in companies and the need for a more excellent and more recurrent articulation between companies and research centers.

The interviewees understand that the region's tourism sector has a low level of knowledge and infrastructure to boost permanent connectivity and the internet of things to qualify the tourist experience in the destination.

Difficulties are mentioned, such as the significant investments in the necessary infrastructures for this purpose, the development asymmetries between the nine islands of the Azores, and the adaptation of the oldest tourist agents to adapt to this new reality, new gadgets, technological equipment, and behavioral changes. Although some interviewees point out that their organizations already have the necessary knowledge to implement technological solutions at this level and that there are already projects of this nature to be implemented in the Azores, the need to improve human resource qualification programs has raised the level of higher education.

In the opinion of the interviewees, the information systems of the Azores are reasonably practical. To improve these information systems, the following recommendations are given:

- Collection of data from the sensor;
- Greater availability of the collected data;
- Construction of a specific information system for the tourism sector includes essential indicators of its evolution and performance.

In the interviewees' opinion, there is also a low utilization and integration of traditional market research tools and data from the web, social networks, and extensive data systems to understand better tourists' profile and preferences visiting the Azores.

## Sustainability

Respondents report that there is an awareness of the value and importance of preserving endogenous natural resources. The efficient management of the territory also deserved positive considerations due to spatial planning plans that have prevented the making of irreversible errors, potentially threatening the sustainability and quality of the destination. They recognize that it has been quite privileged about balanced urban development since there have been policies for the rehabilitation of urban centers. However, concerns are raised about the impacts of the sharp growth of local accommodation and the respective impacts on the supply of tourist accommodation and the rental market.

The degree of preparation for tourism was the factor that deserved the lowest score. The reasons that point to this perception are directed to the need to reinforce human resources training in a sector in which this component is of fundamental importance.

About the assessment of public policies related to sustainability, land transport policies are the ones that raise the most criticism, especially concerning public transport. There is a perception that these do not serve the needs of tourists. Regarding maritime transport policies, they understand that these are good, mainly due to connections throughout the year in the central group of the archipelago (made up of 5 islands next to each other). Air transport policies are the ones that have the best consideration, with the interviewees highlighting the free re-routing system between islands with gateway and islands without gateway. However, they mention that it is necessary to increase the efficiency of this service.

Respondents define *energy efficiency policies* as reasonable, praising energy production from renewable sources but criticizing the low penetration of public electric vehicles—few respondents rate waste management policies as good.

## Accessibility

In terms of accessibility, the interviewees' primary criticism is directed at the circulation that is not facilitated for people with reduced mobility. They consider that, due to the legislation in force, there are already buildings, public spaces, and digital channels adapted to this segment, but that the work should be further developed in the tourist resources (e.g., technological tools in the viewpoints for people with hearing or visual difficulties) and on public transport.

They also mention that there are few tourism products and services for the inclusive tourism segment. The interviewees highlight the excellent but isolated work of a local company recognized in this matter, although other companies have already started to develop products and services for this segment.

## Governance

Respondents agree that the Azores have a structured tourism policy, based on a clear strategy and a long-term vision, capable of promoting competitiveness, valorizing local resources, and the adequacy of the offer to the demand for quality experiences by tourists.

The construction of the strategic plan for tourism in the Azores and the definition of nature tourism as an anchor product for the development of tourism are positive factors in analyzing the interlocutors. They emphasize a discrepancy between the public political discourse and the actions carried out in the territory and that efforts should be continued to understand the needs and preferences of tourists better.

Regarding the current leadership and governance model, the interviewees consider that it is very oriented towards tourism management based on long-term commitments and communicated to all tourism partners in the region. Additionally, they consider that this tourism management will impose great demands in terms of public and private investment and that it will be able to respond to constant innovations and a highly dynamic environment.

## Self-Diagnosis

Following the suggestions of Invat.tur (2015), a self-diagnosis was carried out to compare the current situation in the Azores with a base reference model for Smart Destination. In this way, it was essential to ascertain the degree of maturity and the starting point of the Region for the conversion process.

The self-diagnosis is structured in 9 groups. Each group incorporates a set of indicators that, according to defined criteria, are scored on a pre-defined scale. In total, 78 indicators were evaluated. Each group's score is marked between 0 (lowest score) and 100 (highest score). Invat.tur (2005) presents proposals for technical measurement of the indicators.

The self-diagnosis was carried out according to the analysis of statistical data, the documentary analysis, and the results of the interviews carried out with the stakeholders, duly supported by applying the technical and scientific knowledge of the work team. Table 1 presents a summary of the results obtained and the main conclusions.

The score obtained in the global assessment reveals the immaturity of the destination «Azores» as a Smart Destination. It is noted that the scope of accessibility is the one with the lowest score, which meets the dissatisfaction manifested by the tourist demand identified in other studies, something that also happens in the scope of territorial and urban sustainability.

The areas of connectivity and sensing, and tourism sustainability are those with the highest score. This contributed to the fact that the municipalities where the large urban and tourist centers are located are increasing their territories' intelligent vocation, providing free connectivity points for tourists. It is also a relevant factor in the quality of natural resources and the concern with the destination's environmental and tourist sustainability, which has ensured several distinctions at the international level. However, none of the areas has a score above 50, which demonstrates that there are, in all areas, fields of action that need planning and implementation, especially concerning the incorporation of new technological means in the value chain.

García (2015) points out that there may be differences in the numerical valuation between the analysis carried out by external analysts and the analysis carried out by internal auditors within the scope of this self-diagnosis, which results from information asymmetry.

## SWOT Analysis

In addition to the self-diagnosis, a SWOT Analysis was structured for the Azores' Autonomous Region considering its starting position for Smart Destination, presented in Table 2. The methodology adopted consisted of identifying Strengths, Weaknesses, Opportunities, and Threats and the critical interpretation of the current impact (low, medium, high) and the future trend (improve, maintain, worsen) of each of these elements.

In the internal environment, it appears that the City Councils, especially those that have urban centers, are developing smart city programs to provide a better quality of life for its inhabitants and a visit with more excellent added value for visitors. Additionally, it should be noted that the Azores are increasingly an attractive and accessible destination, which has been reflected in the increase in tourist flows. In terms of environmental sustainability, the islands' natural conditions provide unique energy use opportunities using renewable energy sources. The low incorporation of intelligent systems and tools in the tourist destination's governance and qualification is identified as the main weaknesses. Still, the central gap refers to the low promotion of social and human capital, verifiable by the low qualification of human resources and public partnerships - private with little added value in the destination's smart qualification.

In the external environment, the main opportunities derive from the constant technological evolution and their potential in improving tourist experiences, taking into account the new global trends, especially the new behaviors of the smart tourist, and in the structuring of new models and solutions that allow to reduce seasonality, increase the average stay and encourage more significant expenditure of tourists in the destination. In any case, it is crucial to safeguard the risk of unsustainable growth in tourism that will jeopardize territorial, economic, and social sustainability. The low investment capacity of the Region and regional companies is also a factor that may affect the smart development of the Azores, taking into

*Table 1. Self-diagnosis results*

| Pillar | Score | Degree of Maturity | Remarks |
|---|---|---|---|
| 1. Governance | 42/100 | Reduced | ● There is still no strategy for configuring the Region as a Smart Destination. |
| 2. Territorial and Urban Sustainability | 28/100 | Reduced | ● Although there are plans, their implementation is not yet sufficiently consistent.<br>● There is a deficit in the adoption of technological systems that facilitate and enhance the management of the public sphere's various domains. |
| 3. Touristic Sustainability | 46/100 | Reduced | ● The Azores have been widely awarded and distinguished for their natural beauty and the destination's sustainability by internationally recognized organizations.<br>● There are few environmental certifications for resources, attractions, companies, and organizations. |
| 4. Accessibilities | 25/100 | Reduced | ● Accessibility presents itself as a limiting factor for tourist satisfaction.<br>● There are several attractions that, due to little human intervention, either to preserve the beauty and purity of spaces or due to the lack of planning, present difficulties in access.<br>● At the digital level, gaps in the provision of adapted tourist information are also diagnosed. |
| 5. Connectivity and Sensing | 48/100 | Reduced | ● The concern of the Azores' municipalities in ensuring the free mobile connectivity of tourists and residents to the internet is noticeable, especially in urban centers.<br>● In more remote places, where the ecstasy of tourist experiences is provided, difficulties in coverage and access to the Internet persist.<br>● The degree of incorporation of sensory technology applied to destination management is very low. |
| 6. Information System / Tourism Intelligence | 43/100 | Reduced | ● There is no intelligent and aggregating tourist information system that produces, analyzes and makes information available to stakeholders.<br>● The information that is made available is essentially related to statistical data referring to the evolution of demand and supply. |
| 7. Innovation | 40/100 | Reduced | ● Entrepreneurship has served as an alternative to unemployment, creating important initiatives to boost the economy.<br>● Innovation takes time to be part of all economic agents' processes, being more reactive than proactive. |
| 8. Touristic Information | 35/100 | Reduced | ● There is a lack of incorporation of technological and innovative solutions that allow access to information on time and place to practical and potential consumers.<br>● Social networks are extensively exploited for the promotion destination.<br>● The institutional website needs greater integration of functionalities. |
| 9. Online Marketing | 32/100 | Reduced | ● There is a need for more significant interaction, relationship, and encouragement for the co-creation of content by visitors that serve as visitor loyalty instruments and promote the destination for new consumers through digital word-of-mouth. |
| Overall Evaluation | 338/900 | Reduced | ● There is a low maturity of the Azores as a Smart Destination. |

Source: Authors.

*Table 2. SWOT Analysis of the Autonomous Region of the Azores as an Intelligent Tourist Destination*

| Strengths | Impact | Tendency |
|---|---|---|
| Municipalities with smart city programs | High | Improve |
| Endogenous resources with potential for energy use | High | Improve |
| Environmental preservation and conservation | Medium | Worsen |
| Growth of tourist activity | High | Improve |
| Economic growth in the region | Medium | Improve |
| Presence of internationally recognized Low Cost Carriers (LCC) | High | Improve |
| Entrepreneurial attitude of young entrepreneurs | Medium | Keep |
| Tourist promotion of the destination | High | Keep |
| Tourists' satisfaction | High | Keep |
| Use of renewable energy | High | Improve |
| Existence of a strategic plan for tourism | Medium | Improve |
| Stakeholders' concern with the sustainability of the destination | High | Improve |
| Increased attractiveness for investors | High | Improve |
| Innovative public and private initiatives using technologies | Low | Improve |
| Presence of smart tools | Medium | Improve |
| Integration of Tourism as a priority area in RIS3 | Medium | Keep |
| **Weaknesses** | **Impact** | **Tendency** |
| Territorial fragmentation | High | Keep |
| Low penetration of technologies in tourism products and services | High | Improve |
| Low degree of maturity of the destination as smart | High | Improve |
| Mobility and transport as factors that generate dissatisfaction | High | Keep |
| Few Communication and Information Infrastructures | High | Improve |
| Low connectivity and sensing for big data capture | High | Keep |
| Limitation on the investment capacity of the public and private sector | Medium | Worsen |
| Low qualification of human resources and formation of "talents" | High | Keep |
| Education system with little vocation for ICTs and soft skills | Medium | Worsen |
| Low pro-tourism culture on the side of the population | Low | Improve |
| Little use of smart systems in governance | High | Improve |
| Unavailability of open data on tourist behavior | Medium | Keep |
| Resistance to change and alteration of the *status quo* | High | Improve |
| Low accessibility of tourism resources and promotion channels | High | Improve |
| Quality of the tourist offer is not high | High | Improve |
| Little public-private collaboration towards common goals | High | Keep |
| Little promotion of scientific research | Medium | Worsen |
| Low number of quality and sustainability certifications | Low | Keep |
| Risk of poverty in a substantial part of the population | High | Improve |
| Low average stay | High | Keep |
| Pronounced seasonality | High | Keep |
| **Opportunities** | **Impact** | **Tendency** |
| New tourist behaviors - smart tourist | High | Improve |
| Constant technological evolution | High | Improve |
| Growth of the tourism sector worldwide | High | Keep |
| Recognition of «Azores» as a sustainable destination | Medium | Improve |
| New solutions to reduce seasonality | Medium | Improve |
| New business models | High | Improve |
| National / international partnerships within the scope of PO Azores 2020 and Interreg | Medium | Keep |
| High probability of tourists returning | Medium | Keep |
| Dynamics of foreign investment | High | Improve |
| Increased environmental awareness | High | Improve |
| Potential of technologies in improving governance | High | Improve |
| **Threats** | **Impact** | **Tendency** |
| Low perception of the Azores as a smart destination | Low | Improve |
| Competitiveness of competing destinations | Medium | Improve |
| National and European regulations for data capture and sharing | Medium | Improve |
| Unsustainable growth in tourism | High | Improve |
| Learning curve for certain segments | Low | Improve |
| Capture of segments with low propensity to consumption | High | Worsen |
| Structure of the Community programming period for the period 2021-2027 | High | Keep |

*continued on following page*

*Table 2. Continued*

| Strengths | Impact | Tendency |
|---|---|---|
| Political and economic instability in Europe (e.g. Brexit and extremisms) | Medium | Worsen |
| Country's socioeconomic environment | Medium | Worsen |
| Pandemics | High | Improve |
| Terrorism and insecurity | High | Improve |
| Perception of cheap destination due to LCC | Low | Improve |
| High inflation rate | Medium | Worsen |
| Risk of mass tourism destination | High | Worsen |

Source: Authors.

account a contextual environment that will feel the effects of the economic and financial crisis caused by the pandemic of COVID-19.

## Strategic and Operational Planning

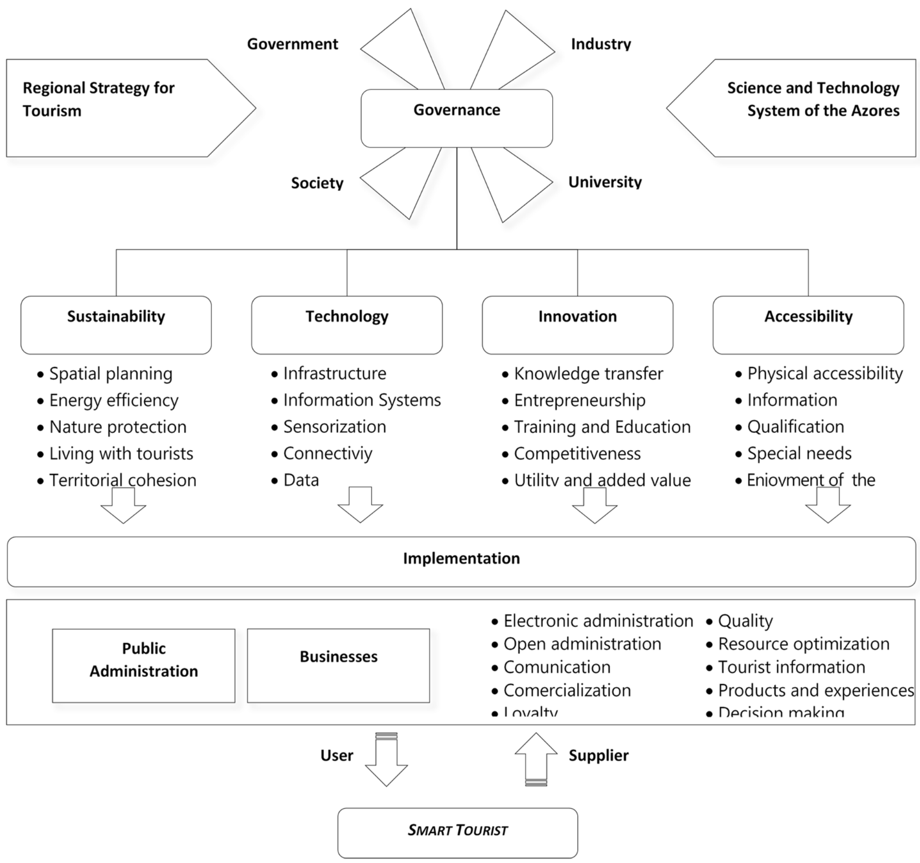
After the detailed diagnosis and the areas of greatest need for intervention are identified, the construction plan is structured, starting the strategic planning and culminating in the action plan's definition.

### Reference Model

Adopting a reference model should be the first step towards the realization and operationalization of a Smart Destination (Invat.tur, 2015). Several factors were considered, including the region's state of maturity as a tourist destination, its ability to generate and integrate intelligence, the resources available, and the potential already existing for this process. The need to do some groundwork to respond directly to the challenges of the fundamental axes of Smart Destination was contemplated. Furthermore, it was considered pertinent to highlight the role of governance, given the evident need to mobilize stakeholders, adding the influence of the quadruple helix (Carayannis & Campbell, 2009) in this system as a factor of consolidation of the governance model.

*To emphasize the regional reality, the whole process was framed in the Azores tourism strategy, highlighting the interaction with the Scientific and Technological System of the Azores (SCTA), understood as an ideal mechanism to involve matters of the avant-garde spirit, technological and scientific. The action for materialization and practical implementation was also assumed, given the recurring difficulty of transposing strategic formulations to reality. Finally, the smart tourist's central role as a user of information and data generator was reinforced, without forgetting the intervention of companies and public administration in the entire system. In this way, the model defined for the Azores arises from the intersection between the fundamental base of Segittur (2015), the operational vocation of Invat.tur (2015), and the Region's paradigm. The modeling proposed in Figure 2 defines the matrix on which transforming the Azores into a Smart Destination will be based, characterizing the optimal functioning of the system to be reached.*

*Figure 2. Reference model to transform the Azores into a Smart Destination*
*Source: Authors.*




## Strategic Orientation

The proposal to transform the Azores into a Smart Destination is based on a long-term vision and is precisely aligned with the tourism sector's regional strategy. The vision defined was: the Azores, a destination of Nature par excellence and a living laboratory where technology and intelligence are placed at the service of the quality of the tourist experience and the efficiency of resources, enhancing the balance between the environment, competitive development, and internal cohesion.

The aim is to prepare the destination and provide the internal equipment that responds to major international trends and smart tourists' needs, consolidating the quality of the tourist experience without compromising the sustainability of regional resources.

In line with the strategic vision based on these principles, each of the reference model's central axes, to which governance is added, supports the definition of five strategic objectives. In turn, these are supported by specific measures geared towards a consequent action plan. Table 3 summarizes this whole framework.

*Table 3. Strategic objectives to convert the Azores into a Smart Destination*

| Axis | Strategic Objective | Measures |
|---|---|---|
| Governance | Catalyze the process of transforming the Azores into Smart Destination, enhancing the qualification of public agents and the active participation of private individuals | • Adapt the government structure and strategy for the conversion process.<br>• Strengthen the concept of Smart Destination with players in the sector.<br>• Promote an active partnership between public and private actors, favoring open, participatory and transparent management. |
| Innovation | Intensify the incorporation of innovative practices in companies and regional public administration, based on collaborative interaction with SCTA | • Enhance the transfer of knowledge through the SCTA.<br>• Encourage entrepreneurship and the creation of new business models, products and services in the tourism value chain.<br>• Promote the development of an open stance towards innovation and disruption of the *status quo*. |
| Sustainability | Optimize the integrated management of the territory and endogenous resources, contributing to their preservation and valorization, as well as to the cohesion of the islands | • Consolidate the management of the territory and the environmental sustainability of tourism in the Region.<br>• Enhance intra-island and inter-island mobility.<br>• Foster energy efficiency, waste management and adaptation to climate change.<br>• Promote hospitality and the appreciation of the Azorean cultural identity. |
| Accessibility | Develop resources and inclusive practices that overcome the current service gaps and the conditions of the territory, facilitating greater accessibility to enjoy the Azores tourist experience | • Improve physical accessibility in the urban, rural and natural environments, as well as in tourist attractions and equipment.<br>• Facilitate digital access and availability of information.<br>• Qualify agents in the tourism sector with the necessary skills to structure and provide inclusive tourist experiences. |
| Technology | Reinforce the use of cutting edge technological resources to provide the Azores tourism sector with an adequate infrastructure for data management and its incorporation into decision processes of destination managers and tourists | • Develop a safe and flexible technological infrastructure, appropriate to the archipelagic nature and tourism reality of the Azores.<br>• Improve the introduction of new technologies to generate, collect, transmit and store data, aiming to support decision making.<br>• Promote the development and use of smart tools to increase the quality of tourism experience and the productivity of organizations. |

Source: Authors.

## Action Plan

The plan's preparation was based on the diagnostic process results, the strategic definitions integrated into the proposed reference model, and the fundamental basis of the concept of Smart Destination.

Each of the actions was classified according to the priority level (critical, necessary, or desirable) and the period in which it should be implemented as indicated. A mapping of the most relevant actors in this context was carried out, both in terms of public administration and in the private sector, and the structuring of a proposal for the management model of the entire process. A pilot project was also defined for each action, which allows a test to each action, evaluating results, and a benchmark, facilitating and increasing their success.

It is intended that the action plan will produce structural effects and lead the Azores to a robust tourist intelligence system. The action plan is geared towards essential work, preparation, and consolidation of the transformation process's fundamental pillars. The focus is on improving the tourist experience, covering all moments of the stay, and building a system that actively contributes to the sustainability and efficiency of the destination managers' decision-making process.

In total, 60 concrete actions were formulated. The actions were presented according to the fundamental axes, the strategic objectives, and the corresponding measures.

### Monitoring and Evaluation Plan

The conversion models for Smart Destination provide for the implementation of monitoring and evaluation systems for the entire process (AENOR, 2018). They aim at a systematic analysis of the development work to assess the degree of achievement of the goals and identify corrective measures.

The proposed monitoring and evaluation system includes a complete and transversal assessment of the work to be carried out and structured to be succinct and objective. It integrates five driving dimensions that will be at the base of the conversion process: (i) the action plan; (ii) the Smart Office, whose work will be focused on leading the conversion process; (iii) the stakeholders involved, determinants for the mobilization of resources, wishes, and initiatives; (iv) the destination, reflecting the sector's performance; and (v) tourists, who will be the users.

Quantitative and qualitative criteria and methods were also defined, reinforcing objectivity and measurable demonstration capacity while considering the possibility of more interpretive measurement, especially those aspects that are difficult to measure. The system also defines a reporting mechanism so that a systematic and periodic assessment is carried out.

Critical elements have been defined to be taken into account throughout the monitoring and evaluation process. These elements will serve as an operational base, guiding the Smart Office's work and measuring the fulfillment of the proposed objectives.

The system includes a set of KPIs that facilitate the measurement of the fulfillment of objectives and the measurement of the degree of evolution of the Azores in transforming into Smart Destination.

## FUTURE RESEARCH DIRECTIONS

Although Smart Destination's concept has already aroused interest on the part of the scientific community, there are several research opportunities, both in the fundamental component and in the empirical component. One of the most relevant aspects will be monitoring and evaluating the results of the developed projects and how they will impact the destination's intelligence in increasing sustainability and the satisfaction of tourists.

Within the scope of the Azores conversion plan to Smart Destination, in addition to the conceptualization of multiple pilot projects, a concrete and detailed pilot project was designed to be implemented in the short term in the municipality of Praia da Vitória, Terceira island, which is characterized attractiveness in terms of the technological business environment. This pilot project included the definition of several concrete actions, partners, suppliers, budgets, and deadlines for implementation, monitoring, and evaluation. A localized implementation allows a concrete and detailed assessment of the impacts before projects on a larger scale are implemented throughout the Autonomous Region of the Azores. Finally, it will also be relevant to understand the differences between the planning processes and the actual results in different destinations compared with the Azores and assess whether the Azores model can be a reference for the conversion of destinations archipelagic islands in Smart Destination.

## CONCLUSION

The Azores conversion plan to Smart Destination followed the primordial phases of a strategic planning process, as presented, for example, in Ponte et al. (2020). The diagnosis included multiple inputs and a methodology adapted to the best technical-scientific practices, namely Segittur (2015) and Invat.tur (2015). Therefore, it was intended to determine the starting point and the degree of maturity of the four axes of developing a Smart Destination suggested by Segittur (2015).

From the diagnosis performed, it is clear that the Azores already have some degree of maturity, especially concerning the sustainability axis, corroborated certification as a Sustainable Tourist Destination. Additionally, it appears that measures such as the adoption of smart tools, the launch of websites with online services and applications for mobile devices are improving the technological and digital environment of the Region.

However, for the Azores to proclaim themselves as a true Smart Destination, efforts will have to be focused on creating a genuine and unequivocal technological, intelligent and innovative environment. To this end, efforts should be focused on improving fundamental aspects, such as exploiting big data and using the knowledge generated.

The Azores have very favorable conditions to become a Smart Destination. It is an increasingly attractive destination with new vitality and high-quality tourist resources. *Tourism* was strategically defined as a vital sector for the economic and social development of the Azores. The synergies created with the existing Smart City municipal programs will provide the archipelago with even more favorable conditions, especially about urban mobility and the technological and digital environment of each municipality.

For strategic and operational planning, adopting a reference model was necessary to achieve the definition and requirements inherent to the development of this concept. A long-term vision, strategic objectives, and specific measures were defined for each of the objectives. The process culminated in defining an action plan (with 60 actions) and a system for monitoring and evaluating the entire process.

However, it is essential to note that the conversion process is gradual, consisting of pilot projects and accompanied by a rigorous process of validating results and improving projects. Furthermore, destination managers must validate the conversion plan with a wide range of stakeholders, given the transversality of actions across different governance and social areas.

## ACKOWLEDGMENT

This research was supported by the INTERREG V A Espanha-Portugal MAC 2014-2020 (grant number MAC/1.1b/133) by the participation of Regional Fund for Science and Technology FRCT of the Azores Regional Government with the scientific support of the authors.

This chapter is financed by Portuguese national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., project number UIDB/00685/2020 and also by the project GREAT - Genuine Rural Experiences in the Azores Tourism with the code: ACORES-01-0145-FEDER-000089.

## REFERENCES

AENOR. (2018). Sistema de gestión de los destinos turísticos inteligentes. Requisitos. *Norma UNE*, *178501*, 2018.

Boes, K., Buhalis, D., & Inversini, A. (2015). Conceptualising Smart Tourism Destination Dimensions. In I. Tussyadiah & A. Inversini (Eds.), *Information and Communication Technologies in Tourism*. Springer. doi:10.1007/978-3-319-14343-9_29

Buhalis, D. (2000). Marketing the competitive destination of the future. *Tourism Management*, *21*(1), 97–116. doi:10.1016/S0261-5177(99)00095-3

Butler, R. (1980). The concept of a tourism area cycle of evolution: Implications for resources. *The Canadian Geographer. Geographe Canadien*, *24*(1), 5–12. doi:10.1111/j.1541-0064.1980.tb00970.x

Carayannis, G., & Campbell, D. (2009). 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, *46*(3/4), 201–234. doi:10.1504/IJTM.2009.023374

Carvalho, S., & Carvalho, J. (2020). The Implications of Digital Marketing and e-Commerce in the Tourism Sector Growth. In Á. Rocha, A. Abreu, J. de Carvalho, D. Liberato, E. González, & P. Liberato (Eds.), *Advances in Tourism, Technology and Smart Systems*. Springer. doi:10.1007/978-981-15-2024-2_15

Castanho, R. A., Couto, G., Pimentel, P., Carvalho, C., Sousa, Á., Graça Batista, M., & Garrido-Velarde, J. (2021). Os impactos da crise sanitária de COVID-19 sobre os Territórios Ultraperiféricos: O caso de estudo do Arquipélago dos Açores (Portugal) [The impacts of the COVID-19 health crisis on the Outermost Territories: The case study of the Azores Archipelago]. *Espacios, 42*(6), 104-116. doi:10.48082/espacios-a21v42n06p08

Castanho, R.A., Couto, G., Lousada, Pimentel, P., Carvalho, C. & Sousa, A. (2020). Princípios de Planeamento Estratégico e Gestão de Turismo Rural em Territórios Ultraperiféricos: O Caso de Estudo do Arquipélago dos Açores. *Revista Ibérica de Sistemas e Tecnologias de Informação (RISTI), E36*(10).

Chen, C., & Chen, F. (2010). Experience quality, perceived value, satisfaction and behavioral intentions for heritage tourists. *Tourism Management*, *31*(1), 29–35. doi:10.1016/j.tourman.2009.02.008

Corte, V., D'Andrea, C., Savastano, I., & Zamparelli, P. (2017). Smart cities and destination management: Impacts and opportunities for tourism competitiveness. *European Journal of Tourism Research*, *17*, 7–27. https://ejtr.vumk.eu/index.php/about/article/download/291/294

Couto, G., Castanho, R. A., Santos, C., Pimentel, P., Sousa, Á., Faria, S., & Graça Batista, M. (2021). Determining Good Practices for Tourism Sustainability in Ultra-Peripheral Territories: A Research-Based on the Azores Region's Touristic Companies' Analysis. *Sustainability*, *2021*(13), 3895. doi:10.3390u13073895

Couto, G., Castanho, R. A., Sousa, A., Pimentel, P., Santos, C., & Carvalho, C. (2020). The Impacts of COVID-19 Crisis over the Tourism Expectations of the Azores Archipelago Residents. *Sustainability*, *2020*(12), 7612. doi:10.3390u12187612

Femenia-Serra, F. (2018). Smart Tourism Destinations and Higher Tourism Education in Spain. Are We Ready for this new Management Approach? In B. Stangl & J. Pesonem (Eds.), *Information and Communication Technologies in Tourism*. Springer Internation Publishing. doi:10.1007/978-3-319-72923-7_33

García, C. (2015). *Smart Cities y Destinos Turísticos Inteligentes: un análise comparativo*. Dissertação de Mestrado. Universidade de Málaga. Available at: https://riuma.uma.es/xmlui/handle/10630/10154

Gretzel, U. (2018). From smart destinations to smart tourism regions. *Investigaciones Regionales, 42,* 171-184. Disponível em: https://investigacionesregionales.org/wp-content/uploads/sites/3/2019/01/10-GRETZEL.pdf

Huang, C., Goo, J., Nam, K., & Yoo, C. (2017). Smart tourism technologies in travel planning: The role of exploration and exploitation. *Information & Management*, *54*(6), 757–770. doi:10.1016/j.im.2016.11.010

Invat.tur. (2015). *Destinos turísticos inteligentes. Manual Operativo para la configuración de Destinos Turísticos Inteligentes*. Comunidade Valenciana.

IPDT. (2016). *Plano Estratégico e de Marketing do Turismo dos Açores*. Available at: https://www.azores.gov.pt/PortalAzoresgov/external/portal/misc/PEM_ACORES2.pdf

Jovicic, D. (2019). From the traditional understanding of tourism destination to the smart tourism destination. *Current Issues in Tourism*, *22*(3), 276–282. doi:10.1080/13683500.2017.1313203

Khan, M., Woo, M., Nam, K., & Chathoth, P. (2017). Smart City and Smart Tourism: A Case of Dubai. *Sustainability*, *9*(12), 2279. doi:10.3390u9122279

Khomsi, M. (2016). The Smart City Ecosystem as an Innovation Model: Lessons from Montreal. *Technology Innovation Management Review*, *6*(11), 26–31. doi:10.22215/timreview/1032

López, G. (2017). *Los Municipios Turísticos del Interior de la Comunitat Valenciana en Internet*. Tese de Doutoramento. Universidade de Valência.

Mihalic, T. (2000). Environmental management of a tourist destination: A factor of tourism competitiveness. *Tourism Management*, *21*(1), 65–78. doi:10.1016/S0261-5177(99)00096-5

Muñoz, A., & Sánchez, S. (2013). Destinos Turísticos Inteligentes. *Harvard Deusto Business Review, 224*, 58-67. Available at: https://www.mincotur.gob.es/Publicaciones/Publicacionesperiodicas/EconomiaIndustrial/RevistaEconomiaIndustrial/395/LOPEZ%20DE%20AVILA%20y%20GARCIA.pdf

Pimentel, P., Oliveira, A., Couto, G., Crispim Ponte, J., & Castanho, R. A. (2020). *The Azores Archipelago as a Region with Vast Potential for the Development of Adventure and Slow Tourism*. IntechOpen. doi:10.5772/intechopen.94411

Ponte, J., Couto, G., Pimentel, P., & Oliveira, A. (2018). Tourism activities and companies in a sustainable adventure tourism destination: The Azores. *Tourism & Management Studies*, *14*(4), 25–38. doi:10.18089/tms.2018.14403

Ponte, J., Couto, G., Pimentel, P., Sousa, Á., & Oliveira, A. (2019). Tourist satisfaction with the Municipality of Ponta Delgada (Azores). *Revista de Gestão e Secretariado*, *10*(3), 192–217. doi:10.7769/gesec.v10i3.896

Ponte, J., Couto, G., Pimentel, P., Sousa, Á., & Oliveira, A. (2020). Municipal Tourism Planning in an Island Territory: The Case of Ribeira Grande in the Azores. *Tourism Planning & Development*. Advance online publication. doi:10.1080/21568316.2020.1816567

Sabre Hospitality Solutions. (2016). *Europe & Middle East Consumer Mega-Trends Impacting Hospitality*. Trendwatching Premium.

Segittur. (2015). *Smart Destination Report: building the future*. Available at: http://www.millennium-destinations.com/uploads/4/1/9/7/41979675/smart-destination_segittur.pdf

Smith, R. (2015). *SMART Tourism Tools: Linking Technology with the Touristic Resources of City Destinations*. Tese de Bacharelado, Universidade NHTV Breda de Ciências Aplicadas. Available at: https://documents.nhtv.nl/load.aspx?doc=thesis%5C2015%5CAT%5CITMC%5CSmithR.pdf

Tavitiyaman, P., Qu, H., Tsang, W., & Lam, C. (2021). The influence of smart tourism applications on perceived destination image and behavioral intention: The moderating role of information search behavior. *Journal of Hospitality and Tourism Management*, *46*, 476–487. doi:10.1016/j.jhtm.2021.02.003

# Chapter 26
# The Douro Demarcated Region: The Relevance of Tourism in the Internationalization Strategies of Companies

**Sérgio António Neves Lousada**
https://orcid.org/0000-0002-8429-2164
*FCEE, DECG, University of Madeira, Portugal & VALORIZA, Portugal & ARAM, University of Extremadura, Spain & Institute of Research on Territorial Governance and Inter-Organizational Cooperation, Poland & CITUR, Madeira, Portugal*

**Cátia Tabau**
*University of Trás-os-Montes e Alto Douro (UTAD), Portugal*

**Eduardo Leite**
*School of Technology and Management, University of Madeira (UMa), Funchal, Portugal & Centre for Tourism Research, Development and Innovation, Madeira, Portugal*

**Andreia Carvalho**
*Higher Institute of Administration and Languages, CIISAL - ISAL Research Center, Madeira, Portugal*

## ABSTRACT

*This chapter seeks to understand the motivations that lead companies to internationalize and how they do it since this has been a constant challenge for business research. For this purpose, a descriptive research was conducted with a qualitative strategy applied on different companies in the wine sector. International trade is a Portuguese tradition that started and reached its peak in the 16th century with the Portuguese and Spanish discoveries, which justifies this study. The wine industry, particularly in the Douro Region, has also always been closely linked to foreign trade and has even benefited from a historic trade agreement with the United Kingdom. The empirical results show that companies are practically born international. The size of the domestic market was the main justification for the demand for external markets. The constant evolution of markets and industries generates opportunities and potential threats to which companies must be able to respond.*

DOI: 10.4018/978-1-7998-8482-8.ch026

## INTRODUCTION

This chapter seeks to contribute to the knowledge of internationalization strategies through the analysis of a representative sample of companies/vineyards in the Douro Demarcated Region (DDR), in Portugal.

It should be noted that the wine sector has a significant impact on the beverage industry in Portugal, especially on employment, turnover and GVA. Besides this direct economic effect, the sector has also an indirect multiplier effect, both upstream and on the employment generated in the production of grapes, and even on the occupancy of the generally deserted rural world. In the latter, the sector plays an essential role in territorial cohesion, which is strategic for Portugal.

In the overall agri-food industries, the productivity of the wine sector in Portugal is significantly higher than all the others, respectively 4.35 and 1.6 times. This productivity allied to its high export capacity - it represents more than 70% of the value of its production - contributes decisively to Portugal's balance of trade. In fact, it traditionally represents more than 15% of the agri-food sector exports and more than 1.5% of national exports.

In this context, the DDR is particularly relevant. The DDR is considered the oldest demarcated and regulated wine region in the world and covers about 250,000 ha, including the Alto Douro Wine Region, with more than 26,000 ha (approximately 10% of the DDR), classified as World Heritage by UNESCO, in the category of cultural landscape.

The unique characteristics of the landscape, the excellent wines associated with gastronomy, and the existence of an exceptional natural and built heritage have attracted national and international investment to the DDR, especially provided by English families, who have become true ambassadors for the Region, both in terms of wine exports and international promotion of the tourist destination Porto and northern Portugal.

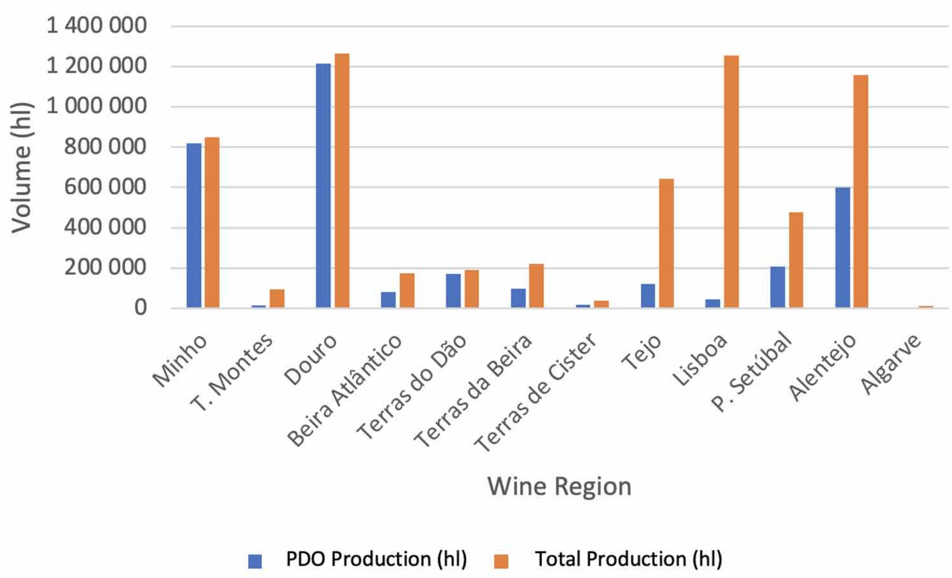
## MATERIALS AND METHODS

The global field of this study is identified with the entire wine sector of the DDR, from the perspective of business internationalization. In this work context, Quivy and Van Campenhoudt (1998) consider that the main methods of information collection are: the survey by questionnaire, the interview, the direct observation, and the collection of pre-existing data (secondary and documentary data).

In this context, the adopted methodological approach of a qualitative nature is divided into two parts: the part corresponding to the theoretical study and the part that concerns the empirical work. In the first part, a survey of the main existing publications (papers, studies, theses, university papers, and other published works) was carried out, as well as exploratory research, with the literature review on the theme of internationalization and the DDR, the exposition of theories and the modes of entry into international markets. The objective of this survey was to try to find out a little more about what has already been written, studied, and debated, as well as the main interpretations or theoretical constructs on the subject.

As for the fieldwork, methods and techniques were used to collect data that was later analyzed, namely in-depth interviews. The technique to be used was to collect information through interviews with members of the selected companies in the DDR wine sector and the collection of pre-existing data from them (on-site, via the internet), in order to understand their internationalization process.

*Figure 1. Production (hl) in the 2020/2021 campaign by wine region (on the mainland). (Includes Port and Douro Wine). Source: IVV, I.P..*




## Introduction to the Portuguese Wine Industry

Portugal is a major player in the European and world wine market. In fact, Portugal ranks fourth in terms of vineyard area and production within the European Union. As far as consumption is concerned, it ranks fifth. According to statistics provided by IVV - Instituto da Vinha e do Vinho, I.P., the mainland regions that contribute to the largest national wine production are Douro (including the production of Port and Douro Wine), Lisbon and Alentejo (see Figure 1). These three regions are responsible for 58% of the total wine production on the mainland. When only the production of Protected Designation of Origin (PDO) is compared, the main producing regions are Douro (35%), followed by Minho (24%) and Alentejo (18%). The PDO production of these three regions represents about 77% of the mainland wine production of the same category.

Competitiveness consists of the ability of companies in wine-producing regions to sustainably increase their shares in the world market, in the context of international trade theory.

The increasing liberalization of the market has added difficulties for European producers, specifically for Douro producers, as is the case of the companies under study.

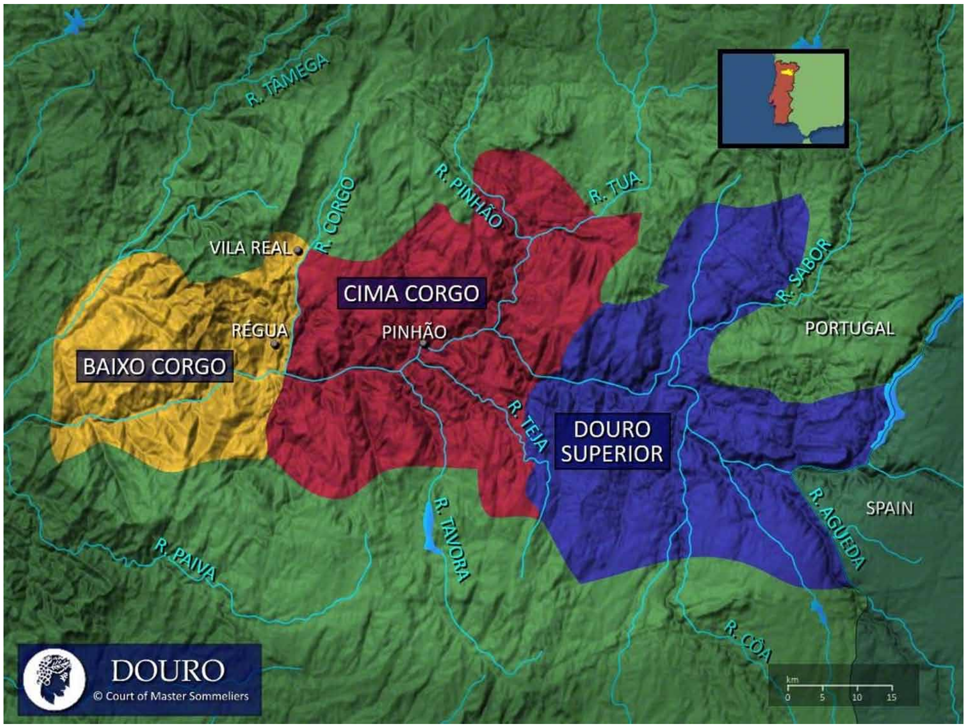
It is not possible to trace a trend of production in short periods of time since the result of the wine campaigns is directly influenced by environmental factors such as climatic conditions. As such, even if the cultivation area is the same or even bigger, the wine production may be lower as a reaction to climatic or environmental events (such as droughts, unseasonably heavy rainfall, frost, hail, pests, among others). Table 1 shows the evolution of the declared wine production by category from the 2009/2010 to the 2018/2019 campaign.

It is possible to note that the production of wine without any type of classification has been decreasing. It is also worth mentioning that the vineyard area planted in July 2018 corresponded to 187,562 ha, of which 83,572 ha belong to PDO regions, *i.e.*, about 39% of the total planted area. However, it represented

*Table 1. Declared Production evolution by category (2009/2010 – 2018/2019 Series). Source: IVV, I.P..*

| Wine Category | 2009/10 | | 2010/11 | | 2011/12 | | 2012/13 | | 2013/14 | | 2014/15 | | 2015/16 | | 2016/17 | | 2017/18 | | 2018/19 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** | **Vol.** | **%** |
| Apt for PDO wine | 2132 | 36 | 2465 | 34 | 2130 | 38 | 2046 | 32 | 2277 | 37 | 2193 | 35 | 2791 | 40 | 2385 | 40 | 2720 | 40 | 2350 | 39 |
| Apt for PDO Fortified Wine | 886 | 15 | 868 | 12 | 681 | 12 | 759 | 12 | 765 | 12 | 820 | 13 | 867 | 12 | 890 | 15 | 918 | 14 | 891 | 15 |
| Apt for PGI Wine | 1261 | 21 | 1693 | 24 | 1292 | 23 | 1475 | 23 | 1686 | 27 | 1764 | 28 | 1880 | 27 | 1626 | 27 | 1897 | 28 | 1986 | 33 |
| Apt for Wine with Ind. of Year/ Grape Variety | 4 | 0,1 | 26 | 0,4 | 28 | 0,5 | 27 | 0,4 | 44 | 1 | 48 | 1 | 37 | 1 | 62 | 1 | 70 | 1 | 41 | 0,7 |
| Wine | 1611 | 27 | 2095 | 29 | 1492 | 27 | 2021 | 32 | 1458 | 23 | 1381 | 22 | 1473 | 21 | 1059 | 18 | 1132 | 17 | 793 | 13 |
| **Total** | **5894** | **100** | **7148** | **100** | **5622** | **100** | **6327** | **100** | **6231** | **100** | **6206** | **100** | **7048** | **100** | **6022** | **100** | **6737** | **100** | **6061** | **100** |

*Figure 2. The Douro Demarcated Region. Source: https://portugalpatrimonios.com/tag/regiao-demarcada/ (accessed in April 2021).*




about 54% of the total production in the 2018/2019 campaign, which reflects a higher efficiency of the vineyard in this type of regions (IVV, I.P., 2021).

The specificities of each region, such as culture and history, natural and environmental resources also influence internationalization strategies.

During the 80's and 90's, Portugal was open to an increasingly globalized world, with its product portfolio. Parallel to this process, another process is emerging that tries to reconcile regional preferences and products with globalization.

The loss of colonial markets and living in an open market of five hundred million consumers has enabled greater exports. The quality of the product had, naturally, to adapt to the normative models of the European Union.

Portugal has only 190 thousand ha of vineyards in comparison with a global total of 3.7 million ha, in the context of the European Union[1].

Despite being a small country, the differences between each of the regions are significant, and each has its own identity. Today Portugal has 31 Protected Designations of Origin, which are representative of this diversity.

## BRIEF CHARACTERISATION OF THE DDR

*"... Douro is a hot and dry region, surrounded by high mountains that protect it from the humid winds from the south, tides from the west, cold from the north, and dry from the east - the southern wind - that withers and burns the crops so much... It is a drowned region that the sun heats strongly and where the light penetrates in spurts..." (Fonseca, 1949, p. 41, quoted by Almeida, 2011, p. 10).*

The DDR is one of the most important and well-known regions in the world. It is divided into three subareas: Lower Corgo in the west, Upper Corgo in the center, and Upper Douro in the east[2], according to Figure 2.

Its area extends over 247,420 hectares (in the upstream stretch of the Douro River valley), which includes the Alto Douro Wine Region, with more than 26 thousand hectares (approximately 10% of the DDR), classified by UNESCO as a World Heritage Site, in the category of cultural landscape. The landscape imposed by the valley carved by the Douro River is, without a doubt, the sign of difference that defines this region. The climatic, orographic, and ecological characteristics of the Douro Region are conditioning factors for the economic exploitation of natural resources and the activities developed there. Stony soils and particularly harsh weather conditions are expected of this region for those engaged in viticulture, which is the main activity for most farmers in the region.

"The Alto Douro region is a burning harsh territory in summer and cold in winter, formed by tight and wild valleys, poor in the aridity of its steep and stony slopes, its lack of water, its almost monoculture, the smallness of its production per vine. These agro-climatic characteristics so particular to this region are also responsible to produce incomparable wines"[3].

These soils are beneficial for the longevity of wines, allowing a higher concentration of grape must with a higher concentration of sugar and color[4].

The typical exploration in the DDR is done in a very *sui generis* way. It is characterized by being divided into small portions, usually limited by schist walls. On its boundaries, one can often find olive trees and sometimes almond trees.

Another significant aspect is the so-called *mortórios*, which represent uncultivated areas covered with natural vegetation and very rich in biodiversity (Andresen *et al.,* 2004). These are woods, scrublands or even forests, constituted by recolonization of areas previously organized for vineyards, olive groves, or almond trees, in which the old schist walls are still visible, abandoned during the last century, after the phylloxera crisis[5], or as a result of the progressive abandonment of the rural world.

A detail associated with production is related to the fact that the best Port wines are produced on the more arid slopes and close to the river whereas table wines are produced on the slopes with cooler climates.

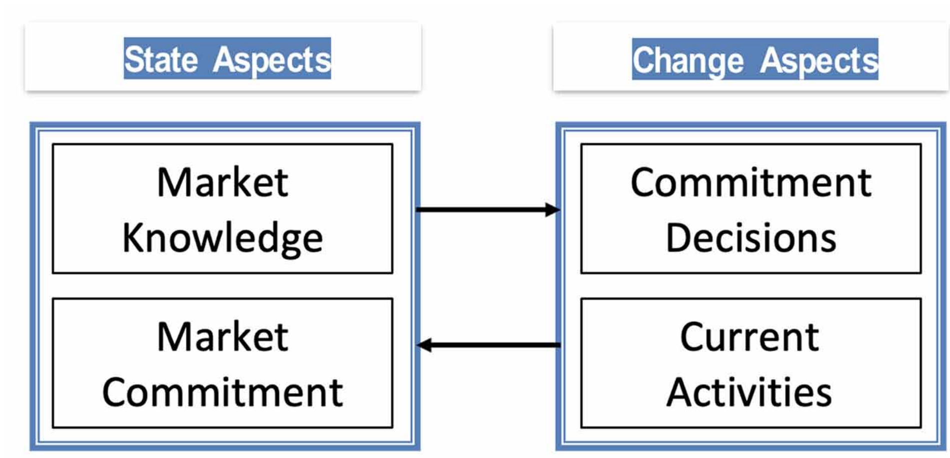
From the 20$^{th}$ century on, it was concluded that the most appropriate grape varieties for Douro and Port wine production are: Touriga Nacional, Touriga Franca, Tinta Barroca, Aragonez and Tinto Cão. Trincadeira is also an important grape variety for the region. In the production of white wines, the most used grape varieties are Gouveio, Malvasia Fina and Rabigato.

Although the total vineyard area in the DDR represents 96% of the area of the Alto Douro Wine Region (42,011 ha), only about 90% is suitable for producing Denomination of Origin (DO).

Thus, of the total area planted with vines, only 26,000 ha are authorized to produce Port Wine[6].

As far as productivity is concerned, the region is not characterized by having very productive grape varieties. It should be noted that the maximum yield allowed is 55 hl/ha (about 7,500 kg/ha). The average productivity is about 30 hl/ha (4,100 kg/ha).

*Figure 3. The Uppsala Model. Source: Johanson and Vahlne (1977, p. 26).*




Small producers have great weight in the production of Douro wine, whereas the cooperatives produce more Port wine.

Of the total volume of wine produced in the DDR, around 50% is dedicated to the production of "Port Wine". The remaining volume goes to the production of high-quality wines using the controlled origin denomination "Douro" or "Douro Wine".

Port Wine is distinguished from ordinary wines by its very particular characteristics: a high alcohol content (usually between 19 and 22% vol.) and an enormous diversity of types, aromas, flavors, "sweetness" and colors[7].

Thus, the importance of the DDR, recognized for the excellence of the wines it produces, justifies special attention to its study, but other motivational and technical factors justify the choice of the subject under study which are presented in the following section.

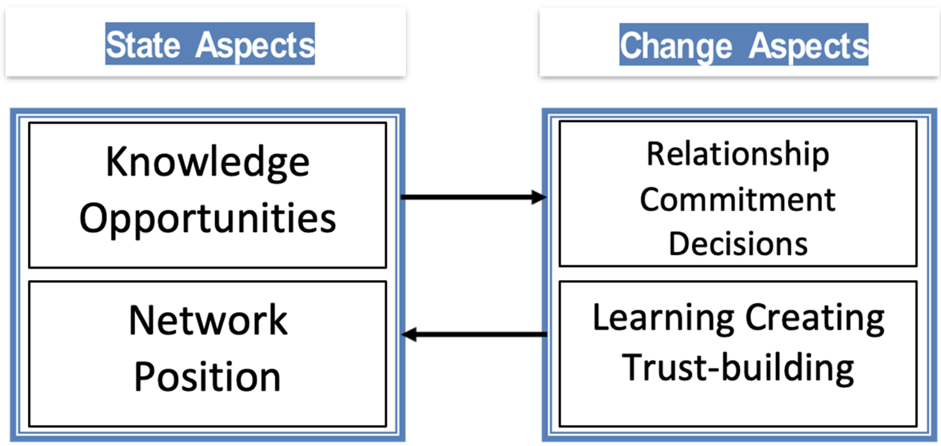
## THEORIES AND MODELS OF INTERNATIONALIZATION

As one can conclude from the previous section, internationalization and globalization are broad concepts that can comprise different theories and models of explanation. Briefly, the theories of the internationalization processes can be grouped into four main models: the Uppsala Model, the Network Perspective, the Market Power Theory, and the Eclectic Paradigm.

The first two models fit into an approach based on behavioral evolution, highlighting the process from the attitudes, perceptions and behaviors of decision-makers who seek to reduce risks in decisions about where and how to expand and emphasize the importance of learning and the accumulation of knowledge in companies (Blomstermo, Eriksson, Sharma, 2004; Dib, Carneiro, 2006). The remaining models fit into an approach based on economic criteria where rational thinking of solutions to issues in the internationalization process prevails, intending to find a decision path that would bring maximization of the economic return (Dib, Carneiro, 2006).

The first model is based on evolutionary stages of internationalization and is commonly known as the Uppsala Model (see Figure 3), named after the Swedish school where it was developed. This model by

*Figure 4. The internationalization process model in the business network. Source: Johanson and Vahlne (2009, p. 1424).*




Johanson and Vahlne (1977) is the result of research conducted by Johanson and Wiedersheim-Paul in 1975 with four Swedish companies and in which they concluded that these companies presented common characteristics, named "establishment chain" and "psychic distance". The "establishment chain" was so named because organizations gradually increase their involvement in international markets as their knowledge of foreign markets and the allocation of resources to these markets increase; "psychic distance" refers to cultural differences as well as management and education practices in another market, that is, there is evidence that the company tends to invest in countries which are culturally close to minimize risks and uncertainties. It is certain that not all companies follow these four phases and that this depends on the market and resources. Companies with more resources may skip the initial phases, as well as they may not evolve to the phase of larger investments when the market is not attractive enough.

The Uppsala model is based on three assumptions:

- ignorance is the biggest obstacle to the internationalization process;
- experience provides the commitment and knowledge in the process;
- companies invest resources gradually, and the greater their knowledge of the market is, the greater their investment will be (Johanson and Vahlne, 1977).

For Johanson and Vahlne (1990, p. 11) "*the internationalization process involves, on the one hand, the interaction between knowledge of the foreign market and operations and, on the other hand, the increased commitment of resources to the foreign market*".

As far as the second model is concerned, the issue of networks is considered a natural evolution of the Nordic School way of thinking. Its followers have played a central role in the development of the industrial network perspective, focusing on the existing relationships between firms and industrial markets.

This model developed by Johanson and Mattsson (1988) describes industrial markets as relationship networks between companies. These authors state that competitive factors and forces in highly internationalized industries create a heterogeneous pattern of entry opportunities. This factor will motivate the firm to choose markets and entry strategies, which may be quite different from what is predicted by the

*Table 2. Results of the interviews conducted to the companies. Source: Authors.*

| Company / Internationalization | Casca Wines | Quinta do Beijo | Wine & Soul | Quinta do Noval Fine Ports since 1715 | Vallegre | Quinta da Pacheca |
|---|---|---|---|---|---|---|
| Beginning of the process | 2009 | 2015 | 2003 | No data (early date) | Early 90's | 2012 (by the new management) |
| Motivations | - Originality of the company's concept (fear of rejection by the domestic market) | - Financial increase of the company | - Search for prestige, notoriety | - Size and difficulties of the Portuguese market | - Search for new customers<br>- Financial and quality increase<br>- Brand dissemination | - Size of the Portuguese market |
| Entry mode | Direct exportation | Direct exportation<br>*Ex works* | Direct exportation | Direct exportation | Direct exportation | Direct exportation |
| Main markets | Europe, China, Angola, Brazil, Canada, Japan, Singapore, Malaysia, USA | England, Germany, China, Japan | USA, Brazil, Canada, Europe, Angola, Hong Kong, Macau | USA, UK, France, other European countries, Brazil, Canada, Argentina, Japan | Denmark, USA, Belgium, Brazil, Taiwan, Japan, Canada, England | France, Germany, Switzerland, UK, Luxembourg, Brazil, USA, Canada, China |
| Assistance in the process | None | IVDP | Partnerships with importers | IVV, I.P. | None | ViniPortugal IVDP |
| Constraints in the process | - Financial capacity;<br>- Low level of knowledge of Portuguese wine in the foreign market | - Lack of experience in the field of contracting and marketing;<br>- Financial capacity | - Lack of institutional support in the sector;<br>- Weak expression of the "wines of Portugal" brand | - Brand unawareness (which may be related to the culture of the destination country);<br>- High value of its top (niche) wines | - Destination country legislation;<br>- Prices charged by the importers (which greatly increases the price for the end consumer);<br>- Language of the destination country;<br>- Lack of brand awareness;<br>- Lack of knowledge about the Portuguese wine;<br>- Geographical distance;<br>- Lack of institutional support;<br>- High financial cost inherent to internationalization | - Poor or non-existent imag of Portugal |
| Requirements for the company to stay in the foreign market | - Availability of time and financial capacity to monitor on-site | - Existence of sufficient stock for rapid replenishment;<br>- Recognition of the importance of the sales staff | - Promotion to the end consumer | - Close contact with the customer abroad;<br>- Working with an agent from the destination country | - Incisive monitoring, on-site, in the destination markets;<br>- Agile and effective response to the customer | - Close and persistent monitoring |
| Weaknesses in comparison with foreign competitors | - Size of the company;<br>- Commercialization of Portuguese wine | - Promotion of products<br>- *Stock* | -------------------- | - No direct competitors in the foreign market | - Some technical aspects to be improved | - Adaptation to globalizatio |
| Advantages compared to foreign competitors | - Commercialization of Portuguese wine | - Varied portfolio | - Capital for investment in travel and promotion in the foreign market | - No direct competitors in the foreign market | ---------------- | - Port Wine production<br>- Location in the DDR |

traditional Uppsala model; however, this will only be possible through the establishment of relationship networks in the new markets. Thus, relationships, both strictly business (Sharma and Johanson, 1987) and personal ones (Lindqvist, 1991) can be used as bridges the entry into other networks. Therefore, suppliers, customers, competitors, or other partners with whom the company has a relationship are assets that will sustain the competitive advantages of network companies that cooperate in internationalization processes.

Dib and Rocha (2009) refer those studies have shown that, with the globalization of markets, some companies have turned to international markets since they were founded, thus contradicting the Uppsala model, which refers to a gradual internationalization process. Thus, Johanson and Vahlne (2009, p. 1411), recognizing that "*economic and regulatory environments have changed dramatically, as have organizational behaviors*", revised their model (see Figure 4).

As for the Market Power theory, Hymer (1983) bases his theory on the reduction of competition in the sense that it forces the company to continuously reinvest its profits and expand its market to remain in it. This theory is based on the search for near-monopoly positions in the market, as a consequence of the exploitation of market imperfections, through the use of company-specific advantages, such as cost

*Table 3. Comparative analysis between the results obtained and the literature - Start of the internationalization process. Source: Authors.*

| **Beginning of the internationalization process** | |
|---|---|
| **Literature:** | **Results:** |
| **For several authors, exporting constitutes the main method of entry of companies into foreign markets, because it is one of the ways that involves less costs and risks; high flexibility.** | **Direct exportation is the only method of beginning (and remaining in the markets) the internationalization of the companies analyzed.** |

*Table 4. Results - Choice of international markets. Source: Authors.*

| Markets |
|---|
| **a) The geographical issue and cultural closeness --> European countries**<br>**b) Secondly, the Portuguese-speaking African countries, with Angola as the main focus;**<br>**c) The so-called “markets of nostalgia”, namely Brazil, the United States of America, and Canada;**<br>**d) The largest markets with the greatest growth potential;**<br>**e) The Far East, has been increasing its importance for Portuguese companies;**<br>**f) One of the companies (Vlg) mentioned the fact that geopolitically stable countries are chosen;**<br>**g) In addition, the “opportunity” factor is also highly considered (half of the sample).** |

advantages. The decision of when to internationalize occurs when one realizes that the opportunities to strengthen its position in the domestic market no longer exist, and the option is to intensify its position abroad and expand its activities to other foreign markets.

The fourth model is named the Eclectic Model or **OLI** Paradigm. Proposed by Dunning (2001), this model seeks to explain the extent, form, and pattern of internationalization through IDE and that it assumes that production takes place where there are different types of advantages, such as:

(i) **O**wnership – the company’s advantages over its competitors; the capabilities developed by the organization in relation to companies located in the destination markets, which allows advantages related to the control of specific resources (qualified human resources, technology, brands) that, in turn, provide an international competitive advantage;

*Table 5. Comparative analysis between the results obtained and the literature - Motivations for internationalization. Source: Authors.*

<table>
<tr><th colspan="2">Motivations</th></tr>
<tr><th>Literature:</th><th>Results:</th></tr>
<tr><td>a) Defense in possible unforeseen events in the domestic market (acts as a risk reducer). Vazquez (2009); Simões (1997); Peng (2006); Oliveira and Teixeira (2011);<br>b) Replication of national success. Grant (1987);<br>c) Exploitation of economies of scale. Grant (1987); Kogut (1985); Peng (2006); Vrontis and Papasolomou (2007); Simões (1997); Soares (2004);<br>d) Opportunity of new markets, obtaining new profits. Peng (2006); Vazquez (2009); Oliveira and Teixeira (2011);<br>e) Efficiency search. Dunning (2000);<br>f) Cost reduction. Grant (1987); Kogut (1985);<br>g) Access to cheaper or more reliable resources. Oliveira and Teixeira (2011); Subsidy (1987);<br>h) Tax evasion or import quota. Oliveira and Teixeira (2011);<br>i) Response to competitors’ movements and access to competencies that allow for competitive advantages. Oliveira and Teixeira (2011); Simões (1997) Soares (2004); Viana and Hortinha (2005);<br>j) Limit of growth of companies in the domestic market. Planelles (2011);<br>k) Disposal of the surpluses that the domestic market does not absorb. Peng (2006); Williamson (2002);<br>l) Company consolidation. Williamson (2002); Simões (1997).</td><td>- Fear of rejection by the domestic market (Originality of the company’s concept) (CW);<br>- Financial increase of the company (Bj and Vlg);<br>- Search for prestige, notoriety/brand dissemination (W&S and Vlg);<br>- Size and difficulties of the Portuguese market (Nv and Pch);<br>- Search for new customers (Vlg);<br>- Increase in quality (Vlg).</td></tr>
</table>

*Table 6. Comparative analysis between the results obtained and the literature - Obstacles/Constraints to internationalization. Source: Authors.*

| **Obstacles/Constraints** | |
|---|---|
| **Literature:** | **Results:** |
| - Economies of scale; | - Financial capacity (CW, Bj, Vlg);<br>- Lack of knowledge of Portuguese wine in the foreign market (CW, W&S, Vlg, Pch);<br>- Lack of experience in the field of contracting and marketing (Bj); |
| - Product differentiation:<br>- capital;<br>- distribution networks; Porter (1986);<br>- public policies; | - Lack of institutional support in the sector (W&S, Vlg); |
| - Costs associated with issues such as coordination and control, as well as administrative systems for managing culturally distinct markets (Geringer, Beamish and Dacosta, 1989); | - Culture of the destination country (Nv); |
| - Loss of competitive advantages, which results from the inability to transfer to international markets the competitive advantages acquired in the domestic market and the inability to create value in international markets (Cuervo-Cazurra and Um, 2007); | - High value of top (niche) wines (Nv); |
| - Lack of complementary resources needed to operate in a new country, in particular the inability to expand, the lack of means and resources to compete in the new country and the lack of infrastructure in the destination markets to optimize the use of the products intended to be marketed (Cuervo-Cazurra and Um, 2007); | - Legislation of the destination country (Vlg); |
| - Cultural differences (Vasquez, 2009). | - Prices charged by importers (which greatly increase the price to the end consumer) (Vlg);<br>- Language of the destination country (Vlg);<br>- Brand unawareness (Nv and Vlg);<br>- Geographic distance (Vlg). |

(ii) **L**ocation in a market – location advantage in a given country so that the company can exploit the ownership advantage abroad, rather than in the origin location. This advantage is related to the characteristics of the destination country (production costs, market size, integration into wider economic spaces);

(iii) **I**nternalization - that is, transferring its own advantages across borders. It is connected to the exploitation of ownership advantages using the company's own channels (through subsidiaries and associates), instead of market mechanisms, which work on the basis of independent companies; these advantages are related to the occurrence of imperfections in the markets that give rise to uncertainty and high transaction costs.

*Table 7. Results obtained - Requirements for companies to stay in the foreign market. Source: Authors.*

| **Requirements for companies to stay in the foreign market** |
|---|
| - Availability of time and financial capacity for persistent on-site follow-up (CW; W&S; Nv and Pch);<br>- Recognition of the importance of the sales staff (Bj);<br>- Existence of sufficient stock for rapid replenishment (Bj);<br>- Agile and effective customer response (Vlg);<br>- Working with an agent in the destination country (Nv). |

## RESULTS AND DISCUSSION

For a better understanding of the results, a comparative analysis between the results obtained and the literature reviewed is presented, systematized in tables, organized according to the most relevant variables in the corporate internationalization process.

Considering the results obtained, all companies that agreed to participate in this research have characteristics and a vocation for exporting that allowed to draw reliable conclusions from the study carried out.

The selected sample covers an important sector of economic activity, different sizes, and present in several international markets.

## CONCLUSION

This chapter is part of a study on the internationalization of companies, focused on the DDR, as it is an international region *par excellence*. Since it is impossible to analyze all the companies that make up the universe of the DDR, a sample was selected based on the criterion of prior knowledge of the company involved in the internationalization process, as well as other companies that have shown interest in collaborating. The study sought to demonstrate, among other factors, strategies and forms of internationalization, as well as the difficulties experienced in internationalization and the advantages, essentially financial ones, for companies operating in international markets. Thus, the study was designed according to the companies involved, the strategies they followed, the characteristics, advantages and disadvantages of expanding their businesses across borders, as well as the availability of directors and managers to answer questions and provide the necessary clarifications to any doubts or other issues.

The methodology selected to investigate the given propositions was based on a qualitative method that, for the study carried out, best suited the objectives to be reached.

For this purpose, open-ended interviews were carried out (in June 2015) with companies that agreed to participate in this study and which, as shown by the presentation of each of them in the previous chapter, have proven their entrepreneurial capability in international markets, regardless of the difficulties that the country is experiencing.

Their motivations for starting the internationalization process were several, but, on the whole, coincided with those presented in the literature review. The size of the domestic market and the current economic and financial difficulties were the main justification for seeking foreign market shares.

The increase in profitability and the reduction of business risks, the search for comparative advantages, the identification of growth opportunities, the knowledge of their brands, the representation of the *made in Portugal* brand, are some more factors that can be achieved through the diversification of markets, namely external ones.

Exportation was identified as the first (and only, so far) internationalization strategy assumed by these companies.

Regarding the export destinations, there are four main routes: (i) the selection of geographically closer markets, namely European countries; (ii) the markets in the Portuguese-speaking African countries, especially Angola; (iii) the destination markets of Portuguese emigration; and (iv) the largest markets with the greatest growth potential.

As for the obstacles to internationalization, which were also identified in the literature review, there are several types. Firstly, there are the issues of administrative bureaucracy and legal aspects applicable to the destination markets, but also in the exportation phase of the country. A second obstacle felt in the internationalization processes includes financial issues, mainly in smaller companies. Then, cultural and religious issues, with great weight in companies producing alcoholic beverages. The Portugal brand is still an obstacle for companies to succeed abroad, mainly due to a lack of knowledge and support to promote Portuguese products. Portugal is still struggling to shake off the image of a country that produces cheap wine and *Vinho Verde* (literally 'green wine'), although some quality wines have their niche.

Public support for the internationalization of companies was considered important, but occasional and diffuse, not considered a determining factor in the decision to internationalize.

It makes perfect sense that companies do not limit themselves to a closed circle within their business area, or even their headquarters' geographical area, but rather, that they invest in new markets that allow them to grow. They should invest in foreign markets, for instance, so that their mission is spread and not only subject to the national market, which, in the case of Portugal, is still in such a premature phase.

Portuguese companies must consider and meet a series of conditions when choosing to export, such as:

- Firstly, they must know their own companies and understand whether they are prepared to take this step;
- To identify the business fields where to be more successful since they correspond to the product or service characteristics that are most valued in the purchasing decision;
- To hold competitive advantages over the competition, namely in specialized areas/products or in previously identified market niches/segments;
- To understand if their products can be exported and what the requirements are;
- To consider the investments needed for promotion, in fairs, and advertising in the target markets;
- To maximize the available, reliable and relevant strategic information that allows the knowledge of the markets and the business opportunities generated therein;
- To recruit human (specialized senior officials and middle managers who are motivated and trained in internationalization), technical (appropriate information systems), and financial (balanced capital structure) resources to control and sustain this entire process;
- To act prudently and responsibly, always according to the company's reality;
- To know the legislation, language, and culture of the countries to which the company intends to sell.

"The company must have as a reference, not the existing space, but a unique "off the map" space. As for the ability to expand, it will be critical that the company's strategic architecture and intent are underpinned by a deep understanding of possible discontinuities, competitor intentions, and constantly changing customer needs" (Hamel and Prahalad, 1994).

A company develops its activity in permanent interaction with its environment. The ongoing evolution of markets and industries generates multiple opportunities and potential threats that companies must know how to respond to. Those that are less fast and effective in the process of adaptation and response to their surrounding environment lose competitiveness and risk losing customers and, ultimately, being eliminated by natural selection.

**Funding:** This study was conducted under the project "Projeto Turismo: caraterização, impacto e sustentabilidade do turismo da Madeira" (M1420-01-0145-FEDER-000007), co-financed by the Madeira Program 14-20, Portugal 2020 and the European Union, through the European Regional Development

Fund, which belongs to the Research Group CITUR - Madeira - Centre for Tourism Research, Development and Innovation.

## REFERENCES

Almeida, C. A. B. (2011). História do Douro e do Vinho do Porto. Porto: Afrontamento.

Blomstermo, A., Eriksson, K., & Sharma, D. D. (2004Domestic Activity and Knowledge Development in the Internationalization Process of Firms. *Journal of International Entrepreneurship*, *2*, 239–258. doi:10.1023/B:JIEN.0000032775.53005.59

Brewer, H. L. (1981). Investor benefits from corporate international diversification. *Journal of Financial and Quantitative Analysis*, *16*(1), 113–126. doi:10.2307/2330669

Buckley, P. J., & Ghauri, P. N. (1993). *The internationalization of the firm: a reader*. Academic Press.

Buhner, R. (1987). Assessing international diversification of West German corporations. *Strategic Management Journal*, *8*(1), 25–37. doi:10.1002mj.4250080104

Cuervo-Cazurra, A., & Un, C. (2007). Types of Difficulties in Internationalization and their Consequences. In A New Generation in International Strategic Management. MPG Books Ltd. doi:10.4337/9781847208859.00012

Defarges, P. M. A. (1993). *Mundialização – O Fim das Fronteiras*. Instituto Piaget.

Dib, L. A., & Carneiro, J. (2006). *Avaliação Comparativa do Escopo Descritivo e Explanatório dos Principais Modelos de Internacionalização de Empresas*. 30° Encontro Nacional de Pós-Graduação e Pesquisa em Administração – ENANPAD, Salvador, BA.

Dib, L. A., & Rocha, A. (2009). Caracterizando o Processo de Internacionalização Born Global: Pesquisa Quantitativa na Indústria Brasileira de Software. Encontro de Estudos em Estratégia, Recife.

Dominguinhos, P. M. (1997). *O processo de internacionalização: a experiência das empresas Portuguesas.* Academic Press.

Dunning, J. (1988). The ecletic paradigm of international production: A restatement and some possible extensions. *Journal of International Business Studies*, *19*(1), 1–31. doi:10.1057/palgrave.jibs.8490372

Dunning, J. (2001). The Eclectic (OLI) paradigma of International Production: Past, Present and Future. *International Journal of the Economics of Business*, *8*(2), 173–190. doi:10.1080/13571510110051441

Dunning, J. H. (2000). The eclectic paradigm as an envelope for economic and business theories of MNE activity. *International Business Review*, *9*(2), 163–190. doi:10.1016/S0969-5931(99)00035-9

Geringer, J. M., Beamish, P. W., & Dacosta, R. C. (1989). Diversification strategy and internationalization: Implications for MNE Performance. *Strategic Management Journal*, *10*(2), 109–119. doi:10.1002mj.4250100202

Grant, R. M. (1987). Multinationality and performance among British manufacturing companies. *Journal of International Business Studies*, *18*(1), 79–89. doi:10.1057/palgrave.jibs.8490413

Grant, R. M., Jammine, A. P., & Thomas, H. (1988). Diversity, diversification and profitability among British manufacturing companies, 1972-1984. *Academy of Management Journal*, *31*(4), 771–801. doi:10.5465/256338

Gugler, P. (1992). Building Transnational Alliances to Create Competitive Advantages. *Long Range Planning*, *25*(1), 90–99. doi:10.1016/0024-6301(92)90314-R

Haguette, T. M. F. (1997). *Metodologias qualitativas na Sociologia* (5th ed.). Vozes.

Hamel & Prahalad. (1994). *Competing for the Future*. Harvard Business Review Press.

Harrigan, K. R. (1988). Joint Ventures and Competitive Strategy. *Strategic Management Journal*, *9*(2), 141–158. doi:10.1002mj.4250090205

Hitt, M. A., Hoskisson, R. E., & Hicheon, K. (1997). International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, *40*(4), 767–798.

Hymer, S. (1983); Empresas multinacionais: a internacionalização do capital. Edições Graal.

Johanson, J., & Mattsson, L. (1988). *Internationalization in industrial system: a network approach. Strategies in global competition*. Croom Helm.

Johanson, J., & Vahlne, J. E. (1977). The internationalization process of the firm: A model of knowledge development and increasing foreign market commitments. *Journal of International Students*, *8*, 23–32.

Johanson, J., & Vahlne, J. E. (1990). The Mechanism of Internationalization. *International Marketing Review*, *7*(4), 11–24. doi:10.1108/02651339010137414

Johanson, J., & Vahlne, J. E. (2009). The Uppsala internationalization process model revisited: From liability of foreignness to liability of outsidership. *Journal of International Business Studies*, *40*(9), 1411–1431. doi:10.1057/jibs.2009.24

Kim, S. W., & Lyn, E. O. (1987). Foreign direct investment theories, entry barriers, and reverse investments in U.S manufacturing industries. *Journal of International Business Studies*, *18*(2), 53–66. doi:10.1057/palgrave.jibs.8490406

Kim, W. C., Hwang, P., & Burgers, W. P. (1993). Multinationals diversification and the risk-return trade off. *Strategic Management Journal*, *14*(4), 275–286. doi:10.1002mj.4250140404

Kogut, B. (1985). Designing global strategies: Profiting from operational flexibility. *Sloan Management Review*, *26*, 27–38.

Leal, J. A., & Serra, R. V. (2002). Notas sobre os fundamentos econômicos da distribuição espacial dos royalties petrolíferos no Brasil. In *XXX Encontro Nacional de Economia*. ANPEC.

Lindqvist, M. (1991). *Infant Multinationals: The Internationalization of Young, Technology-Based Swedish Firms* (Unpublished Doctoral dissertation). Stockholm School of Economics, Institute of International Business.

Lu, J. W., & Beamish, P. W. (2004). International diversification and firm performance: The S-curve hypothesis. *Academy of Management Journal*, *47*(4).

Martins, C. A. (1991). A filoxera na viticultura nacional. Análise Social, 26(112-113), 653.

Moraes, V., & Locatelli, C. (2012). Vinho: uma revisão sobre a composição química e benefícios à saúde. *Evidência - Ciência e Biotecnologia - Interdisciplinar, 10*(1-2), 57-68.

Oliveira, P., & Teixeira, A. (2011). *The Internationalization Profiles of Portuguese SMEs*. FEP working paper, n. 439, nov./2011. Porto: Faculdade de Economia da Universidade do Porto.

Peng, M. W. (2006). *Global Strategy*. South-Western.

Pereira, A. (1988). *O Contrato de «Joint-Venture»* (1st ed.). ICEP.

Planelles, D. (2011). *Internacionalización*. Nuevo Entorno, Nuevas Reglas.

Porter, M. (1986). *Estratégia Competitiva: Técnicas para análise das indústrias e da concorrência*. Editora Campus.

Quivy, R., & Van Campenhoudt, L. (1998). *Manual de Investigação em Ciências Sociais* (2nd ed.). Gradiva.

Rasmussen, U. W. (1988). *Holding e Joint Ventures: Uma análise transacional de consolidações e fusões empresariais*. Aduaneiras.

Remaud, H. (2006). *What makes small wine companies more competitive in their export markets? Market orientation and innovativeness influence.* In Third Annual International Wine *Marketing* Symposium, France.

Sarathy, R., & Terpstra, V. (1991). International Marketing (5th ed.). Dryden Press.

Sharma, D., & Johanson, J. (1987). Technical Consultancy in Internationalisation. *International Marketing Review*, 4.

Simões, V. (1997). Estratégias de internacionalização das empresas portuguesas. In *Comércio e Investimento Internacional*. ICEP – Investimentos, Comércio e Turismo de Portugal.

Soares, C. C. (2004). *Introdução ao comércio exterior: fundamentos teóricos do comércio internacional*. Saraiva.

Vasquez, L. J. (2009). *Comércio Exterior Brasileiro 9ª Edição*. Editora Atlas.

Viana, C., & Hortinha, J. (2005). *Marketing Internacional* (2nd ed.). Sílabo.

Vrontis, D., & Papasolomou, I. (2007). Brand and product building: The case of the Cyprus wine industry. *Journal of Product and Brand Management*, *16*(3), 159–167. doi:10.1108/10610420710751537

Welch, L. S., & Loustarinen, R. K. (1988). Internacionalization: Evolution of a Concept. *Journal of General Management*, *14*(2), 34–55. doi:10.1177/030630708801400203

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171–180. doi:10.1002mj.4250050207

Williamson, P. (2002). Successful Strategies for Export. *Long Range Planning, 24*(1), 57-63.

## KEY TERMS AND DEFINITIONS

**Companies:** Company, corporation or enterprise are legal entities formed by a group of individuals to engage in and operate a profit business and creating value for shareholders.

**Douro Valley:** The Douro Valley, up to Barca de Alva, is the oldest demarcated wine region in the world. First, the river carved the deep valleys out of the land and then Man transformed the schist mountains into soil and walls and planted the vines, green in summer, flame-coloured in autumn.

**Douro Vineyards:** Wine has been produced by traditional landholders in the Douro region for some 2,000 years. Since the 18th century, its main product, port wine, has been world famous for its quality. This long tradition of viticulture has produced a cultural landscape of outstanding beauty that reflects its technological, social and economic evolution (UNESCO).

**Internationalization:** From an economic point of view, internationalization can be defined as process of increasing involvement of companies in international markets.

**Internationalization Models:** Economic theory that explains how firms gradually intensify their activities in foreign markets.

**Globalization:** In economic terms, globalization can be defined as: "(…) the increasing interdependence of world economies as a result of the growing scale of cross-border trade of commodities and services, the flow of international capital and the wide and rapid spread of technologies. It reflects the continuing expansion and mutual integration of market frontiers (…) and the rapid growing significance of information in all types of productive activities and marketization are the two major driving forces for economic globalization." (Committee for Development Policy)

**Market:** From the business perspective market means a group of individuals or organizations that make up the pool of actual and potential customers for their goods and services, distributed for different categories: geographic, demographic or socioeconomic, psychographic, behavioural or sectoral.

**Wine Demarcated Region:** Part of a regulatory geographical indication system used for wine produced in a delimitated region.

## ENDNOTES

1. Source: www.oiv.com (Accessed in April 2021)
2. Source: https://www.ivdp.pt/ (Accessed in April 2021)
3. Source: http://quintadobeijo.pt/?lang=pt (Accessed in April 2021)
4. Source: https://www.ivdp.pt/ (Accessed in April 2021)
5. Phylloxera is the name given to a small insect that was "imported" along with American grape varieties to Europe. These insects fed themselves through the root of the vine, causing tuberous swellings. The root became so deformed that it could not absorb water and nutrients from the soil. This plague was responsible for the widespread devastation of the country's vineyards. The scarcity of wine caused prices to skyrocket. Phylloxera is thought to have arrived in the Douro region in 1868. (Martins, Conceição Andrade (1991)

[6] Source: https://www.ivdp.pt/ (Accessed in April 2021)
[7] Source: http://www.ivv.min-agricultura.pt/np4/home.html (Accessed in April 2021)

# Chapter 27
# The Role of the Geospatial Information System (GIS) in Achieving the Sustainable Development Goals (SDGs):
## A Spatial Framework for Sustainable Planning Processes

**Arian Behradfar**
*University of Extremadura, Spain*

**José Cabezas**
https://orcid.org/0000-0002-7209-3731
*University of Extremadura, Spain*

## ABSTRACT

*The Sustainable Development Goals (SDGs) represent an innovative strategy to transform the socio-economic and environmental aspects of communities. Sustainable development provides the communities with a set of substantial challenges that are totally geospatial in concept and practice. Most of these challenges can be identified, examined, and visualized within a spatial framework. Despite of noteworthy progress in geospatial information system and science, the lack of comprehensive impressions in planning necessitates the integrative role of geospatial information. This study aims to investigate this role in contributing to SDGs by describing each single goal and following objectives. Furthermore, spatial and non-spatial issues regarding every specific SDG will be accurately discussed to determine the spatial aspects in practice. In this way, the communities will be empowered by unique opportunities to integrate and represent geospatial information into the global agenda in a specific manner, specifically in contributing data resources toward measuring and monitoring the 17 SDGs.*

DOI: 10.4018/978-1-7998-8482-8.ch027

## INTRODUCTION

Sustainable Development (SD) is the term commonly and broadly used to describe a complex range of objectives, activities, and mankind behaviors with respect to the environmental, economic and social issues which should be consistent with the aims of meeting the needs and aspirations of the present without compromising the ability of future generations to meet their own. This concept implies that both technological and social settings should be organized so that human activities would not overload the capacity of the biosphere to absorb their impacts (Menash, 2019).

The Sustainable Development Goals (SDGs), also recognized as Global Goals, include a set of 17 areas that have been set in 2015. These broad and universal goals are significantly focused on reducing poverty, safeguarding the globe, and ensuring prosperity is aimed entirely toward an innovative sustainable agenda. Every goal line has particular objectives to be accomplished over the following 15 years. Governments, businesses, and civil societies collectively with the United Nation (UN) have started to achieve these goals based on the Millennium Development Goals (MDGs) (Anwar et al., 2017).

The SDGs have been adopted as part of the 2030 Agenda for SD. Providing in-depth knowledge, these goals foster comprehensive research on global targets. The sustainability of our planet is currently a major concern for the global community and has a central theme for a number of major global initiatives in recent years. The SDGs call for action by all countries to promote prosperity while protecting Earth and life support system. These Goals aim to provide a comprehensive platform for scientific, teaching, and research communities working on various global issues in the field of geography, earth science, environmental science, social science, economy, engineering, policy, planning, and human geosciences in order to contribute knowledge towards achieving the proposed 17 Sustainable Development Goals on the basis of the environmental, social and economic challenges and issues (Kumar et al., 2019).

Economic, social, and environmental processes are inherently spatial. They can hardly be fully understood without taking into account their spatial dimensions. The relationship between man and the environment cannot be represented without a reference to a special location, because the environment is described by the topological relationships among physical objects and human activities produce impacts on the environment spatially (Campagna, 2006).

With global policy and intergovernmental mechanisms, now recognizing and calling for the need to integrate geospatial information into sustainable development processes, the challenge for national geospatial information systems is what tangible action can be taken. There is now emerging understanding, in fact a rapidly growing realization, that implementation the SDGs, and measuring and monitoring their progress, will require new and large amounts of data, more rigorous modeling and analysis, and much better data management. It will also take transformative change and collaborative approaches to link different data – demographic, statistical, earth observations, environmental and other societal geospatial data together with the one thing they have in common – to geo-referencing and location bases. Furthermore, Geospatial Information Technology has the capacity to create, analyse, model and develop the spatial applications and visualization of geographical phenomena and features. In the last decades, GIS provided a plethora of theories, methods, and tools for sustainable development (Scott & Rajabifard, 2017).

With the advent of the latest technology, GIS has improved the capacity to resolve complex issues in digital environments and modelling for the future. As we mentioned, there are 17 Sustainable Development Goals to be fulfilled by 2030. The present study aims to highlight the role of Geospatial Information Systems and Technology in SDGs. The indicators of the SDGs need accessible, timely and reliable spatial data and methods. This spatial framework can provide comprehensive mapping facilities of past, present and future scenarios to help achieve SDGs in a timely manner. These facilities include visualization techniques in the form of maps, charts and statistics by mean of spatial analysis, interactive mapping and web applications. Furthermore, main opportunities and challenges of GIS in achieving SDGs and sustainable planning process will be discussed particularly by each sustainability goal. Several examples of implementation and monitoring process of SDGs will be represented in this study.

## SDG1: NO POVERTY

The SDG1 aims to eradicate extreme poverty for all people around the world. Poverty could be defined as the state of being inferior in quality or insufficient in amount. Generally, it refers to the broad lack of basic needs for livelihood (Kumar et al., 2019). The UN has outlined several objectives and indicators for this SDG. The traditional techniques to measure poverty depends on census data that typically has a frequent cycle of between 5 or 10 years as it is difficult to update the data yearly. In many low- and middle-income countries, accurate census data is unavailable or outdated. GIS can provide alternative methods by mean of mobile mapping to update and fill up such data gaps in an efficient way (Tatem et al., 2017). Furthermore, various poverty models and maps developed in GIS platform provide inequality information within a region and explain the spatial disparities regarding the poverty issues (Kuffer et al., 2018). These models and maps are one of the most important tools for the effective planning and policy making to design and implement social protection strategies. The proposed strategies include allocating subsides, effective resource use, disability and old-age pension, and unemployment insurance. Multi-temporal poverty models can be used to demonstrate the potential hotspots where the international communities have to work together to reduce poverty (Soto et al., 2011).

The distribution of regional gross domestic product per capita is a clear evidence of local and global spatial autocorrelation (Gallo and Ertur., 2003). Spatial patterns of poverty that can be derived using high-resolution satellite data and object-based image analysis is targeting various aspects of poverty alleviation (Kuffer et al., 2016). Furthermore, census data along with aerial-photo interpretation within a GIS framework illustrate that numerous and varied indicators of poverty mostly revolve around unemployment rate, health-infant mortality rate, ethnicity, educational attainment of female household heads, and house quality (Asensio, 1997).

GIS-based poverty models play an undeniable role in data integrating from various sources, and describing poverty. They can generate reliable poverty maps and indicators at district and sub-district level. The application of GIS can provide in insightful idea of the census data, which seems underutilized in developing countries. Poverty Reduction Information System for Monitoring and Analysis (PRISMA) is a framework widely used to conduct spatial analysis of poverty in relation with other socio-economic variables (Avtar et al., 2020).

slope, soil type, distance, travel time to public resources, elevation, type of land use, and demographic variables can be useful to explain spatial patterns of poverty. Restricted circumstances and data insufficiency, especially in the African region, are the main challenges that planners and policy-makers face in poor countries (Blumenstock et al., 2016). In this regard, a global poverty map using a specific poverty index has been introduced. This index is calculated by dividing the population count by the brightness of satellite observed night time light (DMSP night time light data), estimated by number of individuals living in a region. It also depends on other issues such as land cover and land use, topography, and population settlement. This information can be easily updated by mean of multi-temporal satellite data (Elvidge et al., 2009).

The global multi-dimensional poverty index (MPI) is an international measurement of critical multidimensional poverty covering over more than 100 countries. It implements traditional financial poverty measures by discovering the simultaneous and severe deprivations in health, education, and living standards. Several GIS tools such as the raster calculator, map algebra, interpolation, generalization, and weighted overlay are used to carry out a GIS analysis of the various indicators and the overall MPI. This assisted in determining the spatial trend, pattern and distribution of deprivation to analyze the regional poverty situation (Kumi-Boateng, 2015).

The use of satellite imagery along with machine learning methods can also fill the lack of reliable poverty data. The geospatial information derived from satellite data can provide a framework to estimate variations in poverty across local areas by analyzing features such as the density paved and unpaved roads, building density, roof types, and farmlands types. Furthermore, this information can effectively provide updated data to monitor the progress of growth in poverty issues due to the implementation of current policies (Engstrom et al., 2021).

Another effective tool to predict and evaluate spatial poverty trends in regional planning is based on a transfer learning approach using conventional neural networks (CNN). This approach implements the night-time light intensities as a data-rich proxy to monitor poverty. Additionally, this method can be easily generalized to other regional planning purposes and has a great potential to contribute in sustainability challenges (Xie et al., 2015).

The world Bank has represented poverty maps indicating the poverty track to meet SDG 1, poverty situation relative to the world, and each single country, used to generate the upcoming regional and global poverty estimates. These maps are draw based on data from more than 87% of the total population in 138 low-, middle- and high-income countries. Furthermore, with benefit of GIS, many geographical and demographic filters are available to be applied in these maps so that timely information about the spatial proportion of the population rate living below the global and national poverty live by age and sex can be mapped to show regional and local disparity (Kumar et al., 2019).

## SDG 2: NO HUNGER

The main target of this SDG is to end hunger, achieve food security and guarantee access to certain, sufficient and nutritious food by people around the world, particularly the poor, people in vulnerable situations, infants, and children by the year 2030. GIS can efficiently contribute in providing information of sustainable agriculture and food security by the continuous monitoring and assessment of demographic conditions and changing patterns of food demand. There is a growing need for design and development of more efficient integrated system of food production, processing, preservation, and distribution. The FAO (Food and Agriculture Organization) has utilized geospatial data and GIS technology in a wide variety of planning projects, including mapping of food insecurity and poverty, land use and land cover change, studies of forestry, water resources, ecosystem monitoring, crop forecasting, and finally, coherent and coordinated policy making at various levels and scales to meet the SDGs (Campagna, 2006).

With the help of GIS, ensuring sustainable food production systems, implementation of resilient agricultural practices and increasing productivity and production it is possible to maintain ecosystems. Furthermore, strengthening capacity for adaption to climate changes, extreme weather, droughts, flooding and other disasters and progressively improving land and soil quality are other scopes of GIS implementation in food sustainability (Kumar et al., 2019).

GIS can also be used to detect key areas struggling to ensure enough food. GIS tools in spatial analysis can evaluate the current situation of the regional distribution of underweight children all around the world. This evaluation indicates that the regional characteristics, as well as national policies and circumstances play an undeniable role in high causation as well as prevention by analyzing the hotspots of hunger along with climate change scenario at regional scale. Furthermore, the existing problems would be mitigated by improving the domestic food security situation through gaining economic power. However, many regions would face more serious hunger problems if climate change continues to progress. Based on the current projections, SDG 2 can be achieved for these regions only if the international communities could work together and use geospatial data to forecast the agricultural yield at the national, regional, and global levels with use of ground-based observation and weather data in a timely and accurate manner (Avtar et al., 2020).

Satellite data on GIS environment also can provide useful information about poor growing seasons and years of low crop productions. Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) is one of the seminal agencies that implements GIS for agricultural forecasting. Efficient agricultural productivity and climate resilience are necessary to feed the growing population by adopting advanced GIS-based technologies (Merem et al., 2011).

The SDG 2 targets have multiple reinforcing and constraining linkage with other goals. These linkages provide both challenges and substantial scope for solutions to highlight positive and mitigate counteracting interactions. Agriculture and associated changes in land-use are at the center of food security and the food-energy-water-climate nexus. They are also key issues to regional adaption and climate mitigation strategies, adaptation being particularly critical for less industrialized countries (van Soest et al., 2019).

## 3. GOOD HEALTH AND WELL-BEING

The relationship between health and location has been approved and a concern of scientists and researchers. There are many key issues manipulating public health that have led to geographical studies with a vital and effective role in recognizing a spatial connection between the location and health, and enhancing aspects of community health, in addition to planning healthcare services (Khashoggi and Murad, 2020).

Moreover, identifying the relationship between health and location has led to the emergence of a number of healthcare planning challenges that affect the public health. In general, the incompatibility between supply and demand is the basis for concerns of healthcare service planning. In other words, spatial planners have to represent the healthcare services in line with the size of demand in any area (Guagliardo, 2004).

Studying disease epidemiology by empowering growing use of spatial analysis to identify the ecological, environmental and other factors that contribute to the spread of vector-borne diseases, monitoring disease patterns and defining areas that require disease-control planning SDG 3 aims to ensure health and well-being for all, at every stage of life. The Goal addresses all major health priorities, including reproductive, maternal and child health, communicable, non-communicable and environmental diseases, universal health coverage, and access for all to safe, effective, quality and affordable medicines and vaccines. It also calls for more research and development, enlarged health financing, and strengthened capacity of all countries in health risk reduction and management (Guegan et al., 2018) (Braks et al., 2019).

The adopted strategy of this SDG mainly consists of a set of services that contribute to protecting people from diseases and enhancing the treatment options with the lowest costs. This strategy needs to achieve the highest possible level of health for people according to five basic principles: adopting several sectoral plans, preventing an outbreak of disease, decision making by community, using appropriate tools and technologies, and achieving equitable accessibility and spatial distribution of healthcare services (Sherif, 2007)

Spatial equality in accessibility of healthcare services could be achieved by understanding and implementation the concept of spatial planning, and its role in providing an effective and equitable healthcare system for all. A variety of tools and methods are used over spatial planning to make the best sustainable use of available facilities. This type of planning aims to create the desired change in the society with the guidance, control, and follow-up of this change in different aspects (Mokgalaka, 2014). At the health level, the spatial planning of the healthcare system can be defined as a detailed policy to provide healthcare services to all individuals, such as programs and projects used to achieving the perfect health level of the individual and society with specific characteristics in a given period of time, by making the best use of the available materials and human resources (Dallhammer et al., 2018).

In the light of the role of GIS in dealing with main issues affecting the fulfillment of the SDG 3, the concentration of this section will be on reviewing and discussing these empirical issues in good health and well-being planning. There are a number of different early adopter of GIS in health and human services, including epidemiological and biostatistical planners, vector control professionals, environmental health professionals, and human services planners. The epidemiological planning has been supported by various GIS studies and researches in the healthcare planning area, since triad of person, place and time play a vital role in public health investigations and analyses (Avtar et al., 2020). Early on, GIS was used to collect data, geocode it, and finally analyze the data as a result of a disease outbreak or a poorly understood community health challenge. Having all this data in a geospatial framework, GIS can efficiently help them understand disease diffusion as well as to provide situational awareness to leadership (often through static maps) so decisions could be made regarding where health facilities needed to be deployed. GIS also provides analytical tools for exploratory examination of potential sources of outbreaks. Static maps produced through GIS software indicate exact study areas for epidemiological planning process (Maantay & Mclafferty, 2011).

Biostatisticians working on large datasets also appreciate the capabilities of GIS for data management, analytical functions and visualization. Biostatistics is a branch of applied statistics and is concerned with developing and implementing techniques to summarize and analyze medical and biological data. Biostatisticians use GIS to geocode data and analyze large datasets to call for investigations. They also produced static maps through GIS to provide sustainable healthcare planning process with essential visualizations. Environmental health professionals who are in charge of inspections, data collection and vector control, use desktop and mobile GIS. Such working projects that are sometimes independent of public health and well-being agencies include workflows that are inherently geospatial. GIS help them manage large inventories of facilities and sites under regulations and meet numerous regulations such as assurance functions (Davenhall & Kinabrew, 2011).

Individuals working in the marketing and planning departments of healthcare centers also recognize how GIS could help them analyze services and catchment areas, and allocate best sites for new services. In social services, geoinformatics technology staff has the vision that helping case managers see the client in the context of their environment would help them actualize the core functions of social work (Khashoggi and Murad, 2020). A growing number of health departments around the world use GIS in their daily works and it is not just limited to epidemiologists searching for clues to challenging outbreaks or biostatisticians working on disease registries. Public health professionals use GIS to analyze chronic disease trends such as heart disease, diabetes and cancer, evaluate access to public health services, examine the built environment and respond to natural and man-made disasters to design community health communications programs (Salehi & Ahmadian, 2017).

While there is still a heavy desktop GIS presence in healthcare planning departments, increasingly it is also found residing within an organization's IT department supporting web-based applications (both internal and public-facing). The most recent GIS servers allow GIS functionality to be deployed on mobile devices across the entire organization, so it is expected that not only vector control but also many other field-based programs will move in this direction (Davenhall & Kinabrew, 2011). Monitoring factors that affect human health and well-being, like air quality and traffic is another objective that SDG 3 seeks to achieve. Air quality shows very high temporal and spatial variations. GIS techniques have been applied by various researchers primarily to analyze the spatial and temporal distribution of pollutants (Kumar et al., 2016).

The effect of air pollution on public health depends on factors such as the chemical composition of a particular pollutant, the level of concentration, the presence of other pollutants, the existing health of individuals, and period of exposure. Other than air pollution, the most likely risk to public health and well-being in the present car dominated transport system is road accident deaths and injuries worldwide. GIS is a powerful tool in air quality and traffic studies by conducting spatial analysis for the evolution of a suitable methodology and modeling. The application of GIS in various transport issues include infrastructure planning, design and management, transportation safety analysis, travel demand analysis, and traffic monitoring and control (Manisalidis et al., 2020).

In recent years, there has been an increasing demand and attention for spatial data and visualization to identify the areas of the greatest health and well-being hazards and potential threats caused by air pollution. GIS applications and functions in the mentioned fields go beyond what maps or databases can individually represent. GIS is an essential scientific tool for health data processing, analysis of spatial distribution and variation of health threats and monitoring and management of health epidemics (Jerrette et al., 2010). Mainly, medical spatial investigations are based on the following three complementary groups of models:

1. Environmental or ecological models of epidemiology that explain the occurrence or incidence of diseases on the basis of environmental associations and causations.
2. Spatio-temporal models that explain spatial processes, and the implications of space-distance-time involved in the spread and flow patterns of diseases.
3. Behavioral models of epidemiology that explain the behaviors involved in the vector-host-agent relations in the occurrence, persistence and spread of diseases

(Kanankege et al., 2020).

## SDG4: QUALITY EDUCATION

SDG number 4 aims education and strives to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. There are 10 targets outlined in this goal, including free education, equal access to affordable technical, vocational, and higher education, and eliminate all discrimination in education. The SDG 4 is putting strong emphasis on data generation and monitoring to manage the education sector more efficiently and effectively. The goal is very holistic and puts forward the lifelong learning approach, which demands the progress in education for all age groups and at all levels of education. This demands clear indicators and measurements to generate evidence based international discourses and advocacy. Moreover, SDG 4 is a universal and collective commitment of all countries regardless of their level of development. Looking at the data requirements to monitor the education 2030 agenda, it is clear that various data sources need to be used and traditional approaches to data may have reached their limits (Unterhalter, 2019).

One of the most critical aspects of monitoring SDG 4 is measuring equity that necessitates disaggregated data by various characteristics such as age, sex, location, wealth, disabilities, and ethnicity. This issue requires understanding SDG 4 indicators framework and identifying the roles of different parties in generating different types of data for the calculation of the required indicators for planning, management and monitoring of Education sector (Thaung, 2019).

The development of robust and sustainable educational statistical and monitoring system for SDG 4 begins with undertaking a quality assessment of data production chain, data sources, producers, data users and overall institutional arrangement for this data ecosystem to continue. A good educational statistical and monitoring system is always supported by strong political and institutional mechanism, methodological processes, an efficient and effective data management systems, and capable human resources in managing the system generating information and use for planning and monitoring (Ortigara et al., 2018).

Furthermore, in order to achieve SDG 4, it is necessary to provide up-to-date information about literacy rate, education facilities, the number of educational institutes, the number of school-going boys and girls, student–teacher ratios, and infrastructure available in schools (Kumar et al., 2019). Information and communication technologies (ICT) not only changed the educational process all over the world, but also provided it with the tools to fulfil its role in the sustainable development. However, integrating new technologies into education is not easy, especially for more advanced technologies such as GIS, which was specially designed for professional spatial analysis. Due to the rapid development of GIS, this technology is gradually becoming more widely known. For this reason, the demand for education in this area is becoming increasingly relevant, although GIS learning is neither easy nor intuitive. the integration of GIS into education will increase skills in the field of spatial thinking—thus, the spatial literacy of students develops (Mohanty, 2018).

After the outbreak of the COVID-19 crisis worldwide, the form of education had to change and move to a distance form of education implemented by e-learning. This method of learning is currently on the rise due to COVID-19. its flexibility in terms of location, time, effort, and cost, it makes it the most appropriate option for ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (Alqahtani & Rajkhan, 2020).

Even though most of developed countries have set up an education management and information system to collect, store, analyze and disseminate education data as a pillar of planning processes to implement e-learning, diverse challenges still exist to monitor progress on SDG 4 targets and these challenges are listed in detail:

1. Data production systems not ready for E-learning and new ways of education in SDG 4: Basic education is the only area where more than 60 per cent countries around the world have a decent system to collect data. The lack of holistic data collection systems in new education method sub-

sectors and the challenges in some phases of the data production cycle impedes countries from generating the necessary indicators. Similarly, resource constraints in terms of E-learning and related resources are barriers to increasing indicator availability.

2. Need for multiple data sources: E-learning and Education level of SDG 4 will require the adoption of new indictors, new measurements and new tools for monitoring and some SDG 4 targets. While many indicators that are derived from administrative sources are more likely to be collected by most of the countries, data from other sources, such as household surveys, or other alternative sources are not found in a significant proportion of countries. The use of multiple sources of information will be critical in collecting data for education agenda in sustainability.
3. Dearth of disaggregation to measure equity: The SDG 4 and E-learning have a strong focus on equity. Without having data for all the desirable disaggregation, it is not easy to measure an existing inequity. Currently, only three per cent of indicators can be disaggregated by the related characteristics. In order to better identify the dimensions of disadvantage in education and measure equity and inclusion, efforts should be made to increase the capacity of governments to disaggregate data where relevant by some aspects such as sex, age, location, ethnicity and disabilities.
4. Need to harmonize the measurement of learning outcomes: The most SDG 4 objectives include and focus on learning outcomes. Various methodologies and processes have been developed and applied to measure learning outcomes at different levels. However, each assessment has its own framework and methodology. Thus, there is no standardized, nor comparable method to measure learning outcomes.
5. Lack of culture of data sharing and cooperation: Although many types of data and indictors are collected by different organizations and institutions, they are not generally shared and are not easily accessible. Establishing a culture of data sharing for cooperation among data producers is crucial for effective monitoring of the SDG 4. Information from civil society organizations (CSOs) and other non-traditional education providers, which might collect data on aspects of education that are not covered by the traditional education providers, should be taken into consideration to fill data gaps (Thaung, 2019).

## 5. GENDER EQUALITY

SDG 5 seeks to achieve gender equality and empower all women and girls. Gender equality and women empowerment have advanced in recent decades. Their access to education has improved; the rate of child marriage has fallen and progress has been made in the area of sexual and reproductive health and reproductive rights, including fewer maternal deaths. Nevertheless, gender equality remains a persistent challenge for countries all over the world and the lack of equality is a major obstacle to sustainable development, as gender and wealth disparities persist and obstruct universal access to a quality higher education (Sanneving et al., 2013).

The dictionary meaning of gender equality is the state in which access to rights or opportunities is unaffected by gender. According to UNICEF, this means that women and men, and boys and girls, enjoy the same rights, resources, opportunities and protection. Gender equality refers to the equal rights, responsibilities and opportunities of women and men and girls and boys. Equality does not mean that women and men will become the same but that women's and men's rights, responsibilities and opportunities will not depend on whether they are born male or female. Gender equality implies that the interests, needs and priorities of both women and men are taken into consideration, recognizing the diversity of different groups of women and men. Gender equality is not a women's issue but should concern and fully engage men as well as women (Kumar et al., 2019).

Spatial patterns in socioeconomic data reveal issues and trends that would otherwise be missed by data aggregation to planning units. Informing geographic information systems with gender characteristics theory could create a gendered GIS to help the impoverished. This process starts with the research questions, moves into the data collection and is finalized in the graphic representations. GIS has characteristics inherent in its structure that make it possible to produce gendered knowledge that can help gender equality (Meinzen et al., 2012).

Land provides a major source of income, and inequity in land distribution translates into economic disparity. Technology is important for securing land rights across the world today. Geospatial technology can be used to better define problems and identify ways to best solve them. A mobile application called MAST (Mobile Application to Secure Tenure) for better land governance has been recently used for such gender equality purposes. In the absence of readily-available land surveyors, the mobile platform technology was able to map a community's land (Deininger et al., 2012). Land tenure and land security are a priority in the Sustainable Development Goals (SDGs). Technology is the most cost-effective model that we can utilize to achieve these SDGs considering the magnitude of the problem. Developing countries mostly do not have a formal title or any type of recognized secure tenure to land. To solve this problem in the next 10 years, geospatial technology is going to play a prime role (Liu et al., 2019).

GIS applied to maternal and neonatal health data could help in ending preventable maternal and newborn mortality as a main challenge of gender equality achievements. The global focus has now shifted to the achievement of the SDGs which similarly propose to improve maternal health and reduce mortality to less than 70 per 100,000 live births by and reduce neonatal mortality to at least 12 per 1,000 live births in 2030. Achieving these goals will require national maternal and newborn health (MNH) programs to address underlying, localized inequalities. GIS holds substantial potential for supporting efforts to end preventable maternal and newborn deaths. Realizing this potential will require improved access to high quality MNH data at needed resolutions for planners at multiple levels, increased understanding of and skills in using both the software and the maps for planning and implementing MNH programs, and consistent involvement of the community-in the mapping process as well as in the use of high-resolution maps. (Ozdenerol, 2021).

Though the role of gender in GIS is new, gender in GIS can serve to illustrate distribution and access to resources, which in turn can help in solving varied bringing socio-economic issues and reduce disparities between men and women. For this purpose, GIS efficiently provides the possibilities for creating a framework that is capable of addressing issues of gender and development. We argue that the intersection of GIS with feminist thought provides the best path for exploring such possibilities. Feminist epistemology includes ideas of situated knowledges, representation, and reflexivity. Many of these ideas are represented through qualitative research. When these feminist principles are applied to GIS, a redefinition occurs and new possibilities arise (Gilbert & Masucci, 2005).

Gender and development researchers stand to benefit in two ways by combining qualitative methodology with GIS. Specifically, multimedia GIS can help provide a level of transparency in the research process, which has been deemed an essential component of rigorous qualitative research. Second, multimedia GIS offers qualitative researchers a powerful tool for the organization and representation of data. In the international development sphere, GIS is now commonly used for spatial decision making. Many large development institutes have invested heavily in GIS technology and are currently conducting development research with the aid of this powerful tool. Those of us concerned with gender and development issues have much to gain from the use of GIS, particularly if we are aware of its ability to both empower and disenfranchise women and the poor. Informing our geographic information systems with feminist theory could create a gendered GIS to help the impoverished. This process starts with the research questions we ask, moves into the data we collect, and is finalized in the graphic representations we produce. GIS has characteristics inherent in its structure that make it possible to produce gendered knowledge that can help women. Our job is to be cognizant of these characteristics, inform ourselves with feminist theory, and push the boundaries of what is called GIS (Bosak & Schroeder, 2005).

## GOAL 6: CLEAN WATER AND SANITATION

SDG 6 addresses the issues related to clean water and sanitation. This SDG aims to achieve 7 objectives by 2030 include ranging from water resources to the hygiene of people. The application of GIS has been widely applied to accomplish each of the seven objectives. One of the objectives regarding SDG 6 is the universal achievement and equitable access to safe and affordable drinking water for all. In this regard, the assessment of groundwater potential in a semi-arid region by mean of GIS and spatial decision-making systems and techniques can be considered as a clear insight. In this assessment process, a typical procedure has been used to outline groundwater potential zones integrated by spatial data analysis techniques. Using each of specific spatial methods, it is possible to produce groundwater maps and categorize groundwater zones based on groundwater potential indices. On the basis of hydrogeology and geomorphic characteristics, different categories of groundwater prospect zones have been delineated. Moreover, studies in the drought-prone regions also show the importance of GIS and geospatial data to detect groundwater potential zones. In this way, drought mitigation and adaptation can be efficiently examined (Mallick & Rudra, 2021).

Another objective of the SDG 6 is to complete access to suitable and equitable sanitation and hygiene for all and end open defecation by paying close attention to the needs of women, girls, and people in vulnerable situations. Open defecation is a common method in developing countries due to insufficient accessibility to infrastructure and facilities. Various information on land cover and infrastructure can be used for spatial analysis in infrastructure planning and development (Andres et al., 2018).

Spatial data such as landcover integrated with land ownership, slope, soil type, and visibility indicators in GIS can be used to design infrastructure facilities in planning process. These methods are vital for evaluating environmental impacts and cost of construction as well. Furthermore, clustering the zones of a city based on the physical and socio-economic attributes for infrastructure planning is another GIS implementation. In this way, zones can be effectively studied and considered for various particular purposes such as sanitation and housing. Population density and area data can also be employed in GIS to measure the approximate number of users and hence construction costs (Avtar et al., 2020). The study on water pollution and management in urban area is fulfilled by integrating sewage infrastructures, water level data, canal inflow, and groundwater condition to create maps showing the distribution of water pollution. Another study conducted in the communities without basic infrastructure facilities illustrates the importance of GIS–based methods in the bacteriological investigation of water supply to the rural areas. Data on sanitation, health, water sources, and water sampling points can be analyzed and represented in GIS and a base map is created as the basis for infrastructure planning. GIS data fusion methods also allow the overlapping the spatial location of water sources and bacteriological quality data as well as the generation of a map for water management (Edokpayi et al., 2017).

Exploitation of groundwater resources can also be monitored by GIS methods. The study on integrated GIS for groundwater exploitation and recognition of artificial revitalized sites provides an effective insight to reinforce this challenge. In this study, remote sensing data and other relevant datasets have been implemented to extract information on hydro-geomorphic features of hard rock terrain. This information has been integrated with digital elevation model (DEM) and drainage and groundwater data analysis in GIS. As a result, it could be the basis for scheming a suitable groundwater management plan for a hard rock terrain. Additionally, satellite data with multiple applications along with remote sensing methods can be useful to monitor clouds, precipitation, soil moisture, groundwater potential, inland water bodies, change in the river, surface water levels, etc. Next objective of SDG 6 is protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes. The availability of water depends on several factors such as forests, wetlands, and mountain springs. Therefore, protecting and restoring them plays an important role in SDG 6 achievement. Change detection of natural high forests in GIS methods is an explicit instance. In this study, the regional change detection analysis of natural high forests has been conducted using multi-temporal data in GIS. Wetlands are important in mitigating and controlling floods due to the widespread of waterborne diseases, destroying properties and agricultural fields. Therefore, restoring and protecting existing wetlands is a timely necessity and GIS can be efficiently incorporated in this issue. A multipurpose wetland inventory using integrated GIS approaches and specific analysis at different scales has been used in response to past uncertainties and gaps cause serious damages to wetlands. Furthermore, the conditions of wetlands along coastline can be derived using satellite data and GIS to describe trends in land use due to the changes in agriculture, sedimentation, and settlement patterns (Saraf & Choudhury, 1998).

## GOAL 7: AFFORDABLE AND CLEAN ENERGY

The main targets of this SDG are to ensure universal access to affordable, reliable and modern energy services, increase the share of renewable energy and double the improvement in energy efficiency. In this regard, we are currently witnessing three essential trends with regard to energy infrastructure planning, renewable energy generation and storage: from planned production towards fluctuating production on the basis of renewable energy sources, from centralized generation towards decentralized generation and from expensive energy carriers towards cost-free renewable energy carriers. The modifications of the energy infrastructure, necessitated by this increasing renewable energy use, require an extension of power and heat networks and the construction of additional power plants and storage facilities (Appelrath et al., 2012).

The value of implementing GIS-based approaches in energy domain, especially in providing access to modern energy modes have been proven in a great number of researches and projects in the literature; such as renewable energy potential assessment, affordable energy access modeling, energy infrastructure planning, clean energy demand estimation, site planning for renewable energy projects, and visual clean energy impact assessment. Although the above-mentioned approaches are promising and highly suitable for dedicated singular applications of renewable energy, no generic methods for trans-domain integration of energy system models and geospatial analysis processes have been defined yet (Resch et al., 2014).

From a more general point of view, integrating GIS and energy system modeling enables the generation of a more complete picture of the overall energy system and future energy landscapes. We claim that it is not enough to consider space and time as additional parameters, but in fact, space and time need to be fully integrated into energy system modeling processes in order to better understand the spatio-temporal dynamics of, for instance, energy demand, availability and the effectiveness of conventional and renewable resources, capacity and load patterns of energy infrastructures, including decentralized energy storages, and, finally, the return of investments and economic profitability (Blaschke et al., 2013).

In this study, we aim to analyze the inadequacy and deficiency of previous approaches based on GIS for renewable energy modeling and planning efforts, with the main focus on illustrating a set prospective research avenue to achieve sustainable energy resources. GIS has been widely implemented in planning process of renewable energy infrastructure. Allocation of suitable places along with mapping of renewable energy resources are the main usage of GIS in this field. furthermore, geospatial data on land use and land cover, topography, elevation, hydrography, buildings and infrastructure have been broadly employed (Albraheem & Alabdulkarim, 2021). Main studies and projects intend to achieve this SDG address the potential energy supply and updated demand considerations. In this regard, informative and advanced analysis require a comprehensive framework to incorporate mathematical optimization and simulation. GIS modules can efficiently provide this opportunity based on static geodata and dynamic geospatial variables. Furthermore, GIS participates in integrating spatially varying renewable sources, such as wind, solar radiation and geothermal energy (Garcia Zaballos et al., 2019).

As on-site sources of clean power, solar energy systems can not only reduce greenhouse gas emissions and air pollution, but also increase energy security by providing reliable energy resources. Solar electricity systems called photovoltaics (PV) have the potential to generate power when it is needed most; thereby relieving strain on the electricity system and reducing the risk of blackouts (Tawalbeh et al., 2020). To promote the use of PV to investors, it is essential to design a system that showcase solar energy potential in a user-friendly format. This system lets users investigate locations of interest and perform preprocessed analysis. GIS is the obvious tool to achieve this purpose because it starts with a visual reference which is a map of the entire city showing the buildings that had solar installation potential. It also provides baseline of city's solar industry along with grown pace and direct and indirect potential (Chowdhury et al., 2020).

GIS contributes in the PV project by measuring the solar radiation available on building rooftops. Digital elevation model (DEM) that results in a three-dimensional surface model of the city. The solar radiation tools allowed the analysts to model incoming solar radiation and take into account numerous factors, including variation in elevation, orientation (slope and aspect), the shadows cast by topographic features, and changes with time of day or year. After completing the analysis in GIS environment, the solar radiation map can be published, along with a basemap, other layers of interest (e.g., historic and local electric utility districts), an address locator, and geoprocessing tools, to GIS Server for use by the solar web application. This application is originally built by a geoprocessing service that estimates the solar radiation to deliver a more responsive web application. Wrapping the analytics in an easy-to-use Web GIS application is the next step. There is a great potential in Web-GIS that provides the capability of combining GIS-based web server with other contents to display a visual rich map application (Choi et al., 2019; Piragnolo et al., 2015).

According to studies from the biomass collaborative institutes, large and diverse biomass resource could potentially provide a modern and renewable energy. Feedstock for biomass energy production comes from forestry and forest products, agriculture, and urban sources, such as municipal wastes.

Biomass may also emerge in the form of new crops as the SDG 7 leads to reduce consumption of fossil fuels and petrochemical feedstock and use more sustainable and renewable resources for energy and products (Popp et al., 2014).

Recent studies show that dedicated biomass crops for energy, fuels, chemicals, and other bioproducts may develop given sufficient market incentives or in association with new agronomic practices. GIS can efficiently measure the economic feasibility of biomass supply for different types of manufacturing facilities of future bioenergy, biofuel, and bio-based products. Using the ArcGIS Spatial Analyst extension, it is possible to provide future developers with a map of supply overlap to assess potential competition for feedstock among facilities. The GIS work of the Biomass collaborative may support statewide efforts to attract developers and include biomass as a viable renewable resource to meet energy demands (Woo et al., 2018).

## SDG 8: PROMOTE INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH

This SDG aims to Sustain economic growth per capita in agreement with national situations and gross domestic product (GDP) growth per annum, especially in the least developed countries. Information regarding economic growth shown in various map and represented in different spatial ways can demonstrate the status of each country. Tourism is one of the world's fastest-growing industries and could be considered as an important source of foreign exchange and employment for many developing countries. SDG 8 aims to devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products. The travel and tourism sector in the global economy continues to be very robust and seamlessly increasing. The contribution of GIS in economic growth to the world GDP rose to 10.2% in recent years. Worldwide, this sector provides employment to 1 in every 10 people worldwide (Kumar et al., 2019).

## SDG 9: INDUSTRY, INNOVATION AND RESILIENT INFRASTRUCTURE

This SDG aims to achieve sustainable and quality infrastructure to further a new business model that respects the principles of sustainability and adopt clean industrial technologies and processes. In this regard, promoting the innovation and the achievement of equal access to information are the important issues. Due to growing geopolitical tensions, population explosion and ever-changing climatic conditions the need to develop resilient infrastructure cannot be ignored. There is a broad agreement on the need of develop high-quality infrastructure to boost the local and regional economy while it is being underinvested in planning process. A series of natural disasters and calamities has caused widespread destruction to existing infrastructures in many regions (Battistella et al., 2018). To prevent this issue and SDG 9 achievement, it is important to make the current infrastructures resilient. In order to efficiently achieve this target, it is vital to focus on four key aspects: risk assessment, standards and regulations, long term finance and swift recovery of infrastructure in case of a disaster. In simple terms, infrastructure resilience means the ability to reduce the magnitude or duration of disruptive events. The effectiveness of a resilient infrastructure depends upon its ability to anticipate, absorb, adapt to, or rapidly recover from potentially disruptive events. Infrastructure is not only what we can or will build. As a result, it should be considered in terms of the existing land, sources of water and other natural resources available to everyone (Sharifi & Yamagata, 2018). Infrastructure resilience depends on the ability to be functional at the time of a calamity. By Emphasizing on the importance of geospatial technology in this scope, it is time to move from e-governance to geospatial governance or g-governance. In order to achieve resilient infrastructure, proper information sharing between the concerned parties will have to be started from the time of finalization of this concept (Ferrari, 2020).

While the idea of resilient infrastructure is simple, its overall execution may require a dynamic approach through the use of technologies such as geospatial. Information on location along with attached attributes are clearly the key service that geospatial technology can provide. It can easily address the most pressing issue of site selection for facilities in location-allocation procedure. In fact, the geospatial technology, through its vast range of modern tools, can contribute at every stage of infrastructure building such as planning, building, operations and maintenance (Dowman, 2016).

Meanwhile, highlighting the importance of geospatial technology in building information infrastructure in smart cities and g-governance, there will be an opportunity for citizens to address their day-today grievances in urban areas. Using GIS that provide planners with tracking the exact location of the complainant and the kind of challenges faced by residents in a particular area, it is simply possible to address the issues faced by the public. Echoing similar views, GIS not only helps in managing high-velocity data systems but also contributes to monitoring and alerting. The convergence of all modern technologies such as artificial intelligence and machine learning can be efficiently used in GIS to achieve SDG 9 (Kumar et al., 2017).

## SDG 10: REDUCE INEQUALITY WITHIN AND AMONG COUNTRIES

This SDG calls for just, equitable, tolerant, open and socially inclusive world in which the needs of the most vulnerable are met. This call comes at a time when, despite important gains made in lifting people out of poverty, inequalities and large disparities remain in income and wealth, and also in access to food, healthcare, education, land, clean water and other assets and resources essential for living a full and dignified life. Some groups including those in rural areas, women, young people, people with disabilities, indigenous peoples and others have persistently clustered at the bottom of distributions. Real wage growth has constantly declined since 2015 and at the same time, a warming climate, demographic change, decent work deficits, political crises, technological change and conflict risk exacerbating inequalities if actions are not taken toward equality in both opportunities and outcomes. Such inequalities can become self-perpetuating across generations, thus hindering progress towards one of the central objectives of the 2030 Agenda (Kabeer & Santos et al., 2017).

Understanding that development is not sustainable if people are excluded from opportunities, services, and the chance for a better life. SDG 10 calls on the international community to reduce inequality within and among countries. The targets within SDG 10 cast a wide net to capture multiple drivers of inequality and to ensure that no group or individual is left behind. Four targets address within country inequality across social, economic and political dimensions aiming to expand prosperity, inclusion, and social protection. Three targets aim to reduce inequality among countries with attention to cross-border flows of finance and people and the distribution of voice in global institutions. Three other targets focus on the means of implementation and put forward concrete steps for attaining greater equality by directing resource flows toward those most in need (Saiz & Donald, 2017.).

To achieve the proposed objectives and targets regarding SDG 10, it is vital to provide spatially disaggregated data in order to address urban inequalities. Many urban areas suffer from an information crisis that undermines their capacity to develop effective urban policy. It also warns that these areas do not have a sustained or systematic approach to assessing the urban problems and cannot evaluate the success of the implemented policies. Urban indicators are seen as a tool that can improve this situation and the spatial dimension of inequalities makes it a suitable subject for analysis and monitoring with the use of GIS (Martínez, 2005).

Indicators simplify complex phenomena into quantifiable measures that can be used for planning and policy-making. An indicator focuses on and renders intentionally selected areas of the reality. This definition shows the potential that GIS has for operationalizing indicators. While constructing indicators, it is necessary to organize data as it has a geospatial context. The spatial essence of indicators coincides with the usually acknowledged advantages of GIS emerge the need for data management, spatial analysis and visualization. Furthermore, the spatial dimension of urban inequalities and the area-based policies that target deprived areas makes decision support suitable for analysis and monitoring with the use of GIS-based indicators. Besides, the value and potential of GIS in constructing intra-urban indicators was increased by a combination of factors. A growing concern regarding intra-urban inequalities, the implementation of area-based policies, and the developments in ICT and GIS technology (Jakobi et al., 2018).

## SDG 11: SUSTAINABLE CITIES AND COMMUNITIES

During last decade, there has been significant growth in global spatial data acquisition, processing and analysis due to achievements in technologies and computer science. Consequently, more investments and technical applications are required in order to accelerate the integration of geospatial data into the SDG of implementing sustainable cities and human settlements. In this regard, a representative framework including regional datasets of land use and accessibility make it possible to monitor the vital factors and features of SDG 11. This SDG aims to achieve progressive sustainability in urban planning, multiple provision of municipal space, access to public services, and transportation systems concur with socio-economic trends in the digital world (Avtar et al., 2020).

The importance of an integrated framework to sustainable development, including the necessity of quality data and information for planning process has been always emphasized. The high need for geo-spatial data was first captured in a global sustainable development dialogue: the promotion and wider use of earth observation technologies necessitate a framework of data acquisition on environmental impacts, land-use and land cover changes. furthermore, it demands urgent action at all levels of data access, exploring the use of geospatial information by utilizing spatial analysis for further advances to the extent that urban planning is concerned. There are various sectors in urban areas that certainly necessitate the implementation of geospatial information. Acquiring data on these indicators will contribute a lot to the achievement of the sustainable cities through SDG 11 by 2030. Population density, wastewater monitoring, land use and land cover are the main subjects of urban areas indicators (Kurowska et al., 2020, Muayama et al., 2021).

Mentioned data categories can be integrated with other geospatial layers and administrative data of high-resolution satellite images. This data fusion leads to document the site of various treatment facilities and a wide range of significant features in urban area. In this way, existing and potential impact can be efficiently monitored and examined (Núñez et al., 2019). The use of geospatial data and analysis in the implementation of SDG11 will contribute efficiently to filling most of the knowledge gaps in urban planning. It will place many demands on regional statistical systems, as well as cost-effective expansions on monitoring in (Avtar et al., 2020).

Geospatial information and analysis considerably improve the efficiency of the SDG11 indicators in administrative sustainable development from global to local scales. The importance of statistical and geospatial data collecting for the implementation and monitoring of the 2030 Agenda and SDG 11 founds a vital foundation for the constant association among the geospatial field and many other sectors cooperating in planning process and achieving the sustainability of cities. For this purpose, not only the promotion of statistical and geospatial data use as reporting and monitoring tools for achieving the SDG11 is required, but also further support capacity building in the intersection of various disciplines in a transdisciplinary approach based on Geomatics is an essential concern (Chen et al., 2020).

As we discussed, a comprehensive geospatial information community, especially for the achievement of SDG 11 through the utilization of GIS agencies is vital. In this way, it is possible to integrate the geospatial information into the precise sustainable cities goal to congregate, examine and evaluate the progress of targets and indicators regarding SDG 11. Backcasting that was theoretically established to facilitate sustainable planning process in the energy sector is a good case of such implementation of GIS. This project works toward to the back from the proposed upcoming indicators to the current ones to reach the desired targets. The implementation of Backcasting as a considerable scenario along the way between the prospective milestones (mainly 25 years ahead) and present situation plays an undeniable role in SDG 11 fulfillment. In fact, it is a methodology used in modeling urban environments of large scales for planning procedure on the basis of GIS. In this regard, national and international geospatial information institutes have to work in partnership more with the national statistical and earth observatory professional communities (Avtar et al., 2020).

Consequently, sustainability indicators derived based on GIS can efficiently provide solutions for the planning process toward sustainable cities and communities. The final decisions regarding sustainable cities planning and management have to be taken based on an assessment of outcomes. Similarly, any strategy needs to include the right facilities of study, investigation, and prediction of proposed consequences (Mohamadzadeh et al., 2020).

The other purpose of this SDG is to drive economic growth and improve the quality of life of the people by enabling local area development and harnessing technology. Area-based development will transform existing areas, including slums, thereby improving the livability of the whole city. New areas (greenfield) will be developed around cities in order to accommodate the expanding population of urban areas. The smart solutions provided by GIS will enable cities to use technology, information and data to improve infrastructure and services. Comprehensive development in this way will improve the quality of life, create employment and enhance incomes for all, especially the poor and the disadvantaged, leading to inclusive cities (Kumar et al., 2019).

The mapping, modeling, and measurements of urban growth can be analyzed using GIS- and RS-based statistical models. While achieving safe, resilient, sustainable cities and communities surely present the global community with a set of significant social, environmental, and economic challenges where geospatial information can provide a set of science and time-based monitoring solutions. In conclusion, whether collecting and analyzing geospatial data or developing geopolitical policy, GIS provides the integrative approach necessary for global collaboration and consensus decision making towards the achievement of SDG 11 on safe, resilient, and sustainable cities (Murayama et al., 2021).

## SDG 12: SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

Consumption and sustainable production are objectives that aim to "do more and better with less" by increasing the benefits in terms of well-being derived from economic activities, through the reduction of the use of resources, degradation and pollution in the entire production cycle, thus improving the quality of life. In order to achieve this SDG, it is essential to provide references of procedures and methods that are more closely related to the application of information and communication technologies to planning, such as the use GIS. However, it is also still somewhat absent in some policies regarding economic dynamics related to consumption efficiency. Additionally, those policies that refer to georeferencing procedures mainly do so in relation to economic objectives and promotion of production and consumption patterns towards sustainability, rather than from a broader perspective which could include aspects related to the analysis of economic performance of the communities or better decision-making in planning process. Furthermore, only very few policies refer to the use of GIS in connection with the monitoring of economic objectives and stakeholders' satisfaction in a sustainable way. The policies with references to the use of GIS have the commonality of having all been adopted in SDG 10 (Campagna, 2006).

GIS manage geospatial data into visualizations using maps and 3D scenes. GIS can also identify consuming attractions and services in different layers and enable their visual overlap with other spatial information available, such as maps on specific environment, watercourses, protected areas or habitats. With this unique capability, GIS reveals insights into data which are not perceived through simple observations cannot easily recognize patterns, trends and anomalies. With regards to sustainable consumption and production, GIS allows performing analyses and forecasting that are useful to make informed decisions in critical planning processes related to land-use, resource availability, the carrying capacity of a territory or the distribution of economic flows, among others (Knippers et al., 2000). Another advantage of an increased use of geospatial data into sustainable consumption and production planning is the possibility to build integrated, interoperable information infrastructures that facilitate coordination and cooperation among all levels (local, regional, national, international). Since the use of geospatial information provides opportunities to more easily examine economic development at local level, it has potential for countries to integrate data collected at destination level in their national monitoring efforts. Consequently, geospatial data can also be used across different institutional entities, for instance, by socio-economic authorities, leading to cross-sectoral integration and a harmonization of efforts (Scott & Rajabifard, 2017).

## SDG 13: CLIMATE ACTION

This SDG aims to achieve the key understanding to dynamic climate by designing spatial frameworks to integrate diverse pieces of past and future data from a variety of sources and merge them together in a single system by mean of GIS. A particular technical measurement that was specifically acknowledged by national development objectives and strategies of most countries all over the world is the use of GIS, particularly on climate monitoring and analysis. For instance, identification of national development program has been initiated in many countries in aid of the application of GIS on the issues of climate change and food security challenges. It goes without saying that GIS has become a pre-requisite for reliable information bulletins on climate change which was relied on by decision-makers (Santopietro & Scorza, 2021). Various pieces of literature pointed out the following reasons why GIS has become a very important ingredient in climate change concern and decision making related to it. In this regard, many regions in the world are characterized by the lack of a dense network of ground-based measurements for Essential Climate Variables (ECVs). Furthermore, some parameters cannot be directly observed or can be observed with better accuracy from space, just like top of atmosphere radiation budget derived from satellite images. GIS provides climate variables with a large regional coverage up to global coverage while assimilation of satellite data is largely increasing the quality of reanalysis data. Satellite-derived products have the potential to increase the accuracy of gridded climate datasets gained from dense ground-based networks (Avtar et al., 2020).

At present, the application of GIS in dealing with the challenges of climate change has been very beneficial. It is remarkable to mention one of the earliest and globally significant contributions of GIS in climate change study that is the detection of the ozone hole over Antarctica. It was discovered by a British scientist and was confirmed by the Nimbus-7 Total Ozone Mapping Spectrometer (TOMS) in 1978. Since then, the TOMS make maps of daily global ozone concentration. These data are used as scientific shreds of evidence in the First Montreal Protocol where 46 nations agreed to reduce the use of chlorofluorocarbons (CFCs) by 50%. However, like many other great things, it is also being hurdled by some issues and criticisms including that there are types of data which are not accurate down to a more human scale of meters. Moreover, it requires highly technical expertise and involves the use of costly/expensive equipment. Accuracy is also highly dependent on the source data. This pushed different organizations (i.e., NASA, ESRI) to strive for future directions in GIS and global change, including international cooperation, dataset management, and distributed computing. Recent developments in geospatial science and systems open up new possibilities for monitoring climate change impacts on the glacier and permafrost-related hazards and threat to human lives and infrastructure in mountainous areas. Previous studies show the importance of GIS in the assessment of natural hazards in mountainous regions. Consequently, it will play a major role for the sustainability of the region in the near future to achieve SDG 13 (Guo et al., 2019).

## SDG 14: LIFE BELOW WATER

This SDG aims to achieve the sustainable conservation strategies in use of oceans, seas, and marine resources. In this regard, SDG 14 includes seven objectives addressing protection of marine and coastal ecosystems, management of fishing activities, growing socio-economic benefits of the small island and insular territories, sustainable use of marine resources, developing research capacity, and implementing international laws which support sustainable utilization of marine resources (Avtar et al., 2020).

Geospatial information and methods come up with an enhanced interface to accomplish these objectives in several ways. In this regard, sustainable management of coastal ecosystems such as mangrove forests, seagrass beds, and coral reefs using integrated GIS can be considered as a significant case. Examination of ecosystem resilience and recovery mainly followed by an adverse impact using GIS methods. These methods include comprehensive approaches that deals with new technologies and analysis in a GIS environment that integrate findings collected over longer periods with the intention of accurate future prediction. Study of seagrass meadows that supports the significance of geospatial techniques in the sustainable use of the ocean and its resources is another example. Seagrass meadows are vulnerable to external environmental changes and they provide a habitat for coastal fisheries. Consequently, monitoring and conserving seagrass is vital to a well ocean environment. Spatial monitoring of seagrasses can efficiently improve coastal management and delivers a substantial change in location and areal extent over a long time (Carlson et al., 2021).

Oil spills are a common problem in oceans mainly associated with shipping activities. In recent years, the frequency of oil spills has increased due to the development of marine transportation. Oil spills can significantly affect the primary productivity of ocean and marine ecosystems including fisheries, marine animals, and corals. RS-based algorithm has been used widely to detect oil spills. There is a significant improvement in the oil spill detection with the use of microwave remote sensing techniques (Saadoun, 2015).

Oil spills mostly belonging to maritime transportation and activities are an arising challenge in oceans. In the last decade, occurrence rate of oil spills has increased due to the development of maritime infrastructure. Oil spills considerably affect the main productive capacity and efficiency of ocean and marine ecosystems including fisheries, marine animals, and corals. In this regard, GIS-based procedures have been broadly used to detect and diagnose oil spills. Furthermore, substantial advancements of remote sensing technologies allow us to detect and highlight oil spill by mean of microwave remote sensing techniques and satellite-based oil pollution monitoring capabilities (Anyanova, 2011).

Based on Food and Agriculture Organization (FAO) reports in recent years, global fish production aquaculture production have been continuing to rise. Both sectors are very important in other SDGs such as global food security and sustainability. In this regard, the existing challenges are overfishing, degradation of keystone species, and climate change. On the other hand, aquaculture faces difficulties such as competition for space, disease outbreak, labor, and impacts of climate change. The solutions to some of these threats of sustainability include applying satellite remotely sensed information and using them in GIS. In this way, detection of ocean temperature, sea surface height anomaly, ocean color is very vital in operational oceanography. In oceanic fisheries, there are mainly two GIS applications, recognition of possible fishing zones, and expansion of administration measures in order to minimize the catch of endangered species (Dean & Populus, 2013).

## SDG 15: LIFE ON LAND

This SDG aims to ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements. Preserving diverse forms of life on land requires targeted efforts to protect, restore and promote the conservation and sustainable use of terrestrial and other ecosystems. SDG 15 focuses specifically on managing forests sustainably, halting and reversing land and natural habitat and forest degradation, successfully combating desertification and stopping biodiversity loss (Keesstra et al., 2016).

Forest plays a remarkable role in regulating the global carbon cycle at local to the global scale as gigatons of carbon is locked up by them every year. Any important alterations or reduction in the forested zone due to any ins and outs, explicitly cause changes in land use and land cover, the practice of selective logging, huge forest fires, pest, and diseases, would certainly reduce the productiveness and effectiveness forest. Furthermore, previous studies concluded that it is extremely vital to decrease greenhouse gas (GHG) emissions from deforestation and forest degradation as a step towards mitigating climate change, as it a growing concern (Avtar et al., 2020).

As a result, it is essential to develop accurate monitoring tools and maps to investigate the net forest cover, deforestation, and degraded forest area along with quantify the Above Ground Biomass (AGB). GIS techniques that provide comprehensive spatio-temporal coverage have been widely used for proposed purposes in past decades. Furthermore, various sorts of researches and monitoring projects have been carried out to map deforestation and forest degradation using geospatial data and method. Quantifying and monitoring deforestation over years using grid-cell analysis of multi-source and multi-temporal dataset is a case in point of using GIS in the literature. Furthermore, satellite imageries acquired with an overall accuracy of forest cover more than 89% are one of the most useful spatial data sources regarding SDG 15. In this way, regional changes in forest fragmentation in relation to the change of forest area are assessed by mean of utilizing regional land cover data to map forest and forest interior areas. To conclude, it is comprehended that forest area change is not necessarily a good predictor of forest fragmentation changes. However, it is obvious that that there are still some gaps between our understanding of the ecological processes and finding using geospatial techniques. It is required that basic science, technology, and policy evolve and develop hand-in-hand (Zhang et al., 2019).

Studies at regional scale provide insights into overall dynamics in space and time domain of territorial analysis and planning. they are vital for scheming national and international level policy to stop the extent of deforestation and degradation. In this regard, an overlook of environmental trends at local levels are required. In conjunction with the satellite data derived from high-resolution satellite imagery, various location-based information layers integrated and provided by GIS could bring an efficient monitoring system to manage deforestation and forest degradation. In this way, different types of embedded information and maps provide a new local to regional resource for recording the varying scope of forests and suggest opportunities for quantifying future trends through comparison with historical ones (Kraxner et al., 2017).

One more factor that plays a significant role in environmental preservation strategies as the main purpose of SDG 15 is the quantity of biomass. Consequently, it is vital for any territory to assess above-ground biomass precisely, as it has the main part in quantifying carbon stored in the forest. From the convention of destructive techniques to extremely accurate non-destructive techniques, the world has witnessed tremendous growth of technology in the way of quantifying AGB. The forest biomass could be measured by mean of using coherence-based regression analysis of using datasets covering green lands and forests in GIS framework (Pakzad et al., 2015).

Sustainable Development Goal 15 mainly includes objectives that basically underline sustainable management of all types of green land and forest. Achievement of proposed objectives necessitates each territory to found a transparent, consistent, and accurate environmental monitoring system. Definitely, the consequences of the current human activities along with the established and implemented policy-making procedure are the impacts that form the future of the forest ecosystem circumstances. Therefore, it is extremely substantial to estimate future scenarios in conservation policies of the environment. In this regard, the key element of the planning process lies in geospatial approaches and techniques to clarify baseline data and methods on green land loss monitoring and preservation strategies against which upcoming rates of transformation can be evidently assessed. Advances in geospatial science and technology encounter these principles for monitoring, examining and confirmation purposes are as the result of great interest in this scope. By mean of GIS, studies and practical projects in environmental impact assessment field play an undeniable in designing and analyzing the current practiced policies and their implications on the future of green lands as one of the main goals of sustainability. Therefore, it is obvious that the use of an objective specific geospatial technique is essentially important for the implementation and achievement of SDG 15 (Reza Shirazi & Keivani, 2017).

## SDG 16: PROMOTE JUSTICE, AND PEACEFUL AND INCLUSIVE SOCIETIES

The main target of SDG 16 is to promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. The achievement of this objective lies on broadening and strengthening the community participation. GIS is increasingly employed in research studies and development projects that incorporate community participation. Furthermore, there is a rapidly growing number of planning frameworks and procedures that implement GIS to merge with community participation in the context of neighborhood revitalization and urban planning (Attree & Möller-Loswick, 2015).

The role of GIS in an inclusive society and public participation can be summarized into six main concerns:

1. Provide efficient public access to geospatial information and technology
2. Integration and representation of multiple issues of society within a GIS
3. Identification of the potential beneficiaries of participatory GIS projects
4. Development of location-based methodologies and methods for more inclusive community participation in spatial decision-making supporting system
5. Situating of GIS production and implementation in local political context
6. Identification of community contribution to geospatial science and system (Craig et al., 2020).

Community projects and plans based on GIS simultaneously promote the empowerment and marginalization of socially differentiated communities. Therefore, the concept of the participatory process is critical for understanding intensions and reasons of gained benefits from access to GIS. In this regard, public participation GIS (PPGIS) clearly places GIS in participatory planning process. Therefore, local knowledge is integrated by GIS. Yet, there are considerable social and technical challenges in effective strategy and employment of PPGIS (Pedregal et al., 2020).

Community Participation and GIS define the PPGIS as a wide attention with multiple denotations and a global scope. There are several emerging procedures of community interaction with GIS that are linked to the social and geospatial context of PPGIS design and implementation in establishment of urban neighborhood. Whereas remarking significant advancements in incorporating neighborhood contribute in addressing critical housing concerns and challenges, the relationships between community organizations is changing. Specifically, a neighborhood discourse about the local landscape is replaced by an official housing discourse associated with technical planning methods (Bown, 2012).

The main contribution of PPGIS is to provide effective perspectives on how community participation is being linked with geographic information systems and technology and how they might be evolved in the planning process to achieve SDG 16 targets. PPGIS currently include both academic research and community development planning. In spite of basic theme of community participation and GIS in sustainability, various different deviations of PPGIS exist. In this regard, we aim to categorize six main topics that review current dynamics and challenges toward the SDG 16 achievement. Socio-economic context combines conventional participatory field methods with GIS components as the first theme. It also determines the geospatial data and location-based methods used in planning process. The relationship between context and GIS techniques plays a vital role in the implementation and objectives achievement of PPGIS. In this way, spatial multimedia is the dominant PPGIS platform. Moreover, homogenizing the community defines the nature of participation and comprehends variety and complexity of social differentiations within participant communities in the second stand. Integrated community modeling represents significant opportunities and challenges as participation becomes broaden. Third subject is the desired information as the outcome of PPGIS. GIS employs accessible technology to link limited (qualitative) and professional (quantitative) information layers. Advanced spatial analytical capabilities of GIS are implemented based on multimedia platform configurations to deliver spatial decision support systems. However, ambiguous of appropriate data and methods still remains as a serious challenge in this issue. PPGIS can also allow communities to integrate digital data layers and generate new geospatial data representation used in decision making as the fourth topic. This empowerment approach includes crime prevention, housing condemnation and renovation, smart growth, land-use planning, natural resource management, and preservation of indigenous territories as the main themes. Furthermore, disempowerment caused by the reconfiguration of established community groups and stakeholders can be considered as the main barrier of presenting new procedures. As dynamics in the planning process associated with PPGIS affect various existing relations in the community, limited data access for community groups can bring disempowerment. Therefore, the particular methods PPGIS use to empower and disempower various groups of community remain important concerns. Fifth topic is related to use PPGIS as research methodology that contributes to GIS and interdisciplinary studies of place. As PPGIS provides more contextual location-based data analysis, it can efficiently significantly contribute to geography and social science academic researches. It is imperative that community participants fully comprehend the main target of initial participating. In this way, PPGIS directly conducts community-based spatial decision support systems. The final topic that can be considered as the greatest challenge of PPGIS is to contribute to more inclusive spatial decision making. While there has been little systematic long-term evaluation of PPGIS role in local and regional planning, PPGIS currently is penetrating the administrative and bureaucratic structure of planning agencies, development organizations and private sector. Continuous monitoring and assessing of PPGIS procedure over a long period provide insights into effectiveness of PPGIS implementation. As PPGIS aims to support community contribution in particular parts of planning process, the efficient transition from PPGIS product to implementation in the context of local and regional landscape of socio-economic as the central motivation of upcoming PPGIS projects (Nabiyeva & Wheeler, 2020; Craig et al., 2020).

## SDG 17: REVITALIZE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

SDG 17 aims to enhance international support for employing efficient and selected capacity construction in societies to reinforce national strategies to accomplish all the SDGs, including through North–South, South–South and triangular collaboration. Sustainable development of any country needs to adopt new information technology administration to support good governance in planning process. Geospatial technology has proven to be an effective enabler to meet these challenges and remove barriers by developing technical capacity at the individual to collective levels and local to regional scales. Capacity building is an ongoing procedure and comprises varying attitudes, conveying practical information and emerging services while expanding the profits of community contribution, knowledge exchange and ownerships. For instance, The Natural Resources Data Management System (NRDMS) project is a multidisciplinary and multi-institutional research and development plan of action of the Department of Sciences and Technology, Government of India, to develop technology for integrated resource management and capacity building at the micro- to macro-levels in a spatio-temporal context (Cummings et al., 2017).

## DISCUSSION AND CONCLUSION

The 17 goals of SD have been established to enhance human well-being, protect natural resources and ecosystem, and reduce human activities consequences and impact on the earth for the future generation. Unlike the Millennium Development Goals, the SDGs have been taken into account for all communities. Considering a variety of themes and scopes of the SDGs, monitoring is a critical step in successful achievement of them by 2030. Monitoring is an essential phase to reconsider the existing policies for more efficient instructions and accurate targeting. Geospatial data and analysis integrated simply in geospatial information science and system can proficiently provide visualized tools at various scales and levels to detect social environmental and economic concerns and challenges as three main pillars of the SD. For this purpose, data acquisition along with integration of numeric data and spatial context are one of the main GIS contributions in SDGs achievement discussed for every distinct goal and objective in this study. In this way, reliable data obtained by GIS is manipulated in spatial databases to provide clear and precise evidence of local to regional differences and challenges. While SDGs targets broad range of issues and aspects of human well-being, GIS is one of the most efficient tools that pave the way towards successful achievement of discussed goals.

The SDGs accomplishment certainly requires worldwide comprehensive efforts in efficient data acquisition, sharing, processing, and aggregation in a highly multidisciplinary spatial framework. In this regard, geospatial information agencies have to collaborate more closely with national statistical and earth observation professional communities to be more integrated with similar local to regional objectives and aspirations. In this way, it is simply possible to deliver consistent and reliable data that is fit-for-purpose demonstrate the functionality and value of the geospatial data by advancing it into the wider sustainable development policy and planning process. This study also discussed the role of communities for the success of SDGs implementation and accomplishment. Participation and transparency are the key components for a robust, effective and accountable mechanism for SDGs from local to a global scale. In the future, the demand for real-time processing of spatial analysis has high opportunities that can be noticed by the potential use of spatial online services. The integrative approach of partnership, capacity-building, and geospatial data analysis can bring a sustainable solution for any SDG achievement.

## REFERENCES

Albraheem, L., & Alabdulkarim, L. (2021). Geospatial Analysis of Solar Energy in Riyadh Using a GIS-AHP-Based Technique. *ISPRS International Journal of Geo-Information, 10*(5), 291. doi:10.3390/ijgi10050291

Alqahtani, A. Y., & Rajkhan, A. A. (2020). E-Learning Critical Success Factors during the COVID-19 Pandemic: A Comprehensive Analysis of E-Learning Managerial Perspectives. *Education Sciences, 10*(9), 216. doi:10.3390/educsci10090216

Andres, L., Boateng, K., Borja-Vega, C., & Thomas, E. (2018). A Review of In-Situ and Remote Sensing Technologies to Monitor Water and Sanitation Interventions. *Water, 10*(6), 756. doi:10.3390/w10060756

Anwar, B., Xiao, Z., Akter, S., & Rehman, R. (2017). Sustainable Urbanization and Development Goals Strategy through Public–Private Partnerships in a South-Asian Metropolis. *Sustainability*, *9*(11), 1940. Advance online publication. doi:10.3390u9111940

Anyanova, E. (2011). *Oil Pollution and International Marine Environmental Law*. Sustainable Development - Authoritative and Leading-Edge Content for Environmental Management. doi:10.5772/37399

Appelrath, H. J., Kagermann, H., & Mayer, C. (Eds.). (2012). *Future Energy Grid-Migration to the Internet of Energy*. Acatech. doi:10.1007/978-3-642-27864-8

Asensio, S. (1997). Targeting the Poor-Poverty Indicators in A Spatial Context. ITC.

Attree, L., & Möller-Loswick, A. (2015). Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels. *UN Chronicle*, *51*(4), 36–39. doi:10.18356/36c826cb-en

Avtar, R., Aggarwal, R., Kharrazi, A., Kumar, P., & Kurniawan, T. A. (2020). Utilizing Geospatial Information to Implement SDGs and Monitor Their Progress. *Environmental Monitoring and Assessment*, *192*(1), 35. doi:10.100710661-019-7996-9 PMID:31828438

Battistella, C., Cagnina, M., Cicero, L., & Preghenella, N. (2018). Sustainable Business Models of SMEs: Challenges in Yacht Tourism Sector. *Sustainability, 10*(10), 3437. doi:10.3390/su10103437

Blaschke, T., Biberacher, M., Gadocha, S., & Schardinger, I. (2013). Energy landscapes: Meeting Energy Demands and Human Aspirations. *Biomass and Bioenergy*, *55*, 3–16. doi:10.1016/j.biombioe.2012.11.022 PMID:26109751

Blumenstock, J. E., Jean, N., Deaton, A., Banerjee, A., Donaldson, D., & Storeygard, A. (2016). Fighting Poverty with Data. *Science*, *353*(6301), 790–794. doi:10.1126cience.aah5217 PMID:27540154

Bosak, K., & Schroeder, K. (2005). Using Geographic Information Systems (GIS) for Gender and Development. *Development in Practice, 15*(2). 231-237.

Braks, M., Giglio, G., Tomassone, L., Sprong, H., & Leslie, T. (2019). Making Vector-Borne Disease Surveillance Work: New Opportunities from the SDG Perspectives. *Frontiers in Veterinary Science*, *6*, 232. doi:10.3389/fvets.2019.00232 PMID:31380399

Brown, G. (2012). Public Participation GIS (PPGIS) for Regional and Environmental Planning: Reflections on A Decade of Empirical Research. *URISA Journal*, *25*(2), 5–16.

Campagna, M. (2006). GIS for Sustainable Development. Taylor & Francis Group.

Carlson, R. R., Evans, L. J., Foo, S. A., Grady, B. W., Li, J., Seeley, M., Xu, Y., & Asner, G. P. (2021). Synergistic Benefits of Conserving Land-sea Ecosystems. *Global Ecology and Conservation*, *28*, e01684. Advance online publication. doi:10.1016/j.gecco.2021.e01684

Chen, J., Peng, S., Chen, H., Zhao, X., Ge, Y., & Li, Z. (2020). A Comprehensive Measurement of Progress toward Local SDGs with Geospatial Information: Methodology and Lessons Learned. *ISPRS International Journal of Geo-Information, 9*(9), 522. doi:10.3390/ijgi9090522

Choi, Y., Suh, J., & Kim, S.-M. (2019). GIS-Based Solar Radiation Mapping, Site Evaluation, and Potential Assessment: A Review. *Applied Sciences, 9*(9), 1960. doi:10.3390/app9091960

Chowdhury, N., Akram Hossain, C., Longo, M., & Yaïci, W. (2020). Feasibility and Cost Analysis of Photovoltaic-Biomass Hybrid Energy System in Off-Grid Areas of Bangladesh. *Sustainability, 12*(4), 1568. doi:10.3390/su12041568

Craig, W. J., Harris, T. M., & Weiner, D. (2020). *Community Participation and Geographical Information Systems*. CRC Press.

Cummings, S., Regeer, B., de Haan, L., Zweekhorst, M., & Bunders, J. (2017). Critical Discourse Analysis of Perspectives on Knowledge and The Knowledge Society Within the Sustainable Development Goals. *Development Policy Review*, *36*(6), 727–742. doi:10.1111/dpr.12296

Dallhammer, E., Gaugitsch, R., & Neugebauer, W. (2018). *Spatial Planning and Governance within EU Policies and Legislation and Their Relevance to the New Urban Agenda*. European Committee of the Regions.

Davenhall, W. F., & Kinabrew, C. (2011). *GIS in Health and Human Services. Springer Handbook of Geographic Information. Springer Handbooks*. Springer., doi:10.1007/978-3-540-72680-7_29

Dean, A. M., & Populus, J. (2013). Remote sensing and GIS integration. In Advances in geographic information systems and remote sensing for fisheries and aquaculture. FAO Fisheries and Aquaculture Technical Paper.

Deininger, K., Selod, H., & Burns, A. (2012). *The Land Governance Assessment Framework: Identifying and Monitoring Good Practice in the Land Sector. In Agriculture and Rural Development*. World Bank.

Dowman, I. (2016). Sustainable Infrastructure: Geospatial Tech in the Forefront. Europe. *Geospatial World*.

Edokpayi, J. N., Odiyo, J. O., & Durowoju, O. S. (2017). *Impact of Wastewater on Surface Water Quality in Developing Countries: A Case Study of South Africa*. Water Quality, Hlanganani Tutu, IntechOpen. doi:10.5772/66561

Elvidge, C. D., Sutton, P. C., Ghosh, T., Tuttle, B. T., Baugh, K. E., Bhaduri, B., & Bright, E. (2009). A Global Poverty Map Derived from Satellite Data. *Computers and Geosciences, 35*(8), 1652-1660. DOI: .cageo.2009.01.009 doi:10.1016/j

Engstrom, R., Hersh, J., & Newhouse, D. (2021, July 31). Poverty from Space: Using High Resolution Satellite Imagery for Estimating Economic Well-being. *The World Bank Economic Review*, lhab015. Advance online publication. doi:10.1093/wber/lhab015

Ferrari, M. (2020). Reflexive Governance for Infrastructure Resilience and Sustainability. *Sustainability*, *12*(23). doi:10.3390/su122310224

Gallo, J. L., & Ertur, C. (2003). Exploratory Spatial Data Analysis of the Distribution of Regional per Capita GDP in Europe, 1980- 1995. *Papers in Regional Science*, *201*(2), 175–201. doi:10.1007101100300145

García Zaballos, A., Iglesias, E., Adamowicz, A. (2019). *The Impact of Digital Infrastructure on the Sustainable Development Goals: A Study for Selected Latin American and Caribbean Countries.* The Institutions for Development Sector. Inter-American Development Bank.

Gilbert, M., & Masucci, M. (2005). Moving Beyond "Gender and GIS" to a Feminist Perspectives on Information Technologies: The impact of welfare reform on women's IT needs. In A Companion to Feminist Geography (pp. 305-321). Blackwell Publications. doi:10.1002/9780470996898

Guagliardo, M. F. (2004). Spatial Accessibility of Primary Care: Concepts, Methods and Challenges. *International Journal of Health Geographics*, *3*(1), 3. doi:10.1186/1476-072X-3-3 PMID:14987337

Guegan, J. F., Suzan, G., Kati-Coulibaly, S., Nkoko Bonpamgue, D., & Moatti, J. P. (2018). Sustainable Development Goal #3, "Health and Well-being", and the Need for More Integrative Thinking. *Veterinaria México OA.*, *5*(2). Advance online publication. doi:10.21753/vmoa.5.2.443

Guo, H., Fu, W., & Guang, L. (2019). *Scientific Satellite and Moon-Based Earth Observation for Global Change*. Springer. doi:10.1007/978-981-13-8031-0

Jakobi, A., Zsom, B., & Viktoria Vida, Z. (2018). Dimensions of Spatial Inequalities in the Information Age: The Case of Hungary. *Espaço e Economia*, *13*(13). Advance online publication. doi:10.4000/espacoeconomia.4797

Jerrett, M., Gale, S., & Kontgis, C. (2010). Spatial Modeling in Environmental and Public Health Research. *International Journal of Environmental Research and Public Health*, *7*(4), 1302–1329. doi:10.3390/ijerph7041302 PMID:20617032

Kabeer, N., & Santos, R. (2017). *Intersecting Inequalities and the Sustainable Development Goals: Insights from Brazil*. WIDER Working Paper 2017/167. Helsinki: UNU-WIDER.

Kanankege KST, Alvarez J, Zhang L, Perez AM. (2020). An Introductory Framework for Choosing Spatiotemporal Analytical Tools in Population-Level Eco-Epidemiological Research. *Front Vet Sci.*, *7*(7), 339. doi:10.3389/fvets.2020.00339

Keesstra, S., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerda, A., Montanarella, L., Quinton, J., Pachepsky, Y., Putten, W. V., Bardgett, R., Moolenaar, S., Mol, G., Jansen, B., & Fresco, L. (2016). The Significance of Soils and Soil Science Towards Realization of the United Nations Sustainable Development Goals. *Political Science*. *Environmental Sciences (Ruse)*, *2*(2), 111–128. Advance online publication. doi:10.5194oil-2-111-2016

Khashoggi, B. F., & Murad, A. (2020). Issues of Healthcare Planning and GIS: A Review. *ISPRS International Journal of Geo-Information*, *9*(6), 352. doi:10.3390/ijgi9060352

Knippers, R., Sun, Y., Ellis, M. C., Kraak, M. J., Weir, M., Georgiadou, P., Radwan, M. M., Westen, C. J., Kainz, W., & Sides, E. (2000). Principles of Geographic Information Systems: An Introductory Textbook. Corpus ID: 65274933.

Kraxner, F., Schepaschenko, D., Fuss, S., Lunnan, A., Kindermann, G., Aoki, K., Dürauer, M., Shvidenko, A., & See, L. (2017). Mapping Certified Forests for Sustainable Management - A Global Tool for Information Improvement Through Participatory and Collaborative Mapping. *Forest Policy and Economics, Elsevier*, *83*(C), 10–18. doi:10.1016/j.forpol.2017.04.014

Kuffer, M., Pfeffer, K., & Sliuzas, R. (2016). Slums From Space— 15 Years of Slum Mapping Using Remote Sensing. *Remote Sensing*, *8*(6), 455. doi:10.3390/rs8060455

Kuffer, M., Wang, J., Nagenborg, M., Pfeffer, K., Kohli, D., Sliuzas, R., & Persello, C. (2018). The Scope of Earth Observation to Improve the Consistency of the SDG Slum Indicator. *ISPRS International Journal of Geo-Information*, *7*(11), 428. doi:10.3390/ijgi7110428

Kumar, A., Gupta, I., Brandt, J., Kumar, R., Dikshit, A. K., & Patil, R. S. (2016). Air Quality Mapping Using GIS and Economic Evaluation of Health Impact for Mumbai City, India. *Journal of the Air & Waste Management Association*, *66*(5), 470–481. doi:10.1080/10962247.2016.1143887 PMID:26828812

Kumar, D., Singh, R. B., & Kaur, R. (2019). Spatial Information Technology for Sustainable Development Goals, Sustainable Development Goals Series. *Springer International Publishing AG*, *2019*. Advance online publication. doi:10.1007/978-3-319-58039-5

Kumar, P., Gupta, K., Karnatak, H. C., Siddiqui, A., & Senthil Kumar, A. (2017). Geo-enabled e-Democracy Tools and Services for Smart Cities. In T. Vinod Kumar (Ed.), *E-Democracy for Smart Cities. Advances in 21st Century Human Settlements*. Springer. doi:10.1007/978-981-10-4035-1_13

Kumi-Boateng, B. (2015). Where are the Poor? A GIS-Multidimensional Non-Monetary Poverty Index Approach for Ghana. *Ghana Mining Journal December Issue - Geomatics Eng. Articles, 15*(2).

Kurowska, K., Marks-Bielska, R., Bielski, S., Aleknavičius, A., & Kowalczyk, C. (2020). Geographic Information Systems and the Sustainable Development of Rural Areas. *Land, 10*(1), 6. doi:10.3390/land10010006

Liu, J., Fujimori, S., Takahashi, K., Hasegawa, T., Wu, W., Takakura, J., & Masui, T. (2019). Identifying Trade-offs and Co-benefits of Climate Policies in China to Align Policies with SDGs and Achieve the 2 °C Goal. *Environmental Research Letters*, *14*(12), 124070. Advance online publication. doi:10.1088/1748-9326/ab59c4

Maantay, J. A., & Mclafferty, S. (2011). Geospatial Analysis of Environmental Health. *Geotechnologies & the Environment*, *4*. Advance online publication. doi:10.1007/978-94-007-0329-2

Mallick, S. K., & Rudra, S. (2021). *Analysis of Groundwater Potentiality Zones of Siliguri Urban Agglomeration Using GIS-Based Fuzzy-AHP Approach. In Groundwater and Society*. Springer. doi:10.1007/978-3-030-64136-8_7

Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in Public Health*, *8*, 14. doi:10.3389/fpubh.2020.00014 PMID:32154200

Martínez, J. A. (2005). Monitoring Intra-urban Inequality with GIS-based Indicators: Case Study: Rosario, Argentina. In *Proceedings of the Computers in Urban Planning and Urban Management (CUPUM 05)*. Computers in Urban Planning and Urban Management.

Meinzen-Dick, R. S., van Koppen, B., Behrman, J. A., Karelina, Z., Akamandisa, V., Hope, L., & Wielgosz, B. (2012). *Putting Gender on the Map: Methods for mapping gendered farm management systems in Sub-Saharan Africa.* IFPRI Discussion Paper 1153. Washington, DC: International Food Policy Research Institute (IFPRI).

Mensah, J. (2019). Sustainable Development: Meaning, History, Principles, Pillars, and Implications for Human Action: Literature Review. Cogent Social Sciences, 5(1). doi:10.1080/23311886.2019.1653531

Merem, E. C., Yerramilli, S., Twumasi, Y. A., Wesley, J. M., Robinson, B., & Richardson, C. (2011). The Applications of GIS in the Analysis of the Impacts of Human Activities on South Texas Watersheds. *International Journal of Environmental Research and Public Health*, *8*(6), 2418–2446. doi:10.3390/ijerph8062418 PMID:21776238

Mohamadzadeh, P., Pourmoradian, S., Feizizadeh, B., Sharifi, A., & Vogdrup-Schmidt, M. (2020). A GIS-Based Approach for Spatially-Explicit Sustainable Development Assessments in East Azerbaijan Province, Iran. *Sustainability, 12*(24), 10413. doi:10.3390/su122410413

Mohanty, A. (2018). Education for Sustainable Development: A Conceptual Model of Sustainable Education for India. *International Journal of Development and Sustainability*, *7*(9), 2242–2255.

Mokgalaka, H. (2014). *Measuring Access to Primary Health Care: Use of A GIS-based Accessibility Analysis*. CONFERENCE paper.

Murayama, Y., Simwanda, M., & Ranagalage, M. (2021). Spatiotemporal Analysis of Urbanization Using GIS and Remote Sensing in Developing Countries. *Sustainability, 13*(7), 3681. doi:10.3390/su13073681

Nabiyeva, G., & Wheeler, S. (2020). Geographic Information Systems as a Tool to Support the Sustainable Development Goals. *International Journal of Computer and Information Engineering*, *14*(3), 78–85.

Núñez, J. M., Medina, S., Ávila, G., & Montejano, J. (2019). *High-Resolution Satellite Imagery Classification for Urban Form Detection*. Satellite Information Classification and Interpretation. IntechOpen. doi:10.5772/intechopen.82729

Ortigara, A., Kay, M., & Uhlenbrook, S. (2018). A Review of the SDG 6 Synthesis Report 2018 from an Education, Training, and Research Perspective. *Water, 10*(10), 1353. doi:10.3390/w10101353

Ozdenerol, E. (2021). The Global Problem in Gender Inequality - Putting Gender on the Map with GIS. CRC Press.

Pakzad, P., Osmond, P., & Philipp, C. (2015). Review of Tools for Quantifying the Contribution of Green Infrastructure to Carbon Performance. *ICUC9 - 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment*. 10.13140/RG.2.1.1858.4083

Pedregal, B., Laconi, C., & del Moral, L. (2020). Promoting Environmental Justice through Integrated Mapping Approaches: The Map of Water Conflicts in Andalusia (Spain). *ISPRS International Journal of Geo-Information, 9*(2), 130. doi:10.3390/ijgi9020130

Piragnolo, M., Masiero, A., Fissore, F., & Pirotti, F. (2015). Solar Irradiance Modelling with NASA WW GIS Environment. *ISPRS International Journal of Geo-Information, 4*(2), 711–724. doi:10.3390/ijgi4020711

Popp, J., Lakner, Z., Harangi-Rákos, M., & Fári, M. (2014). The Effect of Bioenergy Expansion: Food, Energy, and Environment. *Renewable & Sustainable Energy Reviews*, *32*, 559–578. doi:10.1016/j.rser.2014.01.056

Resch, B., Sagl, G., Törnros, T., Bachmaier, A., Eggers, J.-B., Herkel, S., & Narmsara, S. (2014). GIS-Based Planning and Modeling for Renewable Energy: Challenges and Future Research Avenues. *ISPRS International Journal of Geo-Information, 3*(2), 662–692. doi:10.3390/ijgi3020662

Reza Shirazi, M., & Keivani, R. (2017). Critical Reflections on the Theory and Practice of Social Sustainability in the Built Environment – A Meta Analysis. *Local Environment*, *22*(12), 1526–1545. doi:10.1080/13549839.2017.1379476

Saadoun, M. K. I. (2015). *Impact of Oil Spills on Marine Life*. Emerging Pollutants in the Environment - Current and Further Implications. doi:10.5772/60455

Saiz, I., & Donald, K. (2017). Tackling Inequality Through the Sustainable Development Goals: Human Rights in Practice. *International Journal of Human Rights*, *21*(8), 1029–1049. doi:10.1080/13642987.2017.1348696

Salehi, F., & Ahmadian, L. (2017). The Application of Geographic Information Systems (GIS) in Identifying the Priority Areas for Maternal Care and Services. *BMC Health Services Research*, *17*(1), 482. doi:10.118612913-017-2423-9 PMID:28701226

Sanneving, L., Trygg, N., Saxena, D., Mavalankar, D. & Thomsen, S. (2013). Inequity in India: The Case of Maternal and Reproductive Health. *Global Health Action, 6*(1). doi:10.3402/gha.v6i0.19145

Santopietro, L., & Scorza, F. (2021). *A Methodological Framework for the Comprehensive Assessment of Actions and Territorial Target for the "Sustainable Energy and Climate Action Plan" (SECAP) of Potenza Municipality. Lecture Notes in Civil Engineering, 146*. Springer. doi:10.1007/978-3-030-68824-0_45

Scott, G., & Rajabifard, A. (2017). Sustainable Development and Geospatial Information: A Strategic Framework for Integrating a Global Policy Agenda into National Geospatial Capabilities. *Geo-Spatial Information Science*, *20*(5), 1–18. doi:10.1080/10095020.2017.1325594

Sharifi, A., & Yamagata, Y. (2018). Resilience-Oriented Urban Planning. In Y. Yamagata & A. Sharifi (Eds.), *Resilience-Oriented Urban Planning. Lecture Notes in Energy, 65*. Springer. doi:10.1007/978-3-319-75798-8_1

Sherif, A. (2007). *Towards Spatial Justice in Urban Health Services Planning*. Ph.D. Thesis, University of Utrecht, Utrecht, The Netherlands.

Soto, V., Frias-Martinez, V., Virseda, J., & Frias-Martinez, E. (2011). *Prediction of Socio-economic Levels Using Cell Phone Records BT - User Modeling, Adaption and Personalization* (J. A. Konstan, R. Conejo, J. L. Marzo, & N. Oliver, Eds.). Springer Berlin Heidelberg.

Tatem, A. J. J., Bird, T. J. J., Bjelland, J., Bengtsson, L., Alegana, V. A. A., Iqbal, A. M. M., & ... . (2017). Mapping Poverty Using Mobile Phone and Satellite Data. *Journal of the Royal Society, Interface*, *14*(127), 20160690. doi:10.1098/rsif.2016.0690 PMID:28148765

Tawalbeh, M., Al-Othman, A., Kafiah, F., Abdelsalam, E., Almomani, F., & Alkasrawi, M. (2020). Environmental Impacts of Solar Photovoltaic Systems: A Critical Review of Recent Progress and Future Outlook. *The Science of the Total Environment*, *759*, 143528. Advance online publication. doi:10.1016/j.scitotenv.2020.143528 PMID:33234276

Thaung, N. N. (2019). *Regional Capacity Development Resource Book on Monitoring SDG4-Education 2030 in Asia-Pacific*. United Nations Educational, Scientific and Cultural Organization.

Unterhalter, E. (2019). The Many Meanings of Quality Education: Politics of Targets and Indicators in SDG4. *Global Policy*, *10*(1), 39–51. doi:10.1111/1758-5899.12591

van Soest, H. L., van Vuuren, D. P., Hilaire, J., Minx, J. C., Harmsen, M. J. H. M., Krey, V., Popp, A., Riahi, K., & Luderer, G. (2019). Analysing Interactions Among Sustainable Development Goals with Integrated Assessment Models. *Global Transitions*, *1*, 210–225. doi:10.1016/j.glt.2019.10.004

Woo, H., Acuna, M., Moroni, M., Taskhiri, M., & Turner, P. (2018). Optimizing the Location of Biomass Energy Facilities by Integrating Multi-Criteria Analysis (MCA) and Geographical Information Systems (GIS). *Forests, 9*(10), 585. doi:10.3390/f9100585

Xie, M., Jean, N., Burke, M., Lobell, D., & Ermon, S. (2015). Transfer learning From Deep Features for Remote Sensing and Poverty Mapping. *Proceedings 30th AAAI Conference on Artificial Intelligence*, *30*(1).

Zhang, Y., Liang, S., & Yang, L. (2019). A Review of Regional and Global Gridded Forest Biomass Datasets. *Remote Sensing, 11*(23), 2744. doi:10.3390/rs11232744

# Chapter 28
# Radar as a Key to Global Aeroecology:
## Essentials of Technology and Development Milestones

**Alexey Noskov**
https://orcid.org/0000-0003-0503-6558
*Philipps University of Marburg, Germany*

## ABSTRACT

*Open, systematic, and global approaches are needed to address the challenges of aeroconservation and pest management. Recent technical progress enables deeper investigation and understanding of aeroecology. Radar plays a central role in flying species monitoring in the global scope. The technology provides various ways of target detection and tracking, working for multiple ranges and different visibility. The existing technology allows deploying global monitoring of avian and insect species. This work discusses the essentials of the technology and the history of its application for bird and insect detection. The author describes the development of the topic according to the main groups of radar approaches: pulsed sets, vertical-looking solutions, harmonic systems, and efficient frequency modulated continuous wave radar. Advances in big data processing, robotics, computation, and communications enable practitioners to combine the discussed radar solutions aiming at global avian and insect biodiversity monitoring and negative human impact systematic estimation.*

## INTRODUCTION

Nowadays, damaging human impact on nature is one of the main concerns. The discussion regarding global warming is highly distinguished in this context. Uncountable pieces of evidence confirm human destructive effect to nature which must be reduced and controlled immediately (McKibben, 2003). Researchers come off from the small to large scale. The investigation started from global climatology, deforestation, desertification gradually increases the details.

DOI: 10.4018/978-1-7998-8482-8.ch028

The recent progress in information and communications technology allows us systematically consider even hardly observable worlds. One of such vital worlds is the world of birds and insects. Bird and insect conservation is possibly one of the most critical and urgent questions in this regard. In general, conservation biology stands for a relatively recent, synthetic field that applies ecology, biogeography, population genetics, economics, sociology, anthropology, philosophy, and other disciplines maintaining biological diversity throughout the world (Groom et al., 2012). It is motivated by human-caused global changes that have resulted in the most remarkable episode of mass extinction since the loss of the dinosaurs 65 million years ago. One can notice that in the frame of conservation biology, bird and insect conservation does not occupy a significant part, but, with the mentioned technological progress, it becomes more and more distinguished and recognizable.

Researchers distinguish two main ethic approaches regarding insect conservation: Romantic-Transcendental Preservation and Resource Conservation. The former consider insects a significant part of the ecosystem without intention to affect, intrude or fix something. The latter stands for sustainable utilization of insects. The Romantic-Transcendental Preservation Ethic is especially actual in the context of the nature reserve. Lockwood (2005) has formulated a strong ethic concerning insects, which says that actions that may be reasonably expected to kill or cause nontrivial pain in insects when avoiding these actions have no costs to our welfare have to be minimized. In that regard, our attitude to *Basking malachite* (*Chlorolestes apricans*, an attractive South African damselfly on the verge of extinction) and citrus wax scale (*Ceroplastes brevicauda*, pests on a citrus twig) should tend to be equal (Samways, 2005). Additionally, many emphasize the need for balancing conservation and pest suppression. Regarding this, New (2018) wrote: “Harmonising pest management and insect conservation pose problems in many contexts in which human economic priorities, essentially protecting supplies of food or commodities such as timber, can come into conflict with conservation ideals.” The same ideals should be applied for bird conservation.

Nowadays, all regions concern the bird and insect conservation problems leading to worldwide changes. For instance, McLean et al. (2012) discussed the rich evolution of the UK movement for invertebrate conservation actively, which has been developed from the middle of the 20th century, consolidated in stature through decades, and then diversified and supported more firmly the voluntary sector. Pyle (2012) described the origins and history of insect conservation in North America in the damaging European colonization. Many works provide similar concerns for other regions (e.g., New Zealand (Watts, 2012), Central Europe (Spitzer, 2012), Japan (Ishii, 2012), etc.). Most of the works take into account specific species.

“Fine-grain” conservation with the particular species focus often attracts more extensive interest since it can provide concrete results. Such an approach is especially actual concerning insects about extinction. New (2009) provides a detailed “fine-grain” methodology and solutions applied for various species in Australia. He discusses criteria for assessing priority for advisory or legislative categorization of threatened or protected species, conservation plans, needs in planning habitat and resource supply, and insect management plans for the future. Moreover, he discusses monitoring roles in conservation management. In this regard, the monitoring prevents insect management from being rigid and leads to adaptive and periodically or continuously dynamic management.

Usually, researchers tend to conduct monitoring periodically, arguing time intervals depending on the object and resources (Hauser et al., 2006). Traditional monitoring requires significant resources. Often, such intervals are annual, which makes it impossible to distinguish large-scale processes limiting understating of various trends. Recent progress in technology dramatically reduces prices for electronic devices and data processing. That leads to dramatic changes in approaches to insect and bird monitoring with potential real-time solutions.

## Radar's Essentials

With technical progress and reducing prices for electronic components, radar technology becomes very popular in environmental monitoring research. In comparison to other remote sensing solutions, radar concepts seem more complex and specific. Thus, compact and descriptive introductory information is required. In this and the following section, the author tries to meet these expectations aiming at practitioners without a satisfactory technical background. Shortly and descriptively, he defines radar, describes its history, fundamentals, radar types, signal processing, and applications.

Radar adopts electromagnetic waves in the radio range for object detection. It can measure the parameters: the range (distance to an object), angle, and velocity (radial speed). Radar has multiple applications. As many technologies are designed for military purposes, radar facilitates various civil tasks, from aircraft navigation to environmental monitoring. To effectively utilize this technology (for environmental monitoring in particular), it is crucial to have a systematic overview of radar history and fundamentals. What is more, the basic principles of radar data processing play a crucial role in such studies.

## Brief History

Radar was originally developed for military tasks. United States Navy started to use the term "RADAR" as an abbreviation of RAdio Detection And Ranging (Parker, 2003). Now, the term is used as a regular English noun spelling in low-case.

At the end of the 19th century, Maxwell (1892) proposed equations concerning the behavior of electromagnetic radiation called Maxwell's equations. These equations establish a fundamental theory for electromagnetic phenomena and their applications. The equations are fundamental for uncountable technological solutions using the electromagnetic field. One of the first researchers who noticed the ability to utilize radio waves for object detection was a Russian scientist Alexander Popov (Kostenko, 2001). In 1892, he reported an interference beat caused by the passage of a third vessel and the potential usability of this for object detection.

In 1904, Christian Huelsmeyer (van Loon, 2005) (for the first time in history) showed how to use radio radiation for the detection of distant metallic objects (ships) in dense fog. He proposed the use of radio echoes in a detecting device designed to avoid collisions in marine navigation (Rahman, 2019). One can say that this was a starting point of radar history.

Since then, radio waves have been under severe considerations worldwide. Before the Second World War, the United Kingdom, France, Germany, Italy, Japan, the Netherlands, the Soviet Union, and the United States intensively developed radar and related technologies for their armies (Watson, 2009). These countries massively applied radar technologies in World War II. In 1945, the US Army Air Force issued a report (currently unclassified) systematizing significant variations of available radar and related equipment (USAAF, 1945).

After the war, the utilization of radar has been increased dramatically. Many civil fields have successfully adopted radar technologies. Since 1950, the Doppler principle to radar became popular in the operation of many radar systems (Neng-Jing, 1995). It includes moving target indication, continuous wave, and pulse Doppler radars. In the 1970s, radar systems conduct remote sensing tasks from aircraft and satellites (e.g., the Seasat mission (Born, 1979)). Since the 1980s, phased-array radars facilitate environmental research (e.g., wind speed, ocean waves, sea ice, etc.).

Computer technology that becomes available in the 1990s facilitates retrieving the information about the nature of targets and the environment derived from radar echoes. Also, Doppler weather radar systems applied computer technology to measure precipitation and wind speed. In addition, radar-based altimeters, scatterometers, and imaging radar systems are now widely recognized as highly successful tools for earth observation from aircraft and satellites (Rahman, 2019). Nowadays, radar is a state-of-the-art technology applying in the uncountable military, civil, industrial, and research fields.

## Fundamentals

As mentioned, Maxwell's equations are a basis for radio, television, radar, satellite communications, cellular phones, global positioning systems, microwave heating, and X-ray imaging, etc. Radar is usually described as a detection system utilizing radio waves for range, angle, or velocity of objects definitions. Radar uses the emitted waves' refection as the main principle for its work.

To illustrate this, imagine one staying on the low bench of a wide river, a high bench on the opposite side. How can she measure the river's width without any instruments (Perlya, 1955)? To answer this question, one can remember the following trick from childhood: a distance to lightning equals the number of seconds between seeing lightning and hearing thunder multiplied by the speed of the sound. Thus, if there were 4 seconds, the distance is about 1.2 km (i.e., 4 s x 0.3 km/s). This trick allows calculating the distance to a coming thunderstorm.

Concerning the example with the river width, one can yell "Hey!" and start counting seconds. After some seconds, she will hear the echo; usually, it will be "ey." Knowing the number of seconds, she can easily (but approximately) calculate the distance sound passed. The division of this distance by two is the width of the river. The sound, first, goes from the transmitter (the mouth) reaching the target (the high bench on the opposite side of the river). The sound reflects from the target and goes back to the receiver (the ears). The signal is processed by the indicator (the brain), which calculates the distance. For instance, if 5 seconds is required, the river's width is about 0.75 km (i.e., (5s x 0.3km/s)/2). Figure 1 visualizes the discussed example. It is well known that echolocating animals intensively use the described principle. Bats and dolphins (Liu, 2010) emit the ultrasound for orientation in low-visibility and hunting.

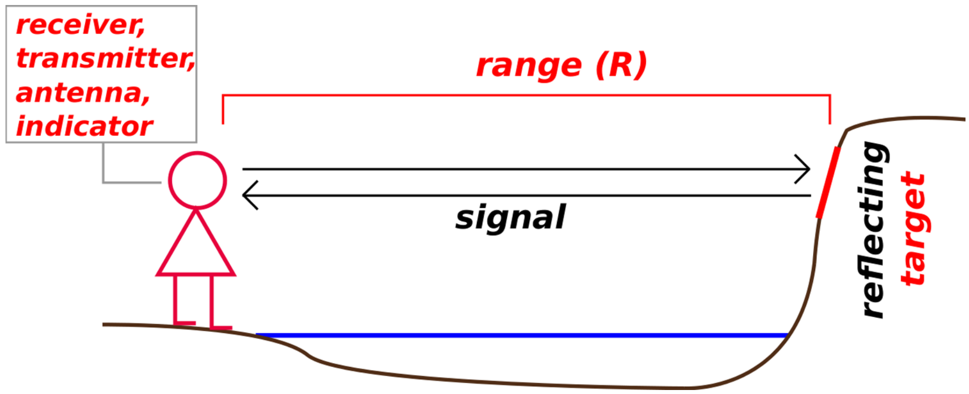
Using this simple illustration, we have introduced several important terms: "transmitter" (emitting waves), "target" (reflecting waves), "receiver," and "indicator." Moreover, the described example allows us to write the following simple equation for the range calculation using radar:

$$R = \frac{t_d \cdot c}{2}$$

where, $t_d$ is a time, $c$ is the speed of the light, and $R$ is the desired range). The speed of the light is used because radar radiates electromagnetic waves in the radio range of the spectrum. Radar belongs to the illumination-reflection systems. In such systems, an agent catches reflected from target waves emitted earlier by this agent. The illumination is directing artificial radio waves towards objects.

Furthermore, one important fact should be clarified. Researchers usually describe the electromagnetic waves using either the wavelength ( $\lambda$ or frequency ( $f$ in Hz or s-1). Since electromagnetic waves are distributed with the speed of the light ( $c$ , any of them can replace the other according to the follow-

*Figure 1. The illumination-reflection principle for the range definition*




ing equation: $\lambda \cdot f = c$ Radio waves considering in this article have a wavelength interval from 1 mm to 10,000 km or a frequency interval from 300 GHz to 30 Hz.

As mentioned, the transmitter emits radio waves (or radar signals) in predetermined directions illuminating desired targets. They scattered and reflected in multiple directions. Objects comprising electrical conductive materials (e.g., metals, water) have high reflectivity of radar signals. Other materials are absorbable and penetrable (or even transparent) for radio waves. Considering this more deeply, one can notice that this subject is not straightforward. Many works concern the properties of materials and objects relating to their ability to reflect-absorb-penetrate.

Many works have recently addressed the properties of buildings affecting the extremely high-frequency radio waves (especially actual for mobile networks). For example, Choi et al. (2015) investigated the properties of several materials for the 1mm wave realm: glass, tile, plasterboard, marble, wood, concrete. They examined these materials for reflectance and transmittance using various incidence and reflection angles. Because the angle significantly affects to results, minimal and maximal values are provided in such investigations. They disclosed that glass has the minor transmission loss, and concrete has the most significant transmission loss. Moreover, in the reflection characteristics, glass has the most negligible reflection loss, and wood has the most significant reflection loss on average.

Coca et al. (2014) investigated the electromagnetic waves reflectivity in the frequency interval from 2 to 3 GHz. They showed that melamine hardboard reflects nearly as well as aluminum. The former is one of the best reflectors. Their results also confirmed a fairly significant dependence of reflection properties on frequency, as reflected power decreases with frequency. In that work, the authors provided evidence of the complexity of the reflection phenomena.

Many researchers investigate the scattering and absorbing phenomena, which complete the reflection research. Lonnqvist et al. (2006) measured reflectivity of various radar (310 GHz) absorbing materials. The “radar cross-section” (Knott, 2004) and “radiation-absorbent material” terms play an important role in such research. The former describes the detectability of an object by radar. A larger value indicates a higher detectability of an object. The latter stands for a material that has been specially designed and shaped to absorb radar emitted radiation. Early radars used long wavelengths larger than the targets and, thus, received an unclear signal. In contrast, many modern systems use shorter wavelengths (a few centimeters or less) to detect small objects.

Noise, inference, and clutter are three phenomena that interrupt the correct target detection (Watts, 1987). Electronic components are the source of signal noise. The noise is an internal source of random variations in the signal. Interference occurs when two waves move simultaneously through a medium. The waves interacting with each other can originate from two or more sources. Clutter stands for radio waves returned from uninteresting targets. Moreover, many works investigate the radar jamming phenomenon. Radar jamming is an active, either intended or unintended (deception), inference emitting in the radar frequency and masking aiming targets (Lothes et al., 1990).

If desired targets can be detected despite the described obstacle factors, another rising question is the distance measurement. Classically, radar transmits a short pulse of the radio signal and measures the time allowing the distance calculations. Longer times between pulses enable us to maximize the range. Each radar uses a specific type of signal; long and short ranges are distinguished. Modern types of radar use frequency modulation (Galati, 2017). They consider the frequency shift to measure distance.

Usually, radar is described through the classical radar range equation aiming at maximal range estimation (Richards et al., 2014; TutorialsPoint, 2021):

$$R_{\max} = \sqrt[4]{\frac{P_t \cdot G \cdot \sigma \cdot A_e}{(4\pi)^2 \cdot P_r}}$$

where, $R_{max}$ is the maximal theoretical range (distance from the radar to target), $P_t$ and $P_r$ is transmitted and received power, A is a radar cross-section (or scattered coefficient) of the target, G is gain of the antenna and $A_e$ .is the effective aperture of the receiving antenna.

Often, this equation is represented in the following form of theoretical maximum range equation (Wolff, 2009a):

$$P_{rx} = \frac{P_{tx} \cdot G^2 \cdot \lambda^2 \cdot \sigma_t}{(4\pi)^3 \cdot R^4 \cdot L_s}\ \mathrm{P_{rx}}$$

is the power returned from a target. $P_{tx}$ is the power transmitted by radar. G is the antenna gain (known value), i.e., antenna's ability to focus outgoing energy to a given direction. Antenna aperture ($\frac{G \cdot \lambda^2}{4\pi}$ measures the effectiveness of receiving the incoming signal. $\sigma_t$ .is a radar cross-section or, in other words, the target's reflection ability. Measures can normally define it. Free-space path loss, denoted by $\left(\frac{1}{4\pi R^2}\right)^2$ is the electromagnetic wave in the free space without obstacles. $\frac{1}{L_s}$ summarizes all loss factors; it is called external and internal losses. Using provided equations, one can estimate various important theoretical values applicable for estimating the radar use and possible limitations.

In radar, the range typically represents the slant range of the target. Ranging is one of the main purposes of radar. Slant range is defined using the described earlier equation ( $R = \frac{t_d \cdot c}{2}$ ) For the pulse radar, A stands for pulse width, i.e., a time required for pulse radiation. The time interval between two consequent pulses is called pulse repetition time ( PRT . The corresponding pulse repetition frequency is calculated as $\mathrm{PRF} = 1 / \mathrm{PRT}$ . PRT comprises receiving time and a short interval of rest time ( $t_{\mathrm{recovery}}$ ). The maximal unambiguous range is depicted as $R_{unamb} = \frac{\left(PRT - \tau\right) \cdot c}{2}$ . Minimal detectable range equals $\frac{\left(\tau + t_{\mathrm{recovery}}\right) \cdot c}{c}$ . For instance, it equals about 150 m for a short-range system with 1 $\mu s$ .pulse width.

The antenna's orientation defines the direction to a target; this can also be described as bearing. Using the elevation angle and the altitude of an antenna, the target's absolute height is determined. The accuracy of derived values is determined as the degree of conformance with the estimated and true values. The radar resolution cell defines a volume where targets cannot be distinguished and visualized as a single target. Range and angular resolutions determine the resolution cell.

Speed measurement is another aim of radar. The most straightforward is to mark two positions of a target and, then, knowing a time interval and distances between two states, the speed calculation becomes obvious. Such an approach applies to a well recognizable and trackable target. In many cases, instant speed detection is required, e.g., for the police radar use case. For this, radar utilizes the Doppler effect.

The Doppler effect (Serway and Vuille, 2017) is the change in wave frequency reflecting from the target object. Increasing and decreasing in frequency indicates decreasing and increasing distance from the observer to the target. Many modern radar systems use this principle in Doppler and pulse-Doppler radar systems (weather and military radar). However, the Doppler effect can only determine the relative speed of the target along the line of sight from the radar to the target. The speed measured using the Doppler effect is called "velocity." The following equation describes it mathematically:

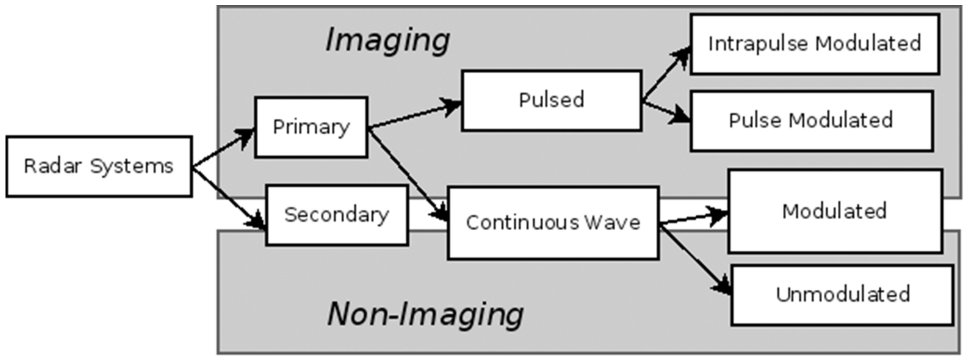
$$\mathrm{f_d} = \mathrm{f_0^{'}} - \mathrm{f_0}$$

where, $\mathrm{f_d}$ .is a Doppler shift, $\mathrm{f_0^{'}}$ .is frequency of the returned echo and $\mathrm{f_0}$ .is the frequency of the transmitted signal.

## Radar Types

Wolff (2009b) introduces a systematic classification of radar systems (see Figure 2), where he proposes two main groups: imaging and non-imaging radar. The former conclude systems producing map-like visualization of the area covered by the radar beam. The latter considers one-dimension measures (e.g., speed gauges and radar altimeters). In primary systems, the target acts as a passive reflector. In secondary, targets emit an active response. Aviation actively uses this principle: airplanes are usually equipped by a transponder (transmitting responder) onboard, and this transponder responds to interrogation by transmitting a coded reply signal. Pulse radar transmits a high-frequency impulse signal of high power. Pulse systems are divided into two categories: pulse and intrapulse modulation. The former utilizes a wave-shaping process produced as a propagating waveform modified by the electrical network properties of the transmission line; the pulse is internally modulated in phase or in frequency, which provides a method (Intrapulse Modulation) to resolve further targets providing overlapping returns (Wolff, 2016).

*Figure 2. Radar types*

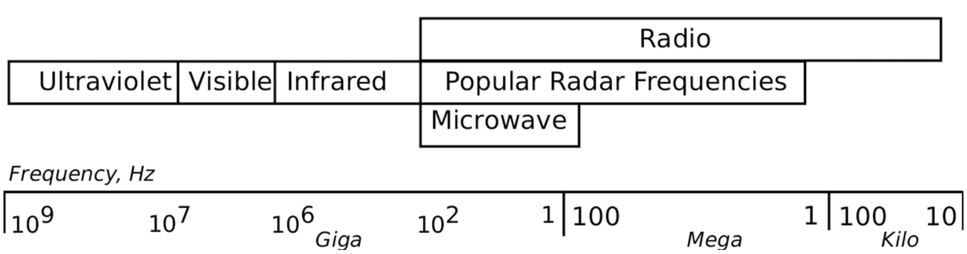



In contrast to pulse radar, continuous wave (CW) sets transmit a high-frequency signal continuously. Thus, there are two primary classes of radar: CW and pulsed. CW sets are cheap and straightforward but generate less information than pulsed radars. In addition, CW systems operate with low peak powers. Conversely, pulsed radars require extra hardware in comparison to CW and operate at high peak power levels.

Early radar versions were based on the transmission of the CW energy and the reception of reflected energy from a moving target (Rahman, 2019). A shift in frequency from the transmitted frequency by an amount known as Doppler shift is the essential basis for CW radar sets. Nowadays, CW systems remain popular and gain high interest. Particular aims determine whether CW or pulsed systems are to be used. The following advantages of CW radars over pulsed radars can be distinguished: simpler and smaller hardware required for CW sets, lower transmitted power level, the shorter range of detecting targets. However, unmodulated CW radars cannot measure the target range. CW systems modulating the signal in amplitude, frequency, or phase overcome this limitation in frequency-modulated CW (FMCW) radar sets. Linear, beat, and sinusoidal modulations are distinguished. FMCW radars use the linear frequency modulation (LFM) technique to measure the range and the Doppler effect.

In addition to the proposed classification, the following types of radar can be distinguished: mono-static, bistatic, and MIMO radars (according to the physical configuration of the transmit and receive antennas), search, and tracking radars. Furthermore, frequency bands, waveforms and pulse rates, and specific applications are utilized to distinguish radars' types. Figure 3 provides a generalized overview of radar frequencies and the electromagnetic spectrum.

*Figure 3. Electromagnetic spectrum and radar frequencies*



Among various types of radars, ultrawideband radar is an outstanding type; it has a high potential in natural sciences. According to Taylor (2016), ultrawideband (UWB) radar is designed to provide X-ray vision into the ground, solid materials, and walls. Such systems have various attractive use cases: remotely measure vital human signs in hospitals (Anishchenko, 2016) and hazardous environments, search for concealed weapons on people passing through a security checkpoint, make high-resolution images of satellites at synchronous orbit range under all weather conditions, locate soil disturbances to find buried objects (ground-penetrating radar) (Taylor et al., 2016), etc. UWB emits a signal with a fractional bandwidth $b_f$ .greater than 25% of the center frequency. This meant the signal absolute bandwidth b divided by the signal center frequency $f_c$. gives the following equation:

$b_f = \frac{b}{f_c} = \frac{2 \cdot (f_h - f_l)}{f_h + f_l}$ .where, $f_h$ .and $f_l$ .escribe the upper and lower frequencies, correspondingly.

## Signal Processing and Applications

Until this moment, the article considered mainly radar itself. Here it starts to discuss objects detection and radar signal, and data processing. A combination of signal and noise is a significant part of signal processing, where the noise component is a random process. The signal may be deterministic (for countable point targets) or stochastic (for uncountable volume scatter) (Hysell, 2018). Detection theory considers these areas. Radar cross-section (discussed earlier) and signal-to-noise ratio (SNR) are two essential terms of detection theory. The latter stands for a measure that compares the desired signal level to the level of background noise. In general, a signal can be distinguished from noise if SNS is higher than 1:1. It should be noticed that many pulse radar systems are threshold-based (i.e., a signal is distinguished from noise by a predefined threshold). Nowadays, more complex solutions are applied regularly.

Radar sets use a matched filter to decrease noise in receivers. It serves as the signal processor for the case where the radar bases detection decisions on a single pulse (Budge and German, 2015). The matched filter maximizes SNR, which is a requirement for maximizing detection probability. First, the amplitude detector determines the magnitude of the signal coming from the matched filter. Then, the threshold device processed the output of the previous process in a binary decision manner.

Signal detection logic determines four detection cases. First, signal-plus-noise larger or equal than a threshold indicates a correct detection. Second, signal-plus-noise less than a threshold is a missed detection event. Third, noise larger or equal than a threshold causes a false alarm case. Finally, noise is less than a threshold is for no false alarm. The first and the last cases stand for desired events. Detection (the first case) and false alarm probability (the third case) are notated correspondingly:

$\mathrm{P_d} = \mathrm{P}(\mathrm{V} \geq \mathrm{T})$ $\mathrm{P_{fa}} = \mathrm{P}(\mathrm{N} \geq \mathrm{T})$ where, $\mathrm{V}$ is signal-plus-noise voltage evaluated at a specific time, and $\mathrm{N}$ is noise voltage evaluated at a specific time. One can notice that $\mathrm{P_d}$ increases as SNR increases. That is the reason for including the matched filter in the receiver. It can be included immediately before the signal processor or as a part of the signal processor.

There are several techniques for $\mathrm{P_d}$ improvement using multiple transmit pulses: coherent integration (North, 1963), non-coherent integration (Swerling, 1960), m-of-n detection (Schwartz, 1956), and cumulative probability (Hall,1956) prediction. A coherent integrator is a type of signal processor that resided between the matched filter and amplitude detector. Such a coherent integrator accumulates the n-pulse sum and forwards it to the amplitude detection and threshold check. A non-coherent integrator is placed between the amplitude detector and the threshold device. The term “non-coherent” is used because the signal loses phase information after the amplitude detector. m-of-n detection is used as a logic process, not a device; radar examines the output of n-pulses and declares the target detection on any m of these pulses. Cumulative probability stands for the probability of increasing using multiple detection attempts. Various types of signal processors implement considered techniques.

The ambiguity function is utilized to understand the reaction of a signal processor to a given signal. The ambiguity function is a response of a signal processor to a radar waveform. Such function “provides a wealth of information about radar waveforms and how they interact with the environment and the radar signal processor” (Budge and German, 2015). Equations of the ambiguity function can be provided for either unmodulated (more straightforward case) and modulated pulse. Here, the “modulated” term means that the waveform coding or phase modulation is applied to transmit the pulse. Frequency modulation is widely used in CW radar sets since unmodulated CW cannot measure the target range. Linear and sinusoidal (nonlinear) frequency modulations are distinguished. In both cases, a time delay ( $\Delta t$ allows calculating the range as follows: $R = \left(\Delta t \cdot c\right) / 2$.

Hysell (2018) has published an extensive introduction to radar and its applications to environmental research. He noticed early radar environmental applications concerning atmospheric experiments by Gregory Breit and Merle A. Tuve in the 1920s. They showed how pulsed radio signals could be used to measure the ionospheric structure measured by “ionosonde” (actually, pulsed radar). Since that time, radar remains extremely popular in environmental monitoring, including the following applications:

- Weather and boundary-layer radar.
- Mesosphere-stratosphere-troposphere (MST) radar.
- Meteor-scatter radar.
- Ionospheric sounders.
- Coherent- and incoherent-scatter radar for ionospheric and space-weather research.
- Radar imaging, including SAR, InSAR, and ISAR
- Planetary radar.
- Ground-penetrating radar for archaeology, paleontology, and Earth science.
- Radars for ornithology, entomology, and other wildlife.

Meteorological objects were observed by the radar massively during its earliest military utilization (especially World War II). Attempts to mitigate the effects of the radar clutter related to the weather lead to weather radar. It remains the most popular radar application in the environmental context. One can distinguish the following representative diameters (in mm) of hydrometeors detected by radar: fog, mist, drizzle, light rain, heavy rain, graupel, hail, sleet, and snow. One of the main goals of radar meteorology is the estimation of rainfall rates from radar echoes. Another goal is the estimation of wind speed and direction (Hysell, 2018).

Another big block of radar applications is radar imaging. It utilizes spatial diversity, transmitters of opportunity, synthetic apertures, multiple antennae pointing positions. Due to these properties, radar can produce a spatial image. For this, radar uses interferometry. It is caused by the physical effect of the superposition of waves from the source vibrating with the same frequency and amplitude (Serway and Vuille, 2017). The interferometer provides a complete range, bearing, and Doppler frequency information for a single target. Image reconstruction based on interferometry with multiple baselines is called aperture synthesis imaging. Synthetic aperture radar (SAR) sets allow airborne and space-borne systems with basic antennas to produce images of distant targets with a high spatial resolution (it is possible to reach 10 cm dimension from a satellite). Such systems take samples of fixed targets at different points along the vehicle trajectory. The enormous size of a required synthetic array affords satisfactory resolution. SAR data are popular in environmental studies. For instance, European ERS-1&2 (inactive today) SAR data are utilized for deriving digital elevation models and their dynamics for glaciers dynamics monitoring (Rao, 2004). Nowadays, famous Sentinel-1 data are utilized for flood research (Clement et al., 2018).

## Aeroecological Radar's Development milestones

The last radar application mentioned earlier, "Radars for ornithology, entomology, and other wildlife," is mainly represented by aeroecological radar (i.e., radar aiming at small flying species, like birds, bats, insects). This topic is already mature but remains very promising due to advances in computers, robotics, and data processing.

Crawford (1949) was possibly the first author who showed that radar could detect as small targets as individual insects. In 1950, Rainey (1955) proposed to use radar for insect swarms. He found that if radar can detect the echo from raindrops, it might detect flying locusts. In the following works, Rainey confirmed it. Later, many studies focused on insect swarm detection with radar.

On the other side, in the 1950s, several works suggested using radar for individual insect detection Plank (1958; Tolbert, Straiton, and Britt 1958). This was finally confirmed in the 1960s. In 1966, Hajovsky et al. Hajovsky, Deam, and LaGrone (1966) discussed the magnitudes of the insect cross-sections and the effects of incident electromagnetic energy polarization along with physical characteristics of the insects. Next year, Glover Glover and (U.S.) (1967) published a book discussing tracking single insects in the atmosphere.

Riley (1980) summarized the early history of insect radar. He distinguished two categories of field trial works conducted in the 1970s: ground and airborne radar. That was an outbreak time for radar entomology; many studies were carried out in Africa and Australia. From that time, wingbeat frequency has facilitated distinguishing birds and insects; it was an outstanding achievement. Moreover, Riley (1980) discussed the following topics: resolving insect species using the size or (even) wingbeats (Schaefer, 1976), aerial density measurements for individually resolved targets Riley (1979) and dense concentration Battan (1973), airspeed and heading Riley (1979; Greneker 1978), and, finally, duration and range of flight Schaefer (1976).

## Pulsed Scanning Radar

Riley (1985) discussed insect cross-section. In that work, the author developed some findings of an earlier work (Riley et al., 1979), where vertical radar's rotating and linear polarization were utilized to measure individual insect alignment and parameters related to body shape. The authors summarized a tree-year work and concluded that it is possible to detect insects approximately using wingbeat frequencies. Moreover, they investigated the takeoff process (systematic increasing of target heights during observation), the connection of the temperature and several insects in the air, orientation and displacement direction, and migration. Finally, the authors showed how to derive the wingbeat frequency from radar data. The wingbeat modulation and large amplitude "polarization" modulation were distinguished. The former refers to the wingbeat; the latter represents the target size.

Additionally, they introduced the "body shape factor" or radar "signatures" obtained by recording the signals returned from insects flying through the stationary radar beam. The authors made a logical observation that short, thin targets produce deeper modulation than short fat. Riley (1985) systematized insect cross-section data and collated it with the available literature. For several insect species, he showed the variation of radar cross-section as a time function of the angle between a body axis and beam vector ("E-vector"). Furthermore, the author collated his data with other available cross-section data, build a graph of the cross-section and mass dependency, and derived a function ("insect radar cross-sections as a function of their mass"). He concluded "that the radar cross-section of an insect may be very approximately represented by that of a spherical water droplet of the same mass, and that this representation holds true over a mass range of 10000:1" and "the aspect dependence of radar cross-section affects insect detectability."

In the 1980s, insect radar was already wildly spread. In addition to the earlier discussed works, some can notice works conducted in America (Mueller and Larkin, 1985) and Australia (Drake et al.,1981). The former work considered dual-polarization radar utilized in central Illinois (USA) during clear nights and ensured that the received echo was from insect rather than atmospheric turbulence or birds due to the magnitude of differential reflectivity, absence of bird wingbeat signatures, the strength of the signal return, and migration schedules of birds in the research area. The later work described research covering Bass Strain (Australia). This work differs from all earlier mentioned. It is very geographical oriented; the authors thoughtfully adjusted their radar data with atmospheric processes and light-trap catches, resulting in a severe scientific basis. Drake et al. applied an entomological pulse radar device operated on a frequency 9.5GHz (X-band, 3.2 cm wavelength) with a nominal peak power of 20kW. They confirmed massive takeoff of insects shortly after sunset observed earlier by many other researchers. Moreover, they noticed a migration from the mainland, and the immigration of targets from nearby source areas was often observed on the radar.

Vaughn (1985) published a review on the radar for birds and insects summarizing relevant achievements known by that year; the author reviewed radar cross-section measurements of birds and insects. He proposed to describe targets either as a prolate spheroid or, due to linear horizontal polarization of many targets, resonant half-wave dipole. Vaughn stated that a comprehensive review of radar entomology is premature because entomologists could learn little about insects except for the problem of either detecting or not detecting these targets. One can disagree with this statement because, as was shown, many earlier works investigated very new aspects of insect behavior with details unknown before (e.g., migrations, takeoffs, etc.). The work showed that flocking and swarming properties of targets are very beneficial for detecting targets on large ranges; the author applied different radar types (0.25μs 1.24º half-power beamwidth ground-based radar, surveillance FAA radar, modified A-scope X-band marine radar). Vaughn described in detail the early history of establishing the entomology radar (we propose to use as a complete review source for that historical period of insect radar); many of the works he cited we have discussed earlier.

The previous work discussed birds and insects together. Indeed, due to the similar behavior of targets, radar entomology and ornithology are very close disciplines. Larkin (1991) admitted a mistake that many of the targets previously considered as birds were actually insects. It leads to a significant revision of his initial findings. The lack of wingbeat patterns of birds, radar-controlled high-power telescopes and spot lamps, and speed and abundance (preferably, in warm months) of targets spotted this problem. As discussed earlier, cross-section (σ) allows estimation of target size and wingbeat patterns; that applied the discrimination of birds from insects. Graphs of distinguished "birdlike" and "insect-like" targets showing the number of tracks versus speed of flight and the number of targets versus radar cross-section confirmed the examined ideas. That work allowed reconsidering the existed approaches and improving the scientific results significantly.

Nevertheless, distinguishing birds and insects remained a popular topic. Thus, Zrnic and Ryzhkov (1998) presented impressive results achieved with a 10cm pencil beam orthogonally polarized returns weather radar. They disclosed that the insects show a high degree of common alignment, and both reflectivity and differential reflectivity has a strong azimuthal dependence. Moreover, Doppler velocities indicated that insects primarily oriented either along or perpendicular to the wind direction.

## Vertical-Looking Principle

Most of the earlier mentioned radar systems are scanning radar covering large areas (Riley, 1980). The vertical-looking radar is another solution, which often supplemented scanning systems and facilitates distinguishing insect species since it can provide higher-detail information (and, as a result, covers a much smaller area). In the 1990s, researchers applied vertical-looking radar widely for entomology purposes. In contrast to earlier established vertical-looking systems for entomology (Beerwinkle et al., 1995; Hobbs, 1991; Smith and Riley, 1996) introduced a novel solution, where the radar's beam nutates by a fraction of a beamwidth. At the same time, the plane of linear polarization rotates. That allows gathering the insects' speed and direction of motion, orientation, and three radar scattering cross-sections related to the insect body mass and shape.

Moreover, the discussed radar was connected to a computer; it was a large achievement. The discussed radar was a 3.2 cm wavelength device with a 1.5 m diameter paraboloid reflector and cylindrical metal shroud (30 cm high and lined on the inside with microwave absorbent material fitted to the rim of the paraboloid enabled to prevent the radar beam sidelobes from intercepting nearby elevated structures. Smith and Riley concluded that the utilized system was effective and explicitly mentioned the advantage of using the specialized software.

In the 2000s, researchers have continued to developed vertical-looking systems based on earlier achievements. Chapman et al. (2002) proposed a solution for estimating the body mass of insects, which allowed monitoring of the altitudinal and temporal dynamics of high-flying insect populations. That research aimed the long-term monitoring of aerial insects, which often comprises studies on the population dynamics of migratory insect species (Perry, 1993; Woiwod and Hanski, 1992), the impact of insect groups (Halbert et al., 1995; Fleming and Tatchell, 1995), and outbreaks of pest species (Tatchell,1991). Chapman et al. reminded that the great advantage of vertical-looking radar is the wobble (nutation) to the vertical beam allowing the mass estimation for over-flying targets, thus providing a powerful aid to identification. Their radar system emitted a circularly symmetric plane-polarized vertically directed beam nutating by 0.1 beam widths around its vertical axis. The plane of polarization was continuously rotated with the altitude range from 150 to 1188m above the system. The beam width was from 13m on the 150m altitude to 60m on the 1200m altitude; it could detect minimal targets from 1mg (low altitude targets) to 15mg (high altitude targets). As in the previous works (e.g., Smith and Riley (1996)), the researchers utilized the correlation coefficient (between recorded and simulated signals) and six parameters (i.e., the speed, direction, and orientation target trajectory parameters and $a_0$. $a_2$. and $a_4$ .target radar scattering parameters). The following classification facilitated the target detection: "fail" targets excluding from further analysis for a signal failed to converge to a solution, "good" (correlation coefficient >0.9), "less good," and "poor" targets (correlation coefficient <0.7). The authors used various equations for the mass estimation; for instance, the target mass was estimated according to the following equation for small targets:

$$m = \left(\left(a_0 - a_2 + a_4\right)\cdot 10^5 / 6.4\right)^{0.5}$$

Moreover, that work showed many other empirical findings and dependencies.

Chapman et al. (2003) described a work conducted with a new vertical-looking radar system. The device had the linearly polarized and slightly oscillated (0.18offset around the vertical axis) beam. The beam continuously rotated by mechanically turning the upward-pointing wave-guide feed about the vertical. The radar proposed two outstanding solutions. First, it detected insects in several 50m-width altitude levels with 30m intervals in-between. Second, it delivered with autonomous data analysis software, which facilitated the individual target data calculation, including the size, shape, alignment, and displacement vectors allowing long-term monitoring of migrant insect populations. The complex software analyzed data using the six discussed earlier parameters plus the distance of the closest approach to the beam's central axis. These seven extracted parameters allowed producing a simulated signal and the correlation between this and the radar return; it provided a quantitative estimation of how well the model has described overflying targets. The authors processed only "good" targets. Even such data comprised rarely reflections from birds and bats, but some straightforward solutions filtered out them using masses and displacement speeds. As in previous works, the body shape of overflying insects utilized the maximum and minimum radar reflectivity denoted by $\sigma_{xx}$ and $\sigma_{yy}$ respectively. For most insects in the UK, $\sigma_{xx}$ corresponds to the situation when the plane of polarization is parallel to the insect's major body axis (length) and at minimum amplitude when it is parallel to its minor axis (width).

Moreover, Chapman et al. noticed that disparities of the $\sigma_{xx} : \sigma_{yy}$ .ratio allow the insect shape estimation: large (e.g., "15:1") is for long thin bodies (e.g., Neuroptera), small (e.g., "5:1") is for more compact beetles, and "1:1" is for Coccinellidae. What is more, the signal modulation facilitated the investigation of orientation behavior (body alignment) and displacement direction. For the target's mass estimation, the authors defined the target's distance from the beam center using the nutation of the radar beam around the vertical axis. They also noticed that the wingbeat frequency could not be extracted in the nutation mode. Thus, the radar was operated for 5 minutes in the nutation model and 1 (following) minute in the non-nutation mode. Chapman et al. concluded that approximately 3 billion or one metric ton of overflying insects in one month in one month.

Furthermore, they proposed an advanced monitoring framework comprising temporal activity, insect layering, common orientation, and migration analysis approaches. In contrast to migrations observed with X-band radar Reynolds and Riley (1997), vertical-looking radar can only define a group of migrating insects' flight headings since it covers a small area. The heading is defined using the body orientation (alignment), displacement direction (however, the displacement direction is primarily determined by wind direction), and displacement speed of overflying migrants.

Harman and Drake (2004) published their approaches to vertical-looking radar (VLR); they called it "zenith-pointing linear-polarized conical-scan (ZLC) configuration." A synthesis paper by Hobbs and

Aldhous (2006) summarized earlier harvested data (Riley, 1985; Aldhous, 1989). The discussion in the previous paragraph work did not consider the wingbeat. However, they concluded that it could be a good extension for the future. In 2004, Wang and Drake (2004) provided detailed results on this topic. They gathered wingbeat parameters using rotary-mode signals in a different, final stage of the data-processing procedure that routinely retrieves trajectory and target parameters from an IMR's conical-scan observations detailed in the previous work.

## Harmonic Radar

All earlier discussed works belong to high-altitude flight observations (mainly using pulse radar). Unfortunately, those approaches do not work for low-altitude targets because of the ground clutter, excluding specific conditions (Loper et al., 1993). Mascanzoni and Wallin (1986) proposed promising solutions for this problem using the radar utilized for locating avalanche victims (Fuks, 1981). It was a harmonic radar system with a reflector (a tiny electronic diode glued to the insect). This diode can reflect microwave beams emitted by portable detection equipment. The proposed technique was effective in a field-trace experiment with carabid beetles. A diode re-radiates a harmonic frequency, i.e., original (or fundamental) wave frequency multiplied by a positive integer number Bingham (1994). In that experiment, Mascanzoni and Wallin used a 915 MHz radar system; the reflector produced a 1830MHz signal (i.e., a harmonic reflection with factor two). They tagged insects with reflectors; this break-through principle has not changed significantly since 1986.

Mascanzoni and Wallin glued a tag along with bodies; later, to improve flying insects' reflection, researchers started to use vertically glued tags. Riley et al. (1996) applied harmonic radar for tracking (bumble) bees' low-altitude flights in a distance range of hundred meters. In that works, the researchers successfully distinguished re-radiated harmonic signal and strong ground clutter. They investigated tree bumblebee (Bombus spp.) colonies and a small hive of honey bees (Apis mellifera). Some regular forages were tagged and observed for several days. They successfully tracked those bees and proved that tagged been could forage. The authors noticed the height potential of harmonic radar for insects' low-altitude flights and admitted that more experiments are required to prove whether the tag significantly modifies insect behavior.

In the subsequent research, Riley and Smith Riley and Smith (2002) improved the design of their harmonic system. They noted that insects with weight more than ca. 50mg can wear an improved 1-12 mg tag. As in earlier works, a transponder (tag) re-radiated the frequency-doubled signals. However, the range was significantly increased up to 900m. Moreover, the new system allowed the authors to collect dynamic and geometrically correct records of the insects' horizontal flight trajectories by day and night.

Later, Colpitts, and Boiteau (2004) attempted to improve tags. They designed a tag with less than 3mg mass, achieving the most prominent possible return signal at the second harmonic frequency. They criticized the earlier works (Riley et al., 1996; Roland et al. 1996; Loevei et al. 1997; Reynolds and Riley 2002) for the lack of the description of expected performance and essential design parameters. What is more, they noticed the results of Riley and Smith (2002) indicated the minimal success of an earlier attempt and, instead, used empirical trimming to optimize performance. Colpitts, and Boiteau addressed the raised issues by providing the detailed description and performance evaluation of their transceiver verified with field experiments. They designed a dipole of length 12 mm with a 1 mm diameter loop that produced the most significant harmonic cross-section of 40 mm at the marine radar frequency of

9.41 GHz. They found that a dipole of 8 mm total length provided the maximum range when the feed point was located 2 mm from the insect.

Psychoudakis et al. (2008) proposed a principally new type of transponders. It was a modified Minkowski loop tag composed of two concentric fractal loops for a radar unit transmitting a 5.9–6 GHz signal and detecting at the 11.8–12 GHz band. The proposed planar geometry (bendable) tag design allowed improving harmonic conversion efficiency; it had a smaller size (9.5x9.5mm) than the earlier solutions and could detect a tagged insect up to 58 m. However, even though the transponder was designed for insects, in that works, the authors seemingly, did not test it with real insects and scheduled it for future work.

One can mention the lack of research on the tag impact on the insect flight. Kim et al. (2016) addressed this issue. They assessed the radar tag impact on five economically important insects. The authors utilized copper wire dipole radar tags described in (Boiteau et al., 2009; Lee et al. 2014): "the total length of the tag was 9mm with a 1mm-diameter loop at the pole, and a 1mm foot bent through 90". Kim et al. noticed the promising potential of the harmonic radar for three examined species; while, it showed a severe impact on two rest insects. The adhesive bond strength was assessed for this. The authors did not observe a significant correlation between bond strength and insect body size for all species. The radar tag attachment affected the flight behavior (including the takeoff) and capacity of five insect species in different ways.

Harmonic radar keeps attracting the height of attention of researchers proposing various novel solutions. For instance, Hsu et al. (2015) proposed to use a pseudorandom code principle in harmonic radar to achieve high sensitivity. Furthermore, advances in harmonic radar hardware and algorithms led to its "in-production" use for insect behavior investigation. For instance, in He et al. (2019), researchers tracked many Chinese citrus flies for several years. As a result, they disclosed that early emerged adult insects migrate into forests. Such works confirm the effectiveness of the technology.

## Frequency Modulated Continuous Wave Radar

Most of the earlier mentioned works considered pulsed radar systems. As an alternative, frequency modulated continuous wave radar (FMCW) can be used for insect detection. FMCW radar is a popular technique for investigating layers in the atmosphere (Metcalf, 1975; Eaton et al., 1995; Dekker et al., 2002). Gallagher et al. (2004) detected meteorological echoes contaminated and obscured by echoes looking like the diurnal cycle of insect behavior. They noticed that the insects began to fly within an hour after sunset and reached a concentration peak near midnight. They found that insects show a robust diurnal cycle; insects are typically dormant during the day and active at night. The radar indicated that the insects started to fly after sunset, reached a peak near midnight with the following density decrease.

Of course, it was not the first attempt to use FMCW radar for insect detection. One of the earliest works was published in 1973 (Richter et al.). Richter et al. have mentioned that a housefly with a backscatter cross-section of 10-3cm2 for a radio wavelength of 10cm at a distance of 1 km produces echoes about 24db above the noise level. They carried out experiments with insects and steel balls and proved that the proposed technique is effective. Then a mobile radar worked for several days in a mild coastal climate area (San Diego) and desert area (Salton sea) to observe insects and atmospheric conditions. The radar antennas were fixed vertically. In the both areas radar registered clear echos from insects. They provided an attractive 3D chart showing the number of insect targets in time by altitude levels. What is more, the authors noticed the capability of the radar to "see" insects through clouds; insects were detected at altitudes up to 700 meters. Richter et al. concluded that FMCW radar could sense atmospheric conditions and insects simultaneously; they also pointed out the correlation between atmospheric conditions and insect behavior in both areas.

Contreras and Frasier (2007) provided the results of the S-band FMCW mobile radar exploitation during one month in Oklahoma. This design allowed the authors to reach an altitude of 2500m. As in work discussed in the previous paragraph, insects appeared as discrete dots in the resulting charts. Actually, as in many other works, the authors just assumed that these dot echos are insects ("assume to be insects"). Although they did not conduct experiments with artificially resided insects and other targets, their assumptions look convincingly since it corresponds to the independent finding in other works on insect radar. Furthermore, Contreras and Frasier proposed a two-dimensional (5x5) median filter to isolate the contribution from insects. That allowed distinguishing target types.

Noskov et al. (2021) suppose that FMCW systems can become the primary trending technology in the radar scope due to their compactness, energy effectiveness, and recent achievements in the data processing. They indicated that among recent advances in insect radar, FMCW approaches are outstanding and show high potential.

## CONCLUSIONS

The present paper provides sufficient and compact information on radar and its applications aiming at the environment monitoring audience. It comprises the relevant references for obtaining all details regarding all described concepts. The author provided a standard and straightforward definition and brief history. Main radar components (i.e., the transmitter, target, receiver, and indicator) were introduced and illustrated through an intuitive life example. The example allowed formulating an equation of radar range. Then, the article discussed the material reflectivity and three relevant phenomena: noise, inference, and clutter. The radar range equation enabled us to provide a comprehensive overview of the major principles behind the technology. It introduced the "cross-section" term, an integral part of most works related to radar. In addition to the range measures, the present paper considered direction and seed measured. The latter comprises Doppler effect measures described in the article. It was shown that the velocity is defined using the Doppler shift (or the difference in the transmitting and receiving frequency). Researchers need to understand the significant types of radar systems. The relevant section showed that there are two main types: pulsed and continuous-wave sets. The modulation approach conducts further subdivisions.

Additionally, radar systems can be monostatic, bistatic, search, and tracking radars. What is more, it is essential to understand the radar frequencies place at the electromagnetic spectrum. After the fundamentals, the paper discussed signal processing and application. It was emphasized that the radar cross-section and signal-to-noise ratio are the most critical components in signal processing. Since threshold-based processing is still the primary approach, it was discussed in detail. Finally, detection and false alarm probability were considered.

What is more, several techniques for detection probability improvement were considered. Then, the continuous wave signal processing was described with a particular focus on the ambiguity function and signal modulation.

Additionally, the author discussed the development of the radar aeroecology according to the main groups of radar approaches. The first group, pulsed scanning systems, has the most extended history and reached a well-established stage, allowing a large range mass target monitoring on a global scale.

Vertical-looking principle of the second group allow higher granulated monitoring. Harmonic radar systems have long history and aim to track individual species. It was indicated that frequency modulated continuous wave radar set can soon play an important, if not a key, role in the radar aeroecology realm.

Advances in data processing, robotics, computation, and communications enable practitioners to combine the discussed radar solutions aiming at global avian and insect biodiversity monitoring and negative human impact systematic estimation. There is a need for global collaboration between aeroecological radar practitioners. First, since meteorological radar data comprise important aeroecological information and cover huge areas worldwide, these sources should be systematically archived and processed for aeroecological purposes mainly aiming at flying species and their habitat conditions. Second, acting insect and bird radar solutions should be continuously maintained for supporting the long term data series collection. Third, aeroecological radar networks should be developed at the global scope. Finally, cost effective compact FMCW radar devices running with autonomous sensor boxes or unmanned vehicles should attract a special attention for cutting-edge large scale aeroconservation and pest management.

## ACKNOWLEDGMENT

This research was funded by the Hessian State Ministry for Higher Education, Research and the Arts, Germany, as part of the LOEWE priority project Nature 4.0—Sensing Biodiversity.

## REFERENCES

Aldhous, A. C. (1989). *An investigation of the polarisation dependence of insect radar cross sections at constant aspect* (PhD Thesis). Ecological Physics Research Group.

Anishchenko, L., Bechtel, T., Ivashov, S., Alekhin, M., Tataraidze, A., & Vasiliev, I. (2016). Bioradiolocation as a technique for remote monitoring of vital signs. In *Advanced Ultrawideband Radar* (pp. 315–340). CRC Press.

Beerwinkle, K., Lopez Jr, J., Schleider, P., & Lingren, P. (1995). *Annual patterns of aerial insect densities at altitudes from 500 to 2400 meters in east-central texas indicated by continuously-operating vertically-oriented radar.* Southwestern Entomologist.

Bingham, R. P. (1994). *Harmonics-understanding the facts*. Dranetz Technologies.

Boiteau, G., Meloche, F., Vincent, C., & Leskey, T. C. (2009). Effectiveness of Glues Used for Harmonic Radar Tag Attachment and Impact on Survival and Behavior of Three Insect Pests. *Environmental Entomology*, *38*(1), 168–175.

Budge, M., & German, S. (2015). *Basic Radar Analysis. Artech House radar series*. Artech House.

Chapman, J., Smith, A., Woiwod, I., Reynolds, D., & Riley, J. (2002). Development of vertical-looking radar technology for monitoring insect migration. *Computers and Electronics in Agriculture*, *35*(2-3), 95–110.

Chapman, J. W., Reynolds, D. R., & Smith, A. D. (2003). Vertical-Looking Radar: A New Tool for Monitoring High-Altitude Insect Migration. *Bioscience*, *53*(5), 503–511.

Clement, M., Kilsby, C., & Moore, P. (2018). Multi-temporal synthetic aperture radar flood mapping using change detection. *Journal of Flood Risk Management*, *11*(2), 152–168.

Coca, E., & Cehan, V. (2014). Laboratory study of electromagnetic waves reflectivity of certain materials. *Proceedings of the 2014 37th International Spring Seminar on Electronics Technology*.

Colpitts, B., & Boiteau, G. (2004). Harmonic radar transceiver design: Miniature tags for insect tracking. *IEEE Transactions on Antennas and Propagation*, *52*(11), 2825–2832.

Contreras, R. F., & Frasier, S. J. (2007). Return from insects in the clear-air convective boundary layer. *IEEE International Geoscience and Remote Sensing Symposium*.

Dekker, P. L., Bajaj, A. N., & Frasier, S. (2002). Radar and acoustic observations during vtmx field campaign. *10th Conference on Mountain Meteorology*.

Drake, V. A., Helm, K. F., Readshaw, J. L., & Reid, D. G. (1981). Insect *migration across bass strait during spring: A radar study. Bulletin of Entomological Research*, *71*(3), 449–466.

Eaton, F. D., McLaughlin, S. A., & Hines, J. R. (1995). A new frequency-modulated continuous wave radar for studying planetary boundary layer morphology. *Radio Science*, *30*(1), 75–88.

Fleming, R., & Tatchell, G. (1995). Shifts in the flight periods of british aphids: a response to climate warming? In *Insects in a changing environment* (pp. 505–508). Royal Entomological Society of London.

Fuks, P. (1981). *Harmonic radar, a modern method for location of avalanche victims.* Division of Electromagnetic Theory, Royal Inst. of Technology.

Galati, G., Pavan, G., & De Palo, F. (2017). Chirp signals and noisy waveforms for solid-state surveillance radars. *Aerospace*, *4*(1), 15.

Gallagher, F., Bowers, J., & Laufenberg, E., Jr., Storwold, D., & Mclaughlin, S. (2004). Possible detection of insects in an urban environment by a frequency modulated-continuous wave radar. *5th Symposium on the Urban Environment*, 347-353.

Groom, M., Meffe, G., & Carroll, C. (2012). *Principles of Conservation Biology*. Sinauer.

Halbert, S., Jennings, M., Cogan, C., Quisenberry, S., & Johnson, J. (1995). Potential use of suction trap collections of aphids as indicators of plant biodiversity. *Insects in a Changing Environment, 504*.

Hall, W. (1956). Prediction of pulse radar performance. *Proceedings of the IRE*, *44*(2), 224–231.

Harman, I., & Drake, V. (2004). Insect monitoring radar: Analytical time-domain algorithm for retrieving trajectory and target parameters. *Computers and Electronics in Agriculture*, *43*(1), 23–41.

Hauser, C. E., Pople, A. R., & Possingham, H. P. (2006). Should Managed Populations Be Monitored Every Year? *Ecological Applications*, *16*, 807–819.

He, Z.-Z., Luo, J., Gui, L.-Y., Hua, D.-K., Du, T.-H., Wang, F.-L., Liang, P., Shi, Y.-F., & Yang, X. (2019). Tracking the movement trajectory of newly emerged adult chinese citrus flies with insect harmonic radar. *Journal of Asia-Pacific Entomology*, *22*(3), 853–859.

Hobbs, S. (1991). A radar signal processor for biological applications. *Measurement Science & Technology*, *2*(5), 415.

Hobbs, S., & Aldhous, A. (2006). Insect ventral radar cross-section polarisation dependence measurements for radar entomology. *IEE Proceedings. Radar, Sonar and Navigation*, *153*(6), 502.

Hsu, M.-L., Jan, S.-J., Tsai, Z.-M., Wang, H., Chang, F.-R., Jau, P.-H., Lin, K.-Y., & Yang, E.-C. (2015). Portable 9.4/18.8 GHz harmonic radar system using pulse pseudorandom code principle. *2015 European Microwave Conference (EuMC).*

Hysell, D. (2018). *Antennas and Radar for Environmental Scientists and Engineers*. Cambridge University Press.

Ishii, M., & Nakamura, Y. (2012). Development and Future of Insect Conservation in Japan. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Kim, J., Jung, M., Kim, H. G., & Lee, D.-H. (2016). Potential of harmonic radar system for use on five economically important insects: Radar tag attachment on insects and its impact on flight capacity. *Journal of Asia-Pacific Entomology*, *19*(2), 371–375.

Knott, E., Schaeffer, J., & Tulley, M. (2004). *Radar Cross Section*. Electromagnetics and Radar Series. Institution of Engineering and Technology.

Kostenko, A. A., Nosich, A. I., & Tishchenko, I. A. (2001). Radar prehistory, soviet side: three-coordinate l-band pulse radar developed in Ukraine in the late 30's. *IEEE Antennas and Propagation Society International Symposium, 4*, 44-47.

Lee, D.-H., Park, C.-G., Seo, B. Y., Boiteau, G., Vincent, C., & Leskey, T. C. (2014). Detectability of halyomorpha halys (hemiptera: Pentatomidae) by portable harmonic radar in agricultural landscapes. *The Florida Entomologist*, *97*(3), 1131–1138.

Liu, Y., Cotton, J. A., Shen, B., Han, X., Rossiter, S. J., & Zhang, S. (2010). Convergent sequence evolution between echolocating bats and dolphins. *Current Biology*, *20*(2), R53–R54.

Lockwood, J. A. (1987). The moral standing of insects and the ethics of extinction. *The Florida Entomologist*, *70*(1), 70–89.

Loevei, G. L., Stringer, I. A., Devine, C. D., & Cartellieri, M. (1997). Harmonic radar - a method using inexpensive tags to study invertebrate movement on land. *New Zealand Journal of Ecology*, *21*(2), 187–193.

Lonnqvist, A., Tamminen, A., Mallat, J., & Raisanen, A. (2006). Monostatic reflectivity measurement of radar absorbing materials at 310 GHz. *IEEE Transactions on Microwave Theory and Techniques*, *54*(9), 3486–3491.

Loper, G. M., Wolf, W. W., & Taylor, O. R. (1993). Radar detection of drones responding to honeybee queen pheromone. *Journal of Chemical Ecology*, *19*(9), 1929–1938.

Lothes, R. N., Szymanski, M. B., & Wiley, R. G. (1990). *Radar vulnerability to jamming*. Artech House.

Mascanzoni, D., & Wallin, H. (1986). The harmonic radar: A new method of tracing insects in the field. *Ecological Entomology*, *11*(4), 387–390.

McKibben, B. (2003). *The End of Nature.* Bloomsbury Publishing.

McLean, I. F. G., & Key, R. S. (2012). A History of Invertebrate Conservation in the British Statutory Conservation Agencies. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Metcalf, J. I. (1975). Microstructure of radar echo layers in the clear atmosphere. *Journal of the Atmospheric Sciences*, *32*(2), 362–362.

Mueller, E. A., & Larkin, R. P. (1985). Insects observed using dual-polarization radar. *Journal of Atmospheric and Oceanic Technology*, *2*(1), 49–54.

New, T. R. (2009). *Insect Species Conservation. Ecology, Biodiversity and Conservation*. Cambridge University Press. doi:10.1017/CBO9780511626876

New, T. R. (2018). *Forests and Insect Conservation in Australia*. Springer International Publishing. doi:10.1007/978-3-319-92222-5

North, D. O. (1963). An analysis of the factors which determine signal/noise discrimination in pulsed-carrier systems. *Proceedings of the IEEE*, *51*(7), 1016–1027.

Noskov, A., Bendix, J., & Friess, N. (2021). A Review of Insect Monitoring Approaches with Special Reference to Radar Techniques. *Sensors (Basel)*, *21*(4), 1474.

Parker, S. (2003). *McGraw-Hill Dictionary of Scientific and Technical Terms*. McGraw Hill Dictionary of Scientific and Technical Terms. McGraw-Hill Education.

Perlya, Y. (1955). *How radiolocator works (Kak rabotaet radiolokator).* Gosudarstvennoe Izdatelstvo Oboronnoy Promyshlennosti.

Perry, J. N., Woiwod, I. P., & Hanski, I. (1993). Using response-surface methodology to detect chaos in ecological time series. *Oikos*, *68*(2), 329–339.

Psychoudakis, D., Moulder, W., Chen, C., Zhu, H., & Volakis, J. L. (2008). A portable low-power harmonic radar system and conformal tag for insect tracking. *IEEE Antennas and Wireless Propagation Letters*, *7*, 444–447.

Pyle, R. M. (2012). The Origins and History of Insect Conservation in the United States. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Rahman, H. (2019). *Fundamental Principles of Radar*. Taylor & Francis. doi:10.1201/9780429279478

Rao, Y. S., Venkataraman, G., & Rao, K. S. (2004). Sar interferometry for dem generation and movemnet of Indian glaciers. *IGARSS 2004. 2004 IEEE International Geoscience and Remote Sensing Symposium*, 2, 1128-1131.

Reynolds, D., & Riley, J. (2002). Remote-sensing, telemetric and computer-based technologies for investigating insect movement: A survey of existing and potential techniques. *Computers and Electronics in Agriculture*, *35*(2), 271–307.

Richards, M., Melvin, W., Scheer, J., Scheer, J., & Holm, W. (2014). *Principles of Modern Radar: Radar Applications*. Electromagnetics and Radar. Institution of Engineering and Technology.

Richards, M., Melvin, W., Scheer, J., Scheer, J., & Holm, W. (2014). *Principles of Modern Radar: Radar Applications*. Electromagnetics and Radar. Institution of Engineering and Technology.

Richter, J. H., Jensen, D. R., Noonkester, V. R., Kreasky, J. B., Stimmann, M. W., & Wolf, W. W. (1973). Remote radar sensing: Atmospheric structure and insects. *Science*, *180*(4091), 1176–1178.

Riley, J. (1980). Radar as an aid to the study of insect flight. *A Handbook on Biotelemetry and Radio Tracking*, 131–140.

Riley, J., & Smith, A. (2002). Design considerations for an harmonic radar to investigate the flight of insects at low altitude. *Computers and Electronics in Agriculture*, *35*(2-3), 151–169.

Riley, J. R. (1985). Radar cross section of insects. *Proceedings of the IEEE*, *73*(2), 228–232.

Riley, J. R., Reynolds, D. R., & Rainey, R. C. (1979). Radar-based studies of the migratory flight of grasshoppers in the middle niger area of mali. *Proceedings of the Royal Society of London. Series B, Biological Sciences*, *204*(1154), 67–82.

Riley, J. R., Smith, A. D., Reynolds, D. R., Edwards, A. S., Osborne, J. L., Williams, I. H., Carreck, N. L., & Poppy, G. M. (1996). Tracking bees with harmonic radar. *Nature*, *379*(6560), 29–30.

Roland, J., McKinnon, G., Backhouse, C., & Taylor, P. D. (1996). Even smaller radar tags on insects. *Nature*, *381*(6578), 120–120.

Samways, M. J. (2005). *Insect Diversity Conservation*. Cambridge University Press. doi:10.1017/CBO9780511614163

Schwartz, M. (1956). A coincidence procedure for signal detection. *I.R.E. Transactions on Information Theory*, *2*(4), 135–139.

Serway, R. A. & Vuille, C. (2017). *College physics.* Brooks Cole.

Smith, A., & Riley, J. (1996). Signal processing in a novel radar system for monitoring insect migration. *Computers and Electronics in Agriculture*, *15*(4), 267–278.

Swerling, P. (1960). Probability of detection for fluctuating targets. *I.R.E. Transactions on Information Theory*, *6*(2), 269–308.

Tatchell, G. (1991). Monitoring and forecasting aphid problems. In *Proceedings of the Conference on Aphid–Plant Interactions: Populations to Molecules*. USDA – Agricultural Research Service and Oklahoma State University.

Taylor, J. D. (2016). Introduction to advanced ultrawideband radar systems. In *Advanced Ultrawideband Radar* (pp. 19–36). CRC Press.

Taylor, J. D., Boryssenko, A., & Boryssenko, E. (2016). Signals, targets, and advanced ultrawideband radar systems. In *Advanced Ultrawideband Radar* (pp. 83–122). CRC Press.

TutorialsPoint. (n.d.). *Radar Systems Tutorial.* https://www.tutorialspoint.com/radar_systems/radar_systems_tutorial.pdf

USAAF. (1945). *Graphic Survey of Radio and Radar Equip.* Used by the Army Air Forces [Sec. 1] Countermeasures Equipment, volume Section One. USAAF.

van Loon, B. (2005). Radar 101: Celebrating 101 years of development. *Proceedings of the IEEE*, *93*(4), 844–846.

VandenBos, G., Knapp, S., & Doe, J. (2001). *Role of reference elements in the selection of resources by psychology undergraduates*. http://jbr.org/articles.html

Vaughn, C. R. (1985). Birds and insects as radar targets: A review. *Proceedings of the IEEE*, *73*(2), 205–227.

Wang, H., & Drake, V. (2004). Insect monitoring radar: Retrieval of wingbeat information from conical-scan observation data. *Computers and Electronics in Agriculture*, *43*(3), 209–222.

Watson, R. (2009). *Radar Origins Worldwide: History of Its Evolution in 13 Nations Through World War II*. Trafford Publishing.

Watts, C., Stringer, I., & Gibbs, G. (2012). Insect Conservation in New Zealand: An Historical Perspective. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Watts, S. (1987). Radar detection prediction in k-distributed sea clutter and thermal noise. *IEEE Transactions on Aerospace and Electronic Systems*, *AES-23*(1), 40–45.

Woiwod, I. P., & Hanski, I. (1992). Patterns of density dependence in moths and aphids. *Journal of Animal Ecology*, *61*(3), 619–629.

Wolff, C. (2009a). *Radar tutorial.* https://www.radartutorial.eu/druck/Book1.pdf

Wolff, C. (2009b). *Radartutorial: Book 2 - radar sets.* https://www.radartutorial.eu/druck/Book2.pdf

Wolff, C. (2016). *Radartutorial: Book 7 - intrapulse modulation.* https://www.radartutorial.eu/druck/Book7.pdf

Zrnic, D. S., & Ryzhkov, A. V. (1998). Observations of insects and birds with a polarimetric radar. *IEEE Transactions on Geoscience and Remote Sensing*, *36*(2), 661–668.

## KEY TERMS AND DEFINITIONS

**Aeroecology:** A discipline aiming at airborne life forms and their interactions with the environment.

**Frequency Modulated Continuous Wave Radar (FMCW):** A radar system radiating continuous transmission power and changing its operating frequency during the measurement.

**Harmonic Radar:** A radar principle in which the second or third harmonic of a transmitted radar frequency is detected

**Pulsed Radar:** A radar system that determines the range to a target using pulse-timing techniques.

**Vertical-Looking Radar:** A sky-oriented radar system gathering fine-grain information about flying species (i.e., body orientation, wingbeat, heading). It often utilizes pulsed radar sets.

# Chapter 29
# Toolkit for Conservation of Urban Biodiversity:
## A Web or Mobile App-Based Tool for Conserving Biodiversity in Urban Areas

**Himanshhu Panwar**
*School of Planning and Architecture, New Delhi, India*

**Meenakshi Dhote**
*School of Planning and Architecture, New Delhi, India*

## ABSTRACT

*Cities present multiple opportunities to create a more sustainable future by way of enhancing resource-efficiency and fostering innovation and political and social responsibility. The imperative for biodiversity in cities therefore goes beyond simple conservation to considerations of internalizing provisions of ecosystem services, which would otherwise be sought from outside the city. By presenting a practical approach to biodiversity planning and management, this toolkit seeks to help local governments harness available resources and opportunities to address global biodiversity loss by providing them a baseline of biodiversity, which would further help them to prepare local biodiversity strategy and action plan under the mandate of Biological Diversity Act 2002 providing the scope to municipal corporations to perform all activities relevant to overall biodiversity management. The study proposes a complete framework for formulating LBSAP using the existing tools for biodiversity assessment and how it can be incorporated into the city development plan for effective implementation.*

## BACKGROUND

Urban biodiversity refers to the variety and variability among living organisms found in a city and the ecological systems in which they occur (Oliveira P. d., et al., 2014). Overall, urban biodiversity responds to a combination of bio-geographic and anthropogenic factors, with a strong influence of the latter (Oliveira J. A., Doll, Moreno-Peñaranda, & Balaban, 2014). In a rapidly urbanizing world under the

DOI: 10.4018/978-1-7998-8482-8.ch029

pressing threat of climate change, there is a growing interest in understanding how cities benefit from local biodiversity and how these benefits can be under threat due to climate change. These areas can provide opportunities for creating a more sustainable future by way of enhancing resource-efficiency, reducing ecological footprints, fostering innovation, political leadership and social responsibility (UNEP, 2015).

Biodiversity in cities plays far more important role not just greenery and some birds & animals. It is an indicator of the ecological health of an area (Aronson, et al., 2017). It provides ecosystem services, which would otherwise be sought from outside the city at a cost and increase in the ecological footprint.

The value of wildlife in cities is often underestimated. Nature in cities is not only a matter of cultivated and managed biodiversity such as urban parks, gardens and lawns. Nowadays, urban wetlands, abandoned industrial sites, roadside verges, vacant lots, derelict lands, ruins, allotment gardens and cemeteries are increasingly recognized as potential reservoirs of urban biodiversity together with arboreta, residential gardens and villas, botanic gardens and individual balconies (European Environment Agency, 2010).

The imperative for biodiversity in cities therefore goes beyond simple conservation, to considerations of internalizing provisions of ecosystem services, which would otherwise be sought from outside the city (Avlonitis, et al., 2013). With the right form and organization, urban areas can provide opportunities, not merely threats, to biodiversity. As cities can play an important role in hosting rare and endangered species and habitat types (European Commission, 2013). The green infrastructure concept brings considerations for biodiversity and ecosystem services to the heart of wider spatial planning and is key to further strengthening sustainable urban development and related spatial policies (Martina, Olaf, & Karsten, 2017).

## NEED

Despite occupying just 2-3% of the Earth's land surface, cities are home to over 50% of the world's population, and this figure is estimated to rise to 90% by the year 2100 (UN, 2018). Urbanisation is occurring at an explosive rate: over 60% of the urban area projected to exist in 2030, has yet to be built (GFDRR and World Bank, 2015). Most of this growth will occur in biodiverse areas such as coastal zones and flood plains, and primarily in Asia and Africa. Such transformation will pose severe and unprecedented challenges to biodiversity conservation. In cities, there is also considerable potential for internal production and use of ecosystem services (Bolund & Hunhammar, 1999). But at the same time, urban biodiversity provides significant ecosystem services contributing to climate change mitigation and adaptation, such as carbon sequestration, air and water purification, mitigation of impacts of environmental pollution, noise reduction, and regulation of microclimate (Gómez-Baggethun, et al., 2013). High biodiversity increases the resilience of a city (National Academy of Sciences, 2013). This entails integrating biodiversity into urban planning to create ecological corridors, stepping stones, green roofs, wetlands, waterways, agricultural patches, etc., that generate tangible benefits for citizens (Avlonitis, et al., 2013).

One such tool used to formulate actions at city level is Local Biodiversity Strategy and Action Plan (LBSAP). It is a guiding strategy, complemented by specific actions and adopted by local governments to achieve optimal and realistic governance and management of biodiversity and ecosystem services.. It is worth noting that despite being a local policy instrument, LBSAPs have the potential to make a significant contribution to reducing biodiversity loss at a global scale. This is because urban areas are such significant consumers of the world's natural resources, the majority of these originating outside the city's boundary (Avlonitis, et al., 2013). It is therefore paramount that cities incorporate consideration of biodiversity and ecosystem services into city governance. In spite of recognizing it as an important decision for local biodiversity conservation in the country, there isn't any robust framework to collect, analyse and formulate data for preparing the action plan. Many cities have formulated LBSAP, but it lacks spatial representation of actions and integrating it into the master planning process still remains a challenge.

Additionally, other tools such as City Biodiversity index (international tool) and People's biodiversity register (national tool) used to access biodiversity are being analysed separately in cities, in spite of the synergies between them. Through this study, synergies between the two was accessed and a holistic framework has been recommended feeding into the effective implementation of LBSAP.

## Aim and Objectives

The aim of the study is to provide a framework for development of local area biodiversity action plan to ensure biodiversity conservation and management in urban areas using the existing biodiversity assessment tools. The objectives are a). Incorporating biodiversity and ecosystem services in local governance for sustainable planning of cities, b). Encourage a common framework to biodiversity conservation, c). Promotion of CBI as a tool for management of natural resources in the cities, d). Identification and involvement of sub-national stakeholders in the biodiversity conservation.

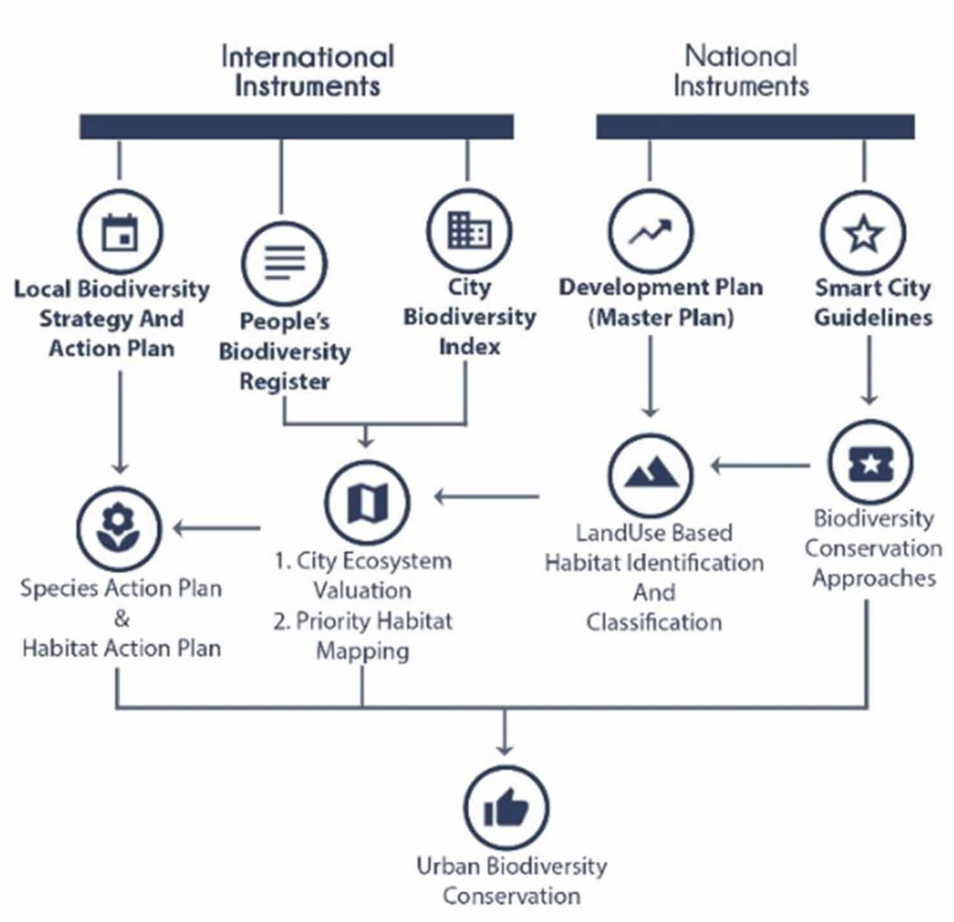
## METHODOLOGY

All the existing national and international tools related to biodiversity conservation have been studied, and relevant tools have been shortlisted and linked in such a way that it produces the framework for local biodiversity planning (figure 1). The tools used are People's Biodiversity Register (PBR), City Biodiversity Index (CBI), City's land use plan along with correlated concepts of biodiversity mapping and planning. PBR provides the listing of all the species diversity with related data, and also enhances the scope of identification of best practices on a local level. Whereas CBI provides the complete framework of status of city biodiversity in terms of natural resources, ecosystem services and governance. Both the processes have their unique methodology and analysis technique but have not been used together as a tool for action plan. In this study, the inter-linkages of both the above mentioned tools have been accessed and highlighted to address the current challenges of biodiversity assessment at city levels. Further, with the help of city land-use plan, an analysis tool has been proposed for habitat identification and classification. Spatially identified habitats have been further characterized using the outcomes of CBI and PBR, and a habitat valuation has been recommended. For formulating the LBSAP, the inputs from the CBI, PBR and habitat valuation map are added and priority habitat areas and focal species are identified. Further, actions and recommendations would be proposed for these identified habitats and species.

## COMPONENTS

Different components related to existing mechanism of biodiversity conservation used in the toolkit have been discussed below.

*Figure 1. Inter-linkages between existing tools for biodiversity conservation*




## City Biodiversity Index

The City Biodiversity Index, also referred to as the Singapore Index on Cities' Biodiversity or the Singapore Index (SI), is a self-assessment tool for cities to evaluate and monitor the progress of their biodiversity conservation efforts against their own individual baselines (CBD, 2015). It comprises: a) "Profile of the City", which provides background information on the city; and b) 23 indicators that measure native biodiversity, ecosystem services provided by biodiversity, and governance and management of biodiversity. The scoring of the Singapore Index is quantitative in nature. Each indicator is assigned a scoring range between zero and four points, with a total possible maximum score of 92 points. The year in which a city first embarks on this scoring will be taken as the baseline year, and this will be measured against future applications of the Index to chart its progress in conserving biodiversity.

*Table 1. List of indicators for city biodiversity index*

| Sl.No. | Indicator | Output |
|---|---|---|
| 1 | Indicator 1: proportion of natural areas in city | Map |
| 2 | Indicator 2: connectivity measures or ecological networks to counter fragmentation | Map |
| 3 | Indicator 3: native biodiversity in built-up areas bird species | Map |
| 4 | Indicators 4: change in number of native species vascular plants | Number/List |
| 5 | Indicators 5: change in number of native species birds | Number/List |
| 6 | Indicators 6: change in number of native species butterflies | Number/List |
| 7 | Indicators 7: change in number of native species reptiles | Number/List |
| 8 | Indicators 8: change in number of native species fresh water fishes | Number/List |
| 9 | Indicator 9: proportion of protected natural areas | Map |
| 10 | Indicator 10: proportion of invasive alien species | Number/List |
| 11 | Indicator 11: regulation of quantity of water | Map |
| 12 | Indicator 12: climate regulation: carbon storage and cooling effect of vegetation | Map |
| 13 | Indicator 13: recreational and educational services | Map |
| 14 | Indicator 14: recreational and educational services | Map |
| 15 | Indicator 15: budget allocated to biodiversity | Number/List |
| 16 | Indicator 16: number of biodiversity projects implemented by the city annually | Number/List |
| 17 | Indicator 17: policy, rules and regulations – existence of local biodiversity strategy and action plan | Number/List |
| 18 | Indicator 18: institutional capacity: number of essential biodiversity-related functionaries in the city | Number/List |
| 19 | Indicator 19: institutional capacity: number of city or local government agencies involved | Number/List |
| 20 | Indicator 20: participation and partnership existence and state of formal or informal public consultatio | Number/List |
| 21 | Indicator 21: participation and partnership number of agencies/ private companies/ ngos/ | Number/List |
| 22 | Indicator 22: Is biodiversity or nature awareness is included in the school curriculum | Number/List |
| 23 | Indicator 23: Number of outreach or public awareness events held in the city per year | Number/List |

## People's Biodiversity Register

A PBR is a document that records status of local biodiversity, landscape, waterscape elements and relationships of various user-groups with these essentially from a (local) people's perspective (TERI, 2017). The preparation of a PBR of villages would entail the vigorous involvement of the local community members through the formation of a Biodiversity Management Committee (BMC), with support from the concerned government bodies and departments and technical expertise (National Biodiversity Authority, 2013). The PBR is a database of traditional knowledge and intellectual property of the local rural community on biological resources. The documentation remains an age old challenge in the era of technology, in which the data is manually added or written and photographs are compiled. This can be overcome by direct uploading of the data (list and respective photos) onto a web platform and from where it can be further rectified and compiled. This provides a necessity of a web/app based platform for surveying easily and effectively.

## LBSAP

Local Biodiversity Strategies and Action Plans are mechanisms for implementing the Convention for Biological Diversity (CBD) and Aichi Biodiversity Targets at the local level, through alignment with National Biodiversity Strategies and Action Plans (CBD, 2011). Basically, LBSAPs are an overarching strategy accompanied by specific actions to achieve that strategy. It is a crucial tool by which local governments may guide the management of biodiversity and ecosystem services, enable local action, and inform overarching city plans and decisions. LBSAPs can be a valuable, integrated planning tool by which local governments may manage internal and external biodiversity, and build a healthy and sustainable future for city dwellers as well as globally for all, whether living in urban or rural settings (Oliveira, Shih, Moreno-Peñaranda, & Phillips, 2014). LBSAPs require a holistic and inclusive approach to plan for and manage the linkages between ecology, economy and society in order to ensure equity and build a sustainable city (Avlonitis, et al., 2013).

### Master Plan

The purpose of a Master Plan is to promote growth and guide and regulate present and future development of towns and cities. The scope of a master plan confines to the broad proposals and allocation of land for various uses such as residential, industrial, commercial, recreational, public and semi-public, etc. It proposes a network of roads and pattern of streets and traffic circulation systems for the present and the future. A master plan identifies areas required to be preserved and conserved and development of areas of natural scenery and landscape together with preservation of features, structures or places of historical, architectural and scientific interest and environmental value. Master plan includes zoning regulations for regulating development within each zone (D.S.Meshram, 2006).

### Citizen Science Dataset and Volunteering

The involvement of non-professionals in scientific research and environmental monitoring, termed Citizen Science (CS), is a mainstream approach for collecting data on earth processes, ecosystems and biodiversity (Chandler, et al., 2016). Using citizen scientists in biodiversity monitoring networks significantly expands the spatial and temporal scale of what is possible, because the additional people allows considerably more data to be collected, both in terms of range and quantity. CS can be a practical way to achieve the geographic coverage required to document ecological patterns and address ecological questions at scales relevant to regional population trends, shifts in species range, patterns of migration, etc (Chandler, et al., 2016).

## FRAMEWORK

The framework is about the collaboration of different ideologies and concepts which are brought down into a complete structure where their inter-linkages are identified and added to components of land use planning which when applied together can provide output which would be significant in conservation of biodiversity in urban areas. It could act as a single window entity where stakeholders, volunteers, NGOs, institutions, local government could work together at their respective levels and enhance the quality of the biodiversity and work together to conserve it by mainstreaming different processes and methods.

### Key Linkages between Components

City biodiversity index (CBI) is formulated through data analysis of cities, indicator wise under the sections- status of natural resources, ecosystem services and governance and scoring is given. The data collected through different departments could be added to the GIS and subsequently maps would be prepared and displayed under each indicator section on a web or mobile portal. Local government bodies can alter or add the data and keep it updated. This would ensure that city's status of environment specifically biodiversity and government measures are accessible to all the users and enhance transparency in the process and efforts of conservation. In CBI, the data related to invasive species, could be used to form the species action plan in local area biodiversity action plan (LBSAP). The data for change in number of species can be arrived from the People's biodiversity register's compilation. The indicator 11 (Table 1) of permeable and non-permeable surfaces for water regulation provides the data which can be used to identify the priority habitat areas for formulating LBSAP. Partnership, Institutional capacity and participation aspects could be linked to the component of volunteering for environmental activities.

PBR data collection could be electronic media based and could add to the CBI component, for change in number or location of species (Indicator 4-8, table 1) which can be upgraded timely. All the species information could be directly uploaded on the web map that can be used for area specific proposals in LBSAP. Local residents can participate through an interactive format of the app/ web-portal which will help feeding data related to nearby biodiversity, grievances and can directly contact the authorities responsible for the action of a particular problem.

In LBSAP, the dataset for species selection and existing greens can be taken from CBI component. The implementation of the actions across the city can be possible through component of volunteering by involvement of NGOs and local citizens. The authorities responsible for biodiversity actions in the city can be taken out from Indicator 18 (table 1) of CBI and directly pitched in for implementation of LBSAP. Volunteering component would have sections for contribution based on roles like as an individual, corporates, schools, RWAs or retired officials. For achieving the actions recommended in LBSAP and data collection under CBI, there is need of human resource, which can be sought through volunteering activities. In the process of formulation of LBSAP, the actions and recommendations should be based on habitat and species conservation. For habitat action plan, identification and classification needs to be done firstly, followed by defining priority habitat areas and then providing conservation or restoration actions for the same. The component of landuse plan would be required for identification of the habitats. Similarly, in the case of species action plan, focal species would be identified and proposed actions would be defined. The GIS landuse shapefiles based on the master plan of the city, needs to be uploaded and it could be converted into ecosystem habitat map using table 3. This part can be automated and local government can actively pursue the city landuse plan as ecosystem habitat map and incorporate it extensively into the decision making activities.

Habitat Identification & Classification: City is divided according to its habitat, of which the identification of the aspects of each habitat is an important task. The mapping would be done according to different land uses. These artificial habitats that the city has, provides broader scope for conservation of different species within the city itself, so there arises a need to identify and conserve them. The classification can be done at two scales large and small meso scale. Meso habitats (small) can range from 1sq.km. to 1000 sq. km; whereas Meso habitats (large) can be from 1000 sq. km. to 10,000 sq. km. Micro habitats (i.e. upto 1sq.km or 100 ha) could include all categories of plots – residential, commercial, institutional, industrial, recreational etc. So, the classifications is done according to the following tables:

The automated habitat map would be available for all the users to view the city as an ecosystem point of view and hence, arrive to better conservation measures involving all the major stakeholders.

## User-Centric Design

Applicability of the toolkit can only be widely enhanced, when it is more user centric and attracts interest of major stakeholders. Figure 2 illustrates the users of components used in the toolkit. It also shows

*Table 2. Landuse and habitats (meso scale - large)*

| S.No. | LANDUSE CATEGORY | ECOSYSTEM TYPE | HABITAT ** TYPE |
|---|---|---|---|
| 1 | BUILT UP LAND (High,moderate density) | **Terrestrial** | Cliffs &caves |
| 2 | BUILT UP LAND (Low density) | **Terrestrial** | Open scrub |
| 3 | AGRICULTURAL LAND (Cultivated) | **Terrestrial** | Open Scrub |
| 4 | AGRICULTURAL LAND (Fallow) | **Terrestrial** | Woodland monoculture |
| 5 | FORESTS (Dense / Open scrub) | **Terrestrial** | Woodland |
| 6 | FORESTS (Plantation) | **Terrestrial** | Woodland monoculture |
| 7 | FORESTS (Open scrub) | **Terrestrial** | Open scrub |
| 8 | WASTELAND (Saline lands) | **Terrestrial** | Open plains |
| 10 | WASTELAND (Rocky) | **Terrestrial** | Rocky |
| 11 | WATER BODIES (River /stream/ drain) | **Aquatic** | Fresh water wetlands |
| 12 | WATER BODIES (Canals) | **Aquatic** | Fresh water wetlands |
| 13 | WATER BODIES (Lakes / ponds) | **Aquatic** | Fresh water wetlands |

Source: (Dhote, 2005) ** This classification is subject to change depending on availability of scientific data. At present it is somewhat subjective.

how users can get involved with the toolkit at various levels and what features it would provide for the biodiversity conservation in the city. The toolkit would be used mainly to access and gather information for biodiversity status of various cities.

## Challenges

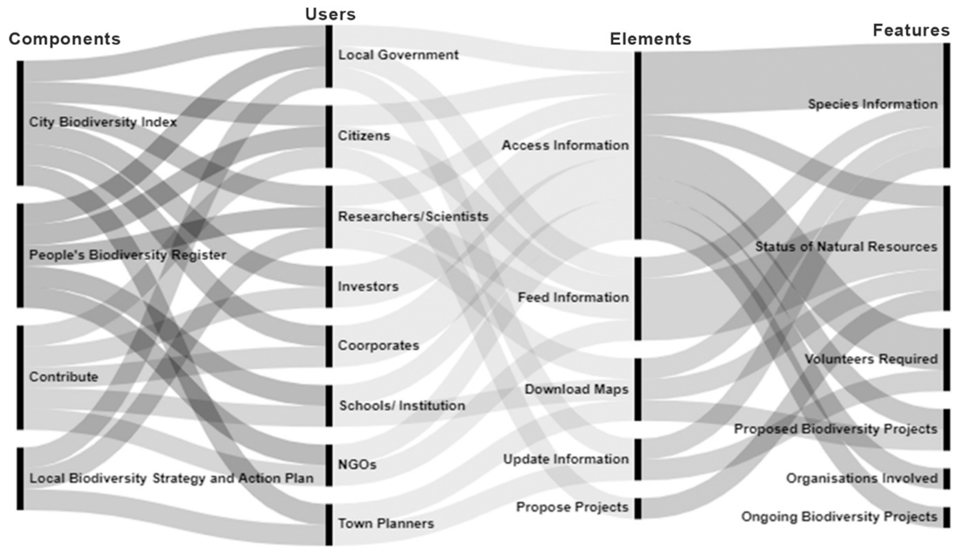
The major challenge for the toolkit lies with the implementation and managing of the database. It can only work if it is institutionalized and involves different set of experts under the same domain. Data validation is extremely important when citizen science data is involved, as it may lead to poor information and may also cause the doubling of data. The database required for biodiversity needs to be validated by series of experts like botanists, zoologists, etc. For the natural resources, the survey and planning institutes need to collectively involve in rectifying the data, so that errors can be minimized. To draw the interest of wide strata of population, certain incentives have to be given based on the involvement. For collecting information and uploading it on the portal of the framework, skill development needs to be done to achieve the true intention of the application/ framework. The terminologies used for the land-uses in different landscapes, have to be synchronized for digital applicability to minimize the errors in uploading and prevent overlapping of information. If these challenges are addressed, the toolkit has the potential to change the entire course of the conservation measures for natural resource and biodiversity in urban areas. Even, if we manage to collect the information and produce LBSAP using the toolkit, it can only implemented effectively if it is incorporated into the master planning process.

*Table 3. Landuse and habitats (meso scale – small)*

| S.No. | USE ZONE | HABITAT ** CATEGORY |
|---|---|---|
| **1** | RESEDENTIAL | |
| | Primary Residential Zone | **Open scrub** |
| | Mixed Residential Zone | |
| | Unplanned/Informal Residential Zone | |
| **2** | COMMERCIAL | |
| | Retail Shopping Zone | |
| | General Business Commercial District/centers | **Cliff &caves** |
| | Wholesale, Godown, Warehousing, Regulated Markets. | |
| 3 | MANUFACTURING | |
| | Service and Light industry | **Open scrub** |
| | Extensive &Heavy Industry | |
| | Special Industrial Zone<br>Hazardous, Chemical and Noxious | |
| 4 | PUBLIC &SEMI-PUBLIC | |
| | Govt./Semi Govt./Public Offices | **Cliff &caves** |
| | Govt. Land(Use Undetermined) | **Open scrub to woodland** |
| | Educational &Research | **Open scrub to woodland** |
| | Medical &Health | **Open scrub to woodland** |
| | Social, Cultural& Religious | **Open scrub** |
| | Utilities &Services | **Open scrub** |
| | Cremation &Burial Grounds | **Open scrub to woodland** |
| 5 | RECREATION | |
| | Playgrounds, Stadium, Sports Complex | **Open scrub to woodland** |
| | Parks &Gardens (Public open spaces) | **Open scrub to woodland** |
| | Multipurpose Open Space (Maidan) | **Open scrub to woodland** |
| **6** | TRANSPORTATION &COMMUNICATION | |
| | Roads | |
| | Railways | |
| | Airport | **Open scrub** |
| | Sea port &Dockyards | |
| | Bus Depots Truck Terminal &Freight Complexes. | |
| | Transmission &Communication | |
| **7** | AGRICULTURE | |
| | Agriculture | **Open scrub** |
| | Forest | **Woodland** |
| | Brick Kilns &Extractive Area | |
| | Water Bodies | **Wetland** |
| **8** | SPECIAL AREA | |
| | Old Built-up Areas | |
| | Heritage & Conservation | |
| | Scenic Value Areas | **Open scrub to woodland** |
| | Village Settlement | |
| | Other Uses | |

Source: (Dhote, 2005) ** This classification is subject to change depending on availability of scientific data. At present it is somewhat subjective

*Figure 2. Users of the toolkit focusing on each component*




## A WAY FORWARD: IMPLEMENTATION OF THE TOOLKIT

Successful implementation of LBSAPs requires vertical integration of strategic planning and implementation, coordination (i.e. agreement on common priorities and division of responsibilities and labour), and cooperation or collaboration (i.e. development of joint work plans, working together) between the various levels of authority. Conservation of biodiversity has to be undertaken in an integrated manner, to ultimately lead to overall resource conservation. Any method applied, has to understand the characteristics of the biodiversity specific to the settlement under study. The study would essentially be carried out in the following sequence:

### Resource Classification - Baseline of Natural Resources of the City

An urban area in an administrative unit has to be first understood in terms of three different classifications mainly Biogeographic zones, Agro-ecological zone and Agro-climate zones based on its classifications.

- **Biogeographic classification** is the division of India according to biogeographic characteristics. It is the study of the distribution of species (biology), organisms, and ecosystems in geographic space and through geological time. There are ten biogeographic zones in India. So, based on the bio-geographic zones, characteristic ecosystems need to be identified and geo-located. (If the areas couldn't be mapped then coordinates should be mentioned.) All the key/dominant species can be listed based in the city's location in each zone.
- **Agro-ecological Zoning** (AEZ) refers to the division of an area of land into smaller units, which have similar characteristics related to land suitability, potential production and environmental impact. So, the selected city would be classified into the agro-ecological zones and all the areas with rich natural ecosystems like peri-urban areas, marshy lands, agricultural lands, etc needs to

be identified. Based on the agro-ecological regions, diversity of livestock would also be assessed and listed out.

- **Agro-climatic zones:** The Planning Commission, as a result of the mid-term appraisal of the planning targets of the Seventh Plan, has divided the country into fifteen broad agro-climatic zones based on physiography, soils, geological formation, Climate, cropping patterns, and development of irrigation and mineral resources for broad agricultural planning and developing future strategies. So, based on the agro-climatic zones where the selected city lies, dominant crops would be identified (cropping season wise).

Listing of recently introduced plants is also available from Forest Department, Development Authorities, Public Works Departments, Municipal Committees and Corporations, Cantonment boards. Many NGOs, ECO clubs, research scholars record the fauna existing in various areas.

## Status of Organismal Species and Ecosystem Diversity

The baseline for the species information can be compiled using the People's Biodiversity Register (PBR) formats on agro-biodiversity, domesticated and urban biodiversity (and for cities which are close to wildlife sanctuaries or natural parks, formats of wild biodiversity can be included).

The Organismal Diversity is diversity at the species level. (National Academy of Sciences, 1988) The baseline generated in PBR including livestock, flora, fauna, and crop will come under this and ecosystem diversity includes the mapped natural ecosystems compiled in the earlier step. A study and analysis of the settlement's growth and changes in biodiversity to understand the extent and nature of changes in the area of ecosystems and type of species have to be appreciated. This would help to protect the ecosystems and species from further degradation. The biodiversity that presently exists - ecosystem diversity and organismal biodiversity and its environmental role have to be recorded. The threats to biodiversity have to accessed from human activities, natural phenomenon, and context dynamics with a negative impact on relevant areas and species. This study also identifies any rare, endangered, threatened, and endemic species of flora and fauna present along the route. City Biodiversity Index can be an efficient tool for accessing, compiling, and managing the status of biodiversity in the city. A total of 23 indicators make up the index, measuring a city's native biodiversity, the ecosystem services provided, and biodiversity governance.

## Sector Specific Plans & Proposals of Line Departments

All the ongoing plans and proposals of line departments like Public Works Department, Animal Husbandry, Horticulture, etc. have to be accessed and listed along with the schemes under which they are working. As per the plans, the applicable areas where the schemes have to be implemented have to be mapped.

## Master Plan Provisions

Growth and development of an urban area are understood spatially with the help of landuse maps at various scales and at various points in time. Landuses are potential habitats for organisms and landuse patterns can form the basis for recording the biodiversity character. Since landuse is recorded at various scales, habitat scales can be correlated to landuse planning. This can be compiled using the integration of works of inline departments like forest and planning departments. The following tasks can be assigned to the respective departments to map the biodiversity-rich landuses or the Green Landuses in the city.

- **Role of Botanical and Zoological departments:** Listing of all the locations with respect to their coordinates of species sightings in the urban area.
- **Role of Urban Development/ Planning Department**: Demarcation of the nearby landuses where the species sighting has taken place or nearby protected areas.

Green landuses - low density residential/ green neighborhoods, institutions, heritage areas, large parks, critical urban gradients, and landscape elements (patch, corridor, matrix) have to be spatially identified and assessed for their biodiversity value. These areas have to be protected from unsuitable development as they serve as habitats for species as well as contribute to environmental protection. The following checklist can be used by Town and Country Planning Organisation (TCPO), Development Authorities, Municipal Bodies, and Forest departments for rectifying the presence of species in different landuses and finalization of Green landuses.

*Table 4. Format to collect information on green landuses in the city*

| Landscape Elements / Landuses | | Presence of Species | Biodiversity's Protection | Spatial Extent of Protection | Assessment of Biodiversity Value |
|---|---|---|---|---|---|
| **Corridors** | Storm water drain | | | | |
| | Roadsides | | | | |
| | Riverside | | | | |
| | Streams, etc | | | | |
| **Patches** | Agriculture | | | | |
| | Commercial | | | | |
| | Recreational | | | | |
| | Industrial | | | | |
| | Public Utility | | | | |
| | Waterbodies | | | | |
| | Forest etc. | | | | |
| **Matrix** | Residentials | | | | |
| **Critical urban gradients** | Heritage | | | | |
| | Institutions, etc | | | | |

It would rectify the identification of green landuses with all the inline departments. Thereafter, detailing of sensitive habitat units within these areas to protect the species has to be mapped. The buffer area needs to be demarcated, and listing of permitted and not permitted landuses and activities has to be undertaken. Based on the observations and the identification of green landuses moderations in the masterplan would be proposed. Like listing of permitted and not permitted land uses and activities within protected areas and around protected areas would help in ensuring conservation of biodiversity at this scale.

## Incorporations into Development Plans

The existing and proposed development needs to be accessed and for the biodiversity action plan proposed, significant measures and strategies need to be suggested for all the inline departments. It would also be linked to the other proposed schemes for implementation.

## CONCLUSION

The chapter discussed the scope of conserving urban biodiversity using existing mechanisms placed worldwide, and how their synergies can be used to produce a robust toolkit. It can be a mobile or web-based application, incorporating all the components. The development of action plans and portals wouldn't be enough if it doesn't address all the stakeholders and isn't incorporated into the master planning process. Even though there are many digitalization challenges associated with this study which haven't been mentioned in the chapter, but it opens up greater opportunities to think about and resolve them. As it is truly said that "there is no Earth B" so, one need to do what all is possible to protect what's there.

## REFERENCES

Aronson, M., Christopher, L., Karl, E., Mark, G., Susannah, L., MacIvor, S., ... Vargo, T. (2017). Biodiversity in the city: Key challenges for urban green space management. *Frontiers in Ecology and the Environment*, *15*(4), 189–196. doi:10.1002/fee.1480

Avlonitis, G., Doll, C. N., Galt, R., Mader, A., Patrickson, S., Moreno-Penaranda, R., . . . Shih, W. (2013). *Biodiversity and Municipal Planning: Local Biodiversity Strategy and Action Plan Guidelines.* Cape Town: ICLEI, SCBD, UNU-IAS.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, *29*(2), 293–301. doi:10.1016/S0921-8009(99)00013-0

CBD. (2011, June). *Updating National Biodiversity Strategies and Action Plans in line with the Strategic Plan for Biodiversity 2011-2020.* Retrieved June 01, 2021, from https://www.cbd.int/doc/training/nbsap/b1-train-intro-nbsap-revised-en.pdf

CBD. (2015, June 01). *Singapore index on cities' biodiversity.* Retrieved June 01, 2021, from cbd.int: https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf

Chandler, M., See, L., Buesching, C. D., Cousins, J. A., Gillies, C., Kays, R. W., . . . Tiago, P. (2016). Involving Citizen Scientists in Biodiversity Observation. In The GEO Handbook on Biodiversity Observation Networks (pp. 211-237). Springer.

Dhote, M. (2005). *Landuse Strategy for Conservation of Biodiversity*. School of Planning & Architecture.

European Commission. (2013). *Nature and Biodiversity*. European Commission.

European Environment Agency. (2010, May 27). *10 messages for 2010 Urban ecosystems.* Retrieved June 10, 2021, from European Environment Agency: https://www.eea.europa.eu/publications/10-messages-for-2010-urban-ecosystems

GFDRR & World Bank. (2015). *Investing in Urban Resilience: Protecting and Promoting Development in a Changing World*. World Bank.

Gómez-Baggethun, E., Gren, Å., Barton, D. N., Langemeyer, J., McPhearson, T., O'Farrell, P., . . . Kremer, P. (2013). Urban Ecosystem Services. *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*, 175-251.

Martina, A., Olaf, B., & Karsten, G. (2017). *Using the Concepts of Green Infrastructure and Ecosystem Services to Specify Leitbilder for Compact and Green Cities—The Example of the Landscape Plan of Dresden*. Sustainability.

Meshram. (2006). Interface between city development plans and master plans. *ITPI Journal*, 1-9.

National Academy of Sciences. (1988). *BioDiversity*. Academy Press.

National Academy of Sciences. (2013). *Resilience and Ecosystem Services*. National Academy of Sciences.

National Biodiversity Authority. (2013). *Guidelines for operationlization of biodiversity management committees (BMCs).* Retrieved June 01, 2021, from nbaindia: http://nbaindia.org/uploaded/pdf/Guidelines%20for%20BMC.pdf

Oliveira, J. A., Doll, C. N., Moreno-Peñaranda, R., & Balaban, O. (2014). *Urban Biodiversity and Climate Change*. Springer.

Oliveira, P. d., & Doll, J. A., N.H., C., Moreno-Peñaranda, Balaban, R. A., & Osman. (2014). Urban biodiversity and climate change. *Global Environmental Change*, 461–468.

Oliveira, P. d., Shih, W.-y., Moreno-Peñaranda, R., & Phillips, A. (2014). *Integrating Biodiversity with Local and City Planning*. UNU-IAS. Retrieved from https://www.niua.org/csc/assets/pdf/key-documents/phase-2/Up-GreenC-and-BIO/Integrating-Biodiversity-with-Local-and-City-Planning.pdf

TERI. (2017, March 10). *Facilitate the preparation of People's Biodiversity Register (PBR) documentation for Chorao - Madel Village*. Retrieved June 01, 2021, from https://www.teriin.org/project/facilitate-preparation-peoples-biodiversity-register-pbr-documentation-chorao-madel-village

UN. (2018, May 16). *68% of the world population projected to live in urban areas by 2050, says UN*. Retrieved June 01, 2021, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UNEP. (2015a). *City-level Decoupling: Urban Resource Flows and Governance of Infrastructure Transitions*. UNEP.

UNEP. (2015b). *Sustainable Consumption and Production Global edition. A Handbook for Policymakers*. UNEP.

# Chapter 30
# Battery Efficiency in Outdoor Sports Environments for Mobile Pervasive Augmented Reality Systems

**Rui Miguel Pascoal**
https://orcid.org/0000-0002-6065-8109
*Instituto Superior de Tecnologias Avançadas, Portugal*

## ABSTRACT

*This work analyses energy expenditure in outdoor sport environments with augmented reality technology. Battery efficiency is becoming a relevant topic in the context of the varied outdoor end-user services, among other realms. It is a key to the acceptance and use of mobile technology. In outdoor environments, battery efficiency can be low, especially when information based on close-to-real-time requires internet access and the use of sensors. Such requirement is today evident with the growth of internet dependence and multiple sensors, which perform both actively and passively via fitness gadgets, smartphones, pervasive systems, and other personal mobile gadgets. In this context, it is relevant to understand how energy is spent with the accelerometer, global position system, and internet access (Wi-Fi or mobile data) providing smart data for outdoor sports activities. Through a prototype, an analysis is made based on the current battery autonomy, and an algorithm model for better battery efficiency is proposed.*

## INTRODUCTION

Battery efficiency in outdoor environments is today a strong user requirement and integrated into different aspects of the social living and social activities, becoming a key users requirement, being one of such components of outdoor activities, such as outdoor sports. Until recently, such solutions were based on dedicated hardware, such as smartphones. Smartphones are portable pervasive personal communication devices found in both developing and developed countries, they are potentially a highly valuable and accurate source of data from which mobility and activity information can be collected (Ball, R., et

DOI: 10.4018/978-1-7998-8482-8.ch030

al., 2014). However, the integration of multiple sensors into these most varied sets of mobile personal devices, such as smart-glasses, smartwatches, and other pervasive mobile gadgets bring in the possibility to consider smart data to improve specific Augmented Reality (AR) meaningful feedback to the users, avoiding information overload (Pascoal, R. M., & Guerreiro, S. L., 2017), as well as look and feel. This aspect is particularly relevant in variable environments, such as outdoor sports as these environments embody high topological variability, intermittent connectivity, constrained devices, and a need for constant middleware readjustment, based on the user's sensed indicators (smart data). For such purpose, it is necessary to re-think the energy needs of mobile pervasive systems of AR, such as MPARS to devise more flexible systems, that can support mobility.

Battery efficiency is an issue especially in outdoor environments, when users often access the Internet and use some sensors, such as GPS and accelerometer sensors, for instance, to recognize sport activities like walking, running, and biking.

In one hand, the accelerometer sensor has been heavily used in smartphones for non-intrusive activity recognition. Based on three axes it measures the acceleration of each axis in the units of g-force (Su, X., Tong, H., & Ji, P., 2014). In other hand, GPS is also heavy used in any location-based app in smart devices, such as smartphones, e.g., almost a quarter of all Android apps available in the Google Play Store use GPS. Apps require monitoring your locations in a continuous fashion, but it consumes the highest power from the smartphones (Dutta, J., Pramanick, P., & Roy, S., 2018).

To resolve, this work introduces an battery efficient context-aware approach which utilizes user's mobility information from the sport's context and as well smartphone's sensing values from the in-built accelerometer to provide a very close estimation of the present location of the user without using continuous GPS. It is an solution without lost the geolocation accuracy.

This paper contributes to the first analysis of energy needs and battery efficiency in outdoor sports environments. The goal is to reduce battery expenditure. The contributions of this work are three-fold:

- To simplify Hardware needs for energy efficiency.
- To handle energy-constrained with intermittent connectivity to the Internet and Global Position System in outdoor sports contexts when MPARS provides meaningful feedback from smart data in close-real-time.
- It proposes a new model of energy efficiency for AR technology in outdoor sports environments.

The rest of the paper is organized as follows. Still, in this section, the main questions of this study are presented. Section II covers the background and discusses energy expenditure for adjusting the MPARS to receive smart data, helped by sensors, and Internet connectivity, applicable in outdoor sports contexts. Section III presents the main focus of the chapter with issues, controversies, problems, and energy needs. Section IV has the experiments with an MPARS prototype to collect battery tests, followed by the hardware and software setup. Section V has the work results, followed by Section VI, which shows a proposal to battery efficiency for MPARS and Section VII the conclusions. Finally, Section VIII the future work and directions.

This work addresses the following open questions:

- How much energy does the GPS and accelerometer sensor need to properly recognize sports activities in outdoor environments?

- How much energy does it spend accessing the Internet, necessary for location accuracy and data exchange with the cloud in outdoor environments?
- How much energy is saved if a method of intermittent use of the accelerometer and GPS sensors is used?
- How much energy is saved if a method of intermittent use of Internet access is used?

## BACKGROUND

Every executed action on a mobile smart system has an associated energy cost. Applications are required to share battery resources in his normal usage of the smart device, i.e., collecting, storing, and communicating data. Several works have promoted the usage of mobile smart systems and fitness gadgets for the collection of various data. Mobility data for the observation of behavioral patterns and research projects have also considered smart device-based data collection as a cost-effective means of collecting mobility and activity data (Raento, M., et al., 2009; Vautin, D. A., & Walker, J. L., 2011).

A pervasive mobile application running on a smart device should seek to minimize resource usage, collect as highly resolute data as possible and avoid impeding the users' normal usage of the device or influence the behavior of the user (Ball, et al. 2014). So, MPARS application needs a context recognition system and context-awareness to better technology adoption and quality of experience (Pascoal, R., et al., 2018), but it requires robust energy efficiency, especially in outdoor environments, to provide more time of Quality of Experience to end-users in the field of computer science which, with the appearance of wearable devices and smart applications is now in its second phase of development. A main difference to the first phase concerns the fact that wearables, as well as mobile personal devices with a large variety of sensors, are carried by users almost 24 hours per day (Pascoal, R. M., et al., 2019). Several works have focused on the way to best adapt battery efficiency to embedded devices, as explained in this section.

The battery efficiency of smart systems, such as smartphones, especially in outdoor environments, is demanding in terms of battery life. The Global Positioning System (GPS) is the most used one and the most ubiquitous (Misra, P., & Enge, P., 1999; Youssef, M., 2010). However, one of the main drawbacks of GPS is that it is an energy-hungry device that can drain the battery of the phone in a few hours, or less (Gaonkar, S., Li, et al, 2008). Different approaches based on time, angle, and received signal strength have been proposed (Tekinay, S., 1998). City-wide Wi-Fi-based localization systems have been proposed, but they either suffer from low accuracy or high energy consumption (Gaonkar, S., Li, et al, 2008; Cheng, Y. C., et al, 2005).

New internal sensors have been introduced in smartphones including the accelerometer. An accelerometer is a sensor that measures the acceleration the system experiences relative to free-fall. The accelerometer has been used to detect activities of the users like walking, race walking, running, or biking, and other outdoor sports, e.g., to merely auto rotate the screen (Pascoal, R. M., et al., 2019; Bayat, A., Pomplun, M., & Tran, D. A., 2014).

The Android API provides four modes for querying the accelerometer that differs in the rate of delivering sensors events. They are called Normal, UI, Game, and Fastest. The rates at which the events are delivered are 4, 10, 20, and 50 events per second respectively. These modes expend different amounts of energy, these are some conclusions of Youssef et al., which research the energy efficiency of the accelerometer sensor, and others (Youssef, M., 2010). In their experiments observed that the average current drained in milliamperes in faster mode 95mA and other extreme normal mode is 15mA. Also, in their experiments, the GPS drained 135mA.

## MAIN FOCUS OF THE CHAPTER

Pascoal et al. investigated sensors for data acquisition outdoors with better results with only the accelerometer and GPS sensor for activity recognition in sport contexts and criteria to select the information, that is, provided to the user under specific conditions, to prevent information overload (Pascoal, R. M., de Almeida, A., & Sofia, R. C., 2019).

Information overload is associated with the excessive quantity of information. if input exceeds the processing capacity, an overload occurs, which is likely to reduce the quality of the decisions (Speier et al., 1999). When a decision-maker is given many sets of information, such as complexity, amount, and contradiction, the quality of its decision is decreased because of the individual's limitation of scarce resources to process all the information and optimally make the best decision (Roetzel, 2019).

Preventing information overload is directly related to better technology adoption and better QoE (Pascoal, R. M., & Guerreiro, S. L., 2017; Pascoal, R., Alturas, B., de Almeida, A., & Sofia, R., 2018). Based on these findings an algorithm was developed and integrated into the MPARS prototype to adjust adequate information to show to the end-users with meaningful feedback. See Figure 1.

Figure 1 is an adaptation of previous works that shows the algorithm of the MPARS prototype and its relationships (Pascoal, R., et al., 2020). The first block – "Adoption Variables" has the technology adoption variables, such as comfort, adjustable system, and familiarity linked with the second block – "QoE input", which has the informative elements, such as weather, biometric, geographic, and social information.

These elements are initially calibrated with the help of the third block – "computation" of adoption weight, and activity weight that calibrate a specific layout and contribute to meaningful feedback, i.e., specific information for an user in a sporting activity.

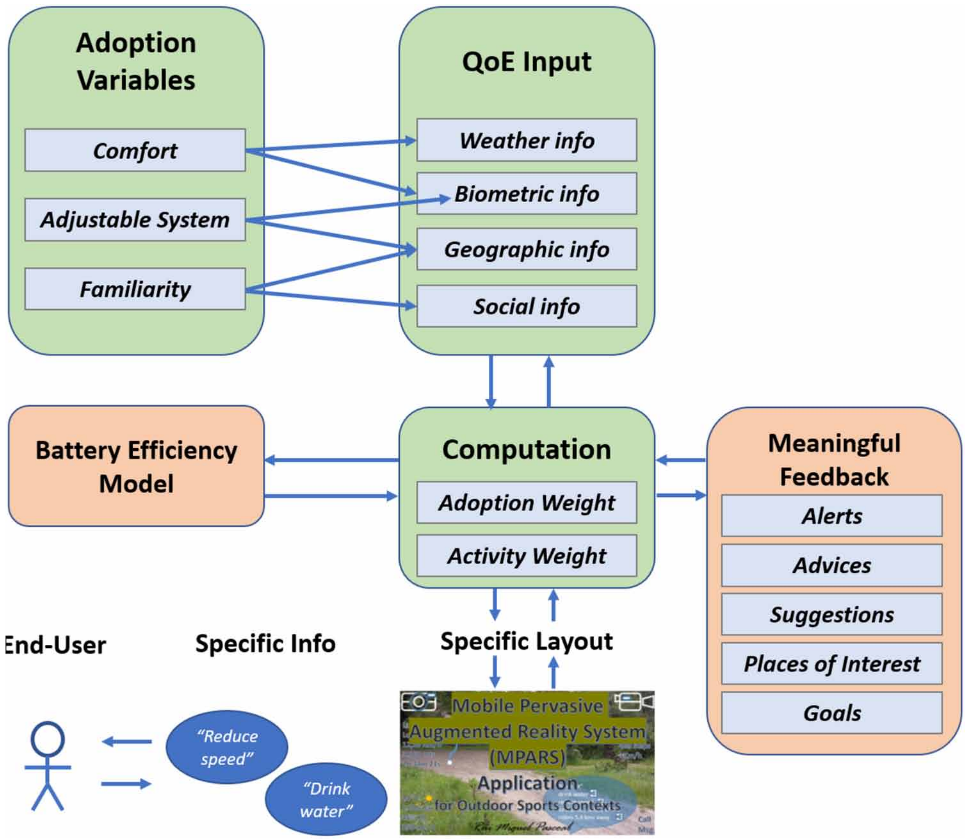
### Issues, Controversies, Problems

Now, see a discussion of issues and some background on smart system dependence on accelerometer sensors, GPS, and Internet access used to activity recognition in applications.

### a. Accelerometer

The accelerometer comprises measurements based on three axes. The raw data stream from the accelerate is the acceleration of each axis in the units of g-force (Su, X., Tong, H., & Ji, P., 2014). This sensor has been used heavily in smartphones for non-intrusive activity recognition. Its popularity is due to the wide availability of both hardware and software libraries for movement detection. If an user changes his/her activity from standing, walking to race walking, or running, it will reflect on the signal shape of the acceleration reading along the vertical axis - there will be an abrupt change in the amplitude. Moreover, the acceleration data could indicate the motion pattern within a given time, which is helpful in complex activity recognition. The accelerometer is often used to identify walking, running, biking, and others, as well as to identify non-movement.

*Figure 1. Concept of the MPARS Algorithm with the computation of adoption weight and activity recognition weight. Adapted from Pascoal, R., et al., 2020).*




## b. GPS

GPS is a satellite-based positioning mechanism that provides a mobile receiving device with its position, as well as the time, under any atmospheric conditions, anytime and anywhere on Earth. GPS works with the assumption that the receiver has a total or partial line of sight of three GPS satellites (four or more for greater accuracy). Obstacles such as mountains and buildings block the relatively weak GPS signals. As soon as a fix is obtained.

The duration required for a GPS fix depends on many parameters, e.g., the surroundings of the device and/or the clearness of the sky. Also, GPS can be an excellent sensor for refining activity recognition, as speed can be derived from GPS data, assuming one knows the type of vehicle in place (Chowdhury, A., Chakravarty, T., & Balamuralidhar, P., 2014).

## c. Internet Access

Internet access is a mandatory user requirement nowadays. Smart systems such as smartphones must exchange data constantly or periodically, for a variety of reasons, for instance, to send and receive emails, share photos and videos on social networks, make Internet calls, etc. Tsetsi et al. survey the smartphone dependence of Internet access, and it is real (Tsetsi, E., & Rains, S. A., 2017). This dependency also applies in our case because the prototype was designed to connect to the Internet frequently, to check the weather, and to adjust the accuracy of the geographic location.

This research has two current technologies to analyze, which delivering broadband wireless Internet access services: “Mobile data 4th Generation (4G)” vs. “Wi-Fi”. Both technologies are wireless, but which one is more efficient in terms of energy consumption?

### d. Internet Access by Wi-Fi

Wireline local area networks (LANs) emerged in the early 1980s as a way to allow collections of PCs, terminals, and other distributed computing devices to share resources and peripherals such as printers, access servers, or shared storage devices. Wi-Fi is the popular name for the wireless Ethernet 802.11b standard for WLANs (Lehr, W., & McKnight, L. W., 2003). Wi-Fi LANs operate using spectrum in the 2.4GHz band. The current generation of WLANs supports up to 11 Mbps data rates within 100m of the base station (Mitchell, B., 2019).

### e. Internet Access by Mobile Data 4G

Mobile Data of 4G is a mobile communication system projected to solve still-remaining problems of 3G (third generation) systems and to provide a wide variety of new services, from high-quality voice to high-definition video to high-data-rate wireless channels. Implementation in the year 2010, higher capacity, completely IP-oriented, multimedia, data to hundreds of megabits. 200Mbps (megabits per second), source:

Download Speeds: Comparing 2G, 3G, 4G & 5G Mobile Networks, 2018. With a seamless connection to a wide range of information and services, and receiving a large volume of information, data, pictures, video, and so on, are the keys of the 4G infrastructures. support the users’ traffic, air interfaces, radio environment, and quality of service. Connection with the network applications can be transferred into various forms and levels correctly and efficiently (Ibrahim, J., 2002).

## EXPERIMENTS

This work implements an experimental environment involving battery efficiency with an Android smartphone. Measurements are taken in an outdoor environment. The measurements have been performed during the period of May 10, 2021, until July 31, 2021. The experiment setup is divided into two parts: Hardware setup and Software setup.

### a. Hardware Setup

In order to measure the power consumed by the Android device, the following setup is used: The smartphone holding a Kirin 620 CPU and 2.0GB of RAM, with battery features in 100%: Voltage of 4.331mV and Current of 3.000mAh. Since the Voltage (V) is constant, the Current (A) can be used as an indication of power consumption. The monitoring application used reports all monitored values through their historical usage (%/h).

## b. Software Setup

A prototype MPARS developed is used, only for academic studies, merely exploratory. The binary code of MPARS prototype can be found at https://goo.gl/8EQ2Kx, with two open-source Android applications running behind the prototype, called: "3D Battery Monitor" (https://play.google.com/store/apps/details?id=ccc71.bmw&hl=en_US), and "Accelerometer Analyzer" (https://accelerometer-monitor.soft112.com/download.html). Sensor speed was adjusted to normal mode for better energy consumption (the high-speed query mode consumes more energy (Youssef, M., 2010). The CPU usage of the smartphone was monitored with an application called "Simple System Monitor" (https://play.google.com/store/apps/details?id=com.dp.sysmonitor.app&hl=pt_PT&gl=US).

The text files (10 logs) from historical usage are analyzed to get an estimate of the power consumption. This is achieved by comparing the average power consumed in the standby state that is consumed when the sensors of interest and Internet access are running.

The tests were done with the battery at 100%, performed with the screen always on, and running the MPARS application. The details of the tests:

- Test 1: Offline without GPS
- Test 2: Offline with GPS
- Test 3: Wi-Fi Data with GPS
- Test 4: Mobile Data 4G with GPS

During the offline test, the Wi-Fi was connected for 1 minute to update the weather data, a phone call was made for 1 minute, an SMS message was sent, and some warning messages were displayed in the prototype, as well as a photo was taken. There were no more applications running in the background for all tests.

See the MPARS prototype and monitoring application in next Figure 2 and Figure 3.

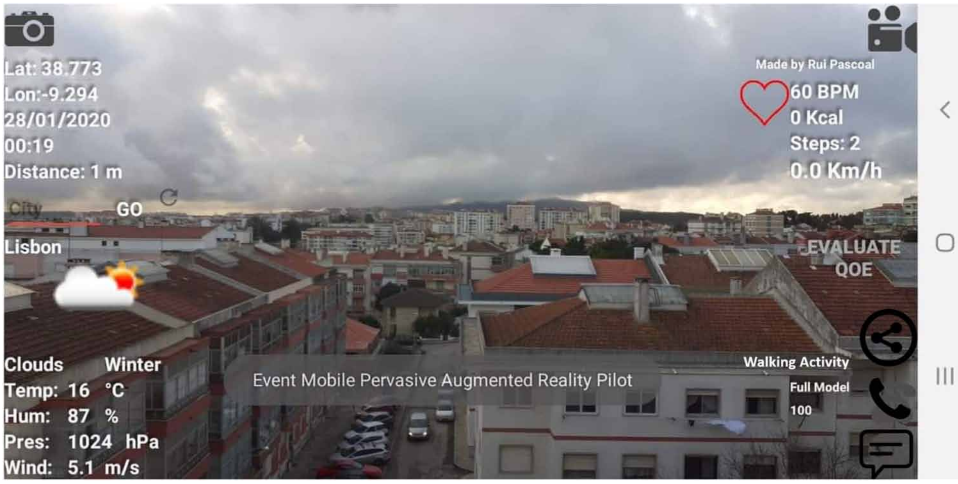
## Results

A collection of battery autonomy time was carried out to verify the differences in spending with the Internet and GPS turned off (offline), as well as with a 4G Internet connection and GPS working, and with a Wi-Fi and GPS connection. See the next Figure 4 with all autonomy results and Table 1 with the details of these results.

Figure 4 and Table 1 shows differences in spending battery. The vertical axis is the percentage of charged battery and the horizontal axis is the battery autonomy in minutes, for instance, in offline (Internet and GPS turned off) battery has more than 510 minutes of autonomy, and with Internet 4G and GPS working it has more than 390 minutes.

When only the GPS chip is turned on, it drains more 11,76% than the GPS chip is turned off. When GPS and 4G of mobile data are turned on it drains more 23,53% than in offline mode. Finally, when GPS and Internet Wi-Fi are turned on drain more 29,41% than in offline mode.

*Figure 2. MPARS prototype with geographic, climatic, biometric, and social information*




## SOLUTIONS AND RECOMMENDATIONS

The solutions and recommendations to dealing with the issues presented in the preceding section is a proposal of a new model of battery efficiency for MPARS. For that several variables were created, declared, and initialized to help of calculating battery efficiency with data collected to compare battery autonomy, for instance:

*Figure 3. "3C Battery Manager" application*

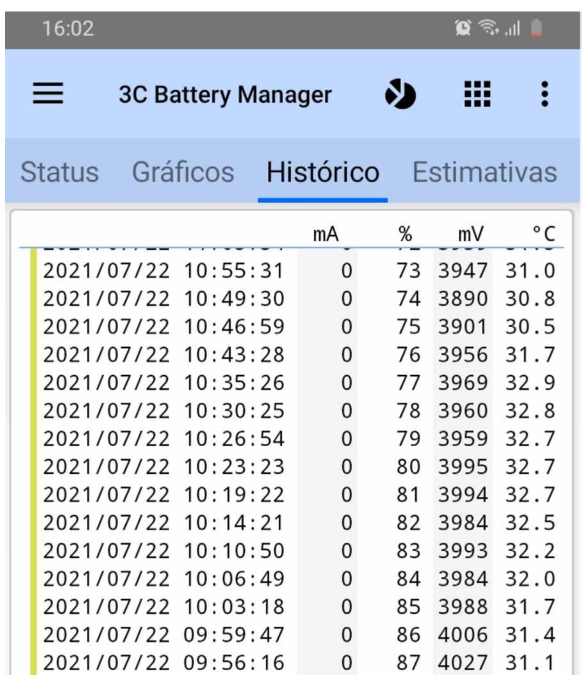


*Figure 4. Compassion of battery autonomy*

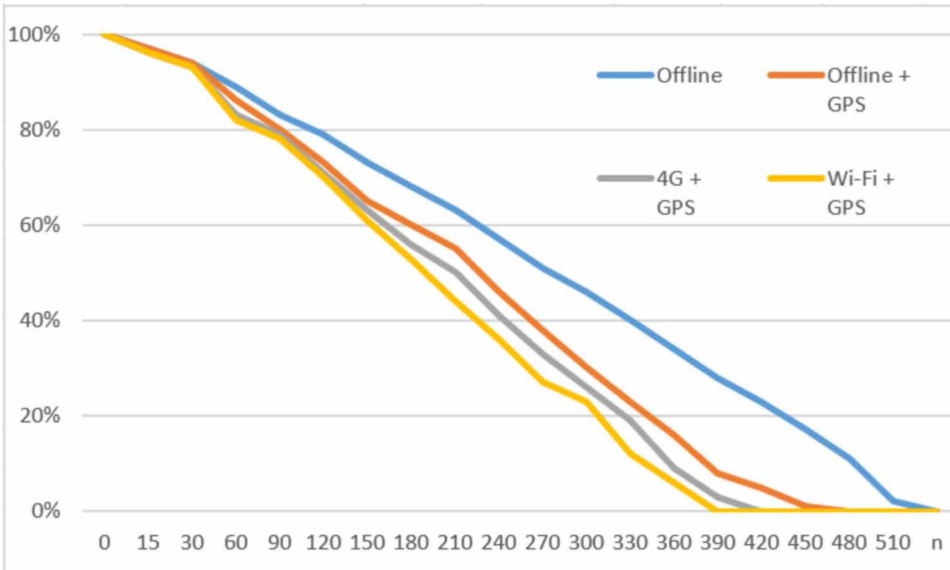



*Table 1. Details of battery autonomy*

| Time (min.) | Time (sec.) | Offline | Offline + GPS | 4G + GPS | Wi-Fi + GPS |
|---|---|---|---|---|---|
| 0 | 0 | 100% | 100% | 100% | 100% |
| 15 | 900 | 97% | 97% | 96% | 96% |
| 30 | 1.800 | 94% | 94% | 93% | 93% |
| 60 | 3.600 | 89% | 86% | 83% | 82% |
| 90 | 5.400 | 83% | 80% | 79% | 78% |
| 120 | 7.200 | 79% | 73% | 71% | 70% |
| 150 | 9.000 | 73% | 65% | 63% | 61% |
| 180 | 10.800 | 68% | 60% | 56% | 53% |
| 210 | 12.600 | 63% | 55% | 50% | 44% |
| 240 | 14.400 | 57% | 46% | 41% | 36% |
| 270 | 16.200 | 51% | 38% | 33% | 27% |
| 300 | 18.000 | 46% | 30% | 26% | 23% |
| 330 | 19.800 | 40% | 23% | 19% | 12% |
| 360 | 21.600 | 34% | 16% | 9% | 6% |
| 390 | 23.400 | 28% | 8% | 3% | 0% |
| 420 | 25.200 | 23% | 5% | 0% | 0% |
| 450 | 27.000 | 17% | 1% | 0% | 0% |
| 480 | 28.800 | 11% | 0% | 0% | 0% |
| 510 | 30.600 | 2% | 0% | 0% | 0% |
| n | ∞ | 0% | 0% | 0% | 0% |

- *Percent of Efficiency (Pe)*
- *Efficiency Offline (Eoff)*
- *Efficiency Offline with GPS (Eoffgps)*
- *Efficiency with 4G and GPS (E4gps)*
- *Efficiency with Wi-Fi and GPS (Ewgps)*
- *Time in seconds (Tm)*
- *Time in seconds (Ts)*
- *Intermittent Connection in seconds (ICs)*

## Equation of Pe and E:

$$Pe = \mathrm{E}^{*}\mathrm{T} \Leftrightarrow E = \frac{Pe}{\mathrm{T}}$$

See Table 2 with the results of battery efficiency.

Table 2 shows the calculation of efficiency (*Eoof*, *Eoffgps*, *E4ggps*, *Ewgps*). The efficiency of *E4ggps* is better than *Ewgps*.

The proposal is an intermittent connection, i.e., turn ON and OFF the required data sources of the smart device with MPARS prototype running (GPS and Internet mobile data connection), but Wi-Fi is discarded because of low range from the station that provides the Access Point, also provides less velocity of communication compared to 4G/5G connection. Mobile Data and GPS sensors are periodically queried (intermittent connectivity) to obtain current location (geographic position and velocity), as well as reduce energy expenditure. It turns on the GPS briefly and infrequently (7 seconds each time) to obtain an accurate geographic position estimation.

With this configuration, we design the necessary model for battery efficiency, making a mathematical model and detailing the technique. See Table 3 with the results of intermittent connection of Internet 4G & GPS (7 seconds in “n” seconds by end-user velocity).

The ICs is 7 seconds when end-users engage in sporting activities, such as walking, race-walking, running, biking, or other outdoor sports. But for better geolocation precision is presented the proposal for better battery efficiency. ICs is directly proportional to end-user velocity. Table 3 shows the results of intermittent connection of Internet 4G & GPS and the gains are better when an end-user has a walking activity or race-walking activity. See following Figure 5 about the algorithm of battery efficiency for the MPARS prototype.

Figure 5 shows the algorithm described in a flowchart to better battery efficiency for the MPARS prototype, and the explanation is:

Step 1 - Start of Algorithm
Step 2 - Declaration and initialization of variables with values by default:

userVelocity = 0; internetConnection = false; gpsConnection = false; loopSeconds = 7; connectionRefress = 60;

Step 3 - Switch by user velocity (userVelocity variable).
In case of velocity equal 0: internetConnection = false; gpsConnection = false;

*Table 2. Calculation of battery efficiency*

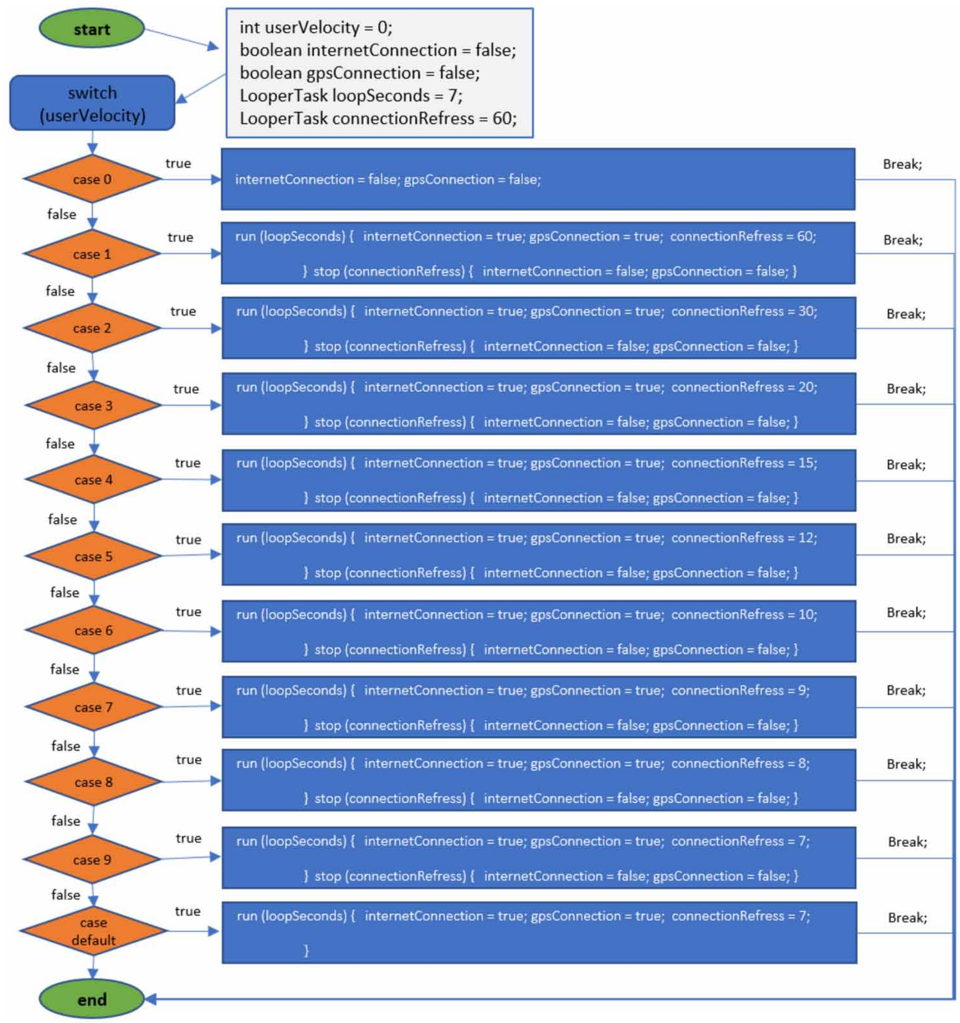
| **Time (min.)** | **Offline** (%) | **Offline + GPS** (%) | **4G + GPS** (%) | **Wi-Fi + GPS** (%) | *Eoff = Pe/Tm* (%) | *Eoffgps = Pe/Tm* (%) | *E4ggps = Pe/Tm* (%) | *Ewgps = Pe/Tm* (%) |
|---|---|---|---|---|---|---|---|---|
| 0 | 100 | 100 | 100 | 100 | ∞ | ∞ | ∞ | ∞ |
| 15 | 97 | 97 | 96 | 96 | 6,4667 | 6,4667 | 6,4000 | 6,4000 |
| 30 | 94 | 94 | 93 | 93 | 3,1333 | 3,1333 | 3,1000 | 3,1000 |
| 60 | 89 | 86 | 83 | 82 | 1,4833 | 1,4333 | 1,3833 | 1,3667 |
| 90 | 83 | 8 | 79 | 78 | 0,9222 | 0,0889 | 0,8778 | 0,8667 |
| 120 | 79 | 73 | 71 | 70 | 0,6583 | 0,6083 | 0,5917 | 0,5833 |
| 150 | 73 | 65 | 63 | 61 | 0,4867 | 0,4333 | 0,4200 | 0,4067 |
| 180 | 68 | 60 | 56 | 53 | 0,3778 | 0,3333 | 0,3111 | 0,2944 |
| 210 | 63 | 55 | 50 | 44 | 0,3000 | 0,2619 | 0,2381 | 0,2095 |
| 240 | 57 | 46 | 41 | 36 | 0,2375 | 0,1917 | 0,1708 | 0,1500 |
| 270 | 51 | 38 | 33 | 27 | 0,1889 | 0,1407 | 0,1222 | 0,1000 |
| 300 | 46 | 30 | 26 | 23 | 0,1533 | 0,1000 | 0,0867 | 0,0767 |
| 330 | 4 | 23 | 19 | 12 | 0,0121 | 0,0697 | 0,0576 | 0,0364 |
| 360 | 34 | 16 | 9 | 6 | 0,0944 | 0,0444 | 0,0250 | 0,0167 |
| 390 | 28 | 8 | 3 | 0 | 0,0718 | 0,0205 | 0,0077 | 0,0000 |
| 420 | 23 | 5 | 0 | 0 | 0,0548 | 0,0119 | 0,0000 | 0,0000 |
| 450 | 17 | 1 | 0 | 0 | 0,0378 | 0,0022 | 0,0000 | 0,0000 |
| 480 | 11 | 0 | 0 | 0 | 0,0229 | 0,0000 | 0,0000 | 0,0000 |
| 510 | 2 | 0 | 0 | 0 | 0,0039 | 0,0000 | 0,0000 | 0,0000 |
| n | 0 | 0 | 0 | 0 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |

in case of velocity equal of 1 to 9 the internet and gps are connected during 7 seconds in a running loop between 60 and 7 seconds respectively, i.e., internetConnection = true; and gpsConnection = true;

*Table 3. Results of intermittent connection of Internet 4G & GPS*

| End-User Velocity **(Km/h)** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 20 | 40 | n | ∞ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Connection Refresh of Mobile Data + GPS by User Velocity (seconds)** | ∞ | 60 | 30 | 20 | 15 | 12 | 10 | 9 | 8 | 7 | 6 | 3 | 2 | 1 | 0 |
| **Battery Autonomy Lost with Intermittent Connection 4G & GPS of 7 seconds in "n" seconds (%)** | 0,00 | 11,67 | 23,33 | 35,00 | 46,67 | 58,33 | 70,00 | 77,78 | 87,50 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Total Time of Battery Efficiency (minutes)** | 510 | 503 | 490 | 473 | 450 | 423 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 | 390 |

*Figure 5. Algorithm of battery efficiency for MPARS prototype*




Next the loop will stop after these seconds and internet and gps connection stoped, and will change variables to false, i.e., internetConnection = false; and gpsConnection = false;

in case default internet and gps will be always connected, i.e., internetConnection = true; and gpsConnection = true;

Step 4 - End of Algorithm

More details of the algorithm are in the Appendix 1.

## FUTURE RESEARCH DIRECTIONS

An efficient data classification in terms of smart data processing is needed, e.g., which classification algorithm is more efficient in energy consumption when is processing for recognizing specific outdoor activities and give smart data to end-users?

Other approaches in the sequence of previous works to reducing the volume of information are by the speed of activity, e.g., if end-user is standing still, they will have all information without restrictions, but a cyclist will have only limited information because of their velocity and attention needs. The attention of information given to users is reduced with increasing speed and compromise their attention (Pascoal, R. M., & Guerreiro, S. L., 2017). Finally, another aspect to help is creating abstractions of alphanumeric written information that is presented to users in iconic form information.

## CONCLUSION

Battery efficiency is a requirement to better *QoE* especially in outdoor sports activities, such as walking, race-walking, running, biking, or other outdoor dynamic sports. This work simplifies the needs of Internet and GPS connectivity and proposed an algorithm to better battery efficiency for the MPARS prototype. The experiments verified the differences in spending with the Internet and GPS turned off, as well as with a 4G Internet connection and GPS working, and with a Wi-Fi and GPS connection.

With Internet and GPS turned off the battery has more than 510 minutes of autonomy, and with Internet 4G and GPS working it has more than 390 minutes. When only the GPS chip is turned on, it drains more 11,76% than the GPS chip is turned off. When GPS and 4G of mobile data are turned on it drains more 23,53% than in offline mode.

Finally, when GPS and Internet Wi-Fi are turned on drain more 29,41% than in offline mode. So, this work will continue to find more gaps of battery energy lost and adjust the algorithm of efficiency for MPARS.

## ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## REFERENCES

Ball, R., Ghorpade, A., Nawarathne, K., Baltazar, R., Pereira, F. C., Zegras, C., & Ben-Akiva, M. (2014, October). *Battery patterns and forecasting in a large-scale smartphone-based travel survey*. In 10th International Conference on Transport SurveyMethods, Fairmont Resort, Jamison Valley, BlueMountains National Park, Australia.

Bayat, A., Pomplun, M., & Tran, D. A. (2014). A study on human activity recognition using accelerometer data from smartphones. *Procedia Computer Science*, *34*, 450–457. doi:10.1016/j.procs.2014.07.009

Cheng, Y. C., Chawathe, Y., LaMarca, A., & Krumm, J. (2005, June). Accuracy characterization for metropolitan-scale Wi-Fi localization. In *Proceedings of the 3rd international conference on Mobile systems, applications, and services* (pp. 233-245). 10.1145/1067170.1067195

Chowdhury, A., Chakravarty, T., & Balamuralidhar, P. (2014, October). Estimating true speed of moving vehicle using smartphone-based GPS measurement. In *2014 IEEE International Conference on Systems, Man, and Cybernetics (SMC)* (pp. 3348-3353). IEEE. 10.1109/SMC.2014.6974444

Download Speeds. Comparing 2G, 3G, 4G & 5G Mobile Networks. (2018, November 23). *Ken's Tech Tips*. https://kenstechtips.com/index.php/download-speeds-2g-3g-and-4g-actual-meaning

Dutta, J., Pramanick, P., & Roy, S. (2018). Energy-efficient GPS usage in location-based applications. In *Information and Decision Sciences* (pp. 345–353). Springer. doi:10.1007/978-981-10-7563-6_36

Gaonkar, S., Li, J., Choudhury, R. R., Cox, L., & Schmidt, A. (2008, June). Micro-blog: sharing and querying content through mobile phones and social participation. In *Proceedings of the 6th international conference on Mobile systems, applications, and services* (pp. 174-186). 10.1145/1378600.1378620

Ibrahim, J. (2002). 4G Features. *Bechtel Telecommunications Technical Journal*, *1*(1), 11–14.

Lehr, W., & McKnight, L. W. (2003). Wireless internet access: 3G vs. WiFi? *Telecommunications Policy*, *27*(5-6), 351–370. doi:10.1016/S0308-5961(03)00004-1

Misra, P., & Enge, P. (1999). Special issue on global positioning system. *Proceedings of the IEEE*, *87*(1), 3–15. doi:10.1109/JPROC.1999.736338

Mitchell, B. (2019, December). *What Is the Real Speed of an 802.11b Wi-Fi Network?* Lifewire. https://www.lifewire.com/actual-speed-of-an-802-11b-wifi-network-818300

Pascoal, R., Almeida, A. D., & Sofia, R. C. (2020). Mobile pervasive augmented reality systems - MPARS: The role of user preferences in the perceived quality of experience in outdoor applications. *ACM Transactions on Internet Technology*, *20*(1), 1–17. doi:10.1145/3375458

Pascoal, R., Alturas, B., de Almeida, A., & Sofia, R. (2018, June). A survey of augmented reality: Making technology acceptable in outdoor environments. In *2018 13th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-6). IEEE.

Pascoal, R. M. (2020). *Acceptance of Online Education in Portugal and in the World: Before and During Covid-19*. Academic Press.

Pascoal, R. M., de Almeida, A., & Sofia, R. C. (2019, September). Activity recognition in outdoor sports environments: smart data for end-users involving mobile pervasive augmented reality systems. In *Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers* (pp. 446-453). 10.1145/3341162.3349299

Pascoal, R. M., & Guerreiro, S. L. (2017). Information overload in augmented reality: The outdoor sports environments. In *Information and Communication Overload in the Digital Age* (pp. 271–301). IGI Global. doi:10.4018/978-1-5225-2061-0.ch012

Raento, M., Oulasvirta, A., & Eagle, N. (2009). Smartphones: An emerging tool for social scientists. *Sociological Methods & Research*, *37*(3), 426–454. doi:10.1177/0049124108330005

Roetzel, P. G. (2019). Information overload in the information age: a review of the literature from business administration, business psychology, and related disciplines with a bibliometric approach and framework development. *Business Research, 12*(2), 479-522.

Speier, C., Valacich, J. S., & Vessey, I. (1999). The influence of task interruption on individual decision making: An information overload perspective. *Decision Sciences*, *30*(2), 337–360. doi:10.1111/j.1540-5915.1999.tb01613.x

Su, X., Tong, H., & Ji, P. (2014). Activity recognition with smartphone sensors. *Tsinghua Science and Technology*, *19*(3), 235–249. doi:10.1109/TST.2014.6838194

Tekinay, S. (1998). Wireless geolocation systems and services. *IEEE Communications Magazine*, *36*(4), 28–28. doi:10.1109/MCOM.1998.667408

Tsetsi, E., & Rains, S. A. (2017). Smartphone Internet access and use: Extending the digital divide and usage gap. *Mobile Media & Communication*, *5*(3), 239–255. doi:10.1177/2050157917708329

Vautin, D. A., & Walker, J. L. (2011). *Transportation impacts of information provision & data collection via smartphones* (No. 11-3500). Academic Press.

Youssef, M., Yosef, M. A., & El-Derini, M. (2010, December). GAC: Energy-efficient hybrid GPS-accelerometer-compass GSM localization. In *2010 IEEE Global Telecommunications Conference GLOBECOM 2010* (pp. 1-5). IEEE.

## KEY TERMS AND DEFINITIONS

**Activity Recognition:** It is the task of knowing the movement of a person based on sensor data, such as an accelerometer, GPS or other sensors, e.g., in a smartphone.

**Autonomy:** In a battery context is the period of time (in minutes or hours) a battery will last for at a specified load level. Autonomy can also be referred to as discharge time, or runtime.

**Efficiency:** It is the fundamental reduction in the amount of wasted resources that are used to produce a given number of goods or services, resulting from the optimization of resource-use to best serve.

**Information Overload:** It is a difficulty in understanding an issue and effectively making decisions when one has too much information and associated with the excessive quantity of information.

**Meaningful Feedback:** Information useful and adequate that brings benefit to those who receive this, especially for the current context.

**Power Consumption:** Refers to the electrical energy per unit time, supplied to operate something, such as a smartphone. It is usually measured in units of watts. The energy used by equipment is always more than the energy really needed.

**Smart Data:** It is data from which signals and patterns have been extracted by intelligent algorithms. Data is amassed, groomed, and then processed before being sent to a platform for further data consolidation and analytics.

## APPENDIX 1

Computer Code - Algorithm of battery efficiency for MPARS prototype:

```
int userVelocity = 0;
boolean internetConnection = false;
boolean gpsConnection = false;
LooperTask loopSeconds = 7;
LooperTask connectionRefress = 60;

switch (userVelocity) {

case 0:  internetConnection = false; gpsConnection = false;
                   break;

case 1:  run (loopSeconds) {
              internetConnection = true; gpsConnection = true;
              connectionRefress = 60;
              }  stop (connectionRefress) {
                internetConnection = false; gpsConnection = false;
              }  break;

case 2:  run (loopSeconds) {
              internetConnection = true; gpsConnection = true;
              connectionRefress = 30;
              }  stop (connectionRefress) {
                internetConnection = false; gpsConnection = false;
              }  break;

case 3:  run (loopSeconds) {
                    internetConnection = true; gpsConnection = true;
              connectionRefress = 20;
              }  stop (connectionRefress) {
                internetConnection = false; gpsConnection = false;
              }  break;

case 4:  run (loopSeconds) {
              internetConnection = true; gpsConnection = true;
              connectionRefress = 15;
              }  stop (connectionRefress) {
              internetConnection = false; gpsConnection = false;
              }  break;
```

```
case 5:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 12;
            }  stop (connectionRefress) {
              internetConnection = false; gpsConnection = false;
            }  break;

case 6:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 10;
            }  stop (connectionRefress) {
              internetConnection = false; gpsConnection = false;
            }  break;

case 7:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 9;
            }  stop (connectionRefress) {
              internetConnection = false; gpsConnection = false;
            }  break;

case 8:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 8;
            }  stop (connectionRefress) {
            internetConnection = false; gpsConnection = false;
            }  break;

case 9:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 7;
            }  stop (connectionRefress) {
            internetConnection = false; gpsConnection = false;
            }  break;

case default:  run (loopSeconds) {
            internetConnection = true; gpsConnection = true;
            connectionRefress = 7;
            }  break;
}
```

# Chapter 31
# The Link Between Climate Change and Digitization of Archives in South Africa

**Nkholedzeni Sidney Netshakhuma**
https://orcid.org/0000-0003-0673-7137
*University of South Africa, South Africa*

## ABSTRACT

*This chapter assesses the link between climate change and digitisation of archives in South Africa. The study found linkage between flooding, fire, and digitization of archives in the sense that records required long-term preservation to be accessible. The chapter focuses on converting paper-based records into digital platforms as a strategic role to prevent records from damage. Heritage institution such as the National Archives of South Africa is in the forefront of the preservation of archives in South Africa. It is their national mandate to preserve archival materials and make them accessible to various stakeholders. The success of digitization is dependent on the organisation strategy. This means that partnership, privacy, copyright need to be considered. The research found that most of the heritage institutions in South Africa lack digitization strategy, which led to loss of institutional memory.*

## INTRODUCTION

This book aim to assess the link between climate change and digitization. This is because South Africa heritage institutions experienced a loss of archives because of ineffective records management systems such as paper-based records. Implementing a sound records management program needs organizations to develop and implement a digitization program to protect records against flood and fires. There is a linkage between climate change such as flooding and fire and digitization of archives in the sense that records need to be preserved to enhance long-term preservation to be accessible. The heritage institutions need to convert paper-based materials into the digital domain, as stated by (Chrons and Sundel, 2011) to ensure long term preservation. Analog materials are digitized to facilitate preservation and access to users (Garaba, 2014). The process of converting paper records into digital platform prevent records from

DOI: 10.4018/978-1-7998-8482-8.ch031

damages as a strategy to prevent records from fire and flood. Heritage institution such as the National Archives of South Africa is in the forefront of the preservation of the public archives (Netshakhuma 2019). It is the national mandate of the National Archives to preserve archival materials and made them accessible to stakeholders.

The book is based on a qualitative research method. Literature and document about digitization in South Africa and another part of the world were reviewed. The review of the literature demonstrates that research on digitization of heritage materials is still in its infancy in South Africa.

Heritage institutions are to digitize archives to protect them from floods and fires and to make them accessible. Preservation of archives with technological components improves authenticity, readability, and intelligibility of records(Boutard, Guastavion, and Turner, 2013). It appears that heritage institutions in South Africa faced the challenges of paper-based records deterioration because of handling. Hence, there is a need to develop a digitization strategy for archives' long-term preservation and access to archives because of the lack of control over heritage resources (Anderson and Hart, 2016). In the context of global warming, changes in weather and climate events are expected because of changes in temperature and precipitation regimes areas (Mallet, Fortin, Germain, 2018). Understanding the impacts of climate-triggered phenomena on archival repositories is imperative for the present and future security records. Lack of digitization is not only a challenge, but it is also an increasingly strategic issue in the management of records in Africa. Adoption of a digitization strategy is vital to ensure the preservation of archives. The quality of technology platforms has an impact on how users view the quality of information communication technology (Leveille and Timms, 2015).

Digitization is defined as an organization's commitment to preserving digital content for future use, specific file format preservation, and ensure compliance with standards and best practices (Delaney and De Jong 2015, Boamah, Dorner and Oliver, 2015). Digitization is conducted to ensure the long-term preservation of records (Bhat, 2018). Organizations are to develop a digitization strategy to preserve records for a long period. Integrity and authenticity are key to ensure the preservation of archives.

Digitization is guided by a records management standard. Standards provide guideline on digital life -cycle management processes, spans an archive's operations, acquisition, ingest, metadata creation, storage, preservation management, and access. According to Leresche (2008), the standardization of description rules and an access point is essential to heritage institutions. According to Leresche the statement of Principles regarding Archival Description, adopted at the International Congress on Archives in Montreal in 1992 identified the aim of archival description standards as follows:

- To ensure the creation of consistent, appropriate, and self-explanatory descriptions.
- To facilitate retrieval and exchange of information about archival material
- To enable sharing of authority data
- To make integrate descriptions from different locations into a unified information system.

Encoded Archival Description (EAD) cares automation and access to a detailed and hierarchical description of archival materials. Based on ISAD (G), ISAAR (CPF) and ISDF standards are necessary for both librarians and archivists. These standards were adopted by the heritage institution to improve access to archives. The standards enable users to identify records for permanent preservation.

Archives stored by the heritage institutions are historical collections, as indicated by (Anderson, 2005). He further elaborates that libraries and archives are products of historical struggles because they keep primary sources for histories. For example, colonial libraries and archives provide a rich history of information about African people. This is shown by the types of materials display in the heritage institutions. In South Africa, libraries and archives are established and informed by economic, social, and political conditions (Schultz, 2013). Schultz further indicates the significance of accessing archives collection and preservation of archival materials reflects the apartheid and colonialism period. This is because the history of South Africa is characterized by apartheid and colonialism. Histories preserved by South Africa heritage institutions reflect political, economic, and social development since the Dutch arrived in South Africa in 1652. Some of the libraries preserved records about the development and establishment and raise of colonialism in South Africa and the rest of Africa.

In South Africa, there is a gradually insistent need to digitize archives because of floods and fire (Netshakhuma, 2021). However, digitization should be conducted as a form of disaster management plan to protect archives from damages. For example, a Tanzanian study conducted by Oweru and Mnjama (2014) at the Records and Archives Management Department in Tanzania found a lack of disaster management plan, air pollution relative humidity. However, the Tanzanian institutions developed a strategy to mitigate flooding and fire at archives buildings. The effects of flooding and fire cause rapid deterioration and decay of archives, as stated by. Olatokun (2008). For example, the recent wildfire in South Africa destroyed archival materials preserved at the University of Cape Town library (Eyewitness News, 2021). The researcher suggests for institutions to digitize their archival materials for future use.

## DIGITIZATION STRATEGY

A study conducted by Olatokun (2008) stated that most African institutions lack a digitization strategy. This is alluded to by Mnjama and Wamukoya (2004) stating the absence of organizations plans to manage records; low awareness of the role of records management to support organizational efficiency and accountability; lack of stewardship and coordination in handling records, absences of legislation, policies, and procedures to guide the management of records, absences of core competence in records and archives management, absence of budgets dedicated for records management; poor security and confidentiality controls; lack of records retention and disposal policies and absence of migration strategies for records. Furthermore, the development of digitization strategy is affected by unreliable software and changing interface platforms, licensing, hardware costs, unreliable electricity, and infrastructure issues that also limit preservation and access to archives (Schultz, 2013). For example, Magama (2018) found that inadequate infrastructure and resources contributed to the lack to support the long-term strategies for the preservation of digital records in the Masvingo province in Zimbabwe. The above-mentioned challenges demonstrated that digitization is not recognized as a strategic long-term in Africa. Hence, the development of preservation policy provides frameworks for the present, future and ensures access to information, as indicated by (Nsibirwa, Hoskins, and Stilwell, 2014).

In 2014, the Department of Arts and Culture in South Africa published a digitisation national policy on the digitization of Heritage resources (Anderson and Hart, 2016). The policy provides guidelines on how government departments conduct the process of digitization of paper-based records, disaster recovery plan was also provided by the plan. The development of a digitization strategy is vital for the long-term preservation of archives. The policy is to state the nature and scope of flood and fire phenomena that threaten archives. The digitization policy also outlines the infrastructure required to digitize archives. It also provides opportunities for heritage institutions to establish internal priorities for digitization (Garaba, 2014). Organization policy provides the framework of the departments of an organization's function.

Some of the Africa institutions invest in archival infrastructure hence their staff is not trained on the digitization process as alluded to by Netshakhuma (2018). However, other institutions lack archives infrastructure to preserve records. The lack of infrastructure may contribute to the loss of institutional memory. The review of the literature shows that some South African institutions are not yet developing digitization strategies to convert paper-based records to the electronic environment. This meant that there was a lack of policy to manage digitized archives handle electronic records management. Based on the literature review, South Africa heritage institutions are required to develop a digitization strategy to preserve their archival and institutional memory. Such strategies and policies need an implementation plan. There should be continuous reviewing of such policies to adhere to the trends in information developed during this fourth industrial revolution. Furthermore, there is a need for institutions to provide planning to disaster planning.

## THE ROLE OF NATIONAL ARCHIVES ON CLIMATE CHANGE

Although flooding and fire occasionally happens, the National archives of South Africa recognize that concerted actions are required to fully address the rate of flooding and fire to human activity. The archives should realize that leading by example may help encourage other heritage institutions to act similarly to reduce future anthropogenic effects on climate. It is the optimism of the author that this analysis motivates the archival profession to consider the ways that flooding and fire impacts may increase the future risk of exposure to extreme and empowers practicing archivists to consider climate change in the management of archival collections.

The review of the literature shows a lack of recognition by the national government of the role play by national archives, as stated by Mnjama (2015). This lack of recognition is demonstrated by the lack of government to employ archivists. This shows a lack of staff to provide strategies to mitigate climate change on archives management. Furthermore, archives preserved in the archives cannot be accessible because of the lack of staff with skills to describe archives. National archives should be prepare disaster prevention and response plans to safeguard the archival heritage of their constituencies.

A study conducted by Nengomasha and Nyanga (2015) stated that a National archive should promote access to archives. Platforms such as email, Twitter, book launch are used as a form of providing access to archival materials.

Based on the literature review, it seems that the National Archives of South Africa and its provincial archives lack comprehensive guidelines to provide digitization archives of materials (Netshakhuma 2020). As a result that the National Archives lack the infrastructure to preserve archival materials, institutions. The National Archives of South advises organizations to keep their electronic version of their records because they (National Archives of South Africa) cannot preserve digital materials.

## INFORMATION COMMUNICATION TECHNOLOGY FRAMEWORK

The development of digital libraries has received attention in recent past years for its significant role in preserving archives. This shows that technological advancements in information communication technology have changed the way records are created, authenticated, and preserved (Majore, Yoo, and Shon, 2014). The information communication technology development provides the heritage institutions to preserve archives. This statement is supported by Caidi (2006) who illustrates that the shift started to take place from an emphasis on collection building and preservation towards an emphasis on users and providing them with e-resources and services. This change raises issues about the overall role of heritage institutions in society. Migration from the manual base system to electronic records management system provides a shift towards providing access to information. The heritage institutions traditionally provide information manuals started to take the consideration of users. However, it seems that most institutions are not prepared to digitize their collection. This has alluded to the study conducted by Nsibirwa, Hoskins, and Stilwell (2014) who stressed that heritage institutions continue to lose cultural heritage resources because they are unable to capture and preserve digital records for posterity. It seems most organizations are not invested in information communication technology to digitize their collection. This may be because the electronic environment is complex to preserve archives, lack of stability led to the loss of institutional memory, reliability, authenticity, security than in the paper-based system. The author is of the view that the South Africa heritage institutions invest in standards to preserve digital records or converting paper records into digital records management systems. This ensures the long-term preservation of archives preserved by various institutions. A study conducted by Olatokun (2008) states that digital technology holds potential for the world's research archives and libraries could change how archival institutions capture, store, preserve and access information. He further elaborates that information communication technology provides reformatting advantages over photocopy and microfilm, including its capabilities to create a higher reproduction of a deteriorating original, the ability to reproduce digital images.

The motivating factor behind the attempt a standardization appears to have been a desire and a need to improve access to archives (Benn, 2019). In the United Kingdom, archivists did not engage with the development of the conceptual principles of the new information technology or with how meaning was being represented and structured. A digitization policy is recognized as a tool to manage the disaster recovery plan. The review of the literature shows a lack of a digitization framework to manage disaster recovery from African countries such as Zimbabwe and Nigeria (Ifijeh, Idiegbeyan-Ose, Segun-Adeniran, and Ilogho, 2016). Furthermore, Magama (2018) states that in Zimbabwe most of the departments function without access policies, digital records disaster management plans, and guidelines for managing digital storage media. This shortcoming affects digital records management.

Digitization has fostered ways of preserving archives (Nsibirwa, Hoskins, and Stilwell 2014). Digitization and internet technologies in Sub-Saharan Africa also present opportunities and challenges (Schultz, 2013). Opportunities brought by digitization include preservation and access to archives. However, it is expensive to maintain digital collections.

In the case of Ghana, most archives in Ghanaian polytechnics were not preserved electronically (Ayoung, Boatbil, and Baada, 2015). It appeared that there was a lack of electronic records management framework to manage all types of records. Records in a digital format are vulnerable to various threats than records in paper format (Muchaonyerwa, 2014). These threats include viruses, obsolete technologies, unauthorized access to records, environmental security, and database security. A study conducted by Molefe and Schellnack – Kelly (2019) states that archives digitization needs to be prioritized because of its significance as a memory of the nation. Furthermore, there is a need to preserve endangered archival resources.

The digitization process has also a negative impact on the long-term preservation of archives. This statement is alluded to by Majore, Yoo, and Shon (2014) who state that media containing digital records become unreadable due to lack of hardware that accesses the media and also files format obsolescence. It became a challenge when collected records were inaccessible because of the lack of an effective management system. It is essential to ensure that records preserved in an electronic environment are trustworthy. The findings show that most organizations are not yet developed an archival management system to manage electronic records. It seems that there is a lack of hardware and software to support the introduction of Information Communication Technology.

Heritage institutions in South Africa such as the Nelson Mandela Centre for Memory based in Johannesburg developed a digitization project to provide access to national and international communities (Netshakhuma, 2020). This has led people around the world to access information about the history of South Africa and the liberation of South Africa since the start of the apartheid system. To date, the Nelson Mandela Centre of Memory has focused its digitization and web access programs on public domain material.

## RESOURCES

To embark on a digitization project requires an organization to acquire resources. funding and investment in digitization technologies and capacity development cannot be sidelined (Sigauke and Chabikwa, 2012, Boamah, Dorner and Oliver, 2015, Zaid and Abioye 2010). De Lusente (2004:90) is of the view that ensuring long-term access to digitized historical records and archives is a formidable task that takes considerable time, effort, and financial investment. It seems most countries are behind on the development and implementation of digitization projects. A study by Mnjama (2005) indicated that the Eastern and Southern Africa Regional Branch (ESARBICA) region experiences a challenge of inadequate funding to conduct training and purchasing digitization infrastructure. The digital projects initiated without financial muscle do not sustain long.

Digitization projects require allocation of funds, time and personnel have to be devoted to the exercise, as it is expensive, and time-consuming (Fabunmi, Paris and Fabunmi, 2006). The rapid technological advancement, the inclusion of Web 2.0 technologies in the archivist's toolkit is a must as archivists require to engage with online users and show that they use social platforms to communicate, share information and create online communities.

A study conducted by Anderson and Hart (2016) indicates that lack of funds has meant that the archives use other opportunities methods to undertake digitization. Some heritage institutions opted for a donation to digitize their collection. Some of these institutions digitized third-party records which led to some institutions lose their institutional memories. Most organizations failed to check and realize the significance of copyright when they agreed to digitize their collection. This means at later such materials end up taken by donors.

## AWARENESS AND TRAINING

The review of the literature shows that most of the African digitization projects were sponsored by developed countries, For example, the Cooperative Africana materials project (CAMP) developed by the United States of America support access and preservation program at the National Archives of Senegal, Uganda. Staff in these countries were trained on scanning and microfilming colonial administration records (Schultz, 2013). CAMP was involved in this project because of the need to preserve these records for a long-term period because of their historical, cultural, and technological significance.

A study conducted by Brenda (2013) found a lack of awareness on the role of electronic records management supporting institutional efficiency and accountability, and that might inform their request for administration to embark on a program to create awareness on the value and urgently streamlining the records management practices to meet standards.

A study conducted by Nengomasha (2013) recommends organizations embark on continuous training and development to increase the level of awareness of keeping archives. Information literacy and user education were deemed necessary issues to address a challenge of access to information and archives preservation (Caidi, 2005). Users are to be trained to access archives using information communication technology. The profession needs to guard against records management standards to ensure that professionals adhere to the level of professionalism within an organization.

## PARTNERSHIPS

Social and political development influence the digitization of archives all over the world. This means that post-colonization to preserve colonial history, the role of liberation archives influences projects to digitize liberation archives. This statement has alluded to the study conducted by Schultz (2013) who indicates that the economic and political influence of the United States of America and European Institutions influence the direction of African digitization efforts. These developed countries use resources to build cultural diplomacy. The CAMP was developed to archive and document African collections.

Studies by Garaba (2010) and Pickover (2009) emphasize the issue of partnerships to enhance access to digitized collections. For example, a collaboration of countries enabled national digital preservation programs in Africa (Boamah, Dorner, and Oliver, 2015). Partnerships with entities from countries in Europe address issues about heritage plundering, cultural asset stripping, transparency, and equity in partnerships, accordingly, seeking funding to be a joint mandate.

A partnership is a gateway for several archives to build a virtual collection of thematically related materials (Garaba, 2014). This means that institutions with similar collections may share collections. This is in cementing partnerships, professional collegiality, and best practices in digital archiving.

Sigauke and Chabikwa (2012) recommend that collaboration of archives, libraries, museum networks, and private-public partnerships be required to study. It appears that the author had a view that collaboration enhances the preservation of archives. It further enhances sharing of expertise and sharing of information and skills. The author is of the view that the collaboration of archivists, museologists, and librarians may the long-term sustainability of digitization initiatives. This would also ensure sharing and use of liberation archives. Digitization facilitates the collaborative and efficient workflow processes that provide opportunities to share information.

Partnerships do not guarantee the provision of access to archives. This view is alluded to by the United States of America study conducted by Fonden and McCune (2018) who indicates that forging partnerships with private social media vendors cause frustration or even failure. However, the author is of the view that when the private sector donated funds to the public heritage institution does not guarantee the success of a project.

The author is of the view that collaboration of heritage institutions in South Africa may contribute to strategies to mitigate flood and fire in archives, preservation of archival materials, sharing resources, better coordinating training programs. Working together can also provide opportunities for various stakeholders to see opportunities for preservation.

## USE OF AND ACCESS OF ARCHIVES

Principles 3 on the International Council Archives' Principles of Access to Archives indicates that archivists have a responsibility to promote access to archives (ICA 2012). This can be done through the development of strategies and policies to promote the use of archival materials neither digital nor manual system. The heritage institutions can use Internet and Web-based publications, educational materials as an enabler to use archival materials (Nengoamsha and Nyanga, 2015). This can be done through the provision of long-term access to digitally stored archives. Information poses a challenge to access archives and is recognized as an essential part of digital data management (Olatokun 2008). The organization provides strategies to ensure the retention of certain records.

Technological advances threatened long-term access to archives because it requires archivists to migrate information to the latest technologies and. Tough (2009) asserts that the problem of digital materials has many factors that work together to make them inaccessible. Garaba (2010:95) points out that in terms of access, archivists are to ensure long-term access to digitized information for the benefit of the users, and the maintenance, therefore. This is alluded to by VanSnick and Ntanos (2018) in their studies to the National Archives of the United Kingdom government found that digitization projects contribute to increasing original documents, which occur as the results of effective survey and research. Pre-digitization is important before full implementation of the digitization project. Pre-digitization is done to ensure that metadata is included in the research. Technological advances foster the obsolescence of access mechanisms and accelerate the loss of archives. NIS0 (2007) describes a digital collection using the following principle: Collections should be described so that a user discovers the characteristics of the collection including access, collection authenticity, and integrity. Each of the above studies makes a valuable contribution to understanding issues associated with long-term electronic records access.

UNESCO in its charter alludes preservation of digital heritage to promote access to heritage as the motivator for preservation and further stresses that cultural heritage to be made accessible to all the people of the world (UNESCO 2003). Furthermore, Pickover (2009) contends that users are to access information about their heritage to interpret the past to understand the present. The public access issues, particularly within the framework of the global socio-economic environment, are of concern to stakeholders.

Mallan (2006) indicates that digitization provides the means to obtain virtual access to a collection of international origin and importance. Importantly, digitization allows the creation of and access to thematic international collections. The slave trade archives, an initiative of the UNESCO Memory of the World Programme, are an example of the importance of digitization to provide access to an international collection. Abid and Radoykov (2003) declare that the slave trade archives are a digital collection of original documentary sources that states the slave trade from the end of the fifteenth century. The digitization of valued original materials begins with the view of preservation and provides access to information. Ngulube (2002a) observes that it is possible to reconstruct historical events if the public has access to primary sources like archives.

Likewise, Mallan (2006) notes that by emphasizing the permanent value of contents, digitization selection ensures valuable and significant regional, institutional or national heritage collections to be increased a broader to a broader audience. Studies by Suar (2004a:2) and Limp (2005) substantiate the importance of disseminating the digitized heritage of a community to the international community to promote culture, heritage, and political development. Developing metadata through categorization of information is an archival practice that assists spread categories of knowledge. Paquet et al. (2009) point out that preservation of metadata plays a role to increase the usability of preserved digital objects and the environment in which it is preserved. Metadata provides future users with all the necessary information needed to access, render and interact with the preserved digital objects concerning their preservation history. Therefore, it is the role of records managers to provide metadata to enable the user to access archives. Metadata is a key in digital long-term archiving (Fantozzi, Bressan, Pretto, and Canazza 2017). This shows that digital technologies present opportunities to link information and rendering the process that transforms information (Withers, 2017). Digital metadata places South Africa histories within networks of reference. metadata are key because they are the only form to describe a document to retrieve and provide an interpretation of data that lacks physical existence.

Not only should there be proof of authenticity of the digital archives, digital access to one's cultural heritage. It also influences the preservation of the original materials. However, Pickover (2009) declares that, over time, sustainability issues could impact negatively archives access. Studies by Pickover, Dale, and Peters (2002) show that information communication technology constitutes a new form of cultural imperialism. This means that rich countries are benefiting by ensuring the preservation of archival materials.

O'Toole (1993) comments that to ensure long-term access to digital information issues such as storage medium, instability and deterioration have to be addressed. Archivists are assigned both the responsibility for the long-term preservation of archives. Currall and Moss (2004) point out that one of the advantages of delivering information across the internet is that content is updated and extended and that users interact with information providers in a way that is not possible in printed format.

Some of the archives could not be accessed in Africa due to the technological obsolescence of hardware and software. Ngulube (2001) reveals that, in Zimbabwe, the Salary Service Bureau lost all the information created and preserved on computer tapes between 1980 and 1994. This means that there is a need to develop records management solutions to ensure that archives are accessible.

Studies by Garaba (2010) and Pickover (2014) show that access to digitized archives promotes reconciliation, fundamental human rights, and freedom, and it is also a precondition for the exchange of ideas in a democratic country. For example, the South Africa Truth and Reconciliation Commission uses archives to serve justice for the victims of the apartheid system in South Africa. Archives enable people to value heritage, memory, and identity. In this regard, Pickover (2014) asserts that the archives are powerful political and financial forces and their historical records need to be made available because the history construction is subject to different ideologies. accessibility of digital artifacts is a privilege of rich people and poor people are not able to access.

## PRIVACY AND INFORMATION SECURITY ISSUES

Digitization projects should consider privacy and information security before records are placed on online platforms. The issue of improvement of information security is necessary because of cyber attacks on information systems. Information security involves the protection of information from internal and external threats to ensure business continuity. Information security systems are to be established to protect unauthorized access, use, disclosure, disruption, modification, perusal, inspection recording. A study conducted by Essien (2019) states that the landscape of cybersecurity is changing with the changing of technology. The review of the literature shows a high number of threats concerning information security. This threat includes a virus, human elements. Both internal and external security measures must be in place within the organization to prevent a threat to the security of information (Ophoff and Miller 2019).

Heritage institutions are to develop protective measures to protect personal information. Furthermore, employees are to comply with security requirements of data protection legislation and internal organizational policies. The study conducted by most computer users has a lack of information security knowledge because of insufficient awareness (Aldawood and Skinners, 2018). The review of the literature shows that most of the users in Africa Users are not aware of risks related to the organization's information systems (Humphreys 2008). This was confirmed by the study conducted by Baloyi and Kotse (2017) on organization readiness in South Africa compliance with Personal Data Protection or Privacy legislation and regulations shows that the majority of 62.5% of the South African public was not aware of the Protection of Personal Information Act No 4 of 2013. In their study, Up to 76.4% of respondents indicated that they did not know the standards their organizations complied with.

In South Africa, the Protection of Personal Information (Act No 4 of 2013) imposes a level of restriction on what type of information to be disseminated to users. This implied historical and cultural records preserved by heritage institutions are to be made available to various stakeholders. The librarians, archivists, records managers to promote long-term preservation of archives to ensure accessible collections in their repositories that are restricted for legal and ethical reasons.

## COPYRIGHT ISSUES

The copyright issues need to be taken into consideration once records are converted from manual to digital platforms. Archivists and librarians also play a role in copyright by preventing its violation (Fabunmi, 2007). The Heritage institutions provide access to information with copyrighted information. Librarians and archivists also provide access information to other people's copyrighted work. Therefore, it is necessary to ensure that such archives are protected against flood and fire. The user's agreements should always be preserved by archival institutions and damage to protect the users' agreements. This means that librarians, archivists, and users are to be familiar with legislation governing copyright in South Africa and other parts of the world. It appears that most users are not aware of the role played by the heritage institution to protect copyrighted materials. Hence, there are relationships between copyright and climate change in the archives institutions. This implied that the organization is to develop a system to ensure that copyright is protected. A study conducted by Fabunmi (2007) indicates that nation has some form of copyright protection for authors. Copyright issues are protected through international conventions and national legislation, for example, the Berne Convention was first adopted in Bern (Berne), Switzerland in 1886 and revised several times. Membership of the convention includes the United States of America and Canada. Most countries signed the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). TRIPS clarifies aspects dealing with copyright law and strengthened copyright protection internationally. According to Fabunmi (2007), Copyright protects authors' original works of authorship such as literary, dramatic, musical, artistic, and other intellectual works regardless of whether the work is published or unpublished. The copyright Act gives the owner the right to reproduce the work in copies; prepare derivative works based upon the work, distribute copies to the public by sale or other transfer of ownership, or by rental, lease, or lending; perform the work publicly; display the work publicly.

In South Africa, the Copyright Act, Act No. 98 of 1978, and its amendments legislated copyright provided guidelines on dissemination and access to information. South Africa's commitment to copyright issues is demonstrated by being part of the Berne Convention for the Protection of Literary and Artistic

Works and TRIPS. Furthermore, South Africa is a signatory of the WIPO Copyright Treaty (Pouris and Inglesi-Lotz, 2017).

## FUTURE RESEARCH DIRECTIONS

Studies on the relationship between climate change and digitization of archives in South Africa are limited. The current study has added up the literature on climate change and digitization in South Africa. Thus, further studies should be conducted to cover climate change and digitization of archives. Further research can also be conducted to assess the legislative framework impacting sustainable development goals of climate change and digitization.

## CONCLUSION

The research has confidence that this study might give South African heritage institutions directions required to develop preservation measures for the protection of archival materials as the results of fire and flooding in South Africa. Digitization of archival materials should be viewed as an emergency in heritage institutions in South Africa. They are to be referred to as an emergency issue because of the high level of disaster in our archival environment, Fabunmi, Paris and Fabunmi 2006). However, the successful implementation of digitization projects requires an organization to invest a lot of funds in digitization projects.

## RECOMMENDATION

The literature review shows that heritage institutions are needed to embrace information communication technology to prevent damage of records neither through flood and fire. To achieve transformation, heritage institutions need to redefine their role vis the user, as well as communication their position to external stakeholders, as alluded to by (Caidi, 2006). The heritage institutions need to change to users -centered model. This means that embracing information communication technology ensures that users remain to access archives.

The research recommends South Africa heritage institutions embark on a digitization project to ensure records protection from any form of climate change such as flooding and natural fire. South Africa heritage institutions to invest in digitization programs so that heritage institutions can go digital in their endeavors of managing and administering records and archives. Organizations are to ensure that staff is trained on records and archives management systems.

## REFERENCES

Abid, A., & Radoykov, B. (2003). *Access and preservation in the information society*. Blackwell.

Aldawood, H., & Skinner, G. (2018). Educating and Raising Awareness on Cyber Security Social Engineering: A literature Review. *IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*.

Anderson, J. (2005). Access and Control of Indigenous Knowledge in Libraries and Archives: Ownership and Future Use. In Correcting Course: Rebalancing Copyright for libraries in the National and International Arena. New York American Library Association and the MacArthur Foundation Columbia University.

Anderson, S., & Hart, G. (2016). Challenges in digitizing liberation archives: A case study. Innovation. *Journal of Appropriate Librarianship and Information Work in Southern Africa*, *53*, 21–38.

Ayoung, D. A., Boatbil, S. C., & Baada, N. F. (2015). Disaster preparedness of libraries: Insight from polytechnic librarians in Ghana. *Information Development*, 1–10.

Baloyi, N., & Kotze, P. (2017). Are Organisations in South Africa Ready to Comply with Personal Data Protection or Privacy Legislation and Regulations? *IST-Africa Conference Proceedings IIMC International Information Management Corporations*. www.IST-Africa.org/Conference2017

Benny, J (2019). Archival Automation in the United Kingdom and the Relationship between Standardization and Computerization. *Information & Culture: A Journal of History*, *54*(2), 159-178.

Bhat, A. W. (2018, June 04). Long-term preservation of big data: Prospects of current storage technologies in digital libraries. *Library Hi Tech*, *36*(3), 539–555. doi:10.1108/LHT-06-2017-0117

Boamah, E., Dorner, G. D., & Oliver, G. (2015). Using theory to understand Digital Preservation Management in Ghana. *PDT&C*, *44*(2), 46–61. doi:10.1515/pdtc-2015-0011

Boutard, G., Guastavino, C., & Turner, J. (2013). A Digital Archives Framework for the Preservation of Artistic Works with Technological Components. *International Journal of Digital Curation*, *8*(1), 42–65. doi:10.2218/ijdc.v8i1.237

Brendan, E. A. (2013). The readiness of universities in managing electronic records: A study of three federal universities in Nigeria. *The Electronic Library*, *31*(6), 792–802. doi:10.1108/EL-04-2012-0037

Caidi, N. (2005). Building Civilisation competencies": A new role for libraries? *The Journal of Documentation*, *62*(2), 194–212. doi:10.1108/00220410610653299

Chrons, O., & Sundell, S. (2011). *Digitalkoot: Making Old Archives Accessible Using Crowdsourcing*. Human Computation: Paper from the 2011 AAA1 Workshop.

De Lusente, Y. (2004). *Long-term access to the digital world: from journal to web. European Commission on preservation and access*. Royal Netherlands Academy of Arts and Sciences.

Delaney, B., & De Jong, A. (2015). Media Archives and Digital Preservation: Overcoming Cultural Barriers. *New Review of Information Networking*, *20*, 73–89.

Essien, D.E. (2019). *Ethical Implications of Cooperation and Safety vis-à-vis Cyber Security in Africa.* DOI: doi:10,4018/978-1-7998-1104-6ch002

Eyewitness news24. (2021). *73,500 valuable items lost from African Studies Collection in UCT library fire*. https://ewn.co.za/2021/04/21/73-500-valuable-items-lost-from-african-studies-collection-in-uct-library-fire

Fabunmi, A.B. (2007). The Roles of Librarians in Copyright Protection in Nigeria. *International Journal of African & African American Studies*, *6*(1), 85 – 93.

Fabunmi, A. B., Paris, M., & Fabunmi, M. (2006). Digitization of Library Resources: Challenges and Implications for Policy and Planning. *International Journal of African & African American Studies*, *2*, 23–36.

Fabunmi, B.A., Paris, M., & Fabunmi, M. (1996). Digitization of Library Resources: Challenges and Implications for Policy and Planning. *International Journal of African & African American Studies,* (2).

Fantozzi, C., Bressan, F., Pretto, N., & Canazza, S. (2017). Tape music archives; From preservation to access. *International Journal on Digital Libraries*, *18*(3), 233–249. doi:10.100700799-017-0208-8

Fedotova, V.G., Kvalenko, A.O., & Malvutina, D.T. (2019). Transformation of Information security systems of enterprises in the context of digitization of national economy. *Ubiquitous Computing and the Internt of Things: Prerequisites for the Development of ICT*, 811 – 822.

Garaba, F. (2010). *An investigation into the management of the records and archives of former liberation movements in East and Southern Africa held by national and private archival institutions (Ph.D. Diss)*. University of Kwazulu Natal.

Garaba, F (2014). Preparing collections for digitization: The case of religious archives in Pietermaritzburg, Kwazulu-Natal, South Africa. *Verbum et Ecclesia, 35*(1).

Humphreys, E. (2008). Information Security management standards: Compliance, governance and risk management. *Information Security Technical Report*, *13*(4), 247–255. doi:10.1016/j.istr.2008.10.010

Ifijeh, G., Idiegbeyan-ose, J., Segun-Adeniran, C., & Ilogho, J. (2016). Disaster Management in Digital Libraries: Issues and Strategies in Developing Countries. *International Journal of Risk and Contingency Management*, *5*(1), 1–14. doi:10.4018/IJRCM.2016010101

Leresche, F. (2008). Libraries and archives: Sharing standards to facilitate access to cultural heritage. World Library and Information Congress. *74th IFLA Genera conference and Council*, 1 – 11.

Leveille, V., & Timms, K. (2015). Through a Records Management Lens: Creating a Framework for Trust in Open Government and Open Government Information. *Canadian Journal of Information and Library Science*, *39*(2), 154–190. doi:10.1353/ils.2015.0010

Limp, P. (2005). The digitization of Africa. *Informing Science: The International Journal of an Emerging Transdiscipline, 52*(2), 4-19.

Magama, B. (2018). Strategies for the preservation of digital records in Masvingo Province of Zimbabwe. *ESARBICA Journal*, *37*, 18–38.

Majore, A. S., Yoo, H., & Shon, T. (2014). Secure and reliable electronic record management system using digital forensic technologies. *The Journal of Supercomputing*, *70*(1), 149–165. doi:10.100711227-014-1137-6

Mallan, K. (2006). Is digitization sufficient for collective remembering? Access to and use of cultural heritage collection. *Journal of information and Library Science, 30*(3-4), 201-220.

Mallet, J., Fortin, G., & Germain, D. (2018). Extreme weather events in northeastern New Brunswick (Canada) for the period 1950—2012: Comparison of newspaper archive and weather station data. *Canadian Association of Geographers*, *62*(2), 130–143. doi:10.1111/cag.12411

Mnjama, N. (2005). Archival landscape in Eastern and Southern Africa. *Library Management*, *26*(8/9), 457–470. doi:10.1108/01435120510631747

Mnjama, N., & Wamukoya, J. (2004). *E-government and e-records management*. Paper presented at the SADC Workshop on E-government, Gaborone, Botswana.

Molefe, N & Schellnack-Kelly, I (2019). Users' perceptions of services at the National Archives and Records Service of South Africa (NARSSA). *Innovation: Journal of Appropriate Librarianship and Information Work in Southern Africa*, *58*, 3 – 15.

Muchaonyerwa, N., & Khayundi, F. (2014). The Management of Digital Records in the Office of the Premier of the Eastern Cape Province, South Africa. *African Journal of Library Archives and Information Science*, *24*(1), 41–52.

Nengomasha, T. C. (2013). The past, present and future of records and archives management in sub-Saharan Africa. *Journal of the South African Society of Archivists*, *46*, 2–11.

Nengomasha, T. C., & Nyanga, H. E. (2015). Access to Archives at the National Archives of Namibia. *ESARBICA Journal*, *34*, 88–103.

Netshakhuma, N. S. (2018). *Capacity building through digitisation: Case of the ANC archives*. *The RIM Quarterly*.

Netshakhuma, N. S. (2019). Analysis of the role and impact of the Mpumalanga Provincial Archives. *Mousaion: South African Journal of Information Studies*, *36*(4), 1–18. doi:10.25159/2663-659X/5642

Netshakhuma, N. S. (2020). Analysis of archives infrastructure in South Africa: Case of Mpumalanga provincial archives. Global Knowledge. *Memory and Communication*, *69*(4/5), 221–239.

Netshakhuma, N. S. (2020). The role of archives in documenting African National Congress Women's League that impacted the development of their records: 1960 – 1990. *Global Knowledge, Memory and Communication, 70*(1/2),44-59.

Netshakhuma, N. S. (2021). The impact of climate change on the Mpumalanga Provincial Archives and records management activities. Records Management Journal. doi:10.1108/RMJ-09-2020-0031

Ngulube, P. (2001). Strategies for managing digital records and documents in the public sector in Sub Saharan Africa. *Records Management*, *22*(3), 198–211.

Ngulube, P. (2002a). Challenges to preservation of our archival heritage. *Archives*, *42*, 27.

Ngulube, P. (2002b). The future of the past: Access to public archives in Southern Africa and challenges to historical research. *Historia (Wiesbaden, Germany)*, *47*(2).

NISO Framework Working Group. (2007). A framework of Guidance for Building Good Digital Collections (3rd ed.). Baltimore: National Information Standards Organization (NISO).

Nsibirwa, Z., Hoskins, R., & Stilwell, C. (2014). Building the South African Nation through Legal Deposit: The Impact of Legislation on Preservation of Digital Materials. *African Journal of Library Archives and Information Science*, *24*(1), 53–65.

O'Toole, J. M. (1993). The symbolic significance of archives. *The American Archivist*, *56*(2), 234–255. doi:10.17723/aarc.56.2.e481x55xg3x04201

Olatokun, M. W. (2008). A survey of Preservation and Conservation Practices and Techniques in Nigerian University Libraries. *LIBRES Library and Information Science Research Electronic Journal*, *18*(2), 1–18.

Ophoff, J., & Miller, S. (2019). Business Priorities Driving BYOD Adoption: A case study of a South African Financial Services Organisation. *Issues in Information Science Information Technology*, *16*, 165–196. doi:10.28945/4303

Oweru, J. P., & Mnjama, N. (2014). Archival preservation practices at the Records and Archives Management Department in Tanzania. *Mousaion: Journal of Information Science in South Africa*, *32*(3), 136–165. doi:10.25159/0027-2639/1680

Pickover, M., Dale, A., & Peters. (2002). DISA: An African perspective on digital technology. *Innovation: Journal of Appropriate librarianship and Information Work in Southern Africa, 24*, 14–20.

Pickover, M. (2009). *Contestations, ownership, access, and ideology: Policy development challenges for the digitization of African heritage and liberation archives*. Paper presented at the First International Conference on African Digital Libraries and Archives (ICADLA-1), Addis Ababa.

Pickover, M. (2014). *Power and politics: Selecting, constructing and preserving digital heritage content in South Africa and Africa*. Paper presented at IFLA, Lyon.

Pouri, A., & Inglesi-Lotz, R. (2017). The contribution of copyright-based industries to the South African economy. *South African Journal of Science*, *113*(11/12), 64–70. doi:10.17159ajs.2017/20160286

Saur, K. G. (2004). *Digital resources from cultural institutions for use in teaching and learning*. A report of the America/ German Workshop. Munchen: K.G. Suar Verlag.

Schultz, M. J. (2013). Supporting Capacity Building For Archives in Africa: Initiatives of the Cooperative Africana Materials Project (Camp) Since 1995. *African Research & Documentation*, *121*, 3–12.

Sgauke, T. D., & Chabikwa, S. (2012). *Beyond the digitisation horizon: Prospects and Issues for archivists and the digitisation of historical records in Zimbabwe*. Paper presented at the South Africa Society of Archivists (SASA) conference, UNISA, Pretoria, South Africa.

Tough, A. G. (2009). Archives in Sub–Saharan Africa Half a century after independence. *Archival Science*, *9*(3-4), 3–4, 187–201. doi:10.100710502-009-9078-1

VanSnick, A., & Ntanos, K. (2018). On digitisation as a Preservation Measure. *Studies in Conservation*, *63*(1), 282–287. doi:10.1080/00393630.2018.1504451

Withers, D. (2017). Ephemeral Feminist Histories and the Politics of Transmission within Digital Culture. *Women's History Review*, *26*(5), 678–691. doi:10.1080/09612025.2016.1166887

Zaid, Y., & Abioye, A. (2010). Museums, Libraries, and Archives; Collaborating for the Preservation of Heritage Materials in Nigeria. *African Research & Documentation*, *114*, 59–70.

## KEY TERMS AND DEFINITIONS

**Apartheid:** It was a system of institutionalised racial segregation introduced by the National Party of South Africa to segregate people base on the colour.

**Archives:** These are records preserved because of their historical, cultural, and social significance.

**Authenticity:** A record is authentic if what it purports to be and if it was created or sent by the person who claims to have sent it.

**CAMP:** Cooperative Africana materials project formed to collect and preserve African newspapers, serials, and ephemera to preserved in the United State of America. Microfilming was used as a method to preserve African history materials.

**Copyright:** It is referred to as the legal right of the owner of intellectual property.

**Cultural Diplomacy:** It is a type of public diplomacy and soft power that includes the exchange of archives materials.

**Cultural Imperialism:** It is the creation and maintenance of unequal relationships between civilization.

**Heritage Institutions:** This includes institutions such as libraries, museums, and archives preserving cultural records. These are social and cultural institutions that play an essential role to preserve institutional memories.

**Integrity:** A record that maintains its integrity is complete and unaltered.

**Preservation:** This is a process designed and developed to ensure the long-term preservation of archival materials.

**User-Centered Model:** The user is a key stakeholder during the provision of information to the library, archives, and museum institution.

# Chapter 32
# Teleworking and Information Security Management in Commercial Sector Companies

**Liz Pacheco-Pumaleque**
*Universidad Nacional Mayor de San Marcos, Peru*

**Alex Pacheco-Pumaleque**
*Universidad Peruana de Ciencias e Informática, Peru*

**Edwin A. Vegas-Gallo**
*Universidad Peruana de Ciencias e Informática, Peru*

**Rosario Pariona-Luque**
*Universidad Nacional Autónoma de Huanta, Peru*

## ABSTRACT

*Currently, working conditions have been evolving continuously, which makes it necessary to incorporate teleworking as a means of support to fulfill the tasks entrusted. However, this type of employment brings with it vulnerabilities within companies that are not prepared for such a situation. For this reason, a teleworking model is proposed to improve the management of information security in organizations in the commercial sector. This research is of a basic type with a non-experimental design and correlational level, with a quantitative approach, the survey technique, and a questionnaire was used as an instrument that was applied to 70 workers in the commerce sector. The results show that 54.29% consider the organizational change in companies as deficient, 62.86% indicate the use of technologies as deficient, and 84.29% consider that the level of confidentiality of the information is regular. These results reflect that information security management must be implemented to provide greater reliability, integrity, productivity, control, and protection to teleworking processes.*

DOI: 10.4018/978-1-7998-8482-8.ch032

## INTRODUCTION

Today the expansion of COVID-19 has caused a strong impact on the labor aspect, therefore it is necessary for companies to adapt to these changes, being essential to put teleworking into practice to maintain their competitiveness. According to (Buitrago, 2020), teleworking makes it possible to work remotely, in order to reduce costs in the company. In addition (Valencia, 2018) maintains that telework allows citizens with disabilities to have the opportunity to be inserted in the labor sector, this being a special way of providing services. For this reason, (Godoy, 2011) mentions that teleworkers require knowledge and intensive use of information and communication technologies (ICT) in the development of their activities. However (Peralta et al., 2020) indicates that the effect of Teleworking in business management can be positive or negative, depending on whether the company has the minimum requirements for its proper execution. Therefore, to ensure that telework is implemented correctly, changes must be carried out in the organization of the company, such as the implementation of machinery and procedures to prevent obsolescence from gaining ground; in addition to teaching methodologies on the efficient use of ICTs in order to obtain a positive impact on business human talent.

This crisis due to the pandemic has changed the employment situation of people, which leads to work outside the company on a mandatory basis, which could cause vulnerability in the data of the organizations, for this there is the security management of the information, taking into account that the most valuable thing for industries is information and as such, it must be correctly secured together with technological assets that guarantee its availability when required, that it is only accessible to authorized persons and devices, taking care that the information is not modified by third parties (Carvajal et al., 2019). The ease of connecting to the network has made it possible for users to share resources and information, which also represents an increased risk of data vulnerability, for this reason it is necessary to implement measures to ensure the confidentiality of information in the organization (Vega, 2012) Therefore, it is important to protect the information, but also to ensure its availability. Considering this approach to information security, it is necessary to take into account three main elements that are: confidentiality, integrity and availability (Rodriguez et al., 2020).

It is important to supervise the use of ICT by the employer and thus effectively develop this new work approach, for this the teleworker has the right to training on information security, data protection and confidentiality, in this way ensures efficiency in the provision of services (Culqui & González, 2016). Focusing on the correct security management, telework will be carried out optimally, therefore since the company decides to apply this work modality, it must propose changes in its organizational culture related to the way in which the organization carries out its activities, the relationship between employees and bosses, the degree of autonomy in decision-making, and personal expression (Garay, 2015).

A study carried out in Bolivia by (Duran, 2020), analyzed the physical space of the worker and the distractions that hinder their concentration to continue with work activities during the pandemic, taking into account that their development is related to family coexistence. You must define working times, respect the physical space of the teleworker, reach family agreements and share the benefits of this modality, to build a balance in work and family life. According to (Silva & Li Bonilla, 2020) the substantial decrease in physical space reduces the carbon footprint, allowing the worker to develop from a more comfortable environment, thanks to the use of the internet that allows connection from anywhere, facilitating execution of the tasks entrusted.

In the research of (Valero & Riaño, 2020) in Colombia, it indicates that teleworking is integrated into its current legislation, for this reason the teleworker enjoys protection if damage to health occurs due to occupational risks, consequently it is Employer's obligation to apply a Occupational Health and Safety Management System, in this way it must have strategic objectives so that all this influences a new organizational culture. Basically, the main reforms that companies must carry out are: technological innovation, information management, the reinforcement of physical and mental health programs, and measuring the impact of teleworking on the system.

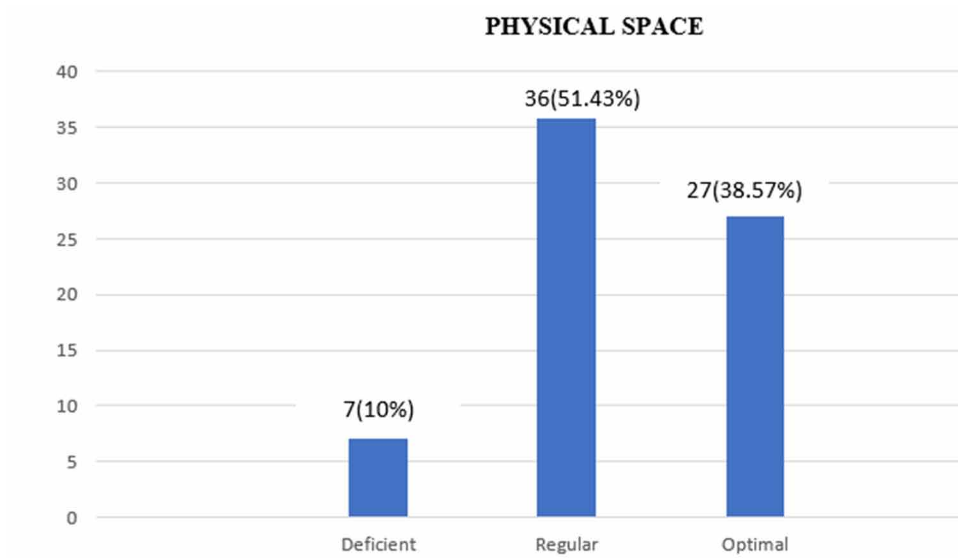
A study carried out in Argentina by (Osio, 2015) indicates that it is necessary to create regulations that allow controlling important aspects of the risks when teleworking, it is necessary to take care of and avoid the abuse of teleworkers. In this sense, a legal framework must be developed that benefits both and that allows teleworkers to guarantee their health and safety during their work activities. Argentina has made important progress in the legal aspect, thanks to the government's vision, added to the support of large technology companies. In this way, we see how a robust legal framework emerges, which has not been limited to just giving space to telework, rather, it has addressed aspects such as: health, safety and prevention.

A report developed in Spain by (Agudo, 2014) concluded that labor flexibility is essential and positively affects business results, the introduction of ICT increases productivity within the organization, therefore teleworkers see great advantages in this practice which motivates them to achieve their work goals effectively.

In the Dominican Republic, teleworking served as a necessary tool to carry out work activities in public administration companies, however, they had complications such as the lack of internet, electricity, computers, tablets or telephone, in addition to a lack of knowledge about the efficient use of ICTs that caused deficiencies in carrying out work activities due to the pandemic (Arias, 2021). In Spain, an analysis of the different occupations that exist in companies showed that 30% of employees could telework, therefore, there is still a great margin for improvement in the use of this work modality because its potential increase is unequal since workers with a lower educational level have greater difficulty in being able to benefit from this form of work (Anghel et al., 2020). In Ecuador, it was proposed to apply a teleworking model to organizations, both public and private, facilitating innovation and providing competitiveness tools. Despite this, the lack of knowledge in information technology in some sectors and resistance to change are barriers to its correct implementation (López & Sisa, 2020). In Chile, teleworking was adopted by organizations, however, some workers did not have telework skills and space at home to work. However, studies have reported that this type of employment in confinement increased different work stressors and puts the desire to telework in the future at risk (Ramírez et al., 2020).

In Peru, a high percentage of companies had to opt for teleworking due to the pandemic, but the lack of technological tools, internet connectivity, work space; Likewise, personal difficulties at home and resistance to change make it difficult to carry out this type of employment (Quispe & Fernández, 2021). This resulted in teleworking not being able to expand optimally, as well as a lack of equal opportunities for all workers. However, the state has been promoting public policies to regulate teleworking, for this it signed a national pact with regional governments, business associations, companies and civil society (Valencia, 2018). For this reason, the use of information technologies is a fundamental point to develop this type of employment. In this sense, the objective of the research is to propose a teleworking model to improve the management of information security in organizations in the commerce sector, which contributes to enhancing productivity through the learning of information technologies that provide resources for the change of the organizational culture ensuring a correct use of this work modality within the companies.

*Figure 1. Physical space dimension*
*Source: own elaboration*




This article describes the importance of teleworking and information security management for the improvement of remote tasks, which includes the development of technological knowledge, as well as being a contribution to companies that choose this modality, and for the development of teleworkers who cannot physically move to a workplace.

## METHOD

This research is of the Basic type with a non-experimental design and correlational level, with a quantitative approach, whose sample is made up of 70 workers, through a simple random sampling. The technique used was the survey and as an instrument a questionnaire was used about the independent variable telework with its dimensions Physical space, Organizational Change and Use of ICT with a total of 18 questions and the dependent variable Information security management with the Confidentiality and Availability dimensions with 18 questions. The measurement scale used was Likert with a Cronbach's Alpha coefficient of 0.886.

## RESULTS

The questionnaire was applied to a total of 70 workers of a company, based on the results the following is presented:

Figure 1 shows the results about the physical space dimension of the independent variable telework, 51.43% indicate that their level of physical space is regular, 38.57% consider it optimal, and 10% deficient.

*Figure 2. Organizational change dimension*
*Source: own elaboration*

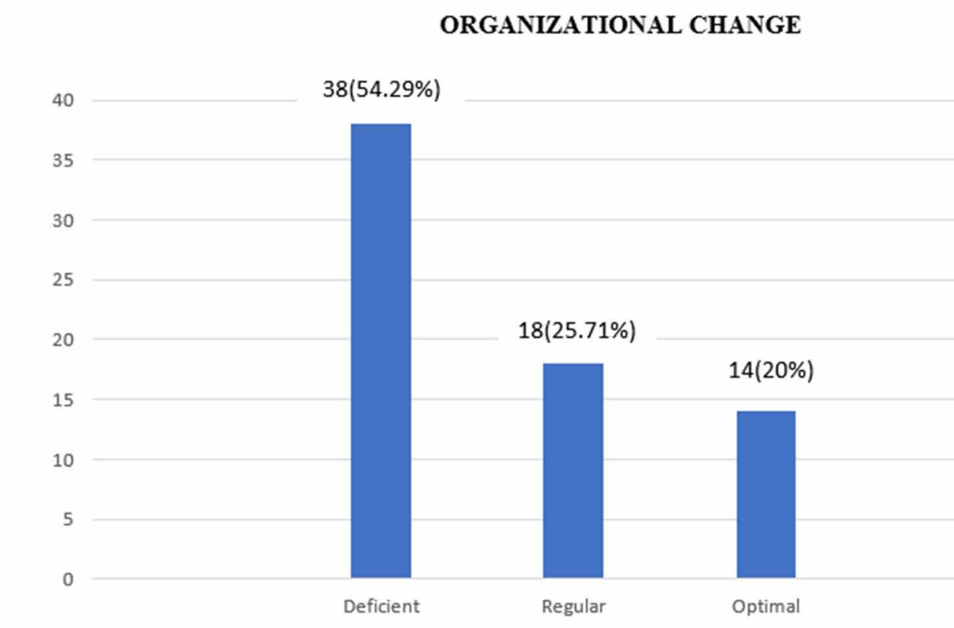



Figure 2 shows the results about the organizational change dimension of the independent variable telework, 54.29% indicate that their level of organizational change is deficient, 25.71% consider it regular and 20% optimal.

Figure 3 shows the results about the ICT use dimension of the independent variable telework, 62.86% indicate that their level of ICT use is deficient, 27.14% consider it regular and 10% optimal.

Figure 4 shows the results about the confidentiality dimension of the dependent variable Information security management, 84.29% indicate that their level of confidentiality is regular, 11.43% consider it optimal and 4.29% deficient.

Figure 5 shows the results about the Availability dimension of the dependent variable Information security management, 88.6% indicate that its level of availability is regular, 11.43% consider it optimal and 4.29% deficient.

## PROPOSAL

Based on the results of the survey, in the figure 6, the following teleworking model is proposed to improve the management of information security in organizations in the commerce sector, which helps us to evaluate the real state of this sector and then obtain ideal results.

*Figure 3. Assessment of ICT use*
*Source: own elaboration*

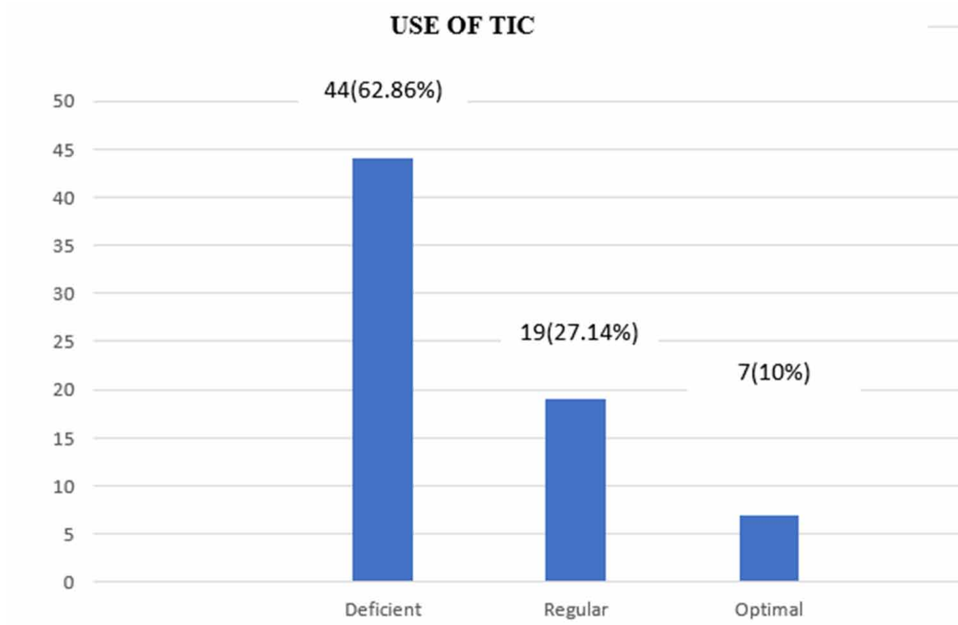



*Figure 4. Level of confidentiality of workers*
*Source: own elaboration*

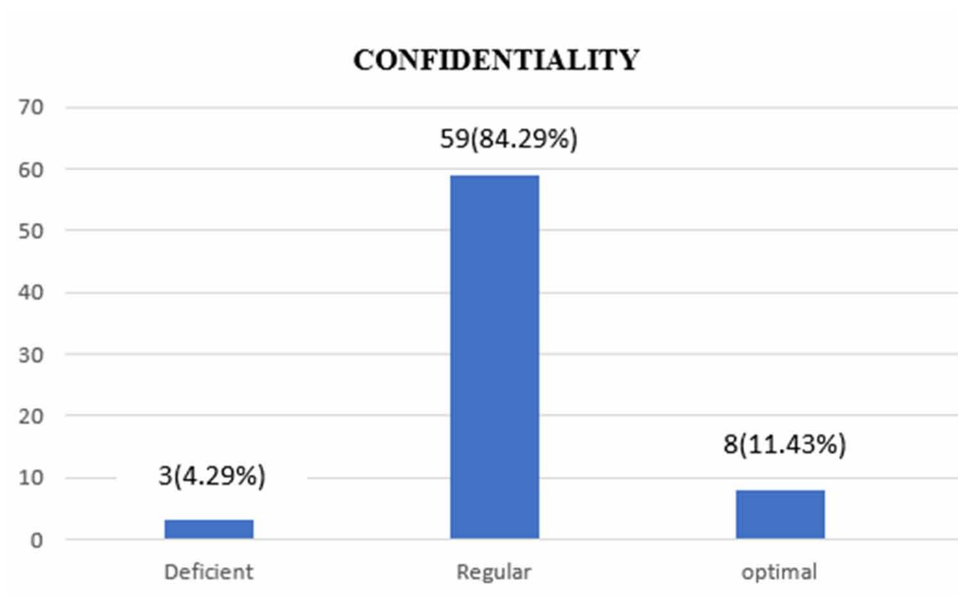


*Figure 5. Assessment of the availability dimension*
*Source: own elaboration*

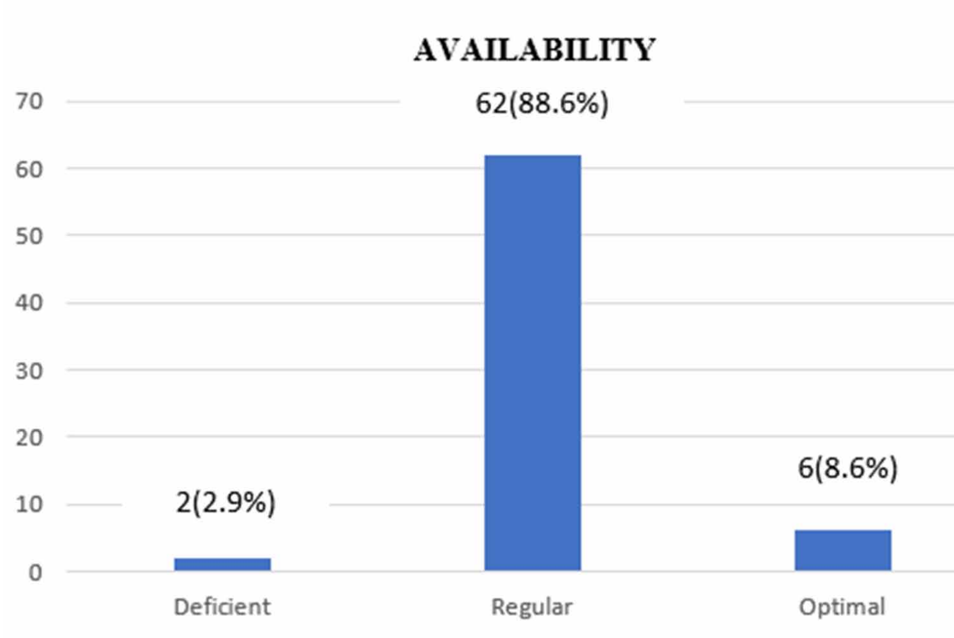
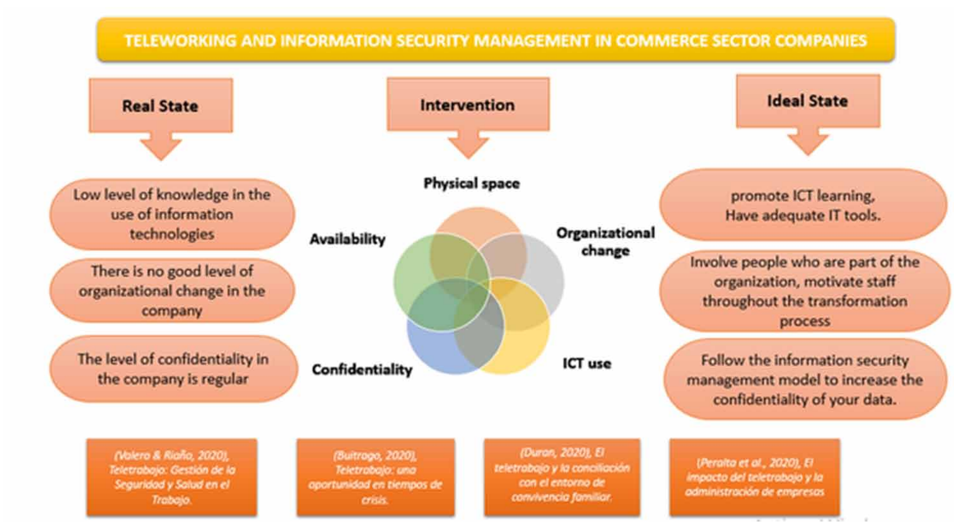



*Figure 6. Teleworking and Information Security Management Model*
*Source: Own elaboration*




## DISCUSSION

In figure 1, 51.43% indicate that their level of conformity in their physical space is regular, this shows great discomfort in the workers, generating demotivation, stress and an emotional imbalance. Which agrees with (Duran, 2020) & (Silva & Li Bonilla, 2020), who point out that the physical space in which workers develop must be respected, in this way the employee will be able to balance his family and work life contributing to the correct fulfillment of their tasks. Also (Ramos et al., 2020), considers that there are difficulties in separating the work space and family, which generates a mental disconnection in work problems. For this reason, the worker must feel comfortable in the space in which he works, without feeling that his work hours are violated.

In figure 2, 54.29% indicate that the level of organizational change is deficient, showing that the company must improve its management capacity and get involved together with the worker, to define the changes that need to be implemented. Which agrees with (Garay, 2015) & (Valero & Riaño, 2020), who point out that organizational change is essential for the development of telework, adaptability to change is necessary by implementing a strategic plan that supports them to meet the objectives labor. For (Martinez et al., 2021), it is essential to strengthen the capacity for teamwork, emotional management and respect for the decisions of the organization, such is the case, of the great challenge that organizations in the area of health to manage the Covid-19 pandemic; following international guidelines to alleviate the pandemic, protect health and prevent the spread of the outbreak.

In figure 3, 62.86% indicate that their level of ICT use is deficient, showing that there is a lack of adaptation to technology, which prevents workers from performing their tasks efficiently. Which coincides with (Godoy, 2011) & (Agudo, 2014), who point out that introducing the use of ICT increases productivity within the organization, this being a great advantage for workers to develop their activities. In addition (Ramirez & Chuquillanqui, 2016) mention that thanks to new information technologies the employer can assume the same level of control and supervision that they have with an ordinary worker.

In figure 4, 84.29% indicate that the level of confidentiality is regular, which means that the company needs to implement security measures with which data protection is ensured, therefore, the training of workers is needed. Which agrees with (Vega, 2012) & (Culqui & González, 2016), who point out that to ensure that confidentiality is not violated in the organization, information security management measures must be applied, which gives the reliability of the processes. Likewise, (Barham, 2014) affirms that emphasis should be placed on the availability and confidentiality of the information, one way is the application of privacy policies on the use and treatment of personal information that is collected or generated through the site website of a company, covering user information, information to third parties and user rights over their information.

In figure 5, 88.6% indicate that the level of availability is regular, which shows that the company has not implemented mechanisms so that the services are available, it continues causing the processes to be slow and therefore does not contribute to the good performance of activities. This coincides with (Carvajal et al., 2019) & (Rodriguez et al., 2020), who point out that availability is a key element because it is essential that the information is available at the time it is required. In the same way, it coincides with (Vega, 2012), who points out that the information must be accessible to be used at the request of an authorized third party or at the request of external or internal users of the institution.

## CONCLUSION

The proposal of this research allows us to ensure that teleworking and information security management present a positive relationship in the results of work in a virtual way. Which helps telework to be a necessary tool in labor, economic and social transformation, thus becoming a phenomenon of development in the organization of work.

Likewise, through the union of telecommunications with the automation of offices, telework allows the decentralization of work in the office, with which employment in rural areas can be guaranteed, and thus allow a better distribution of the population. Teleworking changes the corporate structure, in addition, it brings advantages at an economic, behavioral and social level for all members who use this modality. This study highlights the benefits of teleworking for vulnerable people in society, since this modality provides opportunities for both personal and professional growth.

On the other hand, it should also focus on the training of workers for the use of information technology since, according to the study carried out, many workers still do not feel capable of carrying out tasks remotely, evidencing a lack of knowledge that allow to rely on these technological tools for the development of this modality.

## REFERENCES


Agudo, M. (2014). El teletrabajo en las organizaciones: Análisis de sus beneficios y barreras en las empresas españolas. *Cuadernos de Gestión de Información*, *4*(4), 172–187.

Anghel, B., Cozzolino, M., & Lacuesta, A. (2020). El teletrabajo en España. *Boletín Económico*, *2/2020*, 1–20.

Arias, B. (2021). *El Teletrabajo en la República Dominicana. Ventajas, desventajas y regulación*. Academic Press.

Barham, C. (2014). Confidentiality and security of information. *Anaesthesia and Intensive Care Medicine*, *15*(1), 46–48. doi:10.1016/j.mpaic.2013.11.001

Buitrago, D. (2020). Teletrabajo: Una oportunidad en tiempos de crisis. *CES Derecho*, *11*(1), 1–2.

Carvajal, D. L., Cardona, A., & Valencia, F. J. (2019). Una propuesta de gestión de la seguridad de la información aplicado a una entidad pública colombiana. *Entre Ciencia e Ingeniería*, *13*(25), 68. doi:10.31908/19098367.4016

Culqui, A., & González, A. (2016). El Teletrabajo: Una Innovadora Forma de Organización del Trabajo, una Herramienta de Inclusión Laboral y su Regulación Jurídica en el Perú. *Derecho & Sociedad*, *46*, 95–109.

Duran, N. (2020). *El teletrabajo y la conciliación con el entorno de convivencia familiar durante la pandemia COVID-19*. Academic Press.

Garay, A. (2015). *El cambio en la cultura organizacional como mecanismo para propiciar alternativas efectivas de teletrabajo en las organizaciones [Change in organizational culture as effective mechanism for promoting alternative telecommuting organizations]*. Universidad Militar Nueva Granada.

Godoy, J. (2011). Observatorio Laboral revista venezolana. *Observatorio Laboral Revista Venezolana*, *4*(8), 14.

López, D., & Sisa, F. (2020). Teletrabajo como estrategia de competitividad y desarrollo para las empresas en el Ecuador. *REVISTA ERUDITUS*, *1*(2), 53–70. doi:10.35290/re.v1n2.2020.318

Martinez, G., Zabalegui, A., & Sevilla, S. (2021). Management and leadership of nursing services in the emergency plan for the pandemic COVID-19: The experience of the Clinic Hospital of Barcelona. *Enfermeria Clinica*, *31*(1), S12–S17. doi:10.1016/j.enfcli.2020.05.002 PMID:32419770

Osio, L. (2015). Salud y seguridad en el teletrabajo. *Redalyc, 2*(2), 410–426.

Peralta, Á., Bilous, A., Flores, J., & Bombón, C. (2020). El impacto del teletrabajo y la administración de empresas. *RECIMUNDO: Revista Científica de La Investigación y El Conocimiento, 4*(1), 326–335.

Quispe, A., & Fernández, G. (2021). Teletrabajo en las entidades públicas, una necesidad y prioridad en la actualidad. *Ciencia Latina Revista Científica Multidisciplinar*, *5*(3), 3513–3533. doi:10.37811/cl_rcm.v5i3.547

Ramirez, E., & Chuquillanqui, O. (2016). El Teletrabajo en el Perú: Comentarios al Nuevo Marco Normativo. *Derecho & Sociedad*, *46*, 111–120.

Ramirez, P., Salazar, C., & Camacho, L. (2020). Explorando El Efecto Mediador Del Conflicto De Trabajo Hogar Entre La Sobrecarga Y El Agotamiento En Teletrabajo. *Proceedings of the 36th International Business Information Management Association (IBIMA)*, 11670–11672.

Ramos, V., Ramos-Galarza, C., & Tejera, E. (2020). Teleworking in times of COVID-19. *Revista Interamericana de Psicología*. *Interamerican Journal of Psychology*, *54*(3), e1450–e1450. doi:10.30849/ripijp.v54i3.1450

Rodriguez, L. S., Cruzado, C. F., Mejía, C., & Diaz, M. A. A. (2020). Aplicación de ISO 27001 y su influencia en la seguridad de la información de una empresa privada peruana. *Propósitos y Representaciones*, *8*(3), 786. doi:10.20511/pyr2020.v8n3.786

Silva, G., & Li Bonilla, F. (2020). Factores clave del Teletrabajo que inciden en la relación ganar-ganar entre el trabajador y la empresa costarricense. *Revista Nacional de Administración*, *11*(1), 69–82. doi:10.22458/rna.v11i1.3009

Valencia, A. (2018). Aspectos regulatorios del teletrabajo en el Perú: Análisis y perspectivas. *Revista IUS*, *12*(41). Advance online publication. doi:10.35487/rius.v12i41.2018.319

Valero, I., & Riaño, M. (2020). Teletrabajo: Gestión de la Seguridad y Salud en el Trabajo en Colombia. *Archivos de Prevencion de Riesgos Laborales*, *23*(1), 22–33. doi:10.12961/aprl.2020.23.01.03 PMID:31991075

Vega, W. (2012). *Politicas Y Seguridad De La Informacion*. Revista de Difusión Cultural y Científica de La Universidad La Salle En Bolivia.

# Chapter 33
# Mapping Plastic Greenhouses With LANDSAT 8 Imagery in Valparaiso, Chile:
## Development of a New Methodology Through a Data Cloud Platform

**Ignacio Aguirre**
https://orcid.org/0000-0002-7722-9677
*Centre for Hydrology, University of Saskatchewan, Canada*

**Jacinto Garrido Velarde**
*University of Extremadura, Spain*

**Javier Lozano Parra**
*Universidad Autónoma de Madrid, Spain*

## ABSTRACT

*In the last decades there has been a strong increase around the world in the use of plastic greenhouses (PGs). The Valparaíso region, in the central valley of Chile, has not been the exception, and the area covered by greenhouses has also experienced an increase over the years, reaching 1180 ha in 2007. Taking into account that agriculture in this region employs more than 60,000 people and accounts for 4% of the regional GDP, this information should be available to be included in territorial planning and incorporated into hydrological, economic, and food security models. To do this, the authors propose a new method for identifying the surface covered by PGs based on the intersection of the normalized difference indices and the areas excluded by the masks. The results showed that this methodology was able to identify with a general precision of 86.25% which allowed to classify 1409.85 ha. This area is consistent with the agricultural census carried out in 2007 and with the increase of more than 900 subsidies granted by the government for the installation of new structures.*

DOI: 10.4018/978-1-7998-8482-8.ch033

## INTRODUCTION

In recent years there has been a strong increase in plastic greenhouses (PGs) to have greater water security (Lamalice et al., 2018), resist events such as droughts, floods, or pests (Jiménez-Lao et al., 2020; Perilla & Mas, 2019; Picuno et al., 2011; Sonmez & Koc-San, 2016). Globally, it is estimated that 3,019 x 103 ha are covered by plastic greenhouses (Wu et al., 2016) distributed mainly in China, Italy, Spain, North Africa, and the Middle East (Jiménez-Lao et al., 2020). The central valley of Chile has not been the exception to this trend and the area covered by greenhouses has increased over the years (ODEPA, 2019). According to the agricultural census of 2007, in the Valparaíso region, 1,180 hectares covered with greenhouses were reported, and since then the state has provided more than 900 subsidies for new construction. The spatial distribution of these structures has not been previously mapped and this is vital to be able to incorporate it into hydrological, economic, and food security models, considering that agriculture in this region is one of the main in the country, along with employing more than 60,000 people and generate 4% of the gross domestic product of the region (Yañez, 2019).

The information on the greenhouses can be obtained from land surveys or censuses or through satellite images. In Chile, every 10 years an agricultural census is carried out that registers plastic greenhouses at the national level based on a single form. The last ones correspond to those of 1997 and 2007. These methods have the advantage of providing more information on the cultivated species, however, given their high monetary cost, they cannot be carried out very often and therefore do not realize the rapid advance of the construction of greenhouses. The information is also delivered in an aggregate form, which does not allow its incorporation into spatially distributed models of food security. Another way to obtain the covered area is through satellite images, as in the case of Almería, Spain where Aguilar et al., (2015) have registered greenhouses with an accuracy of 81.3%. The advantages of these methods are their low costs (Yang et al., 2017), the possibility of observing changes on an annual scale (Lu et al., 2014), or on a national scale (Perilla & Mas, 2019), however, no it can be distinguished by species or a scale smaller than the resolution of the image.

According to Jiménez-Lao et al., (2020), there are two groups of techniques to identify greenhouses with satellite images. First, the pixel-based approach where the identification is generated at the level of a cell-based only on its spectral and textural signature. Yang et al., (2017) employ this methodology in Shangdong province, China using the PG-Index greenhouse spectral index together with two conditions based on the normalized difference vegetation index (NDVI) and the normalized difference construction index. (NDBI). Their results using Landsat Enhanced Thematic Mapper Plus (ETM +) have an accuracy of 91.2% based on an analysis with high-resolution Quickbird images (0.6m). Second, the Object-Based Image Analysis Approach considers several pixels that are grouped considering their spectral and spatial information (for example, 3D surveys). Tarantino & Figorito (2012) use these techniques on vineyard crops in southern Italy where considering an image segmentation process, they achieve a precision of 90.25%.

This article studies the total area covered by plastic greenhouses in the Valparaíso region through a pixel-based approach. For this, a methodology is proposed that uses 5 spectral indices such as modified soil adjusted vegetation index, gloss temperature index, normalized difference vegetation index - green, normalized difference construction index, and plastic surface index. The results of these indices are reclassified and then multiplied until a preliminary image is obtained, excluding urban areas and those with high slopes. This methodology has several advantages given that it is not restricted by the user's computer, but runs on a cloud computing platform such as Google Earth Engine (Gorelick et al., 2017) with free access; It is inexpensive since it uses free access images such as Landsat 8, and allows the identification of temporal changes.

The results of this research will allow a better characterization of plastic greenhouses on a regional scale and thus the increase in the area covered from 2007 to 2020 can be observed. These data will serve as inputs in food safety studies, generation of new subsidies, planning agriculture and hydrological modeling considering that they require information to be resolved locally and in a disaggregated manner.

## STUDY AREA

The study area corresponds to the continental part of the Valparaíso Region, in Chile (Figure 1). Its total area is 16,396.10 km2 and presents a marked E-W topographic variation from the Andes mountain range to the Pacific Ocean. In climatic terms, Sarricolea et al. (2017) assign it a Mediterranean climate (*Csb*) with an average rainfall of 576 mm/year mainly concentrated in winter and an average annual temperature of 11.3 ° C.

The region is divided into 37 administrative communes and has had a strong agricultural vocation since colonial times (Chonchol, 1994) due to its soils and water availability (ODEPA, 2019). In recent years, a total of 100,859.0 ha have been irrigated, although projections point to an increase in this area (DGA, 2017). The main cultivated species are avocados (*Persea americana*), table grapes, canned peaches (*Prunus persica*), lettuce (Lactuca sativa), cabbage (*Brassica oleracea var. Capitata*) and pomegranate beans (*Phaseolus vulgaris L*) (Yañez, 2018, 2019).

Valparaíso was selected for this study since it is the region of Chile that concentrates the highest number of greenhouses according to the agricultural censuses of 1997 and 2007 (INE, 1997, INE, 2009, Apey et al., 2009). The main cultivated species are fresh tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*), cucumber (*Cucumis sativus*), and flowers.

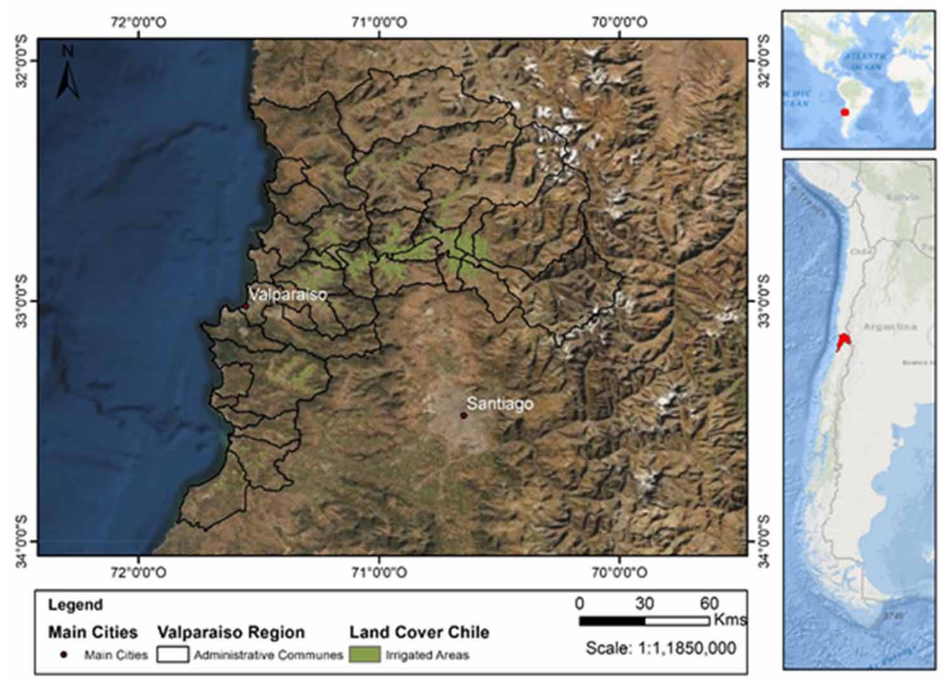
## METHODOLOGY

The main objective of the proposed methodology is the rapid identification of plastic greenhouses from free access images (Landsat 8) at a medium resolution in rural areas with a reproducible methodology. This consists of the following steps: selection of the images, selection of an area, generation of the indices, determination of the threshold, post-processing, and evaluation of the result.

### Image Selection

In this study, Landsat 8 images were used through Google Earth Engine (GEE) developed by Gorelick et al., (2017) accessed at https://earthengine.google.com/. The images were preprocessed with a butt-adjusted correction of the atmosphere (TOA) using the parameters of Chander et al., (2009). The criteria for the selection of images were, a maximum of 10% cloudiness, a high score in the Landsat quality parameter, and that all the images had been obtained between January and April 2020. In Table 1 the images are actually presented used at work, and an average cloud cover on the ground of 2.01% can be observed. All images were obtained between January 3 and April 15. In addition, the selected images have a 9 in the image quality criteria and were obtained with the OLI-TIRS sensor.

*Figure 1. Study Area: Chilean Land cover was developed by Zhao et al., (2016). In this map, the irrigated areas correspond to crop fields categories (from 100 to 150).*
*Source: Authors*




## Spectral Signatures of Plastic Greenhouses

To identify the elements, through indices, the first step is to know their spectral signature with the selected images (Landsat 8), which is presented in Figure 2. This figure also includes irrigated areas and bare soil., since they are the closest categories to where the plastic greenhouses are located. It is observed that greenhouses have a higher value in the visible spectrum while in the NIR band [0.85 - 0.88 μm] the irrigated areas present a higher value.

## Normalized Indices to Identify PGs

From the previous analysis, five spatial indices have been selected, which are simple and quick to apply and have been previously validated to evaluate the presence of greenhouses. The main objective is to use the normalized differences, to find the objective elements and reduce the noise generated by the elements that share wavelengths. All five indices are used simultaneously, then binary reclassified and multiplied by each other.

The first index (Equation 1) refers to the Modified Soil Adjusted Vegetation Index - 2 (MSAVI2) that was described by Qi et al., (1994). This index is developed from the Soil-adjusted vegetation index (SAVI, Huete, 1988) to solve the disadvantage of the R and L parameters that were arbitrarily assigned (Qi et al., 1994). In this work, this index is used to search for PGs due to the high values in the visible bands (RGB channels).

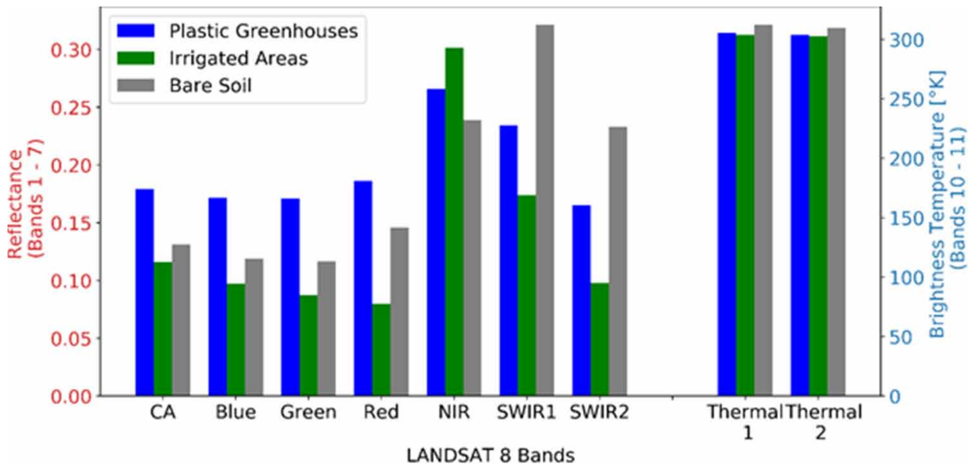
*Table 1. Metadata information about images used in this study. These images and their data were obtained through Google Earth Engine. Cloud Cover refers to the percent of cloud over the full image calculated by CFMASK (Foga et al., 2017). Cloud Cover Land is the percent of cloud cover only over land pixels in the Scene.*

| LANDSAT SCENE ID | DATE ACQUIRED | CLOUD COVER [%] | CLOUD COVER LAND [%] |
|---|---|---|---|
| LC80010822020049LGN00 | 18-02-2020 | 0.01 | 0.03 |
| LC80010822020097LGN00 | 06-04-2020 | 0.02 | 0.05 |
| LC80010832020049LGN00 | 18-02-2020 | 0.01 | 0.03 |
| LC80010832020097LGN00 | 06-04-2020 | 0.01 | 0.05 |
| LC80010842020033LGN00 | 02-02-2020 | 0.3 | 0.55 |
| LC80010842020049LGN00 | 18-02-2020 | 0.01 | 0.02 |
| LC80010842020097LGN00 | 06-04-2020 | 0 | 0.02 |
| LC82320832020003LGN00 | 03-01-2020 | 8.59 | 8.59 |
| LC82320832020035LGN00 | 04-02-2020 | 3.92 | 3.92 |
| LC82320832020067LGN00 | 07-03-2020 | 0.49 | 0.49 |
| LC82320832020083LGN00 | 23-03-2020 | 0.14 | 0.14 |
| LC82320832020099LGN00 | 08-04-2020 | 3.68 | 3.68 |
| LC82330822020010LGN00 | 10-01-2020 | 0.14 | 0.14 |
| LC82330822020026LGN00 | 26-01-2020 | 2.65 | 2.66 |
| LC82330822020042LGN00 | 11-02-2020 | 6.66 | 6.53 |
| LC82330822020058LGN00 | 27-02-2020 | 2.34 | 2.18 |
| LC82330822020074LGN00 | 14-03-2020 | 2.86 | 2.7 |
| LC82330822020090LGN00 | 30-03-2020 | 6.42 | 6.27 |
| LC82330822020106LGN00 | 15-04-2020 | 4.72 | 4.72 |
| LC82330832020010LGN00 | 10-01-2020 | 0.21 | 0.22 |
| LC82330832020026LGN00 | 26-01-2020 | 0.4 | 0.42 |
| LC82330832020074LGN00 | 14-03-2020 | 2.75 | 0.99 |
| LC82330832020106LGN00 | 15-04-2020 | 6.38 | 6.17 |
| LC82330842020010LGN00 | 10-01-2020 | 0.36 | 0.38 |
| LC82330842020026LGN00 | 26-01-2020 | 0.76 | 0.78 |
| LC82330842020058LGN00 | 27-02-2020 | 5.49 | 3.17 |
| LC82330842020074LGN00 | 14-03-2020 | 0.99 | 1.03 |
| LC82330842020090LGN00 | 30-03-2020 | 0.45 | 0.47 |

Source: Authors

$$MSAVI2 = \frac{(2*NIR+1-\sqrt{(2*NIR+1)^2 - 8*(NIR-RED)}}{2}. \quad (1)$$

*Figure 2. Spectral profile of Plastic Greenhouses (PGs), Irrigated Areas and Bare Soil over Valparaiso. Based on more than 70 elements for each type. The scale on the left is for the seven bands while the scale on the right is for the right bands (Thermals). Images considered include TOA correction, the same used in the research.*
*Source: Authors*




The second index (Equation 2) refers to the gloss temperature index (TBRES, Novelli & Tarantino, 2015), which consists of standardization of the gloss temperature of band 10 [10.60 - 11.19 μm] and allows to identify of greenhouses by their temperature difference.

$$TBRES = \frac{T_b - T_{bmin}}{T_{bmax} - T_{bmin}}. \tag{2}$$

The third index (Equation 3) refers to the Normalized Difference Vegetation Index - Green (NDVI-G) developed by Gitelson et al., (1996). It is used to differentiate greenhouses from the surrounding vegetation since the latter is more sensitive to chlorophyll.

$$NDVI_{GREEN} = \frac{NIR - GREEN}{NIR + GREEN}. \tag{3}$$

The fourth index (Equation 4) refers to the normalized difference construction index (NDBI) that was developed by Zha et al., (2003) and implemented in the search for greenhouses by Yang et al., (2017). It is used to search for elements with high reflectance materials, such as greenhouses, without considering the effect of vegetation.

$$NDBI = \frac{SWIR1 - NIR}{SWIR1 + NIR}. \tag{4}$$

The fifth index (Equation 5) refers to the Plastic Surface Index (PSI) developed by Novelli & Tarantino, (2015) for the detection of greenhouses. It is used to detect greenhouses both by temperature difference (energy absorption) and by wavelength difference based on the RED and SWIR2 bands.

$$PSI = \frac{RED - \left(\frac{TBRES + SWIR2}{2}\right)}{RED + \left(\frac{TBRES + SWIR2}{2}\right)}. \quad (5)$$

## Reclassification Using Thresholds

Once the indices have been generated, they are reclassified following the values proposed in Table 2. These are based on the differentiation of more than 70 points distributed by the study area to identify the largest amount of area covered by greenhouses. These points, also used in section 4.1, have been reclassified into two categories of PGs and Non-PGs.

*Table 2. Threshold values for each index. Each index could have values from -1 to 1.*

| Index | MSAVI2 | TBRES | NDVI-G | NDBI | PSI |
|---|---|---|---|---|---|
| Upper Threshold | 0.1 | 0.6 | 0.15 | -1 | -0.55 |
| Lower Threshold | 1 | 0.75 | 0.3 | 0.005 | 0.05 |

Source: Authors

## Post-Processing

The last stage corresponds to the application of two raster masks to exclude certain zones. The first is to exclude areas with a slope greater than 8% or 3.6 ° (Perilla & Mas, 2019) since greenhouses cannot be established at that slope. This was done on the Google Earth Engine using the corrected images from Shuttle Radar Topography Mission (SRTM) version 4, available at 90m resolution. The second was used to exclude urban areas since the objective of the work is advocated in rural areas. Aguilar et al., (2014) comment on the difficulties of correctly identifying greenhouses near urban areas given the high reflectivity of roofs. Given this, Perilla & Mas (2019) generated a layer based on Visible Infrared Imaging Radiometer Suite (VIIRS) images, following a methodology that I consider the light difference between urban and rural areas. In this study, the Cadastral and Updating of Vegetation Resources and Land Use layer developed by the National Forestry Corporation (CONAF) and published by the Ministry of Agriculture (CONAF, 2013) was used. This resource has a resolution of 1: 50000, is in vector format and is locally validated.

*Table 3. Confusion matrix of Plastic Greenhouses (PGs) and other elements reclassified as Non-Plastic Greenhouses or Non-Pgs*

| | | Predicted | | |
|---|---|---|---|---|
| | | **Non-PGs** | **PGs** | **Total** |
| Observed | Non-PGs | 108 | 0 | 108 |
| | PGs | 29 | 74 | 103 |
| | Total | 137 | 74 | 211 |

Source: Authors

## Product Evaluation

To determine the quality of the final product, two processes are considered, a quantitative and a qualitative evaluation (Chuvieco, 1995; Congalton, 2001; Jones & Vaughan, 2010). First, a confusion matrix is generated with which the general precision (Chuvieco, 1995; Jones & Vaughan, 2010) and the kappa coefficient (Jones & Vaughan, 2010) are calculated. The latter is a measure of the quality of the classification against a null hypothesis of a random classification and has a range from 0 to 1, where zero is that a random classification is preferable and 1 that is a result equal to the observed data. For this calculation, more than 200 points of different categories such as roads, reservoirs, irrigation areas, native vegetation areas, and rural areas are considered that are reclassified as non-greenhouses (Non-PGs), while more than 70 greenhouses of plastic are classified as PGs.

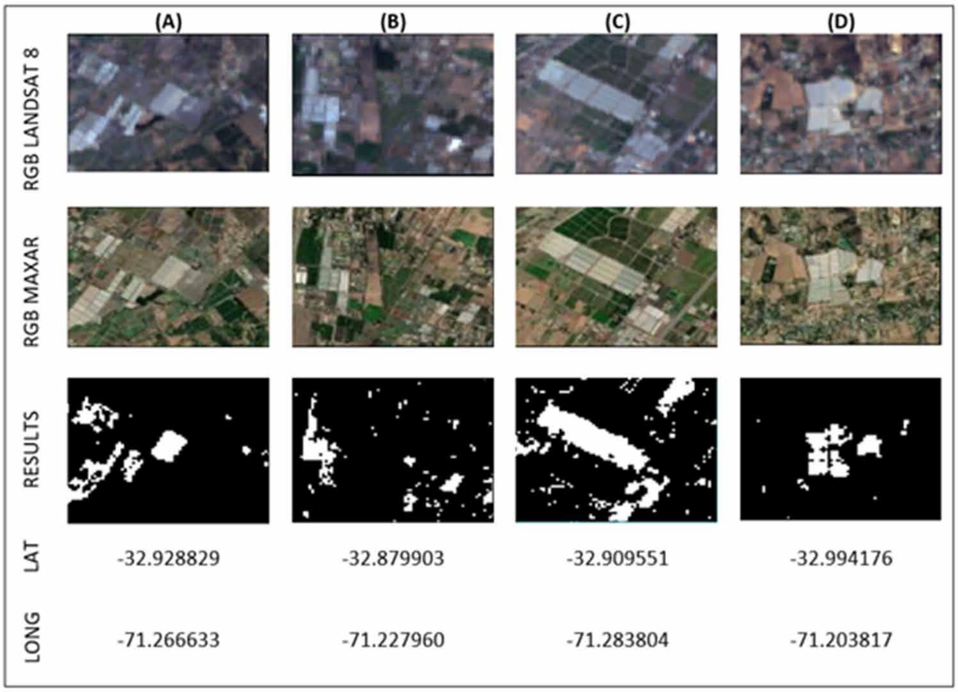
Second, two qualitative / visual comparisons are made. The first with a false color (RGB) composition of Landsat 8 using the same cloud-free base with which the indices were generated. The second with an image with a high resolution image (0.46m) and an accuracy of 10.16m obtained on August 4, 2019, available in ArcGIS as a base map (Courtesy of Maxar and others).

## RESULTS

The final image has a general precision of 86.25% and a kappa coefficient of 0.862, which has allowed us to classify 1409.85 hectares covered by greenhouses in 2020 according to what is presented in the confusion matrix (Table 3). Greenhouses are especially concentrated in the interior valleys such as Quillota, Limache, La Ligua, or Hijuelas, while in the coastal and mountain areas a smaller number is observed.

Figure 3 presents the qualitative/visual comparison of the results. In the upper row, an RGB composition of the same resolution (30m) is presented while the center row presents the same composition with high-resolution images (0.46m). Comparing both images, correct identification of the area covered by PGs is observed. Boxes a and b focus on smaller greenhouses while boxes c and d show larger greenhouses. In the four boxes, the nearby elements are croplands, fallow areas, and areas of natural vegetation.

*Figure 3. Comparison between a false RGB color and resulted image. The first row is a Landsat 8 (cell size of 30m) composition and the central row a Maxar imagery (cell size of 0.46m). The white color depicts the classified greenhouse surface. The coordinates refer to the central point of the image. All the images were obtained at a scale of 1:70,000.*
*Source: Authors*




## DISCUSSION

The discussion is organized based on five analyses, such as quality evaluation, consideration of scale problems, observation of the spatial arrangement of greenhouses, comparison with other studies at the regional level, and advantages and applications of this methodology.

The result of the area covered by greenhouses has a general precision of 86.25%, which is above the average of studies on a regional scale (82.9 ± 13.4, average ± standard deviation) according to the compilation of Morales-Barquero et al., (2019). Table 4 presents the values of different greenhouse identification studies carried out with the pixel-based approach and using medium resolution images where it can be observed that the present study has an acceptable general precision. In the same table, the kappa coefficients are presented and it is observed that the value of this study is close to the average (0.87 ± 0.05) and is also considered acceptable for decision-making, planning, or modeling process (Congalton, 2001).

The identification of greenhouses implies considering a scale problem called border errors (Chuvieco, 1995), which refers to the fact that the object to be identified may have a smaller area than the satellite cell. The present study uses Landsat 8 images with a resolution of 30 m, that is, an area of 900 m2 per cell, however, if greenhouses of smaller areas are presented, the pixel will deliver a mixed signal, which could generate identification problems. This same resolution is shared by other similar studies such as

*Table 4. Comparison of other greenhouse identification studies using pixel-based approach and medium-resolution imagery*

| Study | Year Imagery | Resolution [m] | Imagery | Overall Accuracy [%] | Kappa coefficient |
|---|---|---|---|---|---|
| This Study | 2020 | 30 | Landsat 8 | 86.25 | 0.86 |
| Perilla & Mas, 2019 | 2017/2018 | 10 | Sentinel 2 | 96.64 | |
| Yang et al., 2017 | 2015 | 30 | Landsat 8 | 91.84 | 0.83 |
| | 2012 | 30 | Landsat 5 | 94.15 | 0.85 |
| Lu et al., 2014 | 2011 | 30 | Landsat 5 | 97.82 | 0.97 |
| | 2007 | 30 | Landsat 5 | 85.27 | 0.80 |
| | 1998 | 30 | Landsat 5 | 95.00 | 0.93 |

Source: Table made by authors. With information from Perilla & Mas (2019), Yang et al., 2017 and Lu et al., 2014.

Lu et al., (2014) and Yang et al., (2017) while Perilla & Mas (2019) uses a 10m resolution that is also considered medium resolution. In this work, one of the ways to correct this is through the NDBI index since it allows to distinguish with nearby crops since the index accounts for the reflectivity of what has been built. Other authors have used high-resolution images (<10m) to deliver results such as Carvajal et al., (2006) and Agüera et al., (2008) who used Quickbird © images or González-Yebra et al., (2018) that I include better resolution orthophotos. The advantage of medium resolution images is that their low cost, which allows the reproducibility of the study on an annual basis (Lu et al., 2014) or the identification of greenhouses at larger spatial scales (Perilla & Mas, 2019).

The spatial arrangement of the roof types must be taken into account (Chuvieco, 1995), referring to the problems when identifying elements in mixed environments. The rural area of Valparaíso includes small towns, agricultural areas, roads of different materialities, reservoirs, areas of native vegetation, areas without vegetation, and industrial areas, so distinguishing greenhouses implies differentiating them from all the elements already mentioned. The quality of this discrimination can be observed in Figure 3, where the behavior of the product is observed based on two images of different resolutions (30 and 0.46 m). In both, the result is considered acceptable since it is possible to discriminate the greenhouses with nearby hedges such as crops, bare soil, or areas with water. It is important to highlight that this work, together with Novelli & Tarantino (2015) or Perilla & Mas (2019), has been validated in rural areas, given the problems to distinguish urban areas due to the high reflectivity of their roofs or roads. This is considered a gap in the identification of areas covered by greenhouses at the regional level.

Other studies also report the number of greenhouses for the Valparaíso region. First, the agricultural censuses that provide information at the district level, the sum of which was 1121.88 ha in 1997 and 1180.00 ha in 2007 at the regional level (INE, 1997; 2009, Apey et al., 2009). This latest census is over 13 years old and there is no more up-to-date one. For the year 2020, the present study calculated a value of 1409.85 ha, which represents an increase of 229.85 ha (19.5%). Both studies present the same spatial patterns, a higher concentration of greenhouses in interior valleys such as Quillota, Limache, La Ligua and Hijuelas, while a lower number in coastal areas more associated with urban and industrial development. The eastern zone also has a smaller covered area due to its steeper slopes and smaller population.

One of the reasons to justify the increase in the interior valleys is the delivery of more than 900 subsidies for the direct construction of greenhouses in the region considering a value of 1,671,494 USD

*Table 5. Number of projects that have received subsidies from the government in the Valparaíso region by year.*

| Year | Number of Projects | Percentage of total |
|---|---|---|
| 2013 | 170 | 16.1% |
| 2014 | 172 | 17.3% |
| 2015 | 170 | 16.5% |
| 2016 | 185 | 20.0% |
| 2017 | 98 | 11.0% |
| 2018 | 80 | 8.3% |
| 2019 | 92 | 9.7% |
| 2020 | 11 | 1.2% |
| Total | 978 | 100.0% |

Source: Data obtained from ODEPA (2020). The information was obtained on July 21, 2020, which explains the lower value of the last year.

(1,204,645,647 CLP) through local development programs such as PRODESAL, or the INDAP PDI investment development program (ODEPA, 2020). In the aforementioned areas, these projects account for 50.7% of all projects at the regional level. Table 4 shows the number of projects on an annual basis.

The national land cover study developed by Zhao et al., (2016) presents a category of greenhouses (ID: 120). This was developed mainly from Landsat 8 images, obtained during 2013 and 2014, and to support MODIS images, high-resolution tiles provided by Google Earth, and a DEM from Shuttle Radar Topography Mission (SRTM). The product was developed with the Random Forest classifier, has a national resolution of 30m, and with an accuracy of 80% in the first thickest level, and 73% in the second finest. The authors reported for the Valparaíso region 37.8 ha covered with greenhouses for the study period, a value that is not consistent with the previous agricultural census of 2007 that reports a value of 1180 ha. The differences between what is presented in this study and that of Zhao et al., (2016) are visible both at a gross level and in detail since they do not represent well the areas with the greatest development of these infrastructures such as Quillota, Limache, or La Ligua.

One of the advantages of this method, compared to the other studies, is that it allows obtaining the updated area at a lower cost, compared to an agricultural census, with high precision and with a reproducible methodology that can be automated to repeat annually and observe year-to-year variations.

This method generates inputs to be used in food security and water management plans, considering that the areas with greenhouses have a different albedo and the crops in greenhouses have lower water requirements. According to Antunez & Felmer (2017) in tomato crops, drip irrigation requires 5,000 m3 / ha (90% efficiency), furrow irrigation requires 10,000 m3 / ha (45% efficiency) while greenhouses require 1/3 of the water used outdoors, that is, it is much more efficient.

Future research opportunities involve changes in the temporal and spatial scale. On the one hand, the annual growth of greenhouses can be considered to see years of higher growth while at a spatial level, or a map can be made at the national level of greenhouses distinguishing other valleys of interest such as Azapa, Elqui, or Choapa (Allende et al., 2017; INE, 2009).

## CONCLUSION

In conclusion, free access Landsat 8 images were used in Google Earth Engine to implement a series of normalized difference indices, which were then classified and post-processed with the use of masks (high-slope or urban areas). The result presents a general precision of 86.25% and a kappa index of 0.862 which allowed to successfully classify 1409.85 ha. This calculation is consistent with the previous agricultural census, considering that more than 13 years have passed, and more than 900 projects have been subsidized. The methodology allowed to successfully exclude urban areas, streets, hydraulic infrastructure such as dams or reservoirs and to successfully identify the area covered by greenhouses in the region.

This work presents a methodology that can be used both to make a historical reconstruction of the area covered by greenhouses, or to make an estimate at the national level. Both products are useful in models of food security and water management since crops under greenhouses have other water requirements and other irrigation security. Additionally, new research opportunities are opened related to greenhouses in urban areas or the analysis of temporal changes.

## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

## ACKNOWLEDGMENT

Thanks to NASA for the free availability of the Landsat and SRTM images. Thanks also to Maxar and ESRI, Digital Globe, GeoEye, Earthstar Geographics, CNES / Airbus DS, USDA, USGS, AeroGRID, IGN and the GIS User Community for the high resolution image. Finally, thanks to the Google Earth Engine developer team for making massive tools like that freely available.

## REFERENCES

Agüera, F., Aguilar, F. J., & Aguilar, M. A. (2008). Using texture analysis to improve per-pixel classification of very high resolution images for mapping plastic greenhouses. *ISPRS Journal of Photogrammetry and Remote Sensing*, *63*(6), 635–646. doi:10.1016/j.isprsjprs.2008.03.003

Aguilar, M. A., Bianconi, F., Aguilar, F. J., & Fernández, I. (2014). Object-based greenhouse classification from GeoEye-1 and WorldView-2 stereo imagery. *Remote Sensing*, *6*(5), 3554–3582. doi:10.3390/rs6053554

Aguilar, M. A., Vallario, A., Aguilar, F. J., Lorca, A. G., & Parente, C. (2015). Object-based greenhouse horticultural crop identification from multi-temporal satellite imagery: A case study in Almeria, Spain. *Remote Sensing*, *7*(6), 7378–7401. doi:10.3390/rs70607378

Allende, C. M., Salinas, P. L., Olivares, P. N., Riquelme, S. J., Antúnez, B. A., Martinez, C., J. P., … Felmer, E. S. (2017). *Manual de cultivo de tomate en invernadero*. Academic Press.

Antunez, A., & Felmer, S. (2017). Manejo del riego en tomate. In A. Torres (Ed.), *Manual de cultivo del tomate bajo invernadero* (pp. 66–79). Available at https://www.indap.gob.cl/docs/default-source/default-document-library/manual-de-tomate-invernadero.pdf?sfvrsn=0

Apey, A., Gumucio, A., & Tapia, B. (2009). Variaciones en el uso del suelo agropecuario y forestal chileno: comparación de los censos agropecuarios de 1976, 1997 y 2007. *Agricultura en Cifras*. Available at https://www.odepa.gob.cl/odepaweb/publicaciones/Agrocifras/Agricultura_en_cifras_001.pdf

Carvajal, F., Crisanto, E., Aguilar, F. J., Aguera, F., & Aguilar, M. A. (2006). Greenhouses Detection Using an Artificial Neural Network With a Very High Resolution Satellite Image. *ISPRS Technical Commission II Symposium*, 12–14.

Chander, G., Markham, B. L., & Helder, D. L. (2009). Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. *Remote Sensing of Environment*, *113*(5), 893–903. doi:10.1016/j.rse.2009.01.007

Chonchol, J. (1994). *Sistemas agrarios en América Latina : de la etapa prehispánica a la modernización conservadora*. Fondo de Cultura Económica.

Chuvieco, E. (1995). *Fundamentos de teledetection espacial*. Ediciones RIAL.

CONAF. (2013). *Catastro y Actualización de los Recursos Vegetacionales y Uso de la Tierra*. Available at: https://ide.minagri.gob.cl/geoweb/2019/11/22/planificacion-catastral/

Congalton, R. G. (2001). Accuracy assessment and validation of remotely sensed and other spatial information. *International Journal of Wildland Fire*, *10*(3–4), 321–328. doi:10.1071/WF01031

DGA. (2017). *Estimación de la demanda actual, proyecciones futuras y caracterización de la calidad de los recursos hídricos en Chile*. DGA.

Foga, S., Scaramuzza, P. L., Guo, S., Zhu, Z., Dilley, R. D. Jr, Beckmann, T., Schmidt, G. L., Dwyer, J. L., Joseph Hughes, M., & Laue, B. (2017). Cloud detection algorithm comparison and validation for operational Landsat data products. *Remote Sensing of Environment*, *194*, 379–390. doi:10.1016/j.rse.2017.03.026

Gitelson, A. A., Kaufman, Y. J., & Merzlyak, M. N. (1996). Use of a green channel in remote sensing of global vegetation from EOS- MODIS. *Remote Sensing of Environment*, *58*(3), 289–298. doi:10.1016/S0034-4257(96)00072-7

González-Yebra, Ó., Aguilar, M. A., Nemmaoui, A., & Aguilar, F. J. (2018). Methodological proposal to assess plastic greenhouses land cover change from the combination of archival aerial orthoimages and Landsat data. *Biosystems Engineering*, *175*, 36–51. doi:10.1016/j.biosystemseng.2018.08.009

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. doi:10.1016/j.rse.2017.06.031

Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, *25*(3), 295–309. doi:10.1016/0034-4257(88)90106-X

INE. (1997). *VI Censo Nacional Agropecuario: Principales Resultados*. Available at: http://biblioteca-digital.ciren.cl/handle/123456789/14039

INE. (2009). *VII Censo Nacional Agropecuario: Principales Resultados*. Available at: https://www.ine.cl/estadisticas/economia/agricultura-agroindustria-y-pesca/censos-agropecuarios

Jiménez-Lao, R., Aguilar, F. J., Nemmaoui, A., & Aguilar, M. A. (2020). Remote sensing of agricultural greenhouses and plastic-mulched farmland: An analysis of worldwide research. *Remote Sensing*, *12*(16), 1–20. doi:10.3390/rs12162649

Jones, H. G., & Vaughan, R. (2010). *Remote sensing of vegetation : principles, techniques, and applications*. Oxford University Press.

Lamalice, A., Haillot, D., Lamontagne, M. A., Herrmann, T. M., Gibout, S., Blangy, S., Martin, J.-L., Coxam, V., Arsenault, J., Munro, L., & Courchesne, F. (2018). Building Food Security in the Canadian Arctic through the Development of Sustainable Community Greenhouses and Gardening. *Ecoscience*, *25*(4), 325–341. doi:10.1080/11956860.2018.1493260

Lu, L., Di, L., & Ye, Y. (2014). A decision-tree classifier for extracting transparent plastic-mulched Landcover from landsat-5 TM images. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *7*(11), 4548–4558. doi:10.1109/JSTARS.2014.2327226

Morales-Barquero, L., Lyons, M. B., Phinn, S. R., & Roelfsema, C. M. (2019). Trends in remote sensing accuracy assessment approaches in the context of natural resources. *Remote Sensing*, *11*(19), 1–16. doi:10.3390/rs11192305

Novelli, A., & Tarantino, E. (2015). Combining ad hoc spectral indices based on LANDSAT-8 OLI/TIRS sensor data for the detection of plastic cover vineyard. *Remote Sensing Letters*, *6*(12), 933–941. doi:10.1080/2150704X.2015.1093186

ODEPA. (2020). *Solicitud Transparencia AR004T0001934 y AR004T0001935*. ODEPA.

Oficina de Estudios y Políticas Agrarias (ODEPA) del Ministerio de Agricultura. (2019). Panorama de la agricultura Chilena [Chilean agriculture overview]. ODEPA.

Perilla, G. A., & Mas, J. F. (2019). High-resolution mapping of protected agriculture in Mexico, through remote sensing data cloud geoprocessing. *European Journal of Remote Sensing*, *52*(1), 532–541. doi:10.1080/22797254.2019.1686430

Picuno, P., Tortora, A., & Capobianco, R. L. (2011). Analysis of plasticulture landscapes in Southern Italy through remote sensing and solid modelling techniques. *Landscape and Urban Planning*, *100*(1–2), 45–56. doi:10.1016/j.landurbplan.2010.11.008

Qi, J., Chehbouni, A., Huete, A. R., Kerr, Y. H., & Sorooshian, S. (1994). A modify soil adjust vegetation index. *Remote Sensing of Environment*, *126*(2), 119–126. doi:10.1016/0034-4257(94)90134-1

Sarricolea, P., Herrera-Ossandon, M., & Meseguer-Ruiz, Ó. (2017). Climatic regionalisation of continental Chile. *Journal of Maps*, *13*(2), 66–73. doi:10.1080/17445647.2016.1259592

Sonmez, N. K., & Koc-San, D. (2016). Plastic and glass greenhouses detection and delineation from WorldView-2 satellite imagery. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, 41*(July), 257–262. doi:10.5194/isprsarchives-XLI-B7-257-2016

Tarantino, E., & Figorito, B. (2012). Mapping Rural Areas with Widespread Plastic Covered Vineyards Using True Color Aerial Data. *Remote Sensing*, *4*(7), 1913–1928. doi:10.3390/rs4071913

Wu, C. F., Deng, J. S., Wang, K., Ma, L. G., & Tahmassebi, A. R. S. (2016). Object-based classification approach for greenhouse mapping using Landsat-8 imagery. *International Journal of Agricultural and Biological Engineering*, *9*(1), 79–88. doi:10.3965/j.ijabe.20160901.1414

Yañez, L. (2018). Región de Valparaíso: Información Regional 2018. *Oficina de Estudios y Politicas Agrarías*, 3–15. Available at: https://www.odepa.gob.cl/wp-content/uploads/2018/03/Valparaiso.pdf

Yañez, L. (2019). *Región de Valparaíso: Información Regional 2019*. Available at: https://www.odepa.gob.cl/wp-content/uploads/2019/07/Valparaiso.pdf

Yang, D., Chen, J., Zhou, Y., Chen, X., Chen, X., & Cao, X. (2017). Mapping plastic greenhouse with medium spatial resolution satellite data: Development of a new spectral index. *ISPRS Journal of Photogrammetry and Remote Sensing*, *128*(December), 47–60. doi:10.1016/j.isprsjprs.2017.03.002

Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. *International Journal of Remote Sensing*, *24*(3), 583–594. doi:10.1080/01431160304987

Zhao, Y., Feng, D., Yu, L., Wang, X., Chen, Y., Bai, Y., Hernández, H. J., Galleguillos, M., Estades, C., Biging, G. S., Radke, J. D., & Gong, P. (2016). Detailed dynamic land cover mapping of Chile: Accuracy improvement by integrating multi-temporal data. *Remote Sensing of Environment*, *183*, 170–185. doi:10.1016/j.rse.2016.05.016

# Compilation of References


Aaker, D. A., & Biel, A. (2013). *Brand equity & advertising: Advertising's role in building strong brands*. Psychology Press. doi:10.4324/9781315799537

Abbott, K. (2015). *International Organizations as Orchestrators*. Cambridge University Press.

Abd El-Kawy, O. R., Rød, J. K., Ismail, H. A., & Suliman, A. S. (2011). Land use and land cover change detection in the western Nile delta of Egypt using remote sensing data. *Applied Geography (Sevenoaks, England)*, *31*(2), 483–494. doi:10.1016/j.apgeog.2010.10.012

Abdullah, M. (2020 October 3). *How climate change is undermining peace and security in Nigeria.* HumAngle Media. https://humangle.ng/how-climate-change-is-undermining-peace-and-security-in-nigeria/#

Abessa, D., Famá, A., & Buruaem, L. (2019). The systematic dismantling of Brazilian environmental laws risks losses on all fronts. *Nature Ecology & Evolution*, *3*(4), 510–511. doi:10.103841559-019-0855-9 PMID:30886371

Abid, A., & Radoykov, B. (2003). *Access and preservation in the information society*. Blackwell.

Abramovay, R. (2007). Bem-vindo ao mundo da controvérsia. In J. E. Veiga (Ed.), *Trangênicos sementes da discórdia*. SENAC.

Abranja, N. (2017). O empreendedorismo como base do turismo sustentável: Proposta de modelo conceptual. *Observatório de Inovação do Turismo*, *9*(2). Advance online publication. doi:10.17648/raoit.v11n2.4464

Acaravci, A., & Bostan, F. (2011). Makroekonomik değişkenlerin doğrudan yabancı yatırımlar üzerine etkileri: Türkiye ekonomisi için ampirik bir çalışma. *Çağ Üniversitesi Sosyal Bilimler Dergisi*, *8*(2), 56-68.

Acciona. (n.d.). *Ranking of countries with the highest water stress*. https://www.activesustainability.com/water/ranking-countries-highest-water-stress/

Ackerman, F., & Heinzerling, L. (2002). Pricing the Priceless: Cost-Benefit Analysis of Environmental Protection. *University of Pennsylvania Law Review*, *150*(5), 1553. doi:10.2307/3312947

Adedoyin, F. F., Nathaniel, S., & Adeleye, N. (2020). An investigation into the anthropogenic nexus among consumption of energy, tourism, and economic growth: Do economic policy uncertainties matter? *Environmental Science and Pollution Research International*, *28*(3), 2835–2847. doi:10.100711356-020-10638-x PMID:32895794

Adger, W. N. (2000). Social and ecological resilience: Are they related? *Progress in Human Geography*, *24*(3), 347–364. doi:10.1191/030913200701540465

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281. doi:10.1016/j.gloenvcha.2006.02.006

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockstrom, J. (2005). Social– ecological resilience to coastal disasters. *Science*, *309*(5737), 1036–1039. doi:10.1126cience.1112122 PMID:16099974

Adhikari, K., & Hartemink, A. E. (2016). Linking soils to ecosystem services—A global review. *Geoderma*, *262*, 101–111. doi:10.1016/j.geoderma.2015.08.009

Adhya,, A., Plowright,, P., & Stevens,, J. (2011) Defining sustainable urbanism: towards a responsive urban design. In *Proceedings of the conference on sustainability and the built environment*. King Saud University.

AENOR. (2016). *Sistema de gestión de los destinos turísticos inteligentes*. Requisitos. Norma espanhola UNE 178501 elaborada pelo comité técnico AEN/CTN 178 - Cidades Inteligentes.

AENOR. (2018). Sistema de gestión de los destinos turísticos inteligentes. Requisitos. *Norma UNE*, *178501*, 2018.

Agan, Y., Acar, M. F., & Borodin, A. (2013). Drivers of environmental processes and their impact on performance: A study of Turkish SMEs. *Journal of Cleaner Production*, *51*, 23–33. doi:10.1016/j.jclepro.2012.12.043

Agarwal, V. K. (2005). Environmental laws in India: Challenges for enforcement. *Bulletin of the National Institute of Ecology*, *15*, 227–238.

Agudo, M. (2014). El teletrabajo en las organizaciones: Análisis de sus beneficios y barreras en las empresas españolas. *Cuadernos de Gestión de Información*, *4*(4), 172–187.

Agüera, F., Aguilar, F. J., & Aguilar, M. A. (2008). Using texture analysis to improve per-pixel classification of very high resolution images for mapping plastic greenhouses. *ISPRS Journal of Photogrammetry and Remote Sensing*, *63*(6), 635–646. doi:10.1016/j.isprsjprs.2008.03.003

Aguilar, M. A., Bianconi, F., Aguilar, F. J., & Fernández, I. (2014). Object-based greenhouse classification from Geo-Eye-1 and WorldView-2 stereo imagery. *Remote Sensing*, *6*(5), 3554–3582. doi:10.3390/rs6053554

Aguilar, M. A., Vallario, A., Aguilar, F. J., Lorca, A. G., & Parente, C. (2015). Object-based greenhouse horticultural crop identification from multi-temporal satellite imagery: A case study in Almeria, Spain. *Remote Sensing*, *7*(6), 7378–7401. doi:10.3390/rs70607378

Aguilera, G., Galan, J. L., Campos, J. C., & Rodríguez, P. (2013). *An Accelerated-Time Simulation for Traffic Flow in a Smart City*. FEMTEC. 4th Itern. Congress on Computational Engineering and Sciences, Las Vegas, NV.

Aguilera, R. V., & Cuervo-Cazurra, A. (2004). Codes of good governance worldwide: What is the trigger? *Organization Studies*, *25*(3), 415–443. doi:10.1177/0170840604040669

Ah Kit, J. (2003). Building Stronger Regions—Stronger Futures Strategy, Minister for Community Stronger Futures Strategy. Minister for Community Stronger Futures Strategy Development, Sports, Culture and Arts, Northern Territory Government, Darwin.

Akay, E. Ç., Abdieva, R., & Oskonbaeva, Z. (2015). Yenilenebilir enerji tüketimi, iktisadi büyüme ve karbondioksit emisyonu arasındaki nedensel ilişki: Orta Doğu ve Kuzey Afrika ülkeleri örneği. In *International Conference on Eurasian Economies. Çevre ve Enerji* (pp. 628-636). Academic Press.

Akella, A. S., & Cannon, J. B. (2017). *Strengthening the weakest links: strategies for improving the enforcement of environmental laws globally*. Routledge. doi:10.4324/9781315084589-28

Akers, J. (2013). Making markets: Think tank legislation and private property in Detroit. *Urban Geography*, *34*(8), 1070–1095. doi:10.1080/02723638.2013.814272

Akiner, S. (2000). *Central Asia: A survey of the region and the five republics*. United Nations High Commissioner for Refugees.

Aktas, C. B., & Bilec, M. M. (2012). Service life prediction of residential interior finishes for life cycle assessment. *The International Journal of Life Cycle Assessment*, *17*(3), 362–371. doi:10.100711367-011-0367-6

Al Nuaimi, E., Al Neyadi, H., Mohamed, N., & Al-Jaroodi, J. (2015). Applications of big data to smart cities. *Journal of Internet Services and Applications*, *6*(25), 1–15. doi:10.118613174-015-0041-5

Alavi, A. H., Jiao, P., Buttlar, W. G., & Lajnef, N. (2018). Internet of Things-enabled smart cities: State-of-the-art and future trends. *Measurement*, *129*, 589–606. doi:10.1016/j.measurement.2018.07.067

Alberti, M., & Marzluff, J. (2004). Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions. *Urban Ecosystems*, *7*(7), 241–265. doi:10.1023/B:UECO.0000044038.90173.c6

Albraheem, L., & Alabdulkarim, L. (2021). Geospatial Analysis of Solar Energy in Riyadh Using a GIS-AHP-Based Technique. *ISPRS International Journal of Geo-Information, 10*(5), 291. doi:10.3390/ijgi10050291

Aldawood, H., & Skinner, G. (2018). Educating and Raising Awareness on Cyber Security Social Engineering: A literature Review. *IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*.

Aldhous, A. C. (1989). *An investigation of the polarisation dependence of insect radar cross sections at constant aspect* (PhD Thesis). Ecological Physics Research Group.

Alemu, J. B., Richards, D. R., Gaw, L. Y. F., Masoudi, M., Nathan, Y., & Friess, D. A. (2021). Identifying spatial patterns and interactions among multiple ecosystem services in an urban mangrove landscape. *Ecological Indicators*, *121*, 107042. doi:10.1016/j.ecolind.2020.107042

Alexander, S. (2012). Planned economic contraction: The emerging case for degrowth. *Environmental Politics*, *21*(3), 349–368. doi:10.1080/09644016.2012.671569

Alfasi, N., & Portugali, J. (2007). Planning rules for a self-planned city. *Planning Theory*, *6*(2), 164–182. doi:10.1177/1473095207077587

Ali, G., Abbas, S., Qamer, F. M., Wong, M. S., Rasul, G., Irteza, S. M., & Shahzad, N. (2021). Environmental impacts of shifts in energy, emissions, and urban heat island during the COVID-19 lockdown across Pakistan. *Journal of Cleaner Production*, *291*, 125806. doi:10.1016/j.jclepro.2021.125806

Alkhathlan, K., & Javid, M. (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. *Energy Policy*, *62*, 1525–1532. doi:10.1016/j.enpol.2013.07.068

Allan, C., & Curtis, A. (2005). Nipped in the bud: Why regional scale adaptive management is not blooming. *Environmental Management*, *36*(3), 414–425. doi:10.100700267-004-0244-1 PMID:16132442

Allan, C., Xia, J., & Pahl-Wostl, C. (2013). Climate change and water security: Challenges for adaptive management. *Current Opinion in Environmental Sustainability*, *5*(6), 625–632. doi:10.1016/j.cosust.2013.09.004

Allen,, C., & Clouth,, S. (2012). *A guidebook to the green economy*. UNDESA.

Allende, C. M., Salinas, P. L., Olivares, P. N., Riquelme, S. J., Antúnez, B. A., Martinez, C., J. P., … Felmer, E. S. (2017). *Manual de cultivo de tomate en invernadero*. Academic Press.

Allen, M. (2016). *Strategic communication for sustainable organisations: Theory and practice*. Springer. doi:10.1007/978-3-319-18005-2

Allouche, J. (2007, November). *The governance of Central Asian waters: national interests versus regional cooperation.* Disarmament Forum, Genova, Switzerland.

Almeida, C. A. B. (2011). História do Douro e do Vinho do Porto. Porto: Afrontamento.

Almenar, J. B., Elliot, T., Rugani, B., Philippe, B., Gutierrez, T. N., Sonnemann, G., & Geneletti, D. (2021). Nexus between nature-based solutions, ecosystem services and urban challenges. *Land Use Policy*, *100*, 104898. doi:10.1016/j.landusepol.2020.104898

Alqahtani, A. Y., & Rajkhan, A. A. (2020). E-Learning Critical Success Factors during the COVID-19 Pandemic: A Comprehensive Analysis of E-Learning Managerial Perspectives. *Education Sciences, 10*(9), 216. doi:10.3390/educsci10090216

Alshuwaikhat, H. M., & Abubakar, I. (2008). An integrated approach to achieving campus sustainability: Assessment of the current campus environmental management practices. *Journal of Cleaner Production*, *16*(16), 1777–1785. doi:10.1016/j.jclepro.2007.12.002

Alston, M. (2015). Social work, climate change and global cooperation. *International Social Work*, *58*(3), 355–363. doi:10.1177/0020872814556824

Álvarez, J., Zartha, J. W., & Orozco, G. L. (2019). Barriers to sustainability for small and medium enterprises in the framework of sustainable development- Literature Review. *Business Strategy and the Environment*, *28*(4), 512–524.

Alves Júnior, W. J. F. (2009). *Modelo de gestão compartilhada de bacias hidrográficas e hidrogeológicas: estudo de caso – Aquífero Guarani*. Tese de Doutorado, Universidade Estadual de Campinas.

Amado, M. (2009). Planeamento Urbano Sustentável. Academic Press.

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society, 9*(1), 18. http://www. ecologyandsociety.org/vol9/iss1/art18/

Anderson, J. (2005). Access and Control of Indigenous Knowledge in Libraries and Archives: Ownership and Future Use. In Correcting Course: Rebalancing Copyright for libraries in the National and International Arena. New York American Library Association and the MacArthur Foundation Columbia University.

Anderson, B. (1991). *Imagined Communities: Reflections on the Origin and Spread of Nationalism*. Verso.

Anderson, S., & Hart, G. (2016). Challenges in digitizing liberation archives: A case study. Innovation. *Journal of Appropriate Librarianship and Information Work in Southern Africa*, *53*, 21–38.

Andres, L., Boateng, K., Borja-Vega, C., & Thomas, E. (2018). A Review of In-Situ and Remote Sensing Technologies to Monitor Water and Sanitation Interventions. *Water, 10*(6), 756. doi:10.3390/w10060756

Anghel, B., Cozzolino, M., & Lacuesta, A. (2020). El teletrabajo en España. *Boletín Económico*, *2/2020*, 1–20.

Angulo, F. (2007). Emergencia por derrame de combustible en gasolinera. *Periódico La Nación*. Recuperado de https://www.nacion.com/sucesos/emergencia-por-derrame-de-combustible-en-gasolinera/HRSIYSGWPNFL3DEPMORMPFWYME/story/

Anishchenko, L., Bechtel, T., Ivashov, S., Alekhin, M., Tataraidze, A., & Vasiliev, I. (2016). Bioradiolocation as a technique for remote monitoring of vital signs. In *Advanced Ultrawideband Radar* (pp. 315–340). CRC Press.

ANMP. (2021). Available at https://www.anmp.pt/

Antikainen, M., & Valkokari, K. (2016). A framework for sustainable circular business model innovation. *Technology Innovation Management Review*, *6*(7), 5–12. doi:10.22215/timreview/1000

Antova, G. (2020). *Securing the smart cities of the future*. ITProportal. https://www.itproportal.com/features/securing-the-smart-cities-of-the-future/

Antunez, A., & Felmer, S. (2017). Manejo del riego en tomate. In A. Torres (Ed.), *Manual de cultivo del tomate bajo invernadero* (pp. 66–79). Available at https://www.indap.gob.cl/docs/default-source/default-document-library/manual-de-tomate-invernadero.pdf?sfvrsn=0

Anwar, B., Xiao, Z., Akter, S., & Rehman, R. (2017). Sustainable Urbanization and Development Goals Strategy through Public–Private Partnerships in a South-Asian Metropolis. *Sustainability*, *9*(11), 1940. Advance online publication. doi:10.3390u9111940

Anyanova, E. (2011). *Oil Pollution and International Marine Environmental Law*. Sustainable Development - Authoritative and Leading-Edge Content for Environmental Management. doi:10.5772/37399

Apaydin, Ş., & Tasdogan, C. (2019). Türkiye'de İktisadi Büyüme Ve Birincil Enerji Tüketiminin Karbon Salınımı Üzerindeki Etkisi: Yapısal Var Yaklaşımı. *Akademi Sosyal Bilimler Dergisi*, *6*(16), 19–35.

Apey, A., Gumucio, A., & Tapia, B. (2009). Variaciones en el uso del suelo agropecuario y forestal chileno: comparación de los censos agropecuarios de 1976, 1997 y 2007. *Agricultura en Cifras*. Available at https://www.odepa.gob.cl/odepaweb/publicaciones/Agrocifras/Agricultura_en_cifras_001.pdf

Appelrath, H. J., Kagermann, H., & Mayer, C. (Eds.). (2012). *Future Energy Grid-Migration to the Internet of Energy*. Acatech. doi:10.1007/978-3-642-27864-8

Arce, J. (2019). Estudio Situacional de la PYME en Costa Rica, Serie 2012-2017. [Informe] Dirección General de Apoyo a la Pequeña y Mediana Empresa. Costa Rica: Ministerio de Economía, Industria y Comercio.

Argenti, P. A., Howel, R. A., & Beck, K. A. (2005). The strategic communication imperative. *MIT Sloan Management Review*, *46*(3), 83–89.

Arias, B. (2021). *El Teletrabajo en la República Dominicana. Ventajas, desventajas y regulación*. Academic Press.

Armstrong, G., Adam, S., Denize, S., & Kotler, P. (2014). Principles of marketing (6th ed.). Melbourne: Pearson Australia.

Aronson, M., Christopher, L., Karl, E., Mark, G., Susannah, L., MacIvor, S., ... Vargo, T. (2017). Biodiversity in the city: Key challenges for urban green space management. *Frontiers in Ecology and the Environment*, *15*(4), 189–196. doi:10.1002/fee.1480

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B. O., Levin, S., Mäler, K. G., Perrings, C., & Pimentel, D. (1995). Economic growth, carrying capacity and the environment. *Science*, *268*(5210), 520–521. doi:10.1126cience.268.5210.520 PMID:17756719

Arsel, M. (2020, April 25). *Werkgroep, nieuws, Manifest Nederland na Corona*. https://www.voetafdruk.eu/nieuws/_20200411manifestnederlandnacorona.html

Arunyawat, S., & Shrestha, R. P. (2016). Assessing land use change and its impact on ecosystem services in Northern Thailand. *Sustainability*, *8*(8), 768. doi:10.3390u8080768

Asamblea Legislativa. (1976). Ley 5915. Ley Constitutiva Instituto Costarricense Acueductos y Alcantarillados. San José: Gobierno de la República de Costa Rica.

Asensio, S. (1997). Targeting the Poor-Poverty Indicators in A Spatial Context. ITC.

Ashcraft, K., Kuhn, T., & Cooren, F. (2009). Constitutional amendments: "Materialising" organisational communication. *The Academy of Management Annals*, *3*(1), 1–64. doi:10.5465/19416520903047186

Assadourion, E. (2012). Fazla Gelişmiş Ülkelerde Küçülmenin Yolu [Lexical characteristics of Turkish language]. In L. Starke (Ed.), *Worldwatch Enstitüsü Dünyanın Durumu 2012 Sürdürülebilir Refaha Doğru* (pp. 37–66). Çev. Ayşe Başçı, İş Bankası.

Astorga, Y. (n.d.). *Situación del Recurso Hídrico.* [Informe]. Decimocuarto informe Estado de la Nación en desarrollo humano sostenible. Informe Preliminar. Estado de la Nación en Desarrollo Humano Sostenible. Consejo Nacional de Rectores. La Defensoría de los Habitantes.

Ateljevic, J., & Li, L. (2009). Tourism entrepreneurship – concepts and issues. In J. Ateljevic & S. J. Page (Eds.), *Tourism and Entrepreneurship* (pp. 9–32). Routledge. doi:10.1016/B978-0-7506-8635-8.00002-2

Ateş, D. (2009). Uluslararası İlişkiler Disiplininin Oluşumu, İdealizm/Realizm Tartışması Ve Disiplinin Özerkliği. *Doğuş Üniversitesi Dergisi*, *10*(1), 11–25.

Atri, D., Siddiqi, H. K., Lang, J., Nauffal, V., Morrow, D. A., & Bohula, E. A. (2020). COVID-19 for the cardiologist: A current review of the virology, clinical epidemiology, cardiac and other clinical manifestations and potential therapeutic strategies. *JACC. Basic to Translational Science*, *5*(5), 518–536. doi:10.1016/j.jacbts.2020.04.002 PMID:32292848

Attree, L., & Möller-Loswick, A. (2015). Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels. *UN Chronicle*, *51*(4), 36–39. doi:10.18356/36c826cb-en

Aude, S. A. (2013). Conflicts among farmers and pastoralists in Northern Nigeria induced by freshwater scarcity. *Developing Country Studies*, *3*(12), 25–32.

Avlonitis, G., Doll, C. N., Galt, R., Mader, A., Patrickson, S., Moreno-Penaranda, R., . . . Shih, W. (2013). *Biodiversity and Municipal Planning: Local Biodiversity Strategy and Action Plan Guidelines.* Cape Town: ICLEI, SCBD, UNU-IAS.

Avtar, R., Aggarwal, R., Kharrazi, A., Kumar, P., & Kurniawan, T. A. (2020). Utilizing Geospatial Information to Implement SDGs and Monitor Their Progress. *Environmental Monitoring and Assessment*, *192*(1), 35. doi:10.100710661-019-7996-9 PMID:31828438

Awortwi, N., & Musahara, H. (2016). *Implementation of the Millennium Development Goals. Progresses and Challenges in Some African Countries*. Engelska.

Ayoung, D. A., Boatbil, S. C., & Baada, N. F. (2015). Disaster preparedness of libraries: Insight from polytechnic librarians in Ghana. *Information Development*, 1–10.

Aziz, T. (2021). Changes in land use and ecosystem services values in Pakistan, 1950–2050. *Environmental Development*, *37*, 100576. doi:10.1016/j.envdev.2020.100576

Bäckstrand, K. (2006). Democratizing Global Environmental Governance? Stakeholder Democracy after the World Summit on Sustainable Development. *European Journal of International Relations*, *12*(4), 467–498. doi:10.1177/1354066106069321

Badescu, V., & Schuiling, R. D. (2010). Aral Sea; Irretrievable loss or Irtysh imports. *Water Resources Management*, *24*(3), 597–616. doi:10.100711269-009-9461-y

Baek, J., Cho, Y., & Koo, W. W. (2009). The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics*, *68*(8-9), 2255–2264. doi:10.1016/j.ecolecon.2009.02.021

Bai, J., Chen, X., Li, J., Yang, L., & Fang, H. (2011). Changes in the area of inland lakes in arid regions of Central Asia during the past 30 years. *Environmental Monitoring and Assessment*, *178*(1-4), 247–256. doi:10.100710661-010-1686-y PMID:20830516

Bai, Y., Ochuodho, T. O., & Yang, J. (2019). Impact of land use and climate change on water-related ecosystem services in Kentucky, USA. *Ecological Indicators*, *102*, 51–64. doi:10.1016/j.ecolind.2019.01.079

Baker, R. (2020). *Powering the era of smart cities*. ITProPortal, April 09, 200. https://www.itproportal.com/features/powering-the-era-of-smart-cities/

Baker, M., & Cameron, E. (2008). Critical success factors in destination marketing. *Tourism and Hospitality Research*, *8*(2), 79–97. doi:10.1057/thr.2008.9

Bakker, K. (2012). Water security: Research challenges and opportunities. *Science*, *337*(6097), 914–915. doi:10.1126cience.1226337 PMID:22923564

Balatsky, A. V., Balatsky, G. I., & Borysov, S. S. (2015). Resource demand growth and sustainability due to increased world consumption. *Sustainability*, *7*(3), 3430–3440. doi:10.3390u7033430

Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., & Calabretta, G. (2019). Industrial Symbiosis: Towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives. *Journal of Cleaner Production*, *69*, 10–16. doi:10.1016/j.jclepro.2019.01.091

Ball, R., Ghorpade, A., Nawarathne, K., Baltazar, R., Pereira, F. C., Zegras, C., & Ben-Akiva, M. (2014, October). *Battery patterns and forecasting in a large-scale smartphone-based travel survey*. In 10th International Conference on Transport SurveyMethods, Fairmont Resort, Jamison Valley, BlueMountains National Park, Australia.

Baloyi, N., & Kotze, P. (2017). Are Organisations in South Africa Ready to Comply with Personal Data Protection or Privacy Legislation and Regulations? *IST-Africa Conference Proceedings IIMC International Information Management Corporations*. www.IST-Africa.org/Conference2017

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to $CO_2$ emissions? *Energy Policy*, *113*, 356–367. doi:10.1016/j.enpol.2017.10.050

Baltodano, A. P. (1997). The Study of Public Administration in Times of Global Interpenetration: A Historical Rationale for a Theoretical Model. *Journal of Public Administration: Research and Theory*, *7*(4), 615–638. doi:10.1093/oxfordjournals.jpart.a024368

Balvanera, P., Uriarte, M., Almeida-Leñero, L., Altesor, A., DeClerck, F., Gardner, T., Hall, J., Lara, A., Laterra, P., Peña-Claros, M., Silva Matos, D. M., Vogl, A. L., Romero-Duque, L. P., Arreola, L. F., Caro-Borrero, Á. P., Gallego, F., Jain, M., Little, C., de Oliveira Xavier, R., ... Vallejos, M. (2012). Ecosystem services research in Latin America: The state of the art. *Ecosystem Services*, *2*, 56–70. doi:10.1016/j.ecoser.2012.09.006

Banga, K., & te Velde, D. W. (2020). Covid-19 and disruption of the digital economy; evidence from low and middle-income countries. Digital Pathways at Oxford Paper Series; no. 7.

Banister, D. (2011). Railway Development: Interesting Research Lacking Coherence. *Built Environment*, *37*(1), 116-118.

Barbosa, F. C. (2018). High Speed Rail Technology: Increased Mobility With Efficient Capacity Allocation and Improved Environmental Performance. In *ASME/IEEE Joint Rail Conference* (*Vol. 50978*, p. V001T04A002). American Society of Mechanical Engineers. 10.1115/JRC2018-6137

Barham, C. (2014). Confidentiality and security of information. *Anaesthesia and Intensive Care Medicine*, *15*(1), 46–48. doi:10.1016/j.mpaic.2013.11.001

Barral, B. (2020, April 9). *El coronavirus nos muestra los dañinos efectos de la desigualdad en todo tipo de sociedades*. Naciones Unidas. https://news.un.org/es/story/2020/04/1472682

Barrientos, R., Ascensão, F., Beja, P., Pereira, H. M., & Borda-de-Água, L. (2019). Railway ecology vs. road ecology: Similarities and differences. *European Journal of Wildlife Research*, *65*(1), 12. doi:10.100710344-018-1248-0

Bartkowski, B., & Hansjürgens, B. (2019). Risk and uncertainty as sources of economic value of biodiversity and ecosystem services. In Atlas of Ecosystem Services (pp. 21-24). Springer. doi:10.1007/978-3-319-96229-0_5

Bartkowski, B. (2017). *Economic valuation of biodiversity: an interdisciplinary conceptual perspective*. Routledge. doi:10.4324/9781315175911

Bartkowski, B., Hansjürgens, B., Möckel, S., & Bartke, S. (2018). Institutional economics of agricultural soil ecosystem services. *Sustainability*, *10*(7), 2447. doi:10.3390u10072447

Bartl, A. (2021). The circular economy package of the European Union: Are new paths being taken or is it an old story? *Detritus*, *12*, 12–17.

Bascavusoglu-Moreau, E., Kopera, S., & Wszendybył-Skulska, E. (2013). The role of creativity in development of innovation in tourism. Journal of Entrepreneurship. *Management and Innovation*, *9*(1), 5–15. doi:10.7341/2013911

Bashir, M. F., Ma, B., Komal, B., Bashir, M. A., Tan, D., & Bashir, M. (2020). Correlation between climate indicators and COVID-19 pandemic in New York, USA. *The Science of the Total Environment*, *728*, 138835. doi:10.1016/j.scitotenv.2020.138835 PMID:32334162

Bassi, F., & Dias, J. G. (2020). Sustainable development of small-and medium-sized enterprises in the European union: A taxonomy of circular economy practices. *Business Strategy and the Environment*, *29*(6), 2528–2541. doi:10.1002/bse.2518

Bastian, O., Haase, D., & Grunewald, K. (2012). Ecosystem properties, potentials and services–The EPPS conceptual framework and an urban application example. *Ecological Indicators*, *21*, 7–16. doi:10.1016/j.ecolind.2011.03.014

Battistella, C., Cagnina, M., Cicero, L., & Preghenella, N. (2018). Sustainable Business Models of SMEs: Challenges in Yacht Tourism Sector. *Sustainability, 10*(10), 3437. doi:10.3390/su10103437

Batty,, M. (2013). *A new science of cities*. MIT Press.

Baumol, W. J., & Oates, W. E. (1971). The use of standards and prices for protection of the environment. *The Swedish Journal of Economics*, *73*(1), 42–54. doi:10.2307/3439132

Bayat, A., Pomplun, M., & Tran, D. A. (2014). A study on human activity recognition using accelerometer data from smartphones. *Procedia Computer Science*, *34*, 450–457. doi:10.1016/j.procs.2014.07.009

Bay, C. (2021). *G7 Summit Communique*. Our Shared Agenda For Global Action To Build Back Better.

Bayramoglu, A. T., & Yurtkur, A. K. (2016). Türkiye'de karbon emisyonu ve ekonomik büyüme ilişkisi: Doğrusal olmayan eşbütünleşme analizi. *Bolu Abant İzzet Baysal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *16*(4), 31–46.

BBC. (n.d.). *Resource management – water*. https://www.bbc.co.uk/bitesize/guides/zg2mycw/revision/6

BDO. (2020). *Covid-19 Is Accelerating The Rise Of The Digital Economy*. https://www.bdo.com/insights/business-financial-advisory/strategy,-technology-transformation/covid-19-is-accelerating-the-rise-of-the-digital-e

Beane, J. A., & Apple, M. W. (1999). The case for democratic schools. In M. W. Apple & J. A. Beane (Eds.), *Democratic schools: lessons from the chalk face*. Open University Press.

Beaunoyer, E., Dupéré, S., & Guitton, M. J. (2020). COVID-19 and digital inequalities: Reciprocal impacts and mitigation strategies. *Computers in Human Behavior*, *111*, 106424. doi:10.1016/j.chb.2020.106424 PMID:32398890

Beerwinkle, K., Lopez Jr, J., Schleider, P., & Lingren, P. (1995). *Annual patterns of aerial insect densities at altitudes from 500 to 2400 meters in east-central texas indicated by continuously-operating vertically-oriented radar.* Southwestern Entomologist.

Behravesh, N., & Rocha, E. W. (2020). *Interim global economic forecast*. IHS Markit.

Bekturganov, Z., Tussupova, K., Berndtsson, R., Sharapatova, N., Aryngazin, K., & Zhanasova, M. (2016). Water related health problems in Central Asia - A review. *Water (Basel)*, *8*(6), 219. doi:10.3390/w8060219

Bennett, E. M., Baird, J., Baulch, H., Chaplin-Kramer, R., Fraser, E., Loring, P., & Lapen, D. (2021). Ecosystem services and the resilience of agricultural landscapes. In *Advances in ecological research* (pp. 1–43). Academic Press Inc.

Benny, J (2019). Archival Automation in the United Kingdom and the Relationship between Standardization and Computerization. *Information & Culture: A Journal of History*, *54*(2), 159-178.

Berger, A. (2007). *Drosscape: Wasting Land Urban America*. Princeton Architectural Press.

Berger, P., & Luckmann, T. (1966). *The social construction of reality. A treatise in the sociology of knowledge*. Penguin Books.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating Social–Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press.

Berling-Wolff, S., & Wu, J. (2004). Modeling urban landscape dynamics: A case study in Phoenix, USA. *Urban Ecosystems*, *7*(3), 215–240. doi:10.1023/B:UECO.0000044037.23965.45

Berndtsson, R., & Tussupova, K. (2020). The Future of Water Management in Central Asia. *Water (Basel)*, *12*(8), 2241. doi:10.3390/w12082241

Besada, H. (2018). *Digital Economy and the Implementation of the 2030 Agenda for Sustainable Development*. https://www.unsouthsouth.org/wp-content/uploads/2018/12/Digital-Economy-and-the-Implementation-of-the-2030-Agenda-Hany-Besada.pdf

Bhat, A. W. (2018, June 04). Long-term preservation of big data: Prospects of current storage technologies in digital libraries. *Library Hi Tech*, *36*(3), 539–555. doi:10.1108/LHT-06-2017-0117

Bhatt, J. G., Jani, O. K., & Bhatt, C. B. (2020). Automation based smart environment resource management in smart building of smart city. In T. M. V. Kumar (Ed.), *Smart environment for smart cities* (pp. 93–107). Springer. doi:10.1007/978-981-13-6822-6_3

Bibri, S.E., & Krogstie, J. (2020b). *Smart Eco-City Strategies and Solutions for Sustainability: The Cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden*. Urban Science, Case Report, March 03, 2020.

Bibri, S. E., & Krogstie, J. (2020a). Environmentally data-driven smart sustainable cities: Applied innovative solutions for energy efficiency, pollution reduction, and urban metabolism. *Energy Inform*, *3*(1), 29. doi:10.118642162-020-00130-8

Biela, J., Hennl, A., & Kaiser, A. (2012). Combining Federalism and Decentralization: Comparative Case Studies on Regional Development Policies in Switzerland, Austria, Denmark, and Ireland. *Comparative Political Studies*, *45*(4), 447–476. doi:10.1177/0010414011421767

Bildirici, M., & Ozaksoy, F. (2017). The relationship between woody biomass consumption and economic growth: Nonlinear ARDL and causality. *Journal of Forest Economics*, *27*, 60–69. doi:10.1016/j.jfe.2017.01.002

Bingham, R. P. (1994). *Harmonics-understanding the facts*. Dranetz Technologies.

Birkmann, J., Garschagen, M., Kraas, F., & Quang, N. (2010). Adaptive urban governance: New challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science*, *5*(2), 185–206. doi:10.100711625-010-0111-3

Blair, R. B. (2001). Birds and butterflies along urban gradients in two ecoregions of theU.S. In J. L. Lockwood & M. L. McKinney (Eds.), *Biotic Homogenization* (pp. 459–486). Kluwer. doi:10.1007/978-1-4615-1261-5_3

Blaschke, T., Biberacher, M., Gadocha, S., & Schardinger, I. (2013). Energy landscapes: Meeting Energy Demands and Human Aspirations. *Biomass and Bioenergy*, *55*, 3–16. doi:10.1016/j.biombioe.2012.11.022 PMID:26109751

Blomsma, F., & Brennan, G. (2017). The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *Journal of Industrial Ecology*, *21*(3), 603–614. doi:10.1111/jiec.12603

Blomstermo, A., Eriksson, K., & Sharma, D. D. (2004Domestic Activity and Knowledge Development in the Internationalization Process of Firms. *Journal of International Entrepreneurship*, *2*, 239–258. doi:10.1023/B:JIEN.0000032775.53005.59

Blondin, S. (2019). Environmental migrations in Central Asia: A multifaceted approach to the issue. *Central Asian Survey*, *38*(2), 275–292. doi:10.1080/02634937.2018.1519778

Blöschl, G., Bierkens, M. F. P., Chambel, A., Cudennec, C., Destouni, G., Fiori, A., Kirchner, J. W., McDonnell, J. J., Savenije, H. H. G., Sivapalan, M., Stumpp, C., Toth, E., Volpi, E., Carr, G., Lupton, C., Salinas, J., Széles, B., Viglione, A., Aksoy, H., ... Zhang, Y. (2019). Twenty-three unsolved problems in hydrology (UPH) – a community perspective. *Hydrological Sciences Journal*, *64*(10), 1141–1158. doi:10.1080/02626667.2019.1620507

Blumenstock, J. E., Jean, N., Deaton, A., Banerjee, A., Donaldson, D., & Storeygard, A. (2016). Fighting Poverty with Data. *Science*, *353*(6301), 790–794. doi:10.1126cience.aah5217 PMID:27540154

Boamah, E., Dorner, G. D., & Oliver, G. (2015). Using theory to understand Digital Preservation Management in Ghana. *PDT&C*, *44*(2), 46–61. doi:10.1515/pdtc-2015-0011

Bocken, N., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308–320. doi:10.1080/21681015.2016.1172124

Bocken, N., Schuit, C. S. C., & Kraaijenhagen, C. (2018). Experimenting with a circular business model: Lessons from eight cases. *Environmental Innovation and Societal Transitions*, *28*, 79–95. doi:10.1016/j.eist.2018.02.001

Boes, K., Buhalis, D., & Inversini, A. (2015). Conceptualising Smart Tourism Destination Dimensions. In I. Tussyadiah & A. Inversini (Eds.), *Information and Communication Technologies in Tourism*. Springer. doi:10.1007/978-3-319-14343-9_29

Boetto, H., Bell, K., & Kime, K. (2018). Holistic ecosocial work: A model for transformative change through being, knowing and doing. In M. Powers & M. Rinkel (Eds.), Social work promoting community and environmental sustainability: A workbook for social work practitioners and educators (pp. 46–57). International Federation of Social Workers (IFSW).

Bogaert, J., Rousseau, R., Van Hecke, P., & Impens, I. (2000). Alternative perimeter-area ratios for measurement of 2-D shape compactness of habitats. *Applied Mathematics and Computation*, *111*(1), 71–85. doi:10.1016/S0096-3003(99)00075-2

Boiteau, G., Meloche, F., Vincent, C., & Leskey, T. C. (2009). Effectiveness of Glues Used for Harmonic Radar Tag Attachment and Impact on Survival and Behavior of Three Insect Pests. *Environmental Entomology*, *38*(1), 168–175.

Bokolo, A. J. (2020). Exploring the adoption of telemedicine and virtual software for care of outpatients during and after COVID-19 pandemic. *Irish Journal of Medical Science*, *1971*(1), 1–10. doi:10.100711845-020-02299-z PMID:32642981

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, *29*(2), 293–301. doi:10.1016/S0921-8009(99)00013-0

Bookchin, M. (1996). *Toplumsal ekolojinin felsefesi: Diyalektik doğalcılık üzerine denemeler* (R. G. Öğdül, Çev.). Kabalcı Yayınları.

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: State-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9–19. doi:10.1016/j.jclepro.2012.07.007

Borda-De-Água, L., Barrientos, R., Beja, P., & Pereira, H. M. (2017). Railway Ecology (English Edition) (1st ed. 2017 ed.). Springer.

Borrego, C., Tchepel, O., Barros, N., & Miranda, A. I. (2000). Impact of road traffic emissions on air quality of the Lisbon region. *Atmospheric Environment*, *34*(27), 4683–4690. doi:10.1016/S1352-2310(00)00301-0

Borrello, M. P., Pacucci, S., Caracciolo, F., Lombardi, A., & Cembalo, L. (2020). Consumers are willing to participate in circular business models: A practice theory perspective to food provisioning. *Journal of Cleaner Production*, *259*, 121013. doi:10.1016/j.jclepro.2020.121013

Bosak, K., & Schroeder, K. (2005). Using Geographic Information Systems (GIS) for Gender and Development. *Development in Practice, 15*(2). 231-237.

Bostancı, S. H. (2015). Sustainability strategies and projects of Turkish municipalities. In K. Thomas (Ed.), *Handbook of research on sustainable development and economics* (pp. 56–71). IGI Global. doi:10.4018/978-1-4666-8433-1.ch004

Boutard, G., Guastavino, C., & Turner, J. (2013). A Digital Archives Framework for the Preservation of Artistic Works with Technological Components. *International Journal of Digital Curation*, *8*(1), 42–65. doi:10.2218/ijdc.v8i1.237

Bozkurt, C., & Okumus, İ. (2015). Türkiye'de Ekonomik Büyüme, Enerji Tüketimi, Ticari Serbestleşme ve Nüfus Yoğunluğunun CO2 Emisyonu Üzerindeki Etkileri: Yapisal Kirilmali Eşbütünleşme Analizi. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *12*(32), 23–35.

Braat, L. C., & De Groot, R. (2012). The ecosystem services agenda: Bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem Services*, *1*(1), 4–15. doi:10.1016/j.ecoser.2012.07.011

Bradbury, A., Tomilnson, P., & Millington, A. (2007). Understanding the Evolution of Community Severance and its Consequences on Mobility and Social Cohesion Over the Past Century. *Proceedings of the European Transport Conference 2007*.

Braks, M., Giglio, G., Tomassone, L., Sprong, H., & Leslie, T. (2019). Making Vector-Borne Disease Surveillance Work: New Opportunities from the SDG Perspectives. *Frontiers in Veterinary Science*, *6*, 232. doi:10.3389/fvets.2019.00232 PMID:31380399

Brauman, K. A., Daily, G. C., Duarte, T. K. E., & Mooney, H. A. (2007). The nature and value of ecosystem services: An overview highlighting hydrologic services. *Annual Review of Environment and Resources*, *32*(1), 67–98. doi:10.1146/annurev.energy.32.031306.102758

Brem, A., & Puente-Díaz, R. (2020). Are you acting sustainably in your daily practice? Introduction of the Four-S model of sustainability. *Journal of Cleaner Production*, *267*, 122074. doi:10.1016/j.jclepro.2020.122074

Brendan, E. A. (2013). The readiness of universities in managing electronic records: A study of three federal universities in Nigeria. *The Electronic Library*, *31*(6), 792–802. doi:10.1108/EL-04-2012-0037

Brenner, N. (1998). Global Cities, Glocal States: Global City Formation and State Territorial Restructuring in Contemporary Europe. *Review of International Political Economy*, *5*(1), 1–37. doi:10.1080/096922998347633

Bressanelli, G., Pigosso, D. C. A., Saccani, N., & Perona, M. (2021). Enablers, levers and benefits of circular economy in the electrical and electronic equipment supply chain: A literature review. *Journal of Cleaner Production*, *298*, 126819. doi:10.1016/j.jclepro.2021.126819

Bressanelli, G., Saccani, N., Perona, M., & Baccanelli, I. (2020). Towards circular economy in the household appliance industry: An overview of cases. *Resources*, *9*(11), 128. doi:10.3390/resources9110128

Brewer, H. L. (1981). Investor benefits from corporate international diversification. *Journal of Financial and Quantitative Analysis*, *16*(1), 113–126. doi:10.2307/2330669

Briscoe, J. (2009). Water security: Why it matters and what to do about it. *Innovations: Technology, Governance, Globalization*, *4*(3), 3–28. doi:10.1162/itgg.2009.4.3.3

Broome, B. J. (2009). Dialogue theories. In S. W. Littlejohn & K. A. Foss (Eds.), *Encyclopedia of communication theory* (pp. 301–305). SAGE. doi:10.4135/9781412959384.n111

Brown, G. (2012). Public Participation GIS (PPGIS) for Regional and Environmental Planning: Reflections on A Decade of Empirical Research. *URISA Journal*, *25*(2), 5–16.

Brown, J. H., Ernest, S. K. M., Parody, J. M., & Haskell, J. P. (2001). Regulation of diversity: Maintenance of species richness in changing environments. *Oecologia*, *126*(3), 321–332. doi:10.1007004420000536 PMID:28547444

Bruinsma, F., Pels, E., Priemus, H., Rietveld, P., van Wee, B., & van Wee, B. (2007). *Railway Development*. Beltz Verlag.

Bruna, G., & Pisani, M. A. (2010). Mudanças climáticas e pobreza: reflexões. *Revista Brasileira De Ciências Ambientais*, *18*, 49-57. Recuperado de http://rbciamb.com.br/index.php/Publicacoes_RBCIAMB/article/view/370

Büchs, M., & Koch, M. (2019). Challenges for the degrowth transition: The debate about wellbeing. *Futures*, *105*, 155–165. doi:10.1016/j.futures.2018.09.002

Buckley, P. J., & Ghauri, P. N. (1993). *The internationalization of the firm: a reader*. Academic Press.

Budge, M., & German, S. (2015). *Basic Radar Analysis. Artech House radar series*. Artech House.

Buhalis, D. (2000). Marketing the competitive destination of the future. *Tourism Management*, *21*(1), 97–116. doi:10.1016/S0261-5177(99)00095-3

Buhner, R. (1987). Assessing international diversification of West German corporations. *Strategic Management Journal*, *8*(1), 25–37. doi:10.1002mj.4250080104

Buitrago, D. (2020). Teletrabajo: Una oportunidad en tiempos de crisis. *CES Derecho*, *11*(1), 1–2.

Bulkeley, H., & Betsill, M. (2005). Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change. *Environmental Politics*, *14*(1), 42–63. doi:10.1080/0964401042000310178

Bulkeley, H., & Schroeder, H. (2011). Beyond state/non-state divides: Global cities and the governing of climate change. *Climate Change and Governance.*, *18*(4), 743–766.

Butler, R. (1980). The concept of a tourism area cycle of evolution: Implications for resources. *The Canadian Geographer. Geographe Canadien*, *24*(1), 5–12. doi:10.1111/j.1541-0064.1980.tb00970.x

Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Alemie, T. C., Bastiaensen, J., ... Zhumanova, M. (2014). Citizen science in hydrology and water resources: Opportunities for knowledge generation, ecosystem service management, and sustainable development. *Frontiers of Earth Science*, *2*, 26.

Cadenasso, M. L., & Pickett, S. T. A. (2008). Urbanprinciples for ecological landscape design and management: Scientific fundamentals. *Cities and the Environment*, *1*(2), 4. doi:10.15365/cate.1242008

Cadenasso, M. L., & Pickett, S. T. A. (2013). Three tides: The development and state of the art of urban ecological studies. In S. T. A. Pickett, M. L. Cadenasso, & B. P. McGrath (Eds.), *Resilience in urban ecology and design: Linking theory and practice for sustainable cities* (pp. 29–46). Springer. doi:10.1007/978-94-007-5341-9_2

Cadenasso, M. L., Pickett, S. T. A., & Grove, J. M. (2006a). Dimensions of ecosystem complexity: Heterogeneity, connectivity, and history. *Ecological Complexity*, *3*(1), 1–12. doi:10.1016/j.ecocom.2005.07.002

Cadenasso, M. L., Pickett, S. T. A., & Grove, J. M. (2006b). Integrative approaches to investigating human-natural systems: The Baltimore EcosystemStudy. *Nature Sciences Sociétés*, *14*(1), 1–14. doi:10.1051/nss:2006002

Caidi, N. (2005). Building Civilisation competencies": A new role for libraries? *The Journal of Documentation*, *62*(2), 194–212. doi:10.1108/00220410610653299

Callenbach, E. (2008). *Ecology: A pocket guide, revised and expanded*. University of California Press. doi:10.1525/9780520942226

Calvillo, C. F., Sanchez-Miralles, A., & Villar, J. (2016). Energy management and planning in smart cities. *Renewable & Sustainable Energy Reviews*, *55*, 273–287. doi:10.1016/j.rser.2015.10.133

Campagna, M. (2006). GIS for Sustainable Development. Taylor & Francis Group.

Campbell, B. (1997). Reconceptualisation de l'État au Sud – Participationdémocratique ou managérialisme populiste. In *Crépeau François, Mondialisation deséchanges et fonctions de l'État* (pp. 163–231). Bruylant.

Campisi, T., Severino, A., Al-Rashid, M. A., & Pau, G. (2021). The Development of the Smart Cities in the Connected and Autonomous Vehicles (CAVs) Era: From Mobility Patterns to Scaling in Cities. *Infrastructures, MDPI*, *6*(100), 1–21. doi:10.3390/infrastructures6070100

Canton de Genève. (2013). Plan directeur cantonal 2030. A14: Promouvoir de nouvelles formes de jardins fa-miliaux et encourager la création de plantages. Geneva, Switzerland: République et Canton de Genève.

Caplan, R. (2005). *International Governance and War-Torn Territories. Rule and Reconstruction*. Oxford University Press. doi:10.1093/0199263450.001.0001

Carayannis, G., & Campbell, D. (2009). 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, *46*(3/4), 201–234. doi:10.1504/IJTM.2009.023374

Cardinale, B. J., & Je, D. (2012). gonzalez a, hooper Du. *Perrings C, Venail P, narwani a, mace gm, tilman D, Wardle Da, Kinzig aP, Daily gC, loreau m, grace JB, larigauderie a, srivastava Ds, naeem s*, 59-67.

Cardinale, B. J., Srivastava, D. S., Duffy, J. E., Wright, J. P., Downing, A. L., Sankaran, M., & Jouseau, C. (2006). Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature*, *443*(7114), 989–992. doi:10.1038/nature05202 PMID:17066035

Carley, M. (1995). The bigger picture: Organising for sustainable urban regeneration. *Town and Country Planning*, *64*(9), 236–239.

Carley, M., & Christie, I. (2017). *Managing Sustainable Development*. Routledge. doi:10.4324/9781315091525

Carlisle, S., Kunc, M., Jones, E., & Tiffin, S. (2013). Supporting innovation for tourism development through multi-stakeholder approaches: Experiences from Africa. *Tourism Management*, *35*, 59–69. doi:10.1016/j.tourman.2012.05.010

Carlson, R. R., Evans, L. J., Foo, S. A., Grady, B. W., Li, J., Seeley, M., Xu, Y., & Asner, G. P. (2021). Synergistic Benefits of Conserving Land-sea Ecosystems. *Global Ecology and Conservation*, *28*, e01684. Advance online publication. doi:10.1016/j.gecco.2021.e01684

Carpenter, S. R., & Cottingham, K. L. (1997). Resilience and restoration of lakes. *Conservation Ecology*, *1*(1), 2. doi:10.5751/ES-00020-010102

Carpenter, S. R., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: Resilience of what to what? *Ecosystems (New York, N.Y.)*, *4*(8), 765–781. doi:10.100710021-001-0045-9

Carvajal, D. L., Cardona, A., & Valencia, F. J. (2019). Una propuesta de gestión de la seguridad de la información aplicado a una entidad pública colombiana. *Entre Ciencia e Ingeniería*, *13*(25), 68. doi:10.31908/19098367.4016

Carvajal, F., Crisanto, E., Aguilar, F. J., Aguera, F., & Aguilar, M. A. (2006). Greenhouses Detection Using an Artificial Neural Network With a Very High Resolution Satellite Image. *ISPRS Technical Commission II Symposium*, 12–14.

Carvalho, S., & Carvalho, J. (2020). The Implications of Digital Marketing and e-Commerce in the Tourism Sector Growth. In Á. Rocha, A. Abreu, J. de Carvalho, D. Liberato, E. González, & P. Liberato (Eds.), *Advances in Tourism, Technology and Smart Systems*. Springer. doi:10.1007/978-981-15-2024-2_15

Casper, R., & Sunding, E. (2018). Addressing Today's challenges in automotive remanufacturing. *Journal of Remanufacturing*, *8*(3), 93–102. doi:10.100713243-018-0047-9

Castanho, R. A. (2017). *Sustainable Urban Planning in Transboundary Areas: Analysis of Critical Factors for Territorial Success* (Doctoral Thesis). University of Extremadura (UEx), Department of Vegetal Biology, Ecology and Earth Sciences.

Castanho, R. A., & Couto, G. (2020). Principles of Sustainable Tourism and Cultural Management in Rural and Ultra-peripheral Territories: Extracting Guidelines for its application in the Azores Archipelago. *Cultural Management: Science and Education*. doi:10.30819/cmse.4-1.01

Castanho, R. A., Couto, G., Pimentel, P., Carvalho, C., Sousa, Á., Graça Batista, M., & Garrido-Velarde, J. (2021). Os impactos da crise sanitária de COVID-19 sobre os Territórios Ultraperiféricos: O caso de estudo do Arquipélago dos Açores (Portugal) [The impacts of the COVID-19 health crisis on the Outermost Territories: The case study of the Azores Archipelago]. *Espacios, 42*(6), 104-116. doi:10.48082/espacios-a21v42n06p08

Castanho, R.A. (2020). The Relevance of Political Engagement and Transparency in Cross-Border Cooperation (CBC) Environments. Analyzing Border cities in Europe. *Lex Localis - Journal of Local Self-Government, 18*(3), 487 – 502. . doi:10.4335/18.3.487-502(2020)

Castanho, R.A., Cabezas, J., Loures, L., & Fernández-Pozo, L. (2017). Evolution of Urban Planning Process in the Iberian Peninsula and his Footprints in Cityscape. New Challenges. *Monfragüe Resiliente – Scientific Journal, 8*(2).

Castanho, R.A., Couto, G. & Santos, R. (2021). *Introductory Chapter: Rural Tourism as a Catalyst for Sustainable Regional Development of Peripheral Territories*. doi:10.5772/intechopen.96651

Castanho, R.A., Couto, G., Lousada, Pimentel, P., Carvalho, C. & Sousa, A. (2020). Princípios de Planeamento Estratégico e Gestão de Turismo Rural em Territórios Ultraperiféricos: O Caso de Estudo do Arquipélago dos Açores. *Revista Ibérica de Sistemas e Tecnologias de Informação (RISTI), E36*(10).

Castanho, R.A., Lousada, S., Naranjo Gómez, J.M., Escórcio, P., Cabezas, J. Fernández-Pozo, L. & Loures, L. (2018). *Dynamics of the Land Use Changes and the Associated Barriers and Opportunities for Sustainable Development on Peripheral and Insular Territories: The Madeira Island (Portugal)* [Working Title]. IntechOpen. doi:10.5772/intechopen.80827

Castanho, R. A., Naranjo-Gomez, J. M., Vulevic, A., & Couto, G. (2021). The Land-Use Change Dynamics Based on the CORINE Data in the Period 1990–2018 in the European Archipelagos of the Macaronesia Region: Azores, Canary Islands and Madeira. *ISPRS International Journal of Geo-Information*, *10*(5), 342. doi:10.3390/ijgi10050342

Castellar, J. A. C., Popartan, L. A., Pueyo-Ros, J., Atanasova, N., Langergraber, G., Säumel, I., Corominas, L., Comas, J., & Acuna, V. (2021). Nature-based solutions in the urban context: Terminology, classification and scoring for urban challenges and ecosystem services. *The Science of the Total Environment*, *779*, 146237. doi:10.1016/j.scitotenv.2021.146237 PMID:34030251

Castells, M. (1996). The Rise of the Network Society. Volume 1 of The Information Age: Economy, Society and Culture. Blackwell.

Cavaco, C. (2015). *Urban Analytics: Accelerating the Development of Smart cities in Portugal*. GDT. Available at: https://www.dgterritorio.pt/urbananalytics2015

Cavaco, C. (2015). *Cidades Sustentáveis 2020*. DGT.

Cavanagh, R. D., Melbourne-Thomas, J., Grant, S. M., Barnes, D. K., Hughes, K. A., Halfter, S., Meredith, M. P., Murphy, E. J., Trebilco, R., & Hill, S. L. (2021). Future risk for southern ocean ecosystem services under climate change. *Frontiers in Marine Science*, *7*, 1224. doi:10.3389/fmars.2020.615214

CBD. (2011, June). *Updating National Biodiversity Strategies and Action Plans in line with the Strategic Plan for Biodiversity 2011-2020*. Retrieved June 01, 2021, from https://www.cbd.int/doc/training/nbsap/b1-train-intro-nbsap-revised-en.pdf

CBD. (2015, June 01). *Singapore index on cities' biodiversity*. Retrieved June 01, 2021, from cbd.int: https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf

CCSA. (2021). *How Covid-19 is changing the world: a statistic perspective* (Vol. 3). The World Bank's Development Data Group, UN DESA, and UNCTAD.

CDD. (2020). *Climate change: Recognising the impacts on West Africa*. https://cddelibrary.org/2020/09/30/climate-change-recognising-the-impacts-n-west-africa/

Centro de Integración de Economía y Ecología (CIECO). (2015). *Estudio socioeconómico requerido por MINAE mediante el Oficio VAMCH 227-2014*. Proyecto Alcantarillado Sanitario y Tratamiento de Aguas Residuales para los Cantones de Heredia, San Rafael y San Isidro, y Diseño de la Primera Etapa de Construcción.

Centro Internacional de Política Económica para el Desarrollo Sostenible. (2019). Política para el cambio climático del Cantón de Heredia, Costa Rica: proyecto: formulación e implementación de una política de cambio climático para la municipalidad del Cantón de Heredia: diseño, programación y presupuesto. Heredia, Costa Rica: Author.

Cetin, M., & Yüksel, Ö. (2018). Türkiye ekonomisinde enerji tüketiminin karbon emisyonu üzerindeki etkisi. *Mehmet Akif Ersoy Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *5*(2), 169–186.

Cetintas, H., Bicil, İ. M., & Türköz, K. (2016). Türkiye'de CO2 Salınımları EnerjiTüketimi ve Ekonomik Büyüme İlişkisi. *Finans Politik ve Ekonomik Yorumlar*, (619), 57–67.

Cevreonline. (n.d.). *Su güvenliği*. https://cevreonline.com/su-guvenligi/

Cezar, F. G., & Abrantes, P. C. C. (2003). Princípio da precaução: Considerações epistemológicas sobre o princípio e sua relação com o processo de análise de risco. *Cadernos de Ciência & Tecnologia*, *20*(2), 225–262.

Chaffey, D., & Bosomworth, D. (2012). *What is emotional branding? Smart Insights Digital Marketing Advice.* Available at: https://www.smartinsights.com/online-brand-strategy/emotionalbranding-means-customers-stay-loyal-for-the-long-haul/

Chakravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N., & Shukla, G. (2012). Deforestation: Causes, effects and control strategies. *Global Perspectives on Sustainable Forest Management*, *1*, 1–26.

Chamizo García, H. (2010, December). La gestión del saneamiento ambiental en asentamientos humanos en Costa Rica: Los casos de dos comunidades urbanas y una rural. *Cuadernos de Investigación UNED*, *2*(2), 123–131. doi:10.22458/urj.v2i2.153

Chamizo García, H. A. (2006). La información y el conocimiento en la gestión de políticas públicas de saneamiento ambiental en Costa Rica. *Revista de Ciencias Administrativas y Financieras de la Seguridad Social*, *14*(1), 71–82.

Chamizo, H. G. (2011). Territorio y gestión de las políticas de saneamiento ambiental en asentamientos humanos en Costa Rica. *Revista Geográfica de América Central*, *2*, 1–16.

Chance, T. (2009). Towards sustainable residential communities; the Beddington zero energy development (BedZED) and beyond. *Environment and Urbanization*, *21*(2), 527–544. doi:10.1177/0956247809339007

Chander, G., Markham, B. L., & Helder, D. L. (2009). Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. *Remote Sensing of Environment*, *113*(5), 893–903. doi:10.1016/j.rse.2009.01.007

Chandler, M., See, L., Buesching, C. D., Cousins, J. A., Gillies, C., Kays, R. W., . . . Tiago, P. (2016). Involving Citizen Scientists in Biodiversity Observation. In The GEO Handbook on Biodiversity Observation Networks (pp. 211-237). Springer.

Chang, Y., Lei, S., Teng, J., Zhang, J., Zhang, L., & Xu, X. (2019). The energy use and environmental emissions of high-speed rail transportation in China: A bottom-up modeling. *Energy*, *182*, 1193–1201. doi:10.1016/j.energy.2019.06.120

Chapman, J. W., Reynolds, D. R., & Smith, A. D. (2003). Vertical-Looking Radar: A New Tool for Monitoring High-Altitude Insect Migration. *Bioscience*, *53*(5), 503–511.

Chapman, J., Smith, A., Woiwod, I., Reynolds, D., & Riley, J. (2002). Development of vertical-looking radar technology for monitoring insect migration. *Computers and Electronics in Agriculture*, *35*(2-3), 95–110.

Chen, J., Peng, S., Chen, H., Zhao, X., Ge, Y., & Li, Z. (2020). A Comprehensive Measurement of Progress toward Local SDGs with Geospatial Information: Methodology and Lessons Learned. *ISPRS International Journal of Geo-Information, 9*(9), 522. doi:10.3390/ijgi9090522

Chen, C., & Chen, F. (2010). Experience quality, perceived value, satisfaction and behavioral intentions for heritage tourists. *Tourism Management*, *31*(1), 29–35. doi:10.1016/j.tourman.2009.02.008

Cheng, Y. C., Chawathe, Y., LaMarca, A., & Krumm, J. (2005, June). Accuracy characterization for metropolitan-scale Wi-Fi localization. In *Proceedings of the 3rd international conference on Mobile systems, applications, and services* (pp. 233-245). 10.1145/1067170.1067195

Chen, H., Li, S., & Zhang, Y. (2003). Impact of road construction on vegetation alongside Qinghai-Xizang highway and railway. *Chinese Geographical Science*, *13*(4), 340–346. doi:10.100711769-003-0040-5

Chen, Y., Cai, G., Zheng, L., Zhang, Y., Qi, X., Ke, S., Gao, L., Bai, R., & Liu, G. (2021). Modelling waste generation and end-of -life management of wind power development in Guangdong, China until 2050. *Resources, Conservation and Recycling*, *169*, 105533. doi:10.1016/j.resconrec.2021.105533

Chen, Y., Li, Z., Fang, G., & Li, W. (2018). Large hydrological processes changes in the transboundary rivers of Central Asia. *Journal of Geophysical Research, D, Atmospheres*, *123*(10), 5059–5069. doi:10.1029/2017JD028184

Chesbrough, H. (2010). Business model innovation: Opportunities and barriers. *Long Range Planning*, *43*(2-3), 354–363. doi:10.1016/j.lrp.2009.07.010

Childers, D. L., Pickett, S. T. A., Grove, J. M., Ogden, L., & Whitmer, A. (2014). Advancing urban sustainability theory and action: Challenges and opportunities. *Landscape and Urban Planning*, *125*, 320–328. doi:10.1016/j.landurbplan.2014.01.022

Choi, Y., Suh, J., & Kim, S.-M. (2019). GIS-Based Solar Radiation Mapping, Site Evaluation, and Potential Assessment: A Review. *Applied Sciences, 9*(9), 1960. doi:10.3390/app9091960

Chomsky, N. (2020, April 21). *Estamos ante otro fallo masivo y colosal del capitalismo neoliberal | Cultura y entretenimiento | Agencia EFE*. Agencia EFE. https://www.efe.com/efe/espana/cultura/chomsky-estamos-ante-otro-fallo-masivo-y-colosal-del-capitalismo-neoliberal/10005-4226729

Chonchol, J. (1994). *Sistemas agrarios en América Latina : de la etapa prehispánica a la modernización conservadora*. Fondo de Cultura Económica.

Chowdhury, N., Akram Hossain, C., Longo, M., & Yaïci, W. (2020). Feasibility and Cost Analysis of Photovoltaic-Biomass Hybrid Energy System in Off-Grid Areas of Bangladesh. *Sustainability, 12*(4), 1568. doi:10.3390/su12041568

Chowdhury, A., Chakravarty, T., & Balamuralidhar, P. (2014, October). Estimating true speed of moving vehicle using smartphone-based GPS measurement. In *2014 IEEE International Conference on Systems, Man, and Cybernetics (SMC)* (pp. 3348-3353). IEEE. 10.1109/SMC.2014.6974444

Christopherson, R. W. (1997). Geosystems: An Introduction to Physical Geography (3rd ed.). Upper Saddle River, NJ: Prentice Hall Inc.

Chrons, O., & Sundell, S. (2011). *Digitalkoot: Making Old Archives Accessible Using Crowdsourcing*. Human Computation: Paper from the 2011 AAA1 Workshop.

Churchill, S. A., Inekwe, J., Smyth, R., & Zhang, X. (2019). R&D intensity and carbon emissions in the G7: 1870–2014. *Energy Economics*, *80*, 30–37. doi:10.1016/j.eneco.2018.12.020

Chuvieco, E. (1995). *Fundamentos de teledetection espacial*. Ediciones RIAL.

CISL (The University of Cambridge Institute for Sustainability Leadership). (2018). *Rewiring the Economy, Ten tasks, ten years*. https://www.cisl.cam.ac.uk/resources/publication-pdfs/rewiring-the-economy-report.pdf

City and County of San Francisco. (2021). *Greenhouse gas emissions*. https://sfgov.org/scorecards/environment/greenhouse-gas-emissions

City of Portland. (2007). *ENN-1.01: Food Policy Council (Binding city policy)*. Retrieved September 24, 2007, from http://www.portlandonline. com/auditor/index.cfm?a=ihci&c=checj

City of Vancouver. (2003). *Action plan for creating a just and sustainable food system for the City of Vancouver (RTS Number: 3755)*. Author.

City/Nation/Place Awards. (2018). *Finalists announced*. Available at: http://cityofmusic.cm-idanhanova.pt/noticias-e-agenda/city-nation-place-awards.aspx

Clair, C. C. S., Whittington, J., Forshner, A., Gangadharan, A., & Laskin, D. N. (2020). Railway mortality for several mammal species increases with train speed, proximity to water, and track curvature. *Scientific Reports*, *10*(1), 1–13. doi:10.103841598-020-77321-6 PMID:31913322

CLC. (2020). *Corine Land Cover 2018*. European Environment Agency. https://www.eea.europa.eu/data-and-maps/data/external/corine-land-cover-2018

Clement, D. (2013). *The spatial injustice of crisis-driven neoliberal urban restructuring in Detroit* (Unpublished master's thesis). University of Miami. Retrieved from http://scholarlyrepository.miami.edu/oa_theses/406/

Clement, M., Kilsby, C., & Moore, P. (2018). Multi-temporal synthetic aperture radar flood mapping using change detection. *Journal of Flood Risk Management*, *11*(2), 152–168.

CMCD. (2019). *Centro empresarial*. Available at: http://www.cmcd.pt/empreendedorismo/centro-empresarial/

Coca, E., & Cehan, V. (2014). Laboratory study of electromagnetic waves reflectivity of certain materials. *Proceedings of the 2014 37th International Spring Seminar on Electronics Technology*.

Codosero Rodas, J., Castanho, R. A., Cabezas, J., & Naranjo Gómez, J. (2020). Sustainable valuation of land for development. Adding value with urban planning progress. A Spanish case study. *Land Use Policy*, *92*, 104456. doi:10.1016/j.landusepol.2019.104456

Cohen,, J., & Stewart,, I. (1994). *The collapse of chaos: discovering simplicity in a complex world*. Penguin Group Ltd.

Colding, J. (2011). The role of ecosystem services in contemporary urban planning. In Urban Ecology. Patterns, Processes and Applications. Oxford University Press. doi:10.1093/acprof:oso/9780199563562.003.0028

Colding, J., & Barthel, S. (2012). *The potential of Urban Green Commons in the resilience building of cities*. Elsevier B.V.

Colding, J., Lundberg, J., & Folke, C. (2006). Incorporating green-area user groups in urbanecosystem management. *Ambio*, *35*(5), 237–244. doi:10.1579/05-A-098R.1 PMID:16989508

Collins, J. P., Kinzig, A., Grimm, N. B., Fagan, W. F., Hope, D., Wu, J., & Borer, E. T. (2000). A new urban ecology. *American Scientist*, *88*(5), 416–425. doi:10.1511/2000.5.416

Colpitts, B., & Boiteau, G. (2004). Harmonic radar transceiver design: Miniature tags for insect tracking. *IEEE Transactions on Antennas and Propagation*, *52*(11), 2825–2832.

Common, M., & Stagl, S. (2005). *Ecological economics: an introduction. Cambrigde*. Cambridge University Press. doi:10.1017/CBO9780511805547

CONAF. (2013). *Catastro y Actualización de los Recursos Vegetacionales y Uso de la Tierra*. Available at: https://ide.minagri.gob.cl/geoweb/2019/11/22/planificacion-catastral/

Congalton, R. G. (2001). Accuracy assessment and validation of remotely sensed and other spatial information. *International Journal of Wildland Fire*, *10*(3–4), 321–328. doi:10.1071/WF01031

Cong, L., Zhao, F., & Sutherland, J. W. (2019). A design method to improve end-of use product value recovery for Circular Economy. *Journal of Mechanical Design*, *141*(4), 044502. doi:10.1115/1.4041574

Connett, P. (2013). Zero waste 2020: Sustainability in our hands. In R. Crocker & S. Lehmann (Eds.), Motivating Change: Sustainable Design and Behaviour in the Built Environment (pp. 343–361). Academic Press.

Contreras, R. F., & Frasier, S. J. (2007). Return from insects in the clear-air convective boundary layer. *IEEE International Geoscience and Remote Sensing Symposium*.

Convention on Biological Diversity. (2011). *Aichibiodiversity targets*. https://www.cbd.int/sp/targets/

Convention on the Biological Diversity. (1992). The Earth Summit. United Nations, General Assembly.

Cook, C., & Bakker, K. (2012). Water security: Debating an emerging paradigm. *Global Environmental Change*, *22*(1), 94–102. doi:10.1016/j.gloenvcha.2011.10.011

Cooper, B. B. (2013). *10 Surprising Social Media Statistics That Will Make You Rethink Your Social Strategy*. Fast Company, Business + Innovation. Available at: https://www.fastcompany.com/3021749/work-smart/10-surprising-social-media-statistics-that-willmake-you-rethink-your-social-stra

Cooper, C., & Hall, C. (2008). *Contemporary Tourism Marketing*. ButterworthHeinemann. doi:10.1016/B978-0-7506-6350-2.50006-6

Çorbacı, Ö. L., Özyavuz, M., & Yazgan, M. E. (2011). Peyzaj mimarlığında suyun akıllı kullanımı: Xeriscape [The smart use of water in landscape architecture: Xeriscape]. *International Journal of Agricultural and Natural Sciences*, *4*(1), 25–31.

Cord, A. F., Bartkowski, B., Beckmann, M., Dittrich, A., Hermans-Neumann, K., Kaim, A., Lienhoop, N., Locher-Krause, K., Priess, J., Schröter-Schlaack, C., Schwarz, N., Seppelt, R., Strauch, M., Václavík, T., & Volk, M. (2017). Towards systematic analyses of ecosystem service trade-offs and synergies: Main concepts, methods and the road ahead. *Ecosystem Services*, *28*, 264–272. doi:10.1016/j.ecoser.2017.07.012

Cornell, S., & Kalt, J. P. (1990). Pathways from poverty: development and institution-building on American Indian reservations. *American Indian Culture and Research Journal*, *14*(1), 89–125. https://www.hks.harvard.edu/hpaied/pubs/pub_016.htm

Cornell, S., & Kalt, J. P. (1995). Successful economic development and heterogeneity of government form on Aboriginal Indian reservations, PRS 95-4. Harvard Project on American Indian Economic Development, Malcolm Weiner Center for Social Policy, John F. Kennedy School of Government, Harvard University.

Cortés-Calderón, S., Mora, F., Arreola-Villa, F., & Balvanera, P. (2021). Ecosystem services supply and interactions along secondary tropical dry forests succession. *Forest Ecology and Management*, *482*, 118858. doi:10.1016/j.foreco.2020.118858

Corte, V., D'Andrea, C., Savastano, I., & Zamparelli, P. (2017). Smart cities and destination management: Impacts and opportunities for tourism competitiveness. *European Journal of Tourism Research*, *17*, 7–27. https://ejtr.vumk.eu/index.php/about/article/download/291/294

Cortinovis, C., & Geneletti, D. (2018). Ecosystem services in urban plans: What is there, and what is still needed for better decisions. *Land Use Policy*, *70*, 298–312. doi:10.1016/j.landusepol.2017.10.017

Cosgrove, S. (2001). *Montréal's community gardening program*. Retrieved July 29, 2007, from http://www.cityfarmer.org/Montreal13.html

Cosme, I., Santos, R., & O'Neill, D. W. (2017). Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals. *Journal of Cleaner Production*, *149*, 321–334. doi:10.1016/j.jclepro.2017.02.016

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... Van Den Belt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*(6630), 253-260.

Costanza, R. (2020). Valuing natural capital and ecosystem services toward the goals of efficiency, fairness, and sustainability. *Ecosystem Services*, *43*, 101096. doi:10.1016/j.ecoser.2020.101096

Costanza, R., De Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. doi:10.1016/j.ecoser.2017.09.008

Costanza, R., & Kubiszewski, I. (2012). The authorship structure of "ecosystem services" as a transdisciplinary field of scholarship. *Ecosystem Services*, *1*(1), 16–25. doi:10.1016/j.ecoser.2012.06.002

Costanza, R., & Patten, B. C. (1995). Defining and predicting sustainability. *Ecological Economics*, *15*(3), 193–196. doi:10.1016/0921-8009(95)00048-8

Couto, G., Castanho, R. A., Santos, C., Pimentel, P., Sousa, Á., Faria, S., & Graça Batista, M. (2021). Determining Good Practices for Tourism Sustainability in Ultra-Peripheral Territories: A Research-Based on the Azores Region's Touristic Companies' Analysis. *Sustainability*, *2021*(13), 3895. doi:10.3390u13073895

Couto, G., Castanho, R. A., Sousa, A., Pimentel, P., Santos, C., & Carvalho, C. (2020). The Impacts of COVID-19 Crisis over the Tourism Expectations of the Azores Archipelago Residents. *Sustainability*, *2020*(12), 7612. doi:10.3390u12187612

Cowan, P. J. (2007). Geographic usage of the terms Middle Asia and Central Asia. *Journal of Arid Environments*, *69*(2), 359–363. doi:10.1016/j.jaridenv.2006.09.013

Craig, W. J., Harris, T. M., & Weiner, D. (2020). *Community Participation and Geographical Information Systems*. CRC Press.

Cram, M. (2019). *Smart cities run on smart power*. Ranitan, White Paper. https://www.raritan.com/eu/assets/uploads/Whitepapers/white-paper_smart-cities_A4_EN.pdf

Cretaux, J. F., Letolle, R., & Bergé-Nguyen, M. (2013). History of Aral Sea level variability and current scientific debates. *Global and Planetary Change*, *110*(Special Issue), 99–113. doi:10.1016/j.gloplacha.2013.05.006

Crnogaj, K., Rebernik, M., Bradac Hojnik, B., & Omerzel Gomezelj, D. (2014). Building a model of researching the sustainable entrepreneurship in the tourism sector. *Kybernetes*, *43*(3-4), 377–393. doi:10.1108/K-07-2013-0155

Cuervo-Cazurra, A., & Un, C. (2007). Types of Difficulties in Internationalization and their Consequences. In A New Generation in International Strategic Management. MPG Books Ltd. doi:10.4337/9781847208859.00012

Culqui, A., & González, A. (2016). El Teletrabajo: Una Innovadora Forma de Organización del Trabajo, una Herramienta de Inclusión Laboral y su Regulación Jurídica en el Perú. *Derecho & Sociedad*, *46*, 95–109.

Cummings, S., Regeer, B., de Haan, L., Zweekhorst, M., & Bunders, J. (2017). Critical Discourse Analysis of Perspectives on Knowledge and The Knowledge Society Within the Sustainable Development Goals. *Development Policy Review*, *36*(6), 727–742. doi:10.1111/dpr.12296

Curwell, S., & Cooper, I. (1998). The implications of urban sustainability. *Building Research and Information*, *26*(1), 17–28. doi:10.1080/096132198370074

Curwell, S., Deakin, M., & Symes, M. (Eds.). (2005). *Sustainable urban development, volume 1: The framework and protocols for environmental assessment*. Routledge. doi:10.4324/9780203299913

Cyrus, S. H. H., Cornelia, Y. I. C., & Roger, C. M. H. (2020). Mental Health Strategies to Combat the Psychological Impact of COVID-19 Beyond Paranoia and Panic. *Academic Medicine*, *49*(3), 155–160. PMID:32200399

D'Alisa, G., Demaria, F., & Kallis, G. (Eds.). (2020). Küçülme: Yeni bir çağ için kavram dağarcığı (A. C. Sarı, B. Öktem, B. Gürden, Y. Kurtsal, Çev.). Metis Yayıncılık.

D'Amato, D., Bartkowski, B., & Droste, N. (2020). Reviewing the interface of bioeconomy and ecosystem service research. *Ambio*, *49*(12), 1–19. doi:10.100713280-020-01374-0 PMID:33044700

DaCunha, M. (2014). *6 Social Media Marketing Strategies to Improve Your Efforts in 2014.* WordStream. Available at: https://www.wordstream.com/blog/ws/2014/01/09/social-mediamarketing-strategies

Dade, M. C., Mitchell, M. G., McAlpine, C. A., & Rhodes, J. R. (2019). Assessing ecosystem service trade-offs and synergies: The need for a more mechanistic approach. *Ambio*, *48*(10), 1116–1128. doi:10.100713280-018-1127-7 PMID:30474830

Dahlberg, E. (2009). *Turkey Environmental and Climate Change Policy Brief.* https://sidaenvironmenthelpdesk.se/wordpress3/wp-content/uploads/2013/04/Turkey-Environment-and-Climate-Change-Policy-Brief-Draft-090213.pdf

Dajian, Z. (2008). Background, pattern and policy of China for developing circular economy. *Zhongguo Renkou Ziyuan Yu Huanjing*, *6*(4), 3–8. doi:10.1080/10042857.2008.10684889

Dalkic, G., Balaban, O., Tuydes-Yaman, H., & Celikkol-Kocak, T. (2017). An assessment of the CO2 emissions reduction in high speed rail lines: Two case studies from Turkey. *Journal of Cleaner Production*, *165*, 746–761. doi:10.1016/j.jclepro.2017.07.045

Dalla Corte, T. (2018). O direito (des)humano à água: o tratamento jurídico da água no século XXI. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Dallhammer, E., Gaugitsch, R., & Neugebauer, W. (2018). *Spatial Planning and Governance within EU Policies and Legislation and Their Relevance to the New Urban Agenda*. European Committee of the Regions.

Daly, H. E. (2007). *Ecological Economics and Sustainable Development: Selected Essays of Herman Daly*. Edward Elgar Publishing. doi:10.4337/9781847206947

Daly, H., & Farley, J. (2004). *Economia ecológica: princípios e aplicações*. Instituto Piaget.

Dartnell, L. R., & Kish, K. (2021). Do responses to the COVID-19 pandemic anticipate a long-lasting shift towards peer-to-peer production or degrowth? *Sustainable Production and Consumption*. . doi:10.1016/j.spc.2021.05.018

Dasoler, B. T., Kindel, A., Beduschi, J., Biasotto, L. D., Dornas, R. A. P., Gonçalves, L. O., Lombardi, P. M., Menger, T., de Oliveira, G. S., & Teixeira, F. Z. (2020). The need to consider searcher efficiency and carcass persistence in railway wildlife fatality studies. *European Journal of Wildlife Research*, *66*(5), 81. doi:10.100710344-020-01417-7

Daune, L., & Mongé, N. (2011). L'agriculture urbaine, un fondement dans le projet de territoire. *Urbia—Les Cahiers du développement urbain durable, 12*, 85-106.

Davenhall, W. F., & Kinabrew, C. (2011). *GIS in Health and Human Services. Springer Handbook of Geographic Information. Springer Handbooks*. Springer., doi:10.1007/978-3-540-72680-7_29

De Groot, R. S., Wilson, M. A., & Boumans, R. M. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, *41*(3), 393–408. doi:10.1016/S0921-8009(02)00089-7

De Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, *145*, 75–89. doi:10.1016/j.ecolecon.2017.08.001

de Jong, M., Joss, S., Schraven, D., Zhan, Ch., & Weijnen, M. (2015). Sustainable–Smart–Resilient–Low Carbon–Eco–Knowledge Cities; Making Sense of a Multitude of Concepts Promoting Sustainable Urbanization. *Journal of Cleaner Production*, *109*(1), 25–38. doi:10.1016/j.jclepro.2015.02.004

de los Ríos, I. C., & Charnley, F. J. S. (2017). Skills and capabilities for a sustainable and circular economy: The changing role of design. *Journal of Cleaner Production*, *160*, 109–122. doi:10.1016/j.jclepro.2016.10.130

De Lusente, Y. (2004). *Long-term access to the digital world: from journal to web. European Commission on preservation and access*. Royal Netherlands Academy of Arts and Sciences.

de Man, A. (2019). The Sustainable Development Goals and the rights-based approach to development: Compatible or missing the point? *African Human Rights Law Journal*, *19*(1), 445–469. doi:10.17159/1996-2096/2019/v19n1a21

De Roo,, G., Hillier,, J., & van Wezemael,, J. (Eds.). (2020). *Complexity and planning: systems, assemblages and simulations*. Ashgate Publishing. doi:10.4337/9781786439185

Dean, A. M., & Populus, J. (2013). Remote sensing and GIS integration. In Advances in geographic information systems and remote sensing for fisheries and aquaculture. FAO Fisheries and Aquaculture Technical Paper.

Deane. (2005). *Why the media matters*. Paper prepared by Communication for Social Change Consortium for the Global Forum for Media Development.

Deane, J., Dixit, K., Mue, N., Banda, F., & Waisbord, S. (2003). The other information revolution: Media and empowerment in developing countries. In E. B. Girard & S. O'Siochru (Eds.), *Communicating in the information society* (pp. 65–100). UNRISD.

Dechezleprêtre, A., & Glachant, M. (2014). Does foreign environmental policy influence domestic innovation? Evidence from the wind industry. *Environmental and Resource Economics*, *58*(3), 391–413. doi:10.100710640-013-9705-4

Decreto-Lei 227/1967 de 28 de fev - *Código de Mineração.* (1967). Retrieved from http://www.planalto.gov.br/ccivil_03/Decreto-Lei/Del0227.htm

Decreto-Lei 7.841 de 8 de ago - *Código de Águas Minerais.* (1945). Retrieved from http://www.planalto.gov.br/ccivil_03/decreto-lei/1937-1946/Del7841.htm

Deelstra, T., Boyd, D., & van den Biggelaar, M. (2006). Multifunctional land use, promoting urban agriculture in Europe. In Sustainable Development: Opportunities for Change. Department of the Environment, Transport and the Regions. Consultation Paper on a Revised UK Strategy, DETR, London.

Defarges, P. M. A. (1993). *Mundialização – O Fim das Fronteiras*. Instituto Piaget.

Deininger, K., Selod, H., & Burns, A. (2012). *The Land Governance Assessment Framework: Identifying and Monitoring Good Practice in the Land Sector. In Agriculture and Rural Development*. World Bank.

Dekker, P. L., Bajaj, A. N., & Frasier, S. (2002). Radar and acoustic observations during vtmx field campaign. *10th Conference on Mountain Meteorology*.

del Río Castro, G., Fernández, M. C. G., & Colsa, Á. U. (2020). Unleashing the convergence amid digitalization and sustainability towards pursuing the Sustainable Development Goals (SDGs): A holistic review. *Journal of Cleaner Production*, *122204*. Advance online publication. doi:10.1016/j.jclepro.2020.122204

Delaney, B., & De Jong, A. (2015). Media Archives and Digital Preservation: Overcoming Cultural Barriers. *New Review of Information Networking*, *20*, 73–89.

Delloitte. (2021). *2021 climate check: Business' views on environmental sustainability-Distruptive 2020 slows climate action, but executives determined to act*. https://www2.deloitte.com/global/en/pages/risk/articles/2021-climate-check-business-views-on-environmental-sustainability.html

Demirtaş, I. (2017). *Ekolojik ve Ekonomik Krizlere Alternatif Çözüm Olarak Yeşil Ekonomi Politikaları*. Alternatif Politika, İklim Değişikliği ve Enerji Özel Sayısı.

Demirtaş, I. (2021). Yeşil Ekonomi: Kavramsal Bir Tartışma. In Z. Savaşkan, Ç. Söker, & F. H. Yılmaz (Eds.), *Çevre Hukuku ve Politikaları Kavramlar, Teoriler ve Tartışmalar* [Lexical characteristics of Turkish language] (pp. 325–358). Seçkin Publishing.

den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a Circular Economy development of a typology of key concepts and terms. *Journal of Industrial Ecology*, *21*(3), 517–525. doi:10.1111/jiec.12610

Deng, C., Liu, J., Nie, X., Li, Z., Liu, Y., Xiao, H., Hu, X., Wang, L., Zhang, Y., Zhang, G., Zhu, D., & Xiao, L. (2021). How trade-offs between ecological construction and urbanization expansion affect ecosystem services. *Ecological Indicators*, *122*, 107253. doi:10.1016/j.ecolind.2020.107253

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In D. A. Buchanan & A. Bryman (Eds.), *The Sage handbook of organizational research methods* (pp. 671–689). Sage Publications.

Dernbach, J. C., & Mintz, J. A. (2011). *Environmental laws and sustainability: An introduction*. Academic Press.

Detroit Works Project. (2014). *Detroit future city: Detroit strategic framework plan*. Retrieved from http://detroitfuturecity.com/wp-content/uploads/2014/12/DFC_Full_2nd.pdf

Deutsch, L., Folke, C., & Skanberg, K. (2003). The critical natural capital of ecosystem performance as insurance for human well-being. *Ecological Economics*, *44*(2-3), 205–217. doi:10.1016/S0921-8009(02)00274-4

DGA. (2017). *Estimación de la demanda actual, proyecciones futuras y caracterización de la calidad de los recursos hídricos en Chile*. DGA.

Dhote, M. (2005). *Landuse Strategy for Conservation of Biodiversity*. School of Planning & Architecture.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M. A., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., ... Zlatanova, D. (2015). The IPBES Conceptual Framework—Connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. doi:10.1016/j.cosust.2014.11.002

Dib, L. A., & Carneiro, J. (2006). *Avaliação Comparativa do Escopo Descritivo e Explanatório dos Principais Modelos de Internacionalização de Empresas*. 30° Encontro Nacional de Pós-Graduação e Pesquisa em Administração – ENANPAD, Salvador, BA.

Dib, L. A., & Rocha, A. (2009). Caracterizando o Processo de Internacionalização Born Global: Pesquisa Quantitativa na Indústria Brasileira de Software. Encontro de Estudos em Estratégia, Recife.

Didovets, I., Lobanova, A., Krysanova, V., Menz, C., Babagalieva, Z., Nurbatsina, A., Gavrilenko, N., Khamidov, V., Umirbekov, A., Qodirov, S., Muhyyew, D., & Hattermann, F. F. (2021). Central Asian rivers under climate change: Impacts assessment in eight representative catchments. *Journal of Hydrology. Regional Studies*, *34*, 100779. doi:10.1016/j.ejrh.2021.100779

Diffenbaugh, N. S., & Burke, M. (2019). Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(20), 9808–9813. doi:10.1073/pnas.1816020116 PMID:31010922

Diop-Christensen, A. (2018). Beating the 'unemployable' with a stick? How Danish street-leel workers transformed a Danish work-first policy. In M. Kamali & J. Jönsson (Eds.), *Neoliberalism, Nordic welfare states and social work: Current and future challenges* (pp. 205–215). Routledge. doi:10.4324/9781315111834-18

Direção Regional do Turismo. (2019). *Revisão do Programa de Ordenamento Turístico da Região Autónoma dos Açores*. Relatório POTRAA Intermédio. Versão Consulta Pública.

Dodson, M., & Smith, D. E. (2003). *Governance for sustainable development: strategic issues and principles for Indigenous Australian communities.* CAEPR Discussion Paper No. 250, CAEPR. http://www.anu.edu.au/caepr/discussion.php

Dogan, E., & Turkekul, B. (2016). $CO_2$ emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research International*, *23*(2), 1203–1213. doi:10.100711356-015-5323-8 PMID:26351068

Dogru, B. (2016). *100 Maddede sürdürülebilirlik rehberi*. SKD-Türkiye Yayınları.

Dominelli, L. (2018). *Yeşil sosyal hizmet* (A. İ. Çoban, Çev.). Nika Yayınevi.

Dominguinhos, P. M. (1997). *O processo de internacionalização: a experiência das empresas Portuguesas.* Academic Press.

Dominish, E., Retamal, M., Sharpe, S., Lane, R., Rhamdhani, M. A., Corder, G., Giurco, D., & Florin, N. (2018). Slowing and Narrowing the flow of metals for consumer goods: Evaluating opportunities and barriers. *Sustainability*, *10*(4), 1096–1119. doi:10.3390u10041096

Donatiello, J. E. (2015). The world's population: An encyclopedia of critical issues, crises, and ever-growing countries. *Reference and User Services Quarterly*, *54*(4), 85. doi:10.5860/rusq.54n4.85b

Dong, L., Fujita, T., Dai, M., Geng, Y., Ren, J. Z., Fuijii, M., Wang, Y., & Ohnishi, S. (2016). Towards preventative eco-industrial development: An industrial and urban symbiosis case in one typical industrial city in China. *Journal of Cleaner Production*, *114*, 387–400. doi:10.1016/j.jclepro.2015.05.015

Dovers, S. (2005). *Environment and sustainability policy: Creation, implementation, evaluation*. Federation Press.

Dow, K. (2000). Social dimensions of gradients in urban ecosystems. *Urban Ecosystems*, *4*(4), 255–275. doi:10.1023/A:1015767231137

Dowman, I. (2016). Sustainable Infrastructure: Geospatial Tech in the Forefront. Europe. *Geospatial World*.

Download Speeds. Comparing 2G, 3G, 4G & 5G Mobile Networks. (2018, November 23). *Ken's Tech Tips*. https://kenstechtips.com/index.php/download-speeds-2g-3g-and-4g-actual-meaning

Drake, V. A., Helm, K. F., Readshaw, J. L., & Reid, D. G. (1981). Insect *migration across bass strait during spring: A radar study. Bulletin of Entomological Research*, *71*(3), 449–466.

Droste, N., D'Amato, D., & Goddard, J. J. (2018). Where communities intermingle, diversity grows–The evolution of topics in ecosystem service research. *PLoS One*, *13*(9), e0204749. doi:10.1371/journal.pone.0204749 PMID:30265733

Drummond, J., & Barros-Platiau, A. F. (2006). Brazilian environmental laws and policies, 1934–2002: A critical overview. *Law & Policy*, *28*(1), 83–108. doi:10.1111/j.1467-9930.2005.00218.x

Drury, F. (2019). *Enchanting photos of the abandoned village taken over by hippies living in fairytale houses in the Spanish mountains*. MailOnline. http://www.dailymail.co.uk/news/article-3139295/Enchanting-photos-abandoned-village-taken-Spanish-hippies-living-fairytale-houses-mountains.html

Dryzek, J. (1987). *Rational ecology: Environment and political economy*. Blackwell.

Duchacek, I. D. (1990). Perforated sovereignties: toward a typology of new actors in international relations. In H. J. Michelmann & P. Soldatos (Eds.), *Federalism and international relations: the role of subnationalunits* (pp. 1–33). Oxford University Press.

Duedahl, P. (2016). A History of UNESCO: Global Actions and Impacts. Palgrave Macmillan UK. doi:10.1007/978-1-137-58120-4

Dulac, J. (2013). *Global land transport infrastructure requirements*. International Energy Agency.

Dunning, J. (1988). The ecletic paradigm of international production: A restatement and some possible extensions. *Journal of International Business Studies*, *19*(1), 1–31. doi:10.1057/palgrave.jibs.8490372

Dunning, J. (2001). The Eclectic (OLI) paradigma of International Production: Past, Present and Future. *International Journal of the Economics of Business*, *8*(2), 173–190. doi:10.1080/13571510110051441

Dunning, J. H. (2000). The eclectic paradigm as an envelope for economic and business theories of MNE activity. *International Business Review*, *9*(2), 163–190. doi:10.1016/S0969-5931(99)00035-9

Durán Sosa, R. (2020). El establecimiento del agua como recurso fundamental en temporada del Covid-19: Caso de la Empresa de Servicios Públicos de Heredia, Costa Rica. *Revista Científica Monfragüe Resiliente*, *XIII*, 278–288.

Duran, N. (2020). *El teletrabajo y la conciliación con el entorno de convivencia familiar durante la pandemia COVID-19*. Academic Press.

Durán, A., del Río, M. C., & Álvarez, J. (2017). Bibliometric analysis of publications on wine tourism in the databases Scopus and WoS. *European Research on Management and Business Economics*, *23*(1), 8–15. doi:10.1016/j.iedeen.2016.02.001

Dutta, J., Pramanick, P., & Roy, S. (2018). Energy-efficient GPS usage in location-based applications. In *Information and Decision Sciences* (pp. 345–353). Springer. doi:10.1007/978-981-10-7563-6_36

Dutton, W. H., Blumler, J. G., & Kraemer, K. L. (1987). *Wired cities: Shaping future communication*. Macmillan.

Eaton, F. D., McLaughlin, S. A., & Hines, J. R. (1995). A new frequency-modulated continuous wave radar for studying planetary boundary layer morphology. *Radio Science*, *30*(1), 75–88.

Eberhard, Ch. (2008). *Law in a Globalizing World: Towards 'Good Governance' Through socio-intercultural Dialogue? Revista Direito, Estado e Sociedade, 33*.

EC. (2021). *Packaging and Packaging Waste Directive.* European Commission. https://ec.europa.eu/environment/topics/waste-and-recycling/packaging-waste_en#ecl-inpage-508

ECLAC. (2020a). *The 2030 Agenda for Sustainable Development in the new global and regional context: Scenarios and projections in the current crisis*. https://www.cepal.org/en/publications/45338-2030-agenda-sustainable-development-new-global-and-regional-context-scenarios-and

ECLAC. (2020b). *The social challenge in times of COVID-19*. https://www.cepal.org/en/publications/45544-social-challenge-times-covid-19

ECLAC. (2021, March 18). *Countries of Latin America and the Caribbean Commit to Implementing the 2030 Agenda for Sustainable Development and Building Forward Better*. https://foroalc2030.cepal.org/2021/en/news/countries-latin-america-and-caribbean-commit-implementing-2030-agenda-sustainable-development

Economics of Ecosystems and Biodiversity (TEEB). (2011). *TEEB manual for cities: Ecosystem services in urban management*. Author.

Edokpayi, J. N., Odiyo, J. O., & Durowoju, O. S. (2017). *Impact of Wastewater on Surface Water Quality in Developing Countries: A Case Study of South Africa*. Water Quality, Hlanganani Tutu, IntechOpen. doi:10.5772/66561

Eijgenraam, C., & Ossokina, I. (2008). Cost-benefit analysis of railway station area development: The case of Amsterdam South Axis. In *Railway Development* (pp. 191–211). Physica-Verlag HD. doi:10.1007/978-3-7908-1972-4_10

El Gaucho Periódico (Redacción). (2017). Factores políticos limitan manejo integrado de la quebrada seca. *El Gaucho Periódico. El periódico de Belén*. Recuperado de https://periodicoelguacho.com/factores-politicos-limitan-manejo-integrado-del-quebrada-seca/

Elia, V., Gnoni, M. G., & Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of Cleaner Production*, *142*, 2741–2751. doi:10.1016/j.jclepro.2016.10.196

Ellegaard, O., & Wallin, J. A. (2015). The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*, *105*(3), 1809–1831. doi:10.100711192-015-1645-z PMID:26594073

Ellen MacArthur Foundation (EMAF). (2013). *Towards the Circular Economy: Economic and business Rationale for an Accelerated Transition*. Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

Ellen MacArthur Foundation (EMAF). (2015). *Towards a Circular Economy: Business Rationale for an Accelerated Transition*. Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf

Ellen MacArthur Foundation (EMAF). (2019). *Completing the picture – how the circular economy tackles climate change.* Retrieved from: https://www.ellenmacarthurfoundation.org/publications/completing-the-picture-climate-change

Ellen MacArthur Foundation. (2015). *Delivering the Circular Economy. A toolkit for policy makers. Resource document.* https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Policymaker-Toolkit.pdf

Elmqvist, T., Wall, M., & Berggren, A. L. (2001). Tropical forest reorganization after cyclone and fire disturbance in Samoa: remnant trees as biological legacies. *Cons Ecol, 5*, 10. http://www.consecol.org/vol5/iss2/art10

Elvidge, C. D., Sutton, P. C., Ghosh, T., Tuttle, B. T., Baugh, K. E., Bhaduri, B., & Bright, E. (2009). A Global Poverty Map Derived from Satellite Data. *Computers and Geosciences, 35*(8), 1652-1660. DOI: .cageo.2009.01.009 doi:10.1016/j

Enerdata. (2021). *Total energy consumption*. https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html

EnergyWatch. (2020). *The top 10 sustainability trends to watch in 2020*. Retrieved from https://energywatch-inc.com/

Engstrom, R., Hersh, J., & Newhouse, D. (2021, July 31). Poverty from Space: Using High Resolution Satellite Imagery for Estimating Economic Well-being. *The World Bank Economic Review*, lhab015. Advance online publication. doi:10.1093/wber/lhab015

Environmental education and communication for a sustainable world. (2000). InDay, B. (Ed.), *Handbook for international practitioners*. AED.

EPA. (2017). *Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy.* United States Environmental Protection Agency. https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

Erdin, C., & Ozkaya, G. (2020). Contribution of small and medium enterprises to economic development and quality of life in Turkey. *Heliyon*, *6*(2), e03215. doi:10.1016/j.heliyon.2020.e03215 PMID:32055722

ERM Group. (2021). *Sustainability Report*. Author.

Erşen, E. (2020). *Koranavirüs, Küreselleşme ve Uluslararası Sistem Covid-19 Sonrası Uluslararası Sistem: Eski Sorunlar Yeni Trendler*. SAM Publishing.

Esen, Ö., Yıldırım, D. C., & Yıldırım, S. (2020). Threshold effects of economic growth on water stress in the Eurozone. *Environmental Science and Pollution Research International*, *27*(25), 31427–31438. doi:10.100711356-020-09383-y PMID:32488700

Eskinat, R. (2016). Binyıl kalkınma hedeflerinden sürdürülebilir kalkınma hedeflerine. *Anadolu Üniversitesi Hukuk Fakültesi Dergisi*, *2*(3), 267–282.

ESPH. (2020). *Resumen ejecutivo proyecto de Saneamiento Ambiental de Heredia* [Informe]. Empresa de Servicios Públicos de Heredia.

Essien, D.E. (2019). *Ethical Implications of Cooperation and Safety vis-à-vis Cyber Security in Africa.* Doi:10,4018/978-1-7998-1104-6ch002

Estes, J. A., & Duggins, D. O. (1995). Sea otters and kelp forests in Alaska: Generality and variation in a community ecological paradigm. *Ecological Monographs*, *65*(1), 75–100. doi:10.2307/2937159

Esteves, C. C. (2012). *O regime jurídico das águas minerais na constituição de 1988*. Tese de Doutorado, Universidade Estadual de Campinas.

EurActiv. (2004). *Sustainable Development: Introduction*. Author.

European Commission. (2001). *Joint Research Centre Map Projections for Europe*. Institute for Environment and Sustainability.

European Commission. (2001). *White paper on governance*. Brussels, Belgium: European Commission.

European Commission. (2011). *Cities of tomorrow - Challenges, visions, ways forward*. Available at: https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/citiesoftomorrow/citiesoftomorrow_final.pdf

European Commission. (2013). *Nature and Biodiversity*. European Commission.

European Commission. (2015). *Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Closing the loop-An EU action plan for the Circular Economy. COM/2015/0614 final.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

European Commission. (2020). *Leading the way to a global circular economy: state of play and outlook*. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/31079d7e-3a96-11eb-b27b-01aa75ed71a1/language-en

European Commission. (2021a). *Smart cities-Cities using technological solutions to improve the management and efficiency of the urban environment*. https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

European Commission. 2021b). *Energy union*. https://ec.europa.eu/energy/topics/energy-strategy/energy-union_en

European Environment Agency. (2010, May 27). *10 messages for 2010 Urban ecosystems.* Retrieved June 10, 2021, from European Environment Agency: https://www.eea.europa.eu/publications/10-messages-for-2010-urban-ecosystems

European Environment Agency. (2018). *Water in the city*. https://www.eea.europa.eu/signals/signals-2018-content-list/articles/close-up-2014-water-in

European Union (EU). (2020). *Policy Forum on Development*. Working Group: Social Pillar of Sustainable Development. www. europa.eu

Eusébio, C., Kastenholz, E., & Breda, Z. (2014). Tourism and sustainable development of rural destinations: A stakeholders' view. *Revista Portuguesa de Estudos Regionais*, *36*, 13–21.

Eustat. (2020). *Indice de Desarrollo Humano por indicadores según países. 2020.* https://www.eustat.eus/elementos/ele0013500/indice-de-desarrollo-humano-por-indicadores-segun-paises/tbl0013566_c.html

Evans, A. (2010). *Resource scarcity, climate change and the risk of violent conflict*. World Development Report 2011 Background Paper.

Evans, S., Vladimirova, D., Holgado, M., Van Fossen, K., Yang, M., Silva, E. A., & Barlow, C. (2017). Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models. *Business Strategy and the Environment*, *26*(5), 597–608. doi:10.1002/bse.1939

Evrard, D., Rejeb, H. B., Zwolinski, P., & Brissaud, D. (2021). Designing immortal products: A lifecycle scenario-based approach. *Sustainability, 13*(6), 3574.

Ewald, F. (1996). Philosophie de la précaution. *L'Annee Sociologique*, *46*(2), 402.

Expansión. (2020). *Datosmacro.com*. https://datosmacro.expansion.com/paises/costa-rica

Eyewitness news24. (2021). *73,500 valuable items lost from African Studies Collection in UCT library fire*. https://ewn.co.za/2021/04/21/73-500-valuable-items-lost-from-african-studies-collection-in-uct-library-fire

Fabunmi, A.B. (2007). The Roles of Librarians in Copyright Protection in Nigeria. *International Journal of African & African American Studies*, *6*(1), 85 – 93.

Fabunmi, B.A., Paris, M., & Fabunmi, M. (1996). Digitization of Library Resources: Challenges and Implications for Policy and Planning. *International Journal of African & African American Studies,* (2).

Fabunmi, A. B., Paris, M., & Fabunmi, M. (2006). Digitization of Library Resources: Challenges and Implications for Policy and Planning. *International Journal of African & African American Studies*, *2*, 23–36.

Fagerholm, N., Oteros-Rozas, E., Raymond, C. M., Torralba, M., Moreno, G., & Plieninger, T. (2016). Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS. *Applied Geography (Sevenoaks, England)*, *74*, 30–46. doi:10.1016/j.apgeog.2016.06.007

Falk, B. (2013). The resilient farm and homestead. Chelsea Green Publishing.

Fantozzi, C., Bressan, F., Pretto, N., & Canazza, S. (2017). Tape music archives; From preservation to access. *International Journal on Digital Libraries*, *18*(3), 233–249. doi:10.100700799-017-0208-8

FAO. (2003). *Communication and natural resource management*. FAO.

FAO. (2005). *Communication for development roundtable report. Focus on sustainable development*. Report of the 9th UN Roundtable on Communication for Development. Rome: FAO.

Faria, C. A. P. de. (2003). Idéias, conhecimento e políticas públicas: um inventáriosucinto das principais vertentes analíticas recentes. *Revista Brasileira de Ciencias Sociais*, *18*(51), 21-30.

Faulkner, S. L., & Trotter, S. P. (2017). Data saturation. In J. Matthes, S. C. Davis, & R. F. Potter (Eds.), The International Encyclopedia of Communication Research Methods (pp. 1–2). doi:10.1002/9781118901731.iecrm0060

Fedotova, V.G., Kvalenko, A.O., & Malvutina, D.T. (2019). Transformation of Information security systems of enterprises in the context of digitization of national economy. *Ubiquitous Computing and the Internt of Things: Prerequisites for the Development of ICT*, 811 – 822.

Fehling, M., Nelson, B. D., & Venkatapuram, S. (2013). Limitations of the Millennium Development Goals: A literature review. *Global Public Health: An International Journal for Research, Policy and Practice*, *8*(10), 1109–1122. doi:10.1080/17441692.2013.845676 PMID:24266508

Feichas, R. V. (2018). Insights de compliance e efeitos disruptivos sobre os meios de proteção das águas minerais no perímetro das estâncias hidrominerais. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Femenia-Serra, F. (2018). Smart Tourism Destinations and Higher Tourism Education in Spain. Are We Ready for this new Management Approach? In B. Stangl & J. Pesonem (Eds.), *Information and Communication Technologies in Tourism*. Springer Internation Publishing. doi:10.1007/978-3-319-72923-7_33

Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., & Ribeiro-Soriano, D. (2020). Circular economy business models: The state of research and avenues ahead. *Business Strategy and the Environment*, *29*(8), 3006–3024. doi:10.1002/bse.2554

Fernández, Y. F., López, M. F., & Blanco, B. O. (2018). Innovation for sustainability: The impact of R&D spending on CO2 emissions. *Journal of Cleaner Production*, *172*, 3459–3467. doi:10.1016/j.jclepro.2017.11.001

Ferrari, M. (2020). Reflexive Governance for Infrastructure Resilience and Sustainability. *Sustainability*, *12*(23). doi:10.3390/su122310224

Fetscherin, M., & Heinrich, D. (2015). Consumer brand relationships research: A bibliometric citation meta-analysis. *Journal of Business Research*, *68*(2), 380–390. doi:10.1016/j.jbusres.2014.06.010

Fick, S. & Hijmans, R. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology, 37*(12), 4302-4315.

Finlayson, J. (1991). *Don't Depend on Me: Autonomy and Dependence in an Aboriginal Community in North Queensland* (PhD Thesis). Anthropology Department, ANU, Canberra.

Fischer, D. (2020). *The challenges of implementing the Sustainable Development Goals in Asia*. EU. Available at: ttps://europa.eu/capacity4dev/articles/challenges-implementing-sustainable-development-goals-

Fischer, E., Seneviratne, S., Lüthi, D., & Schär, C. (2007). Contribution of land-atmosphere coupling to recent European summer heat waves. *Geophysical Research Letters*, *34*(6), 1–6. doi:10.1029/2006GL029068

Fleming, R., & Tatchell, G. (1995). Shifts in the flight periods of british aphids: a response to climate warming? In *Insects in a changing environment* (pp. 505–508). Royal Entomological Society of London.

Fodha, M., & Zaghdoud, O. (2010). Economic growth and pollutant emissions in Tunisia: An empirical analysis of the environmental Kuznets curve. *Energy Policy*, *38*(2), 1150–1156. doi:10.1016/j.enpol.2009.11.002

Foga, S., Scaramuzza, P. L., Guo, S., Zhu, Z., Dilley, R. D. Jr, Beckmann, T., Schmidt, G. L., Dwyer, J. L., Joseph Hughes, M., & Laue, B. (2017). Cloud detection algorithm comparison and validation for operational Landsat data products. *Remote Sensing of Environment*, *194*, 379–390. doi:10.1016/j.rse.2017.03.026

Folke, C., Pritchard, L., Berkes, F., Colding, J., & Svedin, U. (1998). *The Problem of Fit Between Ecosystems and Institutions.* International Human Dimensions Programme (IHDP). IHDP Working Paper No 2. www.uni-bonn.de/IHDP/public.htm

Folke, C., Biggs, R., Norström, A. V., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, *21*(3), art41. doi:10.5751/ES-08748-210341

Folke, C., Carpenter, S. R., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *Ambio*, *31*(5), 437–440. doi:10.1579/0044-7447-31.5.437 PMID:12374053

Folke, C., Holling, C. S., & Perrings, C. (1996). Biological diversity, ecosystems and the human scale. *Ecological Applications*, *6*(4), 1018–1024. doi:10.2307/2269584

Folke, C., Jansson, A., Larsson, J., & Costanza, R. (1997). Ecosystem appropriation by cities. *Ambio*, *26*, 167–172.

Fontaine, B., Roucou, P., Gaetani, M., & Marteau, R. (2011). Recent changes in precipitation, ITCZ convection and northern tropical circulation over North Africa (1979-2007). *International Journal of Climatology*, *31*(5), 633–648. doi:10.1002/joc.2108

Forman, R. T. T., Sperling, D., Bissonette, J. A., Clevenger, A. P., Cutshall, C. D., Dale, V. H., Fahrig, L., France, R. L., Goldman, C. R., Heanue, K., Jones, J., Swanson, F., Turrentine, T., & Winter, T. C. (2003). *Road Ecology*. Amsterdam University Press.

Forman, R. T., & Alexander, L. E. (1998). Roads and their major ecological effects. *Annual Review of Ecology and Systematics*, *29*(1), 207–231. doi:10.1146/annurev.ecolsys.29.1.207

Forum das Cidades. (2016). *Rede De Cidades Criativas*. Available at: https://www.forumdascidades.pt/content/rede-de-cidades-criativas

Forys, E. A., & Allen, C. R. (2002). Functional group change within and across scales following invasions and extinctions in the Everglades ecosystem. *Ecosystems (New York, N.Y.)*, *5*(4), 339–347. doi:10.100710021-001-0078-0

Foster, K. R. (2003, Winter). O princípio da precaução: bom senso ou extremismo ambiental? *IEEE Technology and Society Magazine*.

Fraccascia, L., Giannoccaro, I., & Albino, V. (2019a). Business models for industrial symbiosis: A taxonomy focused on the form of governance. *Resources, Conservation and Recycling*, *146*, 114–126. doi:10.1016/j.resconrec.2019.03.016

Freytag,, T., Gössling,, S., & Mössner,, S. (2019). Living the green city: Freiburg's Solarsiedlung between narratives and practices of sustainable urban development. *Local Environment*, *19*(6), 644–659.

Friedmann, J., & Wolff, G. (1982). World city formation: An agenda for research and action. *International Journal of Urban and Regional Research*, *6*(3), 309–344. doi:10.1111/j.1468-2427.1982.tb00384.x

Friedrich, J., & Oberhänsli, H. (2004). Hydrochemical properties of the Aral Sea water in summer 2002. *Journal of Marine Systems*, *47*(1), 77–88. doi:10.1016/j.jmarsys.2003.12.010

Friends of the Earth International. (2021, May). *Historic victory: judge forces Shell to drastically reduce CO2 emissions*. https://www.foei.org/features/historic-victory-judge-forces-shell-to-drastically-reduce-co2-emissions

Frost, T. M., Carpenter, S. R., Ives, A. R., & Kratz, T. K. (1995). Species compensation and complementarity in ecosystem function. In C. G. Jones & J. H. Lawton (Eds.), *Linking species and ecosystems*. Chapman & Hall. doi:10.1007/978-1-4615-1773-3_22

Fuks, P. (1981). *Harmonic radar, a modern method for location of avalanche victims.* Division of Electromagnetic Theory, Royal Inst. of Technology.

Fundo de Maneio e Observatório do Turismo dos Açores. (2018). *Proposta de Plano para Tornar os Açores num Destino Turístico Inteligente - Diagnóstico*. Elaborado para o Fundo Regional para a Ciência e Tecnologia.

Funtowicz, S., & Ravetz, J. (1997). Ciência pós-normal e comunidades ampliadas de pares face aos desafios ambientais. *Historia, Ciencias, Saude—Manguinhos*, *4*(2), 219–230. doi:10.1590/S0104-59701997000200002

Fu, Q., Li, B., Hou, Y., Bi, X., & Zhang, X. (2017). Effects of land use and climate change on ecosystem services in Central Asia's arid regions: A case study in Altay Prefecture, China. *The Science of the Total Environment*, *607*, 633–646. doi:10.1016/j.scitotenv.2017.06.241 PMID:28709097

Gaceta. (2014). *Decreto Ejecutivo 38071-MINAE, 2014*. Crea Comisión de Gestión Integral de la Cuenca del Río Grande de Tárcoles. Sistema Costarricense de Información Jurídica. Imprenta Nacional.

Gain, A. K., Giupponi, C., & Wada, Y. (2016). Measuring global water security towards sustainable development goals. *Environmental Research Letters*, *11*(12), 124015. doi:10.1088/1748-9326/11/12/124015

Galati, G., Pavan, G., & De Palo, F. (2017). Chirp signals and noisy waveforms for solid-state surveillance radars. *Aerospace*, *4*(1), 15.

Galera, H., Sudnik-Wójcikowska, B., Wierzbicka, M., & Wiłkomirski, B. (2011). Encroachment of forest species into operating and abandoned railway areas in north-eastern Poland. *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology, 145*(1), 23–36.

Gallagher, F., Bowers, J., & Laufenberg, E., Jr., Storwold, D., & Mclaughlin, S. (2004). Possible detection of insects in an urban environment by a frequency modulated-continuous wave radar. *5th Symposium on the Urban Environment*, 347-353.

Gallo, J. L., & Ertur, C. (2003). Exploratory Spatial Data Analysis of the Distribution of Regional per Capita GDP in Europe, 1980- 1995. *Papers in Regional Science*, *201*(2), 175–201. doi:10.1007101100300145

Gamboa, A. M., & Galicia, L. (2011). Differential influence of land use/cover change on topsoil carbon and microbial activity in low-latitude temperate forests. *Agriculture, Ecosystems & Environment*, *142*(3-4), 280–290. doi:10.1016/j.agee.2011.05.025

Gaonkar, S., Li, J., Choudhury, R. R., Cox, L., & Schmidt, A. (2008, June). Micro-blog: sharing and querying content through mobile phones and social participation. In *Proceedings of the 6th international conference on Mobile systems, applications, and services* (pp. 174-186). 10.1145/1378600.1378620

Garaba, F (2014). Preparing collections for digitization: The case of religious archives in Pietermaritzburg, Kwazulu-Natal, South Africa. *Verbum et Ecclesia, 35*(1).

Garaba, F. (2010). *An investigation into the management of the records and archives of former liberation movements in East and Southern Africa held by national and private archival institutions (Ph.D. Diss)*. University of Kwazulu Natal.

Garay, A. (2015). *El cambio en la cultura organizacional como mecanismo para propiciar alternativas efectivas de teletrabajo en las organizaciones [Change in organizational culture as effective mechanism for promoting alternative telecommuting organizations]*. Universidad Militar Nueva Granada.

J. García Raya (Ed.). (2006). *Cronología básica del ferrocarril español de vía ancha*. *IV Congreso Historia Ferroviaria*, Málaga.

García Zaballos, A., Iglesias, E., Adamowicz, A. (2019). *The Impact of Digital Infrastructure on the Sustainable Development Goals: A Study for Selected Latin American and Caribbean Countries.* The Institutions for Development Sector. Inter-American Development Bank.

García, C. (2015). *Smart Cities y Destinos Turísticos Inteligentes: un análise comparativo*. Dissertação de Mestrado. Universidade de Málaga. Available at: https://riuma.uma.es/xmlui/handle/10630/10154

Garrone, P., & Grilli, L. (2010). Is there a relationship between public expenditures in energy R&D and carbon emissions per GDP? An empirical investigation. *Energy Policy*, *38*(10), 5600–5613. doi:10.1016/j.enpol.2010.04.057

Gaur, J., & Mani, V. (2018). Antecedents of closed-loop supply chain in emerging economies: A conceptual framework using stakeholder's perspective. *Resources, Conservation and Recycling*, *139*, 219–227. doi:10.1016/j.resconrec.2018.08.023

Gaybullaev, B., Chen, S. C., & Kuo, Y. M. (2012). Large-scale desiccation of the Aral Sea due to over-exploitation after 1960. *Journal of Mountain Science*, *9*(4), 538–546. doi:10.100711629-012-2273-1

Geissdoerfer, M., Morioka, S. N., De Carvalho, M. M., & Evans, S. (2018a). Business models and supply chains for the circular economy. *Journal of Cleaner Production*, *190*, 712–721. doi:10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. J. (2017). The Circular Economy-A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. doi:10.1016/j.jclepro.2016.12.048

Geissdoerfer, M., Vladimirova, D., & Evans, E. (2018b). Sustainable business model innovation: A review. *Journal of Cleaner Production*, *198*, 401–416. doi:10.1016/j.jclepro.2018.06.240

General Directorate of Environmental Impact Assessment, Permit and Inspection. (2020). Environmental Indicators. Author.

Geng, Y., Zhang, P., Cote, R. P., & Fujita, T. (2008). Assessment of the National Eco-Industrial Park Standard for Promoting Industrial Symbiosis in China. *Journal of Industrial Ecology*, *13*(1), 15–26. doi:10.1111/j.1530-9290.2008.00071.x

Geringer, J. M., Beamish, P. W., & Dacosta, R. C. (1989). Diversification strategy and internationalization: Implications for MNE Performance. *Strategic Management Journal*, *10*(2), 109–119. doi:10.1002mj.4250100202

GESI. (n.d.). *GESI Digital With Purpose (Full Report)*. https://gesi.org/research/gesi-digital-with-purpose-full-report

Gesicki, A. L. D., & Sindico, F. (2013). Gestão das águas minerais no Brasil – panorama legal atual e perspectivas futuras. *Revista do Instituto Geológico*, *34*(2), 69–88. doi:10.5935/0100-929X.20130010

Geybullayeva, A. (2021). *Turkey: Pandemic restrictions out, new restrictions*. Globalvoices. https://globalvoices.org/2021/06/24/turkey-pandemic-restrictions-out-new-restrictions-in/

GFDRR & World Bank. (2015). *Investing in Urban Resilience: Protecting and Promoting Development in a Changing World*. World Bank.

Gherghina, Ș. C., Botezatu, M. A., Hosszu, A., & Simionescu, L. N. (2020). Small and medium-sized enterprises (SMEs): The engine of economic growth through investments and innovation. *Sustainability*, *12*(1), 347. doi:10.3390u12010347

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, *114*, 11–32. doi:10.1016/j.jclepro.2015.09.007

Gil, A. C. (2008). *Como elaborar projetos de pesquisa*. Atlas.

Gilbert, M., & Masucci, M. (2005). Moving Beyond "Gender and GIS" to a Feminist Perspectives on Information Technologies: The impact of welfare reform on women's IT needs. In A Companion to Feminist Geography (pp. 305-321). Blackwell Publications. doi:10.1002/9780470996898

Gillespie, D. (1999). *Report to Bawinanga Aboriginal Corporation, Maningrida NT—Strategic Planning Issues for the Corporation*. Unpublished report, Tallagella Pty Ltd.

Girardet,, H. (1996). *The GAIA atlas of cities: new directions for sustainable urban living*. Gaia Books Limited.

Girard, L. F., & Nocca, F. (2019). Moving towards the circular economy/city model: Which tools for operationalizing this model? *Sustainability*, *11*(22), 6253. doi:10.3390u11226253

Gitelson, A. A., Kaufman, Y. J., & Merzlyak, M. N. (1996). Use of a green channel in remote sensing of global vegetation from EOS- MODIS. *Remote Sensing of Environment*, *58*(3), 289–298. doi:10.1016/S0034-4257(96)00072-7

Giulio, G. M. D., Torres, R. R., Vasconcellos, M. P., Braga, D. R. G. C., Mancini, R. M., & Lemos, M. C. (2019). Eventos extremos, mudanças climáticas e adaptação no Estado de São Paulo. *Ambiente & Sociedade*, *22*. Advance online publication. doi:10.1590/1809-4422asoc0277r1vu19l4ao

Giurco, D., Littleboy, A., Boyle, T., Fyfe, J., & White, S. (2014). Circular economy: Questions for responsible minerals, additive manufacturing and recycling of metals. *Resources*, *3*(2), 432–453. doi:10.3390/resources3020432

Glare, P. G. W. (Ed.). (1968). *Oxford Latin dictionary*. Oxford University Press.

Gluckman, M. (1968). The utility of the equilibrium model in the study of social change. *American Anthropologist*, *70*(2), 219–237. doi:10.1525/aa.1968.70.2.02a00010

Godoy, J. (2011). Observatorio Laboral revista venezolana. *Observatorio Laboral Revista Venezolana*, *4*(8), 14.

Golley, F. B. (1993). *A History of the Ecosystem Concept in Ecology: More Than the Sum of the Parts*. Yale University Press.

Gómez-Baggethun, E., Gren, Å., Barton, D. N., Langemeyer, J., McPhearson, T., O'Farrell, P., . . . Kremer, P. (2013). Urban Ecosystem Services. *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*, 175-251.

Gomez-Baggethun, E., Corbera, E., & Reyes-Gar-cia, V. (2013). Traditional ecological knowledge and global environmental change: Research findings and policy implications. *Ecology and Society*, *18*(4), 72. doi:10.5751/ES-06288-180472 PMID:26097492

Gontard, N., Sonesson, U., Birkved, M., Majone, M., Bolzonella, D., Celli, A., Angellier-Coussi, H., Jang, G. W., Verniquet, A., Broeze, J., Schaer, B., Batista, A. P., & Sebok, A. (2018). A research challenge vision regarding management of agricultural waste in a circular bio-based economy. *Critical Reviews in Environmental Science and Technology*, *48*(6), 614–654. doi:10.1080/10643389.2018.1471957

González-Yebra, Ó., Aguilar, M. A., Nemmaoui, A., & Aguilar, F. J. (2018). Methodological proposal to assess plastic greenhouses land cover change from the combination of archival aerial orthoimages and Landsat data. *Biosystems Engineering*, *175*, 36–51. doi:10.1016/j.biosystemseng.2018.08.009

Goodwell, A., Kumar, P., Fellows, A., & Flerchinger, G. (2018). Dynamic process connectivity explains ecohydrologic responses to rainfall pulses and drought. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(37), 1–10. doi:10.1073/pnas.1800236115 PMID:30150371

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. doi:10.1016/j.rse.2017.06.031

Gorenflo, L. J., Romaine, S., & Mittermeier, R. A. (2012). Co-occurrence oflinguistic and biological diversity in biodiver-sity hotspots and high biodiversity wilderness areas. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 8032–8037.

Gourevitch, J. D., Alonso-Rodríguez, A. M., Aristizábal, N., de Wit, L. A., Kinnebrew, E., Littlefield, C. E., Moore, M., Nicholson, C. C., Schwartz, A. J., & Ricketts, T. H. (2021). Projected losses of ecosystem services in the US disproportionately affect non-white and lower-income populations. *Nature Communications*, *12*(1), 1–9. doi:10.103841467-021-23905-3 PMID:34112778

Graham, S., & Marvin, S. (2001). *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. Routledge.

Grant, R. M. (1987). Multinationality and performance among British manufacturing companies. *Journal of International Business Studies*, *18*(1), 79–89. doi:10.1057/palgrave.jibs.8490413

Grant, R. M., Jammine, A. P., & Thomas, H. (1988). Diversity, diversification and profitability among British manufacturing companies, 1972-1984. *Academy of Management Journal*, *31*(4), 771–801. doi:10.5465/256338

Green, C. O. M. (2002). *Heating up society to take environmental action*. AED.

Gretzel, U. (2018). From smart destinations to smart tourism regions. *Investigaciones Regionales, 42,* 171-184. Disponível em: https://investigacionesregionales.org/wp-content/uploads/sites/3/2019/01/10-GRETZEL.pdf

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *Science*, *319*(5864), 756–760. doi:10.1126cience.1150195 PMID:18258902

Grindle, M. S. (2004). Good enough governance: Poverty reduction and reform in developing countries. *Governance: An International Journal of Policy, Administration and Institutions*, *17*(4), 525–548. doi:10.1111/j.0952-1895.2004.00256.x

Groom, M., Meffe, G., & Carroll, C. (2012). *Principles of Conservation Biology*. Sinauer.

Grove, J. M. (2009). Cities: Managing densely settled social–ecological systems. In F. S. Chapin III, G. P. Kofinas, & C. Folke (Eds.), *Principles of ecosystem stewardship: Resilience-based natural resource management in a changing world* (pp. 281–294). doi:10.1007/978-0-387-73033-2_13

Gruber, S. (2011). The impact of climate change on cultural heritage sites: Environmental law and adaptation. *Carbon & Climate L. Rev.*, *5*(5), 209–219. doi:10.21552/CCLR/2011/2/181

Grunewald, K., & Bastian, O. (2015). Ecosystem Services (ES): More Than Just a Vogue Term? In Ecosystem Services–Concept, Methods and Case Studies (pp. 1-11). Springer.

GTZ. (2006). *'Strategic communication for sustainable development: A conceptual overview'. A report by GTZ Rioplus Environmental Policy and Promotion of Strategies for Sustainable Development*. Eschborn.

Guagliardo, M. F. (2004). Spatial Accessibility of Primary Care: Concepts, Methods and Challenges. *International Journal of Health Geographics*, *3*(1), 3. doi:10.1186/1476-072X-3-3 PMID:14987337

Guegan, J. F., Suzan, G., Kati-Coulibaly, S., Nkoko Bonpamgue, D., & Moatti, J. P. (2018). Sustainable Development Goal #3, "Health and Well-being", and the Need for More Integrative Thinking. *Veterinaria México OA.*, *5*(2). Advance online publication. doi:10.21753/vmoa.5.2.443

Gugler, P. (1992). Building Transnational Alliances to Create Competitive Advantages. *Long Range Planning*, *25*(1), 90–99. doi:10.1016/0024-6301(92)90314-R

Gülboy, B. S. (2021). Covid 19 Pandemisinin Uluslararası Yapı ve Ulus Devlet Boyutunda Güvenlik Kavramına Etkileri, Covid 19 Pandemisinin Küresel Siyasette Ulusal Ve Uluslararası Ölçekte Güvenlik Algısı Ve Pratiklerine. İstanbul University Center of Political Science and International Relations.

Guldmann, E., & Huulgaard, R. D. (2020). Barriers to circular business model innovation: A multiple-case study. *Journal of Cleaner Production*, *243*, 1–13. doi:10.1016/j.jclepro.2019.118160

Gunarathne, N., de Alwis, A., & Alahakoon, Y. (2020). Challenges facing sustainable urban mining in the e-waste recycling industry in Sri Lanka. *Journal of Cleaner Production*, *251*, 119641. doi:10.1016/j.jclepro.2019.119641

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: Understanding Transformations in Human and Systems*. Island Press.

Guo, H., Fu, W., & Guang, L. (2019). *Scientific Satellite and Moon-Based Earth Observation for Global Change*. Springer. doi:10.1007/978-981-13-8031-0

Guo, L. (2015). Inequity Aversion and Fair Selling. *JMR, Journal of Marketing Research*, *52*(1), 77–89. doi:10.1509/jmr.12.0175

Guo, L., & Xia, Z. (2014). Temperature and precipitation long-term trends and variations in the Ili-Balkhash Basin. *Theoretical and Applied Climatology*, *115*(1-2), 219–229. doi:10.100700704-013-0883-3

Gusmerotti, N. M., Testa, F., Corsini, F., Pretner, G., & Iraldo, F. (2019). Drivers and approaches to the circular economy in manufacturing firms. *Journal of Cleaner Production*, *230*, 314–327. doi:10.1016/j.jclepro.2019.05.044

Guterres, A. (2020). *Video speech*. https://www.un.org/en/un-coronavirus-communications-team/above-all-human-crisis-calls-solidarity

Guterres, A. (2020, April 23). *We are all in this Together: Human Rights and COVID-19 Response and Recovery*. United Nations. https://www.un.org/en/un-coronavirus-communications-team/we-are-all-together-human-rights-and-covid-19-response-and

Haas, P. (1992). Introduction: Epistemic communities and international policy coordination. *International Organization*, *46*(1), 1–35. doi:10.1017/S0020818300001442

Habitat III. (2016). *Revised zero draft of the new urban agenda.* https://www.habitat3.org/zerodraft

Haguette, T. M. F. (1997). *Metodologias qualitativas na Sociologia* (5th ed.). Vozes.

Hahladakis, J. N., & Iacovidou, E. (2018). Closing the loop on plastic packaging materials: What is quality and how does it affect their circularity? *The Science of the Total Environment*, *630*, 1394–1400. doi:10.1016/j.scitotenv.2018.02.330 PMID:29554759

Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators*, *60*, 565–573. doi:10.1016/j.ecolind.2015.08.003

Halbert, S., Jennings, M., Cogan, C., Quisenberry, S., & Johnson, J. (1995). Potential use of suction trap collections of aphids as indicators of plant biodiversity. *Insects in a Changing Environment, 504*.

Hale, G. (2020). *The Effect of COVID-19 on CO2 Emissions*. https://econofact.org/the-effect-of-covid-19-on-co2-emissions

Hale, T. N., & Mauzerall, D. L. (2004). Thinking Globally and Acting Locally: Can the Johannesburg Partnerships Coordinate Action on Sustainable Development? *Journal of Environment & Development*, *13*(3), 220–239. doi:10.1177/1070496504268699

Hallahan, K. (2004). Communication management. In R. L. Heath (Ed.), *Encyclopedia of public relations* (Vol. 1, pp. 161–164). SAGE.

Hallahan, K., Holtzhausen, D. R., van Ruler, B., Verčič, D., & Sriramesh, K. (2007). Defining strategic communication. *International Journal of Strategic Communication*, *1*(1), 3–35. doi:10.1080/15531180701285244

Hall, P. (1966). *The World Cities*. Heinemann.

Hall, W. (1956). Prediction of pulse radar performance. *Proceedings of the IRE*, *44*(2), 224–231.

Hamel & Prahalad. (1994). *Competing for the Future*. Harvard Business Review Press.

Hamwey, R. (2020). *Environmental impacts of coronavirus crisis, challenges ahead*. UNCTAD. https://unctad.org/news/environmental-impacts-coronavirus-crisis-challenges-ahead

Hanbay Kahriman, E. (2020). An Evaluation on Positive and Negative Externalities of Global Climate Change. *Journal of Turkish Court of Accounts*, *33*(118), 101–131.

Handley, S. M., & Angst, C. M. (2015). The impact of culture on the relationship between governance and opportunism in outsourcing relationships. *Strategic Management Journal*, *2015*(36), 1412–1434. doi:10.1002mj.2300

Hansen, A. J., Defries, R., & Turner, W. (2004). Land use change and biodiversity: a syn-thesis of rates and consequences during the period of satellite imagery. In G. Gutman & C. Justice (Eds.), *Land Change Science: Observing, Monitoring, andUnderstanding Trajectories of Change on the Earth's Surface* (pp. 277–299). Springer Verlag.

Hansen, E. B., & Bøgh, S. (2021). Artificial intelligence and internet of things in small and medium-sized enterprises: A survey. *Journal of Manufacturing Systems*, *58*, 362–372. doi:10.1016/j.jmsy.2020.08.009

Harman, I., & Drake, V. (2004). Insect monitoring radar: Analytical time-domain algorithm for retrieving trajectory and target parameters. *Computers and Electronics in Agriculture*, *43*(1), 23–41.

Harrigan, K. R. (1988). Joint Ventures and Competitive Strategy. *Strategic Management Journal*, *9*(2), 141–158. doi:10.1002mj.4250090205

Harris, E. (2020). *The Changing Global Context for SDG Implementation – Challenges and Opportunities*. UN. Available at: https://www.un.org/en/desa/changing-global-context-sdg-implementation-%E2%80%93-challenges-and-opportunities

Hasan, S. S., Deng, X., Li, Z., & Chen, D. (2017). Projections of future land use in Bangladesh under the background of baseline, ecological protection and economic development. *Sustainability*, *9*(4), 505. doi:10.3390u9040505

Hasan, S. S., Zhen, L., Miah, M. G., Ahamed, T., & Samie, A. (2020). Impact of land use change on ecosystem services: A review. *Environmental Development*, *34*, 100527. doi:10.1016/j.envdev.2020.100527

Haser, D., & Uluslararası, İ. G. K. (2018). *Soğuk Savaş Sonrası Dönemde Güvenlik*. İstanbul University Institute of Social Sciences.

Hauser, C. E., Pople, A. R., & Possingham, H. P. (2006). Should Managed Populations Be Monitored Every Year? *Ecological Applications*, *16*, 807–819.

Havlicek, T. D., & Carpenter, S. R. (2001). Pelagic species size distributions in lakes: Are they discontinuous? *Limnology and Oceanography*, *46*(5), 1021–1033. doi:10.4319/lo.2001.46.5.1021

Hawkes, J. (2001). The Fourth Pillar of Sustainability: Culture's Essential Role in Public Planning. Melbourne: Common Ground P/L.

Hearne, R., & Donoso, G. (2014). Water markets in Chile: Are they meeting needs? In Water markets for the 21st Century. What have we learned? Global Issues in Water Policy. Springer.

Heide, M., von Platen, S., Simonsson, C., & Falkheimer, J. (2018). Expanding the scope of strategic communication: Towards a holistic understanding of organisational complexity. *International Journal of Strategic Communication*, *12*(4), 452–468. doi:10.1080/1553118X.2018.1456434

Heilbroner, R. (1970). *Ecological Armageddon*. https://www.nybooks.com/articles/1970/04/23/ecological-armageddon/

Hendranastiti, N. D. (2021). *COVID-19 and Degrowth: A Momentum to Restructure the System*. https://worldfinancial-review.com/covid-19-and-degrowth-a-momentum-to-restructure-the-system/

Hernández, F. (2016). *Plan local de primera respuesta a emergencias en el Poliducto de Recope, Poblado de Colorado de Turrialba, Provincia de Cartago. In Proyecto de Grado para el título de Licenciatura en Geografía con énfasis en Ordenamiento Territorial*. Universidad Nacional, Costa Rica.

Herold, M., Couclelis, H., & Clarke, K. C. (2005). The role of spatial metrics in the analysis and modeling of urban land use change. *Computers, Environment and Urban Systems*, *29*(4), 369–399. doi:10.1016/j.compenvurbsys.2003.12.001

Herrington, G. (2021). Update to limits to growth: Comparing the World3 model with empirical data. *Journal of Industrial Ecology*, *25*(3), 614–626. doi:10.1111/jiec.13084

Herzog, F., & Lausch, A. (2001). Supplementing land-use statistics with landscape metrics: Some methodological considerations. *Environmental Monitoring and Assessment*, *72*(1), 37–50. doi:10.1023/A:1011949704308 PMID:11693553

Heyes, G., Sharmina, M., Mendoza, J. M. F., Gallego-Schmid, A., & Azapagic, A. (2018). Developing and implementing circular economy business models in service-oriented technology companies. *Journal of Cleaner Production*, *177*, 621–632. doi:10.1016/j.jclepro.2017.12.168

He, Z.-Z., Luo, J., Gui, L.-Y., Hua, D.-K., Du, T.-H., Wang, F.-L., Liang, P., Shi, Y.-F., & Yang, X. (2019). Tracking the movement trajectory of newly emerged adult chinese citrus flies with insect harmonic radar. *Journal of Asia-Pacific Entomology*, *22*(3), 853–859.

Hickman, R., Bonilla, D., Givoni, M., & Banister, D. (2015). *International Handbook on Transport and Development*. Edward Elgar Publishing. doi:10.4337/9780857937261

Hirschi, M., Seneviratne, S. I., Alexandrov, V., Boberg, F., Boroneant, C., Christensen, O. B., Formayer, H., Orlowsky, B., & Stepanek, P. (2011). Observational evidence for soil-moisture impact on hot extremes in southeastern Europe. *Nature Geoscience*, *4*(1), 17–21. doi:10.1038/ngeo1032

Hisrich, R. D. (1986). The woman entrepreneur: characteristics, skills, problems and prescriptions for success. In D. L. Sexton & R. W. Smilor (Eds.), *The Art and Science of Entrepreneurship* (pp. 61–86). Ballinger Publishing Company.

History. (2018). The Goths and Visgoths. *The History Channel*. Available at: https://www.history.com/topics/ancient-rome/goths-and-visigoths

Hitt, M. A., Hoskisson, R. E., & Hicheon, K. (1997). International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, *40*(4), 767–798.

Hobbs, S. (1991). A radar signal processor for biological applications. *Measurement Science & Technology*, *2*(5), 415.

Hobbs, S., & Aldhous, A. (2006). Insect ventral radar cross-section polarisation dependence measurements for radar entomology. *IEE Proceedings. Radar, Sonar and Navigation*, *153*(6), 502.

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. *Futures*, *82*, 15–25. doi:10.1016/j.futures.2016.05.012

Ho, C. W. L., Caals, K., & Zhang, H. (2020). Heralding the digitalization of life in post-pandemic east asian societies. *Journal of Bioethical Inquiry*, *17*(4), 657–661. doi:10.100711673-020-10050-7 PMID:33169256

Hodgson, K., Caton Campbell, M., & Bailkey, M. (2011). Urban agriculture: growing healthy, sustainable places. Washington, DC: American Planning Association.

Hofste, R. W., Reig, P., & Schleifer, L. (2019). *17 Countries, Home to One-Quarter of the World's Population, Face Extremely High Water Stress*. https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress

Holden, C. (2003). Decommodification and the Workfare State. *Political Studies Review*, *1*(3), 303–316. doi:10.1111/1478-9299.t01-2-00001

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, *4*(1), 1–23. doi:10.1146/annurev.es.04.110173.000245

Holling, C. S. (1996). Engineering resilience versus ecological resilience. In P. C. Schulze (Ed.), *Engineering within ecological constraints*. National Academy Press.

Hossain, M. S. (2011). Panel estimation for $CO_2$ emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy*, *39*(11), 6991–6999. doi:10.1016/j.enpol.2011.07.042

Hough, M. (1995). *Cities and Natural Process*. Routledge. doi:10.4324/9780203292433

Howell, A., & Fan, C. C. (2011). Migration and inequality in Xinjiang: A survey of Han and Uyghur migrants in Urumqi. *Eurasian Geography and Economics*, *52*(1), 119–139. doi:10.2747/1539-7216.52.1.119

Howitt, R., Doohan, K., Suchet-Pearson, S., Cross, S., Lawrence, R., Lunkapis, G. J., Muller, S., Prout, S., & Veland, S. (2013). Socio-intercultural capacity deficits: Con-tested geographies of coexistence in natural resource management. *Asia Pacific Viewpoint*, *54*(2), 126–140. doi:10.1111/apv.12014

Hsu, M.-L., Jan, S.-J., Tsai, Z.-M., Wang, H., Chang, F.-R., Jau, P.-H., Lin, K.-Y., & Yang, E.-C. (2015). Portable 9.4/18.8 GHz harmonic radar system using pulse pseudorandom code principle. *2015 European Microwave Conference (EuMC).*

Huang, C., Goo, J., Nam, K., & Yoo, C. (2017). Smart tourism technologies in travel planning: The role of exploration and exploitation. *Information & Management*, *54*(6), 757–770. doi:10.1016/j.im.2016.11.010

Hudson, S., & Ritchie, J. (2009). Branding a Memorable Destination Experience. The Case of ‘Brand Canada’. *International Journal of Tourism Research*, *11*(2), 217–228. doi:10.1002/jtr.720

Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). *Remote Sensing of Environment*, *25*(3), 295–309. doi:10.1016/0034-4257(88)90106-X

Hughes, M. (2011). Do 70 per cent of all organizational change initiatives really fail? *Journal of Change Management*, *11*(4), 451–464. doi:10.1080/14697017.2011.630506

Hui, S. C. M. (2011). *Green roof urban farming for buildings in high-density urban cities.* Invited paper for the Hainan China World Green Roof Conference 2011, Hainan, China.

Hulkower, S., Doulis, M., & Friedfel, D. (2019). Getting Greener: Cost-Effective Options for Achieving New York State’s Greenhouse Gas Goals. Citizen Budget Commission.

Humphreys, E. (2008). Information Security management standards: Compliance, governance and risk management. *Information Security Technical Report*, *13*(4), 247–255. doi:10.1016/j.istr.2008.10.010

Hunt, J., & Smith, D. E. (2006). *Building Indigenous community governance in Australia: preliminary research findings.* CAEPR Working Paper No. 31, CAEPR, CASS, ANU.

Hunt, J., & Smith, D. E. (2007). *Indigenous Community Governance Project: Year two research findings.* CAEPR Working Paper No. 36, CAEPR, CASS, ANU.

Hunt, D. V., Lombardi, D. R., Atkinson, S., Barber, A. R., Barnes, M., Boyko, C. T., Brown, J., Bryson, J., Butler, D., Caputo, S., Caserio, M., Coles, R., Cooper, R. F. D., Farmani, R., Gaterell, M., Hale, J., Hales, C., Hewitt, C. N., Jankovic, L., ... Rogers, C. D. (2012). Scenario archetypes: Converging rather than diverging themes. *Sustainability*, *4*(4), 740–772. doi:10.3390u4040740

Hussain, Z., Mishra, J., & Vanacore, E. (2020). Waste to energy and circular economy: The case of anaerobic digestion. *Journal of Enterprise Information Management*, *33*(4), 817–838. doi:10.1108/JEIM-02-2019-0049

Hymer, S. (1983); Empresas multinacionais: a internacionalização do capital. Edições Graal.

Hynes, H. P. (1996). *A Patch of Eden: America's Inner-city Gardeners*. Chelsea Green Publishing Company.

Hysell, D. (2018). *Antennas and Radar for Environmental Scientists and Engineers*. Cambridge University Press.

Ibarra-Sarlat, R. (2019). *Cambio Climático y Gobernanza. Una Visión Transdisciplinaria*. Instituto de Investigaciones Jurídicas UNAM. https://www.dijuris.com/libro/cambio-climatico-y-gobernanza-una-vision-transdisciplinaria_40648

Ibrahim, J. (2002). 4G Features. *Bechtel Telecommunications Technical Journal*, *1*(1), 11–14.

Ibrahim, M. H. (2015). Oil and food prices in Malaysia: A nonlinear ARDL analysis. *Agricultural and Food Economics*, *3*(1), 1–14. doi:10.118640100-014-0020-3

ICAA. (2002). Análisis Sectorial de agua potable y saneamiento en Costa Rica. San José, Costa Rica: Instituto Costarricense de Acueductos y Alcantarillado.

ICG. (2020 May 18). *Violence in Nigeria's North West: Rolling back the mayhem*. https://www.crisisgroup.org/africa/west-africa/nigeria/288-violence-nigerias-north-west-rolling-back-mayhem

IEA. (2021). *CO2 emissions*. https://www.iea.org/reports/global-energy-review-2021/co2-emissions

Ifijeh, G., Idiegbeyan-ose, J., Segun-Adeniran, C., & Ilogho, J. (2016). Disaster Management in Digital Libraries: Issues and Strategies in Developing Countries. *International Journal of Risk and Contingency Management*, *5*(1), 1–14. doi:10.4018/IJRCM.2016010101

IISD. (2009). *What is Sustainable Development?* International Institute for Sustainable Development.

INE. (1997). *VI Censo Nacional Agropecuario: Principales Resultados*. Available at: http://bibliotecadigital.ciren.cl/handle/123456789/14039

INE. (2009). *VII Censo Nacional Agropecuario: Principales Resultados*. Available at: https://www.ine.cl/estadisticas/economia/agricultura-agroindustria-y-pesca/censos-agropecuarios

INE. (2021, April 30). *Tourist activity with a very negative year-on-year change but less pronounced, reflecting the comparison with a month already affected by the pandemic*. Press release. Retrieved from https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=471119801&DESTAQUESmodo=2&xlang=en

INEC. (2011). *Censo 2011.* Instituto Nacional de Estadísticas y Censos. República de Costa Rica. https://www.inec.cr/

INEC. (2020). *Estadísticas demográficas 2011-2050. Proyecciones nacionales.* Instituto Nacional de Estadísticas y Censos. República de Costa Rica. https://www.inec.cr/

İnsani Tüketim Amaçlı Sular Hakkında Yönetmelik [Regulation on Water for Human Consumption]. (n.d.). https://www.resmigazete.gov.tr/eskiler/2005/02/20050217-3.htm

International Labor Organization (ILO) & The Organisation for Economic Co-operation and Development (OECD). (2020). *The impact of the COVID-19 pandemic on jobs and incomes in G20 economies*. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---cabinet/documents/publication/wcms_756331.pdf

International Labor Organization (ILO). (2020). *A gender-responsive employment recovery: Building back fairer*. Policy Biref, Jluy 2020. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_751785.pdf

International Labor Organization (ILO). (n.d.). *Millennium Development Goals*. https://www.ilo.org/global/topics/millennium-development-goals/lang--en/index.htm

Invat.tur. (2015). *Destinos turísticos inteligentes. Manual Operativo para la configuración de Destinos Turísticos Inteligentes*. Comunidade Valenciana.

Invat.tur. (2015). *Destinos turísticos inteligentes. Manual Operativo para la configuración de Destinos Turísticos Inteligentes.* Em parceria com o Instituto Universitário de Investigações Turísticas da Universidade de Alicante. Obtido de https://www.thinktur.org/media/Manual-de-destinos-tur%C3%ADsticos-inteligentes.pdf

IPCC. (2014). *Cambio climático 2014*. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full_es.pdf

IPCC. (2018). Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. World Meteorological Organization.

IPDT. (2016). *Plano Estratégico e de Marketing do Turismo dos Açores*. Available at: https://www.azores.gov.pt/PortalAzoresgov/external/portal/misc/PEM_ACORES2.pdf

IPDT. (2016). *Plano Estratégico e de Marketing do Turismo dos Açores*. Elaborado para o Governo Regional dos Açores. Obtido de http://www.azores.gov.pt/PortalAzoresgov/external/portal/misc/PEM_ACORES2.pdf

IPI Consulting Network. (2019). Available at: http://www.ipiconsultingnetwork.com/en/domains-of-activity/economy-of-culture-creative-industries-and-tourism

IRP. (2020). Practical lessons for recovery from the Covid-19 pandemic-principles for recovery. International Recovery Platform, Japan, December 2020. Kamala Valiyeva, Kovid-19 İle Ulus Devleti Yeniden Düşünmek. *İstanbul Ticaret University Journal of Social Sciences, 19*(37), 390-403.

Ishida, T., & Isbister, K. (2000). Digital cities: Technologies, experiences, and future perspectives. LNCS, 1765.

Ishii, M., & Nakamura, Y. (2012). Development and Future of Insect Conservation in Japan. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Ivanov, I., Orlova, L., & Vlasova, T. (2021). Digitalization as a Factor of Sustainable Development of Industrial Enterprises. *IOP Conference Series. Earth and Environmental Science*, *666*(6), 062047. doi:10.1088/1755-1315/666/6/062047

İyikan, N. (2013). Almanca kaynaklara göre Aral Gölü (Kumu) sorununda Rusya faktörü. *Akademik Bakış*, *6*(12), 223–241.

Jackson, J. B. C., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., Bradbury, R. H., Cooke, R., Erlandson, J., Estes, J. A., Hughes, T. P., Kidwell, S., Lange, C. B., Lenihan, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R. S., Tegner, M. J., & Warner, R. R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science*, *293*(5530), 629–638. doi:10.1126cience.1059199 PMID:11474098

Jacobs and IPST. (2006). *Pulp and Paper Industry: Energy Bandwidth Study.* Institute of Paper Science and Technology, Georgia Institute of Technology, Atlanta, GA. https://www.energy.gov/sites/prod/files/2013/11/f4/doe_bandwidth.pdf

Jacobs, S., Dendoncker, N., Martín-López, B., Barton, D. N., Gomez-Baggethun, E., Boeraeve, F., McGrath, F. L., Vierikko, K., Geneletti, D., Sevecke, K. J., Pipart, N., Primmer, E., Mederly, P., Schmidt, S., Aragão, A., Baral, H., Bark, R. H., Briceno, T., Brogna, D., ... Washbourne, C. L. (2016). A new valuation school: Integrating diverse values of nature in resource and land use decisions. *Ecosystem Services*, *22*, 213–220. doi:10.1016/j.ecoser.2016.11.007

Jacobs, S., Haest, B., de Bie, T., Deliège, G., Schneiders, A., & Turkelboom, F. (2013). Biodiversity and ecosystem services. In *Ecosystem Services* (pp. 29–40). Elsevier. doi:10.1016/B978-0-12-419964-4.00003-2

Jaeger, J. A. (2015). Improving environmental impact assessment and road planning at the landscape scale. Handbook of Road Ecology, 32-42.

Jakobi, A., Zsom, B., & Viktoria Vida, Z. (2018). Dimensions of Spatial Inequalities in the Information Age: The Case of Hungary. *Espaço e Economia*, *13*(13). Advance online publication. doi:10.4000/espacoeconomia.4797

James, P., Magee, L., Scerri, A., & Steger, M. B. (2015). *Urban Sustainability in Theory and Practice*. Routledge.

Janoschka, M. (2002). El nuevo modelo de la ciudad latinoamericana: Fragmentación y privatización. *EURE. Revista Latinoamericana de Estudios Urbano Regionales*, *28*(85), 11–29. doi:10.4067/S0250-71612002008500002

Janssen, A. B., Hilt, S., Kosten, S., de Klein, J. J., Paerl, H. W., & Van de Waal, D. B. (2021). Shifting states, shifting services: Linking regime shifts to changes in ecosystem services of shallow lakes. *Freshwater Biology*, *66*(1), 1–12. doi:10.1111/fwb.13582

Jaradat, A. A., & Boody, G. (2011). Modeling agroecosystem services under simulated climate and land-use changes. *International Scholarly Research Notices*.

Jenks, M., & Jones, C. (Eds.). (2010). Dimensions of the sustainable city. New York: Springer.

Jensen, J. P., Prendeville, S. M., Bocken, N., & Peck, D. (2019). Creating sustainable value through remanufacturing: Three industry cases. *Journal of Cleaner Production*, *218*, 304–314. doi:10.1016/j.jclepro.2019.01.301

Jerrett, M., Gale, S., & Kontgis, C. (2010). Spatial Modeling in Environmental and Public Health Research. *International Journal of Environmental Research and Public Health*, *7*(4), 1302–1329. doi:10.3390/ijerph7041302 PMID:20617032

Jessop, B. (2005). Critical Realism and the Strategic-Relational Approach. *New Formations: A Journal of Culture. Theory and Politics*, (56), 40–53.

Jew, E. K., Burdekin, O. J., Dougill, A. J., & Sallu, S. M. (2019, February). Rapid land use change threatens provisioning ecosystem services in miombo woodlands. *Natural Resources Forum*, *43*(1), 56–70. doi:10.1111/1477-8947.12167

Jha, L. K., & Sen, P. P. (1991). *Social Forestry*. Himalaya Publishing House.

Jiao, J., Jiang, G., & Yang, R. (2018). Impact of R&D technology spillovers on carbon emissions between China's regions. *Structural Change and Economic Dynamics*, *47*, 35–45. doi:10.1016/j.strueco.2018.07.002

Jiménez-Lao, R., Aguilar, F. J., Nemmaoui, A., & Aguilar, M. A. (2020). Remote sensing of agricultural greenhouses and plastic-mulched farmland: An analysis of worldwide research. *Remote Sensing*, *12*(16), 1–20. doi:10.3390/rs12162649

Jin, G., Wang, P., Zhao, T., Bai, Y., Zhao, C., & Chen, D. (2015). Reviews on land use change induced effects on regional hydrological ecosystem services for integrated water resources management. *Physics and Chemistry of the Earth Parts A/B/C*, *89*, 33–39. doi:10.1016/j.pce.2015.10.011

Johanson, J., & Mattsson, L. (1988). *Internationalization in industrial system: a network approach. Strategies in global competition*. Croom Helm.

Johanson, J., & Vahlne, J. E. (1977). The internationalization process of the firm: A model of knowledge development and increasing foreign market commitments. *Journal of International Students*, *8*, 23–32.

Johanson, J., & Vahlne, J. E. (1990). The Mechanism of Internationalization. *International Marketing Review*, *7*(4), 11–24. doi:10.1108/02651339010137414

Johanson, J., & Vahlne, J. E. (2009). The Uppsala internationalization process model revisited: From liability of foreignness to liability of outsidership. *Journal of International Business Studies*, *40*(9), 1411–1431. doi:10.1057/jibs.2009.24

Johnson, G., & Scholes, K. (1999). *Exploring corporate strategy* (5th ed.). Prentice Hall Europe.

Johnstone, N., Hascic, I., & Popp, D. (2010). Renewable energy policies and technological innovation: Evidence based on patent counts. *Environmental and Resource Economics*, *45*(1), 133–155. doi:10.100710640-009-9309-1

Jones, H. G., & Vaughan, R. (2010). *Remote sensing of vegetation : principles, techniques, and applications*. Oxford University Press.

Jørgensen, K. E. (2009). *The European Union and International Organizations*. Routledge. doi:10.4324/9780203884416

Jørgensen, M. S., & Remmen, A. (2018). A methodological approach to development of circular economy options in business. *Procedia CIRP*, *69*, 816–821. doi:10.1016/j.procir.2017.12.002

Jovicic, D. (2019). From the traditional understanding of tourism destination to the smart tourism destination. *Current Issues in Tourism*, *22*(3), 276–282. doi:10.1080/13683500.2017.1313203

Ju, M. J., Oh, J., & Choi, Y. H. (2021). Changes in air pollution levels after COVID-19 outbreak in Korea. *The Science of the Total Environment*, *750*, 141521. doi:10.1016/j.scitotenv.2020.141521 PMID:32829258

Kabeer, N., & Santos, R. (2017). *Intersecting Inequalities and the Sustainable Development Goals: Insights from Brazil*. WIDER Working Paper 2017/167. Helsinki: UNU-WIDER.

Kahle, L. R., & Gurel-Atay, E. (Eds.). (2014). *Communicating Sustainability for the Green Economy*. M.E. Sharpe.

Kaiser, J., Haase, D., & Krueger, T. (2021). Payments for ecosystem services: A review of definitions, the role of spatial scales, and critique. *Ecology and Society*, *26*(2), art12. doi:10.5751/ES-12307-260212

Kaklauskas, A., & Gudauskas, R. (2016). Intelligent decision-support systems and the Internet of Things for the smart built environment. In *Start-Up Creation* (pp. 413–449). Woodhead Publishing. doi:10.1016/B978-0-08-100546-0.00017-0

Kaletová, T., Loures, L., Castanho, R. A., Aydin, E., Gama, J., Loures, A., & Truchy, A. (2019). Relevance of Intermittent Rivers and Streams in Agricultural Landscape and Their Impact on Provided Ecosystem Services—A Mediterranean Case Study. *International Journal of Environmental Research and Public Health*, *2019*(16), 2693. doi:10.3390/ijerph16152693 PMID:31357719

Kalin Arroyo, M. T., Zedler, P. H., & Fox, M. D. (Eds.). (1995). *Ecology and biogeography of Mediterranean ecosystems in Chile, California, and Australia*. Springer-Verlag. doi:10.1007/978-1-4612-2490-7

Kallis, G. (2011). In defence of degrowth. *Ecological Economics*, *70*(5), 873–880. doi:10.1016/j.ecolecon.2010.12.007

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research On Degrowth. *Annual Review of Environment and Resources*, *43*(1), 291–316. doi:10.1146/annurev-environ-102017-025941

Kalverkamp, M., & Young, S. B. (2019). In support of open-loop supply chains: Expanding the scope of environmental sustainability in reverse supply chains. *Journal of Cleaner Production*, *214*, 573–582. doi:10.1016/j.jclepro.2019.01.006

Kamau, M., Chasek, P., & O'Connor, D. (2018). *Transforming Multilateral Diplomacy: The Inside Story of the Sustainable Development Goals*. Avalon Publishing. doi:10.4324/9780429491276

Kanankege KST, Alvarez J, Zhang L, Perez AM. (2020). An Introductory Framework for Choosing Spatiotemporal Analytical Tools in Population-Level Eco-Epidemiological Research. *Front Vet Sci.*, *7*(7), 339. doi:10.3389/fvets.2020.00339

Kaplan, A. (2019). *How big data will drive smart city innovation*. ITProPortal. https://www.itproportal.com/features/how-big-data-will-drive-smart-city-innovation/

Karadag, H. (2015). The role and challenges of small and medium-sized enterprises (smes) in emerging economies: An analysis from turkey. *Business and Management Studies*, *1*(2), 179–188. doi:10.11114/bms.v1i2.1049

Karakas, M. (2020). Covid-19 salgınının çok boyutlu sosyolojisi ve yeni normal meselesi. *İstanbul Üniversitesi Sosyoloji Dergisi, 40*(1), 541-573. doi:10.26650/SJ.2020.40.1.0048

Karman, A. (2020). Towards crystallizing circular business models: A critical analysis of literature. *Journal of Sustainability Science and Management*, *15*(6), 175–194. doi:10.46754/jssm.2020.10.001

Kasman, A., & Duman, Y. S. (2015). $CO_2$ emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*, *44*, 97–103. doi:10.1016/j.econmod.2014.10.022

Kates, R., Parris, T., & Leiserowitz, A. (2005). What is Sustainable Development? Goals, Indicators, Values, and practice. *Environment*, *47*(3), 8–21. doi:10.1080/00139157.2005.10524444

Katircioglu, S. T. (2014). International tourism, energy consumption, and environmental pollution: The case of Turkey. *Renewable & Sustainable Energy Reviews*, *36*, 180–187. doi:10.1016/j.rser.2014.04.058

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2005). *Governance matters IV: governance indicators for 1996–2004.* World Bank Policy Research Working Paper 3237. Available at https://worldbank.org/wbi/governance/pubs/govmatters4.html

Kaufmann, D. (2005). Back to basics: Ten myths about governance and corruption. *Finance & Development*, *42*(3). http://www.imf.org/external/pubs/ft/ fandd/2005/09/index.htm

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2003). *Governance matters III: Governance indicators for 1996–2002*. The World Bank. doi:10.1596/1813-9450-3106

Kaygalak, İ., & Isik, Ş. (2007). Kentleşmenin Yeni Ekonomik Boyutları. *Ege Coğrafya Dergisi*, *16*(1-2), 17–35.

Keeler, B. L., Hamel, P., McPhearson, T., Hamann, M. H., Donahue, M. L., Prado, K. A. M., ... Wood, S. A. (2019). Social-ecological and technological factors moderate the value of urban nature. *Nature Sustainability*, *2*(1), 29–38. doi:10.103841893-018-0202-1

Keen, I. (1989). Aboriginal governance. In J. C. Altman (Ed.), Emergent Inequalities in Aboriginal Australia. University of Sydney.

Keesstra, S., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerda, A., Montanarella, L., Quinton, J., Pachepsky, Y., Putten, W. V., Bardgett, R., Moolenaar, S., Mol, G., Jansen, B., & Fresco, L. (2016). The Significance of Soils and Soil Science Towards Realization of the United Nations Sustainable Development Goals. *Political Science*. *Environmental Sciences (Ruse)*, *2*(2), 111–128. Advance online publication. doi:10.5194oil-2-111-2016

Keleş, R., Hamamcı, C., & Çoban, A. (2012). *Çevre politikası*. İmge Kitapevi Yayınları.

Keller, K. L. (2013). Strategic brand management: building, measuring, and managing brand equity (4th ed.). Pearson Education.

Kemp, R., Parto, S., & Gibson, R. B. (2005). Governance for sustainable development: Moving from theory to practice. *International Journal of Sustainable Development*, *8*(1/2), 12–30. doi:10.1504/IJSD.2005.007372

Kennedy,, C., Cuddihy,, J., & Engel-Yan,, J. (2020). The changing metabolism of cities. *Journal of Industrial Ecology*, *11*(2), 43–59.

Kennedy,, C., Pincetl,, S., & Bunje,, P. (2010). The study of urban metabolism and its applications to urban planning and design. *Environmental Pollution*, *159*(8–9), 1965–1973. PMID:21084139

Kezer, K., & Matsuyama, H. (2006). Decrease of river runoff in the Lake Balkhash basin in Central Asia. *Hydrological Processes*, *20*(6), 1407–1423. doi:10.1002/hyp.6097

Khan, M. E., Li, P., & Zhao, D. (2015). Water pollution progress at borders: The role of changes in China's political promotion incentives. *American Economic Journal. Economic Policy*, *7*(4), 223–242. doi:10.1257/pol.20130367

Khan, M., Woo, M., Nam, K., & Chathoth, P. (2017). Smart City and Smart Tourism: A Case of Dubai. *Sustainability*, *9*(12), 2279. doi:10.3390u9122279

Khan, Z., Sisi, Z., & Siqun, Y. (2019). Environmental regulations an option: Asymmetry effect of environmental regulations on carbon emissions using non-linear ARDL. *Energy Sources. Part A, Recovery, Utilization, and Environmental Effects*, *41*(2), 137–155. doi:10.1080/15567036.2018.1504145

Khashoggi, B. F., & Murad, A. (2020). Issues of Healthcare Planning and GIS: A Review. *ISPRS International Journal of Geo-Information*, *9*(6), 352. doi:10.3390/ijgi9060352

Khedher, M. (2015). A Brand for Everyone: Guidelines for Personal Brand Managing. *The Journal of Global Business Issues*, *9*, 19–27.

Khmara, Y., & Kronenberg, J. (2020). Degrowth in the context of sustainability transitions: In search of a common ground. *Journal of Cleaner Production*, *267*(122072), 1–13. doi:10.1016/j.jclepro.2020.122072

Khomsi, M. (2016). The Smart City Ecosystem as an Innovation Model: Lessons from Montreal. *Technology Innovation Management Review*, *6*(11), 26–31. doi:10.22215/timreview/1032

Khvoynitskaya, S. (2020). *Paving the way for lower energy consumption in smart cities*. ITProPortal. https://www.itproportal.com/features/paving-the-way-for-lower-energy-consumption-in-smart-cities/

Kim, J., Jeong, U., Ahn, M.-H., Kim, J. H., Park, R. J., Lee, H., Song, C. H., Choi, Y.-S., Lee, K.-H., Yoo, J.-M., Jeong, M.-J., Park, S. K., Lee, K.-M., Song, C.-H., Kim, S.-W., Kim, Y. J., Kim, S.-W., Kim, M., Go, S., ... Liu, X. (2020). New era of air quality monitoring from space: Geostationary environment monitoring spectrometer (GEMS). *Bulletin of the American Meteorological Society*, *101*(1), E1–E22. doi:10.1175/BAMS-D-18-0013.1

Kim, J., Jung, M., Kim, H. G., & Lee, D.-H. (2016). Potential of harmonic radar system for use on five economically important insects: Radar tag attachment on insects and its impact on flight capacity. *Journal of Asia-Pacific Entomology*, *19*(2), 371–375.

Kim, S. W., & Lyn, E. O. (1987). Foreign direct investment theories, entry barriers, and reverse investments in U.S manufacturing industries. *Journal of International Business Studies*, *18*(2), 53–66. doi:10.1057/palgrave.jibs.8490406

Kim, W. C., Hwang, P., & Burgers, W. P. (1993). Multinationals diversification and the risk-return trade off. *Strategic Management Journal*, *14*(4), 275–286. doi:10.1002mj.4250140404

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2016). Changes of ecosystem service values in response to land use/land cover dynamics in Munessa–Shashemene landscape of the Ethiopian highlands. *The Science of the Total Environment*, *547*, 137–147. doi:10.1016/j.scitotenv.2015.12.127 PMID:26780139

Kinzig, A. P., Pacala, S. W., & Tilman, D. (Eds.). (2002). *The functional consequences of biodiversity*. Princeton University Press.

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence from the European Union (EU). *Ecological Economics*, *150*, 264–272. doi:10.1016/j.ecolecon.2018.04.028

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. doi:10.1016/j.resconrec.2017.09.005

Kirci, B., Cetin, M., Saygın, S., & Alaşahan, Y. (2018). Ekonomik Büyüme, Finansal Gelişme, Enerji Tüketimi Ve Dış Ticaretin Çevre Kirliliği Üzerindeki Etkisi: Türkiye Ekonomisi İçin Bir Nedensellik Analizi (1960-2013). *Balkan Sosyal Bilimler Dergisi*, *7*(13), 26–43.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1–14. doi:10.100710708-013-9516-8

Kivyiro, P., & Arminen, H. (2014). Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. *Energy*, *74*, 595–606. doi:10.1016/j.energy.2014.07.025

Klein, N. (2020, March 13). *Coronavirus Is the Perfect Disaster for 'Disaster Capitalism.'* VICE. https://www.vice.com/en/article/5dmqyk/naomi-klein-interview-on-coronavirus-and-disaster-capitalism-shock-doctrine

Kliksberg, B. (2004). *Más ética, más desarrollo*. Temas Grupo Editorial.

Klueger, J. (2021). *The COVID-19 Pandemic's Impact on Global CO2 Emissions Didn't Last Very Long*. https://time.com/5943530/covid-19-co2-emissions-climate-change/

Knapp, S. (2019). The link between diversity, ecosystem functions, and ecosystem services. In *Atlas of Ecosystem Services* (pp. 13–15). Springer. doi:10.1007/978-3-319-96229-0_3

Knickmeyer, D. (2020). Social factors influencing household waste separation: A literature review on good practices to improve the recycling performance of urban areas. *Journal of Cleaner Production*, *245*, 118605. Advance online publication. doi:10.1016/j.jclepro.2019.118605

Knippers, R., Sun, Y., Ellis, M. C., Kraak, M. J., Weir, M., Georgiadou, P., Radwan, M. M., Westen, C. J., Kainz, W., & Sides, E. (2000). Principles of Geographic Information Systems: An Introductory Textbook. Corpus ID: 65274933.

Knott, E., Schaeffer, J., & Tulley, M. (2004). *Radar Cross Section*. Electromagnetics and Radar Series. Institution of Engineering and Technology.

Knox, P. (1995). World cities in a world-system. In P. Knox & P. Taylor (Eds.), *World Cities in a World-System* (pp. 3–20). Cambridge University Press. doi:10.1017/CBO9780511522192.002

Kogut, B. (1985). Designing global strategies: Profiting from operational flexibility. *Sloan Management Review*, *26*, 27–38.

Koksharov, V., Starodubets, N., & Ponomareva, M. (2019). Assessment of an enterprise circular economy development. *WSEAS Transactions on Business and Economics*, *63*, 559–567.

Kolasa, J., & Pickett, S. T. A. (2005). Changing academic perspectives of ecology: A view from within. In M. J. Mappin & E. A. Johnson (Eds.), *Environmental education and advocacy* (pp. 50–71). Cambridge University Press.

Konecnik, M., & Go, F. (2008). Tourism destination brand identity: The case of Slovenia. *Journal of Brand Management*, *15*(3), 177–189. doi:10.1057/palgrave.bm.2550114

Koops J. A. (2011). *The European Union an Integrative Power: Assessing the EU's Effective Multilateralism Towards NATO and the United Nations*. Brussels: VUBPress.

Koops, J., & Biermann, R. (Eds.). (2017). *Palgrave Handbook of Inter-Organizational Relations in World Politics*. Palgrave Macmillan. doi:10.1057/978-1-137-36039-7

Körbalta, H. (2019). Türkiye'de Yerel Su Güvenliği. *Güvenlik Bilimleri Dergisi*, *8*(1), 55–84. doi:10.28956/gbd.562965

Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essential contested concept. *Journal of Cleaner Production*, *175*, 544–552. doi:10.1016/j.jclepro.2017.12.111

Korhonen, K., & Lappalainen, A. (2004). Examining the environmental awareness of children and adolescents in the Ranomafana region, Madagascar. *Environmental Education Research*, *10*(2), 195–216. doi:10.1080/13504620242000198177

Kostenko, A. A., Nosich, A. I., & Tishchenko, I. A. (2001). Radar prehistory, soviet side: three-coordinate l-band pulse radar developed in Ukraine in the late 30's. *IEEE Antennas and Propagation Society International Symposium, 4*, 44-47.

Kothari, A., Camill, P., & Brown, J. (2013). Conservation as if people also mattered: Policy and practice of community-based conservation. *Conservation & Society*, *11*(1), 1–15. doi:10.4103/0972-4923.110937

Kourtit, K., Nijkamp, P., & Arribas-Bel, D. (2012). Smart cities perspective—A comparative European study by means of self-organizing maps. *Innovation*, *25*(2), 229–246.

Kozluk, T., & Zipperer, V. (2015). Environmental policies and productivity growth. *OECD Journal: Economic Studies*, *2014*(1), 155–185.

Kozymka, I. (2014). *The Diplomacy of Culture: The role of UNESCO in Sustaining Cultural Diversity*. Palgrave Macmillian. doi:10.1057/9781137366269

Kraxner, F., Schepaschenko, D., Fuss, S., Lunnan, A., Kindermann, G., Aoki, K., Dürauer, M., Shvidenko, A., & See, L. (2017). Mapping Certified Forests for Sustainable Management - A Global Tool for Information Improvement Through Participatory and Collaborative Mapping. *Forest Policy and Economics, Elsevier*, *83*(C), 10–18. doi:10.1016/j.forpol.2017.04.014

Kreimer,, A., Arnold,, M., & Carlin,, A. (Eds.). (2003). *Building safer cities: the future of disaster risk*. The International Bank for Reconstruction and Development/The World Bank.

Kubiszewski, I., Costanza, R., Anderson, S., & Sutton, P. (2020). The future value of ecosystem services: Global scenarios and national implications. In *Environmental Assessments*. Edward Elgar Publishing. doi:10.4337/9781788976879.00016

Kuffer, M., Pfeffer, K., & Sliuzas, R. (2016). Slums From Space— 15 Years of Slum Mapping Using Remote Sensing. *Remote Sensing*, *8*(6), 455. doi:10.3390/rs8060455

Kuffer, M., Wang, J., Nagenborg, M., Pfeffer, K., Kohli, D., Sliuzas, R., & Persello, C. (2018). The Scope of Earth Observation to Improve the Consistency of the SDG Slum Indicator. *ISPRS International Journal of Geo-Information*, *7*(11), 428. doi:10.3390/ijgi7110428

Kumar, A., Gupta, I., Brandt, J., Kumar, R., Dikshit, A. K., & Patil, R. S. (2016). Air Quality Mapping Using GIS and Economic Evaluation of Health Impact for Mumbai City, India. *Journal of the Air & Waste Management Association*, *66*(5), 470–481. doi:10.1080/10962247.2016.1143887 PMID:26828812

Kumar, D., Singh, R. B., & Kaur, R. (2019). Spatial Information Technology for Sustainable Development Goals, Sustainable Development Goals Series. *Springer International Publishing AG*, *2019*. Advance online publication. doi:10.1007/978-3-319-58039-5

Kumar, P., Gupta, K., Karnatak, H. C., Siddiqui, A., & Senthil Kumar, A. (2017). Geo-enabled e-Democracy Tools and Services for Smart Cities. In T. Vinod Kumar (Ed.), *E-Democracy for Smart Cities. Advances in 21st Century Human Settlements*. Springer. doi:10.1007/978-981-10-4035-1_13

Kumar, V., Sezersan, I., Garza-Reyes, J. A., Gonzalez, E. D. R. S., & AL-Shboul, M. A. (2019). Circular economy in the manufacturing sector: Benefits, opportunities and barriers. *Management Decision*, *57*(4), 1067–1086. doi:10.1108/MD-09-2018-1070

Kumi-Boateng, B. (2015). Where are the Poor? A GIS-Multidimensional Non-Monetary Poverty Index Approach for Ghana. *Ghana Mining Journal December Issue - Geomatics Eng. Articles, 15*(2).

Kundzewicz, Z. W., Krysanova, V., Benestad, R. E., Hov, Ø., Piniewski, M., & Otto, I. M. (2018). Uncertainty in climate change impacts on water resources. *Environmental Science & Policy*, *79*, 1–8. doi:10.1016/j.envsci.2017.10.008

Kurowska, K., Marks-Bielska, R., Bielski, S., Aleknavičius, A., & Kowalczyk, C. (2020). Geographic Information Systems and the Sustainable Development of Rural Areas. *Land, 10*(1), 6. doi:10.3390/land10010006

Kuzmits, B. (2006). *Cross-bordering water management in Central Asia.* ZEF Working Paper Series, No. 66. University of Bonn, Center for Development Research (ZEF).

Labrianidis, L., Ferrão, J., Hertzina, K., Kalantaridis, C., Piasecki, B., & Smallbone, D. (2003). The Future of Europe's Rural Periphery; Final Report. In *5th Framework Programme of the European Community*. Routledge.

Lagiosa, J. (2015). *Idanha-a-Nova formaliza candidatura a Cidade da Música da UNESCO*. Beiranews. Available at: https://beiranews.pt/2015/07/idanha-a-nova-formaliza-candidatura-a-cidade-da-musica-da-unesco/

Lamalice, A., Haillot, D., Lamontagne, M. A., Herrmann, T. M., Gibout, S., Blangy, S., Martin, J.-L., Coxam, V., Arsenault, J., Munro, L., & Courchesne, F. (2018). Building Food Security in the Canadian Arctic through the Development of Sustainable Community Greenhouses and Gardening. *Ecoscience*, *25*(4), 325–341. doi:10.1080/11956860.2018.1493260

Lambin, E. F. (2005). Conditions for sustainability of human-environment systems: Information, motivation, and capacity. *Global Environmental Change*, *15*(3), 177–180. doi:10.1016/j.gloenvcha.2005.06.002

Langemeyer, J., & Connolly, J. J. (2020). Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science & Policy*, *109*, 1–14. doi:10.1016/j.envsci.2020.03.021

Larraín, S., & Poo, P. (2010). *Conf lictos por el Agua en Chile. Entre los derechos humanos y las reglas del mercado*. Embajada de Holanda y Fundación Heinrich Böll.

Larson, K. L., Nelson, K. C., Samples, S. R., Hall, S. J., Bettez, N., Cavender-Bares, J., Groffman, P. M., Grove, M., Heffernan, J. B., Hobbie, S. E., Learned, J., Morse, J. L., Neill, C., Ogden, L. A., O'Neil-Dunne, J., Pataki, D. E., Polsky, C., Chowdhury, R. R., Steele, M., & Trammell, T. L. E. (2016). Ecosystem services in managing residential landscapes: Priorities, value dimensions, and cross-regional patterns. *Urban Ecosystems*, *19*(1), 95–113. doi:10.100711252-015-0477-1

Larsson, M. (2018). *Circular Business Models - Developing a Sustainable Future*. Palgrave Macmillan. doi:10.1007/978-3-319-71791-3

Lasswell, H. (1948). *The structure and function of communication and society: The communication of idea*. Institute for Religious and Social Studies.

Latouche, S. (2006). *How do we learn to want less? The globe downshifted. Le Monde Diplomatique*. https://www.jussemper.org/Resources/Economic%20Data/Resources/The%20 globe%20downshifted,%20by%20Serge%20Latouche.pdf

Latouche, S. (2009). *Farewell to Growth*. Polity Press.

Lawler, J. J., Lewis, D. J., Nelson, E., Plantinga, A. J., Polasky, S., Withey, J. C., Helmers, D. P., Martinuzzi, S., Pennington, D., & Radeloff, V. C. (2014). Projected land-use change impacts on ecosystem services in the United States. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(20), 7492–7497. doi:10.1073/pnas.1405557111 PMID:24799685

Lawrence, G. (2005). Promoting sustainable development: The question of governance. In F. H. Buttel & P. McMichael (Eds.), *New directions in the sociology of global development* (pp. 145–174). Elsevier.

Laws, E., & Thyne, M. (2012). *Hospitality, tourism and lifestyle concepts: Implications for quality management and customer satisfaction*. Routledge. doi:10.4324/9780203051177

Le Galès, P., & Harding, A. (1998). Cities and states in Europe. *West European Politics*, *21*(3), 120–145. doi:10.1080/01402389808425260

Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F., & Peters, G. P. (2020). Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nature Climate Change*, *10*(7), 647–653. doi:10.103841558-020-0797-x

Leal Filho, W., Brandli, L. L., Lange Salvia, A., Rayman-Bacchus, L., & Platje, J. (2020). COVID-19 and the UN sustainable development goals: Threat to solidarity or an opportunity? *Sustainability*, *12*(13), 5343. doi:10.3390u12135343

Leal, J. A., & Serra, R. V. (2002). Notas sobre os fundamentos econômicos da distribuição espacial dos royalties petrolíferos no Brasil. In *XXX Encontro Nacional de Economia*. ANPEC.

Lee, K. (2018). *GENTRIFICATION: Changing Neighbourhoods for Better or Worse*. Available at: https://www.democratsabroad.org/bc_gentrification_changing_neighborhoods_for_better_or_worse

Lee, D.-H., Park, C.-G., Seo, B. Y., Boiteau, G., Vincent, C., & Leskey, T. C. (2014). Detectability of halyomorpha halys (hemiptera: Pentatomidae) by portable harmonic radar in agricultural landscapes. *The Florida Entomologist*, *97*(3), 1131–1138.

Lee, K. H., & Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534–542. doi:10.1016/j.jclepro.2015.05.114

Lefebvre, H. (1996). The right to the city. *Writings on Cities, 63181*.

Lehmann, S. (2011). Optimizing Urban Material Flows and Waste Streams in Urban Development through Principles of Zero Waste and Sustainable Consumption. *Sustainability*, *3*(1), 155–183. doi:10.3390u3010155

Lehr, W., & McKnight, L. W. (2003). Wireless internet access: 3G vs. WiFi? *Telecommunications Policy*, *27*(5-6), 351–370. doi:10.1016/S0308-5961(03)00004-1

Leichenko, R., & O'Brien, K. (2019). *Climate and society: Transforming the future*. John Wiley & Sons.

Lemos, M. C., & Agrawal, A. (2006). Environmental governance. *Annual Review of Environment and Resources*, *31*(1), 297–325. doi:10.1146/annurev.energy.31.042605.135621

Leresche, F. (2008). Libraries and archives: Sharing standards to facilitate access to cultural heritage. World Library and Information Congress. *74th IFLA Genera conference and Council*, 1 – 11.

Lerner, H., & Lasswell, D. (1951). *The Policy Sciences: Recent Developments in Scope and Method*. Stanford University Press.

Leveille, V., & Timms, K. (2015). Through a Records Management Lens: Creating a Framework for Trust in Open Government and Open Government Information. *Canadian Journal of Information and Library Science*, *39*(2), 154–190. doi:10.1353/ils.2015.0010

Levin, S. (1999). *Fragile dominion: complexity and the commons*. Perseus Books.

Lewandowski, M. (2016). Designing the Business Models for Circular Economy—Towards the Conceptual Framework. *Sustainability*, *8*(1), 1–28. doi:10.3390u8010043

Leys, A. J., & Vanclay, J. K. (2011). Social learning: A knowledge and capacity building approach for adaptive co-management of contested landscapes. *Land Use Policy*, *28*(3), 574–584. doi:10.1016/j.landusepol.2010.11.006

Liam, M., Andy, S., Paul, J., Thom, J. A., Padgham, L., Hickmott, S., Deng, H., & Cahill, F. (2013). Reframing social sustainability reporting: Towards an engaged approach. *Environment, Development and Sustainability*, *15*(1), 225–243. doi:10.100710668-012-9384-2

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, *115*, 36–51. doi:10.1016/j.jclepro.2015.12.042

Limp, P. (2005). The digitization of Africa. *Informing Science: The International Journal of an Emerging Transdiscipline, 52*(2), 4-19.

Linden, E., Bengtsson, B. E., Svanberg, O., Sundström, G., & Board, N. S. E. P. (1979). The acute toxicity of 78 chemicals and pesticide formulations against two brackish water organisms, the bleak (Alburnus alburnus) and the harpacticoid Nitocra spinipes. *Chemosphere*, *8*(11-12), 843–851. doi:10.1016/0045-6535(79)90015-8

Linder, M., & Williander, M. (2017). Circular business model innovation: Inherent uncertainties. *Business Strategy and the Environment*, *26*(2), 182–196. doi:10.1002/bse.1906

Lindqvist, M. (1991). *Infant Multinationals: The Internationalization of Young, Technology-Based Swedish Firms* (Unpublished Doctoral dissertation). Stockholm School of Economics, Institute of International Business.

Lindsey, A. (2013). *What is Online Marketing?* TN Media. Available at: http://www.tnmedia.com/what-is-online-marketing/

Ling, O. G. (2005). *Sustainability and Cities: Concept and Assessment*. Institute of Policy Studies. doi:10.1142/5755

Lin, J., Huang, J., Prell, C., & Bryan, B. A. (2021). Changes in supply and demand mediate the effects of land-use change on freshwater ecosystem services flows. *The Science of the Total Environment*, *763*, 143012. doi:10.1016/j.scitotenv.2020.143012 PMID:33162131

Linstone, H. A., & Turoff, M. (1975). *The Delphi method: Techniques and applications*. Addison-Wesley.

Lioubimtseva, E. (2014). Impact of Climate Change on the Aral Sea and Its Basin. In P. Micklin, N. Aladin, & I. Plotnikov (Eds.), *The Aral Sea* (pp. 405–427). Springer. doi:10.1007/978-3-642-02356-9_17

Lioubimtseva, E. (2015). A multi-scale assessment of human vulnerability to climate change in the Aral Sea Basin. *Environmental Earth Sciences*, *73*(2), 719–729. doi:10.100712665-014-3104-1

Lioubimtseva, E., & Henebry, G. M. (2009). Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. *Journal of Arid Environments*, *73*(11), 963–977. doi:10.1016/j.jaridenv.2009.04.022

Lipschutz, R. D. (1997). From Place to Planet: Local Knowledge and Global Environmental Governance. *Global Governance*, *3*(1), 83–102. doi:10.1163/19426720-00301005

Littlejohn, S. W. (1983). *Theories of human communication* (2nd ed.). Wadsworth.

Liu, J., Fujimori, S., Takahashi, K., Hasegawa, T., Wu, W., Takakura, J., & Masui, T. (2019). Identifying Trade-offs and Co-benefits of Climate Policies in China to Align Policies with SDGs and Achieve the 2 °C Goal. *Environmental Research Letters*, *14*(12), 124070. Advance online publication. doi:10.1088/1748-9326/ab59c4

Liu, W., Liu, L., & Gao, J. (2020). Adapting to climate change: Gaps and strategies for Central Asia. *Mitigation and Adaptation Strategies for Global Change*, *25*(8), 1439–1459. doi:10.100711027-020-09929-y

Liu, Y., Cotton, J. A., Shen, B., Han, X., Rossiter, S. J., & Zhang, S. (2010). Convergent sequence evolution between echolocating bats and dolphins. *Current Biology*, *20*(2), R53–R54.

Liu, Y., Yan, B., & Zhou, Y. (2016). Urbanization, economic growth, and carbon dioxide emissions in China: A panel cointegration and causality analysis. *Journal of Geographical Sciences*, *26*(2), 131–152. doi:10.100711442-016-1259-2

Li, Z., Fu, J., Lin, G., Jiang, D., Liu, K., & Wang, Y. (2019). Multi-scenario analysis of energy consumption and carbon emissions: The case of Hebei province in China. *Energies*, *12*(4), 624. doi:10.3390/en12040624

Li, Z., Xia, J., Deng, X., & Yan, H. (2021). Multilevel modelling of impacts of human and natural factors on ecosystem services change in an oasis, Northwest China. *Resources, Conservation and Recycling*, *169*, 105474. doi:10.1016/j.resconrec.2021.105474

Ljungqvist, J., Barthel, S., Finnveden, G., & Sörlin, S. (2010). The Urban Anthropocene: Lessons for Sustainability from the Environmental History of Constantinople. In P. Sinclair, F. Herschend, C. Isendahl, & G. Nordquist (Eds.), *The Urban Mind, cultural and environmental dynamics Studies in Global Archaeol-ogy* (Vol. 15, pp. 368–394). University Press.

Lockwood, J. A. (1987). The moral standing of insects and the ethics of extinction. *The Florida Entomologist*, *70*(1), 70–89.

Loevei, G. L., Stringer, I. A., Devine, C. D., & Cartellieri, M. (1997). Harmonic radar - a method using inexpensive tags to study invertebrate movement on land. *New Zealand Journal of Ecology*, *21*(2), 187–193.

Loft, L., & Lux, A. (2010). *Ecosystem Services*. Eine Einführung.

Lonnqvist, A., Tamminen, A., Mallat, J., & Raisanen, A. (2006). Monostatic reflectivity measurement of radar absorbing materials at 310 GHz. *IEEE Transactions on Microwave Theory and Techniques*, *54*(9), 3486–3491.

Loodin, N. (2020). Aral Sea: An environmental disaster in twentieth century in Central Asia. *Modeling Earth Systems and Environment*, *6*(4), 2495–2503. doi:10.100740808-020-00837-3

Loper, G. M., Wolf, W. W., & Taylor, O. R. (1993). Radar detection of drones responding to honeybee queen pheromone. *Journal of Chemical Ecology*, *19*(9), 1929–1938.

López, G. (2017). *Los Municipios Turísticos del Interior de la Comunitat Valenciana en Internet*. Tese de Doutoramento. Universidade de Valência.

López, D., & Sisa, F. (2020). Teletrabajo como estrategia de competitividad y desarrollo para las empresas en el Ecuador. *REVISTA ERUDITUS*, *1*(2), 53–70. doi:10.35290/re.v1n2.2020.318

López, F. J. D., Bastein, T., & Tukker, A. (2019). Business model innovation for resource-efficiency, circularity and cleaner production: What 143 cases tell us. *Ecological Economics*, *155*, 20–35. doi:10.1016/j.ecolecon.2018.03.009

Lordkipanidze, M., Brezet, H., & Backman, M. (2005). The entrepreneurship factor in sustainable tourism development. *Journal of Cleaner Production*, *13*(8), 787–798. doi:10.1016/j.jclepro.2004.02.043

Loreau, M., Naeem, S., & Inchausti, P. (2001). Biodiversity and ecosystem functioning: Current knowledge and future challenges. *Science*, *294*(5543), 804–808. doi:10.1126cience.1064088 PMID:11679658

Lothes, R. N., Szymanski, M. B., & Wiley, R. G. (1990). *Radar vulnerability to jamming*. Artech House.

Loures, L. (2011). *Planning and Design in Post-industrial Land Transformation: East bank Arade river, Lagoa - case study* (Doctoral thesis). Faculdade de Ciências e Tecnologia, Universidade do Algarve, Faro, Portugal.

Loures, L., Santos, R., & Panagopoulos, T. (2007). Urban Parks and Sustainable Development – The Case Study of Portimão City, Portugal. In A. Stamou, T. Panagopoulos, E. Stamatiou, A. Hatzopoulou, & D. Antunes (Eds.), *Energy, Environment, Ecosystems & Sustainable Development* (pp. 127–131). WSEAS Press.

Lousada, S., Escórcio, P., Castanho, R., Loures, L., Naranjo Gómez, J. M., Fernández-Pozo, L., Mora Aliseda, J., & Cabezas, J. (2018). A Multi-variated Analysis on Ultra-peripheral Territories. A Case Study Approach: Sustainability Indicators Proposal for Madeira Island. In T. R. Aranzadi (Ed.), Planeamiento Sectorial: Recursos Hídricos, Espacio Rural y Fronteras (pp. 293–303). Academic Press.

Lovell, S. T., DeSantis, S., Nathan, C. A., Olson, M. B., Mendez, V. E., Kominami, H. C., Erickson, D. L., Morris, K. S., & Morris, W. B. (2010). Integrating agroecology and landscape multifunc-tionality in Vermont: An evolving framework to evaluate the design of agroecosystems. *Agricultural Systems*, *103*(5), 327–341. doi:10.1016/j.agsy.2010.03.003

Łowicki, D. (2008). Land use changes in Poland during transformation: Case study of Wielkopolska region. *Landscape and Urban Planning*, *87*(4), 279–288. doi:10.1016/j.landurbplan.2008.06.010

Lozano-Parra, J., & Schnabel, S. (2015). Respuesta de la vegetación herbácea a las variaciones hídricas del suelo. In Estudios de la Zona No Saturada. Universidad de Alcalá de Henares.

Lozano-Parra, J., Schnabel, S., Pulido, M., Gómez-Gutiérrez, Á. & Lavado-Contador, F. (2018c). Effects of soil moisture and vegetation cover on biomass growth in water-limited environments. *Land Degradation and Development, 29*(12), 4405-4414.

Lozano-Parra, J., Van Schaik, L., Schnabel, S. & Gómez-Gutiérrez, Á. (2016). Soil moisture dynamics at high temporal resolution in a mediterranean watershed with scattered tree cover. *Hydrological Processes, 30*(8), 1155-1170.

Lozano-Parra, J., Lozano-Fondón, C., Pulido, M., & García-Marín, R. (2018a). El papel del agua sobre la biomasa vegetal en la zona semiárida con clima mediterráneo de Chile. *Revista de Geografía Norte Grande*, (71), 71. doi:10.4067/S0718-34022018000300091

Lozano-Parra, J., Pulido, M., Lozano-Fondón, C., & Schnabel, S. (2018b). How do soil moisture and vegetation covers influence soil temperature in drylands of Mediterranean regions? *Water (Basel)*, *10*(12), 1747. doi:10.3390/w10121747

Lub, X. D., Rijnders, R., Caceres, L. N., & Bosman, J. (2015). The future of hotels: The Lifestyle Hub. A design-thinking approach for developing future hospitality concepts. *Journal of Vacation Marketing*, 1–16.

Luck, G. W., Daily, G. C., & Ehrlich, P. R. (2003). Population diversity and ecosystem services. *Trends in Ecology & Evolution*, *18*(7), 331–336. doi:10.1016/S0169-5347(03)00100-9

Lüdeke-Freund, F., Gold, S., & Bocken, N. (2018). A review and typology of circular business model patterns. *Journal of Industrial Ecology*, *23*(1), 36–61. doi:10.1111/jiec.12763

Lu, J. W., & Beamish, P. W. (2004). International diversification and firm performance: The S-curve hypothesis. *Academy of Management Journal*, *47*(4).

Lu, L., Di, L., & Ye, Y. (2014). A decision-tree classifier for extracting transparent plastic-mulched Landcover from landsat-5 TM images. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *7*(11), 4548–4558. doi:10.1109/JSTARS.2014.2327226

Lundberg, J., & Moberg, F. (2003). Mobile link organisms and ecosystem functioning: Implications for ecosystem resilience and management. *Ecosystems (New York, N.Y.)*, *6*(1), 87–98. doi:10.100710021-002-0150-4

Luo, M., Sa, C., Meng, F., Duan, Y., Liu, T., & Bao, Y. (2020). Assessing extreme climatic changes on a monthly scale and their implications for vegetation in Central Asia. *Journal of Cleaner Production*, *271*, 122396. doi:10.1016/j.jclepro.2020.122396

Lusa. (2014). *Idanha-a-Nova candidata-se a Cidade da Música da UNESCO*. Publico.pt. Available at: https://www.publico.pt/2014/11/19/culturaipsilon/noticia/idanhaanova-candidatase-a-cidade-da-musica-da-unesco-1676776

Lusa. (2015). *Óbidos e Idanha-a-Nova entram na rede de cidades criativas da UNESCO*. Publico.pt. Available at: https://www.publico.pt/2015/12/11/culturaipsilon/noticia/obidos-entra-nas-cidades-da-literatura-da-unesco-1717150

Luxner, L. (2015). Reviving the North Aral Sea. *AramcoWorld*, *66*(5), 1–17.

Maantay, J. A., & Mclafferty, S. (2011). Geospatial Analysis of Environmental Health. *Geotechnologies & the Environment*, *4*. Advance online publication. doi:10.1007/978-94-007-0329-2

Maas, B., Fabian, Y., Kross, S. M., & Richter, A. (2021). Divergent farmer and scientist perceptions of agricultural biodiversity, ecosystem services and decision-making. *Biological Conservation*, *256*, 109065. doi:10.1016/j.biocon.2021.109065

Macdonald, G. (2000). Economies and personhood: demand sharing among the Wiradjuri of New South Wales. In G. W. Wenzel, G. Hovelsrud-Borda, & N. Kishigami (Eds.), The Social Economy of Sharing: Resource Allocation and Modern Hunter-Gatherers. National Museum of Ethnology.

Mace, G. M., Norris, K., & Fitter, A. H. (2012). Biodiversity and ecosystem services: A multilayered relationship. *Trends in Ecology & Evolution*, *27*(1), 19–26. doi:10.1016/j.tree.2011.08.006 PMID:21943703

Machlis, G. E., Force, J. E., & Burch, W. R. Jr. (1997). The human ecosystem. 1. The human ecosystem as an organizing concept in ecosystem management. *Society & Natural Resources*, *10*(4), 347–367. doi:10.1080/08941929709381034

Maes, J., Paracchini, M. L., Zulian, G., Dunbar, M. B., & Alkemade, R. (2012). Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. *Biological Conservation*, *155*, 1–12. doi:10.1016/j.biocon.2012.06.016

Maffi, L., & Woodley, E. (2012). *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan. doi:10.4324/9781849774697

Magama, B. (2018). Strategies for the preservation of digital records in Masvingo Province of Zimbabwe. *ESARBICA Journal*, *37*, 18–38.

Mahmoud, M. I., Sloan, S., Campbell, M. J., Alamgir, M., Imong, I., Odigha, O., Chapman, H. M., Dunn, A., & Laurance, W. F. (2017). Alternative Routes for a Proposed Nigerian Superhighway to Limit Damage to Rare Ecosystems and Wildlife. *Tropical Conservation Science*, *10*. doi:10.1177/1940082917709274

Majore, A. S., Yoo, H., & Shon, T. (2014). Secure and reliable electronic record management system using digital forensic technologies. *The Journal of Supercomputing*, *70*(1), 149–165. doi:10.100711227-014-1137-6

Malhotra, N. K., Birks, D. F., & Wills, P. A. (2012). Marketing research: An applied orientation (4th ed.). London: Pearson.

Malik, M. Y., Latif, K., Khan, Z., Butt, H. D., Hussain, M., & Nadeem, M. A. (2020). Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. *The Science of the Total Environment*, *726*, 138421. doi:10.1016/j.scitotenv.2020.138421 PMID:32481222

Mallan, K. (2006). Is digitization sufficient for collective remembering? Access to and use of cultural heritage collection. *Journal of information and Library Science, 30*(3-4), 201-220.

Mallet, J., Fortin, G., & Germain, D. (2018). Extreme weather events in northeastern New Brunswick (Canada) for the period 1950—2012: Comparison of newspaper archive and weather station data. *Canadian Association of Geographers*, *62*(2), 130–143. doi:10.1111/cag.12411

Mallick, S. K., & Rudra, S. (2021). *Analysis of Groundwater Potentiality Zones of Siliguri Urban Agglomeration Using GIS-Based Fuzzy-AHP Approach. In Groundwater and Society*. Springer. doi:10.1007/978-3-030-64136-8_7

Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in Public Health*, *8*, 14. doi:10.3389/fpubh.2020.00014 PMID:32154200

Manninen, K., Koskela, S., Antikainen, R., Bocken, N., Dahlbo, H., & Aminoff, A. (2018). Do circular economy business models capture intended environmental value propositions? *Journal of Cleaner Production*, *171*, 413–422. doi:10.1016/j.jclepro.2017.10.003

Marengo, J. A., Tomasella, J., & Nobre, C. A. (2017) Climate Change and Water Resources. In Waters of Brazil. Springer. Recuperado de doi:10.1007/978-3-319-41372-3_12

Markov, T., & Font, V. (2018). Does the circular economy grow the pie? The case of rebound effects from smartphone reuse. *Frontiers in Energy Research*, *6*, 1–11.

Maron, M., Mitchell, M. G., Runting, R. K., Rhodes, J. R., Mace, G. M., Keith, D. A., & Watson, J. E. (2017). Towards a threat assessment framework for ecosystem services. *Trends in Ecology & Evolution*, *32*(4), 240–248. doi:10.1016/j.tree.2016.12.011 PMID:28190532

Martin, D. F. (1993). *Autonomy and Relatedness: An Ethnography of the Wik People of Western Cape York Peninsula* (PhD Thesis). ANU, Canberra.

Martina, A., Olaf, B., & Karsten, G. (2017). *Using the Concepts of Green Infrastructure and Ecosystem Services to Specify Leitbilder for Compact and Green Cities—The Example of the Landscape Plan of Dresden*. Sustainability.

Martínez, J. A. (2005). Monitoring Intra-urban Inequality with GIS-based Indicators: Case Study: Rosario, Argentina. In *Proceedings of the Computers in Urban Planning and Urban Management (CUPUM 05)*. Computers in Urban Planning and Urban Management.

Martínez-Alier, J., Pascual, U., Vivien, F. D., & Zaccai, E. (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics*, *69*(9), 1741–1747. doi:10.1016/j.ecolecon.2010.04.017

Martinez, G., Zabalegui, A., & Sevilla, S. (2021). Management and leadership of nursing services in the emergency plan for the pandemic COVID-19: The experience of the Clinic Hospital of Barcelona. *Enfermeria Clinica*, *31*(1), S12–S17. doi:10.1016/j.enfcli.2020.05.002 PMID:32419770

Martinez, L. H. (2005). Post industrial revolution human activity and climate change: Why The United States must implement mandatory limits on industrial greenhouse gas emissions. *Journal of Land Use & Environmental Law*, 403–421.

Martins, C. A. (1991). A filoxera na viticultura nacional. Análise Social, 26(112-113), 653.

Martins, A. M. (2006). *Águas minerais do estado do Rio de Janeiro*. Departamento de Recursos Minerais do Governo do Estado do Rio de Janeiro.

Martynenko, T. S., & Vershinina, I. A. (2018). Digital Economy: The Possibility of Sustainable Development and Overcoming Social and Environmental Inequality in Russia. *Revista ESPACIOS*, *39*(44). https://www.revistaespacios.com/a18v39n44/a18v39n44p12.pdf

Ma, S., Wang, L. J., Zhu, D., & Zhang, J. (2021). Spatiotemporal changes in ecosystem services in the conservation priorities of the southern hill and mountain belt, China. *Ecological Indicators*, *122*, 107225. doi:10.1016/j.ecolind.2020.107225

Mascanzoni, D., & Wallin, H. (1986). The harmonic radar: A new method of tracing insects in the field. *Ecological Entomology*, *11*(4), 387–390.

Mason, I. M., Guzkowska, M. A. J., Rapley, C. G., & Street-Perrott, F. A. (1994). The response of lake levels and areas to climatic change. *Climatic Change*, *27*(2), 161–197. doi:10.1007/BF01093590

Matovic. (2018). *Creative Cities Mapping Creativity Driven Cities. 12 Good Practices from UNESCO Creative Cities Network*. Deusto Cities Lab Katedra.

Matthey, A. (2010). Less is more: The influence of aspirations and priming on well-being. *Journal of Cleaner Production*, *18*(6), 567–57. doi:10.1016/j.jclepro.2009.03.024

Matthies, A. L., Peeters, J., Hirvilammi, T., & Stamm, I. (2020). Ecosocial innovations enabling social work to promote new forms of sustainable economy. *International Journal of Social Welfare*, *29*(4), 378–389. doi:10.1111/ijsw.12423

Matzdorf, B., Reutter, M., & Hübner, C. (2010). *Gutachten-Vorstudie Bewertung der Ökosystemdienstleistungen von HNV-Grünland (High Nature Value Grassland) Abschlussbericht. Institut für Sozioökonomie Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) eV*. Müncheberg.

McCall, T. (1973). *Legislative address, Governor Tom McCall, Oregon, (1973).* Retrieved July 20, 2008, from http://arcweb.sos.state.or.us/governors/McCall/legis1973.html

McCollum, D. L., Krey, V., Riahi, K., Kolp, P., Grubler, A., Makowski, M., & Nakicenovic, N. (2013). Climate policies can help resolve energy security and air pollution challenges. *Climatic Change*, *119*(2), 479–494. doi:10.100710584-013-0710-y

McDonnell, M. J., & Hahs, A. (2009). Comparative ecology of cities and towns: Past, present and future. In M. J. McDonnell, A. Hahs, & J. Breuste (Eds.), *Ecology of cities and towns: A comparative approach* (pp. 71–89). Cambridge University Press. doi:10.1017/CBO9780511609763.006

McDonough, W., & Braungart, M. (2002). Cradle to Cradle: Remaking the Way We Make Things. North Point Press.

McGrath, M. (2020). *Climate change: Covid pandemic has little impact on rise in CO2*. https://www.bbc.com/news/science-environment-55018581

McKibben, B. (2003). *The End of Nature.* Bloomsbury Publishing.

McKinney, M. L. (2002). Urbanization, biodiversity, and conservation. *Bioscience*, *52*(10), 883–890. doi:10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2

McLean, I. F. G., & Key, R. S. (2012). A History of Invertebrate Conservation in the British Statutory Conservation Agencies. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

McLeman, R. A. (2011). Settlement abandonment in the context of global environmental change. *Global Environmental Change*, *21*, 108–120. doi:10.1016/j.gloenvcha.2011.08.004

McMichael, A. J., Haines, J. A., Slooff, R., Sari Kovats, R., & World Health Organization. (1996). *Climate change and human health: an assessment* (No. WHO/EHG/96.7). World Health Organization.

McNutt, M. (2013). Climate change impacts. *Science*, *341*(6145), 435. doi:10.1126cience.1243256 PMID:23908191

MDGs Report. (2015, March 24). *The Millennium Development Goals Report.* https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf

Meadows, D., Meadows, D., Randers, J., & Behrens, W. (1972). *The Limits to Growth*. Universe Books. https://www.clubofrome.org/publication/the-limits-to-growth/

Mehdipour, N., Fakheran, S., Soffianian, A., & Pourmanafi, S. (2019). Road-induced fragmentation and the environmental value of roadless areas in a partly protected landscape in Central Iran. *Environmental Monitoring and Assessment*, *191*(7), 1–12. doi:10.100710661-019-7571-4 PMID:31236686

Mei, N. S., Wai, C. W., & Ahamad, R. (2016). Environmental awareness and behaviour index for Malaysia. *Procedia: Social and Behavioral Sciences*, *222*(7), 668–675. doi:10.1016/j.sbspro.2016.05.223

Meinzen-Dick, R. S., van Koppen, B., Behrman, J. A., Karelina, Z., Akamandisa, V., Hope, L., & Wielgosz, B. (2012). *Putting Gender on the Map: Methods for mapping gendered farm management systems in Sub-Saharan Africa.* IFPRI Discussion Paper 1153. Washington, DC: International Food Policy Research Institute (IFPRI).

Memis, A., Kupusuzoglu, A., & Ceylan, N. B. (2019). Avrupa Birliği'ne Aday Ülkelerde Yenilenebilir Enerji Tüketimi, Ekonomik Büyüme Ve Nüfus Yoğunluğu'nun Karbon Emisyonu Üzerindeki Etkisi: Panel Veri Analizi. *International Conference on Empirical Economics and Social Science (ICEESS' 19),* 703-712.

Mensah, J. (2019). Sustainable Development: Meaning, History, Principles, Pillars, and Implications for Human Action: Literature Review. Cogent Social Sciences, 5(1). doi:10.1080/23311886.2019.1653531

Merem, E. C., Yerramilli, S., Twumasi, Y. A., Wesley, J. M., Robinson, B., & Richardson, C. (2011). The Applications of GIS in the Analysis of the Impacts of Human Activities on South Texas Watersheds. *International Journal of Environmental Research and Public Health*, *8*(6), 2418–2446. doi:10.3390/ijerph8062418 PMID:21776238

Merlan, F. (1998). *Caging the Rainbow: Places, Politics and Aborigines in a North Australian Town*. University of Hawai'i Press. doi:10.1515/9780824861742

Merlan, F. (2005). Explorations towards intercultural accounts of socio-cultural reproduction and changes. *Oceania*, *75*(3), 167–182. doi:10.1002/j.1834-4461.2005.tb02878.x

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, *178*, 703–722. doi:10.1016/j.jclepro.2017.12.112

Meshram. (2006). Interface between city development plans and master plans. *ITPI Journal*, 1-9.

Metcalf, J. I. (1975). Microstructure of radar echo layers in the clear atmosphere. *Journal of the Atmospheric Sciences*, *32*(2), 362–362.

Miafodzyeva, S., & Brandt, N. (2013). Recycling behaviour among householders: Synthesizing determinants via a meta-analysis. *Waste and Biomass Valorization*, *4*(2), 221–235. doi:10.100712649-012-9144-4

Miao, Y., Dai, T., Yang, X., & Song, J. (2021). Landscape fragmentation associated with the Qingzang Highway and its influencing factors—A comparison study on road sections and buffers. *Geography and Sustainability*, *2*(1), 59–67. doi:10.1016/j.geosus.2021.03.001

Micklin, P. (2014). The Siberian Water Transfer Schemes. In P. Micklin, N. Aladin, & I. Plotnikov (Eds.), *The Aral Sea* (pp. 381–404). Springer. doi:10.1007/978-3-642-02356-9_16

Mihalic, T. (2000). Environmental management of a tourist destination: A factor of tourism competitiveness. *Tourism Management*, *21*(1), 65–78. doi:10.1016/S0261-5177(99)00096-5

Millennium Ecosystem Assessment (MA). (2005). http://www.MAweb.org

Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends in Ecology & Evolution*, *20*(8), 430–434. doi:10.1016/j.tree.2005.05.013 PMID:16701413

Milne, B. T. (1991). Lessons from applying fractal models to landscape patterns. In *Quantitative Methods in Landscape Ecology–Then Analysis and Interpretation of Landscape Heterogeneity* (pp. 199–235). Springer-Verlag. doi:10.1007/978-1-4757-4244-2_9

Ministerio de Ambiente y energía (MINAE). (2020). *Ríos limpios. Estrategia nacional para la recuperación de cuencas urbanas 2020-2030*. http://www.da.go.cr

Misra, P., & Enge, P. (1999). Special issue on global positioning system. *Proceedings of the IEEE*, *87*(1), 3–15. doi:10.1109/JPROC.1999.736338

Mitchell, B. (2019, December). *What Is the Real Speed of an 802.11b Wi-Fi Network?* Lifewire. https://www.lifewire.com/actual-speed-of-an-802-11b-wifi-network-818300

Mnjama, N., & Wamukoya, J. (2004). *E-government and e-records management*. Paper presented at the SADC Workshop on E-government, Gaborone, Botswana.

Mnjama, N. (2005). Archival landscape in Eastern and Southern Africa. *Library Management*, *26*(8/9), 457–470. doi:10.1108/01435120510631747

Mocca, E. (2020). The local dimension in the degrowth literature. A critical discussion. *Journal of Political Ideologies*, *25*(1), 78–93. doi:10.1080/13569317.2019.1696926

Mohamadzadeh, P., Pourmoradian, S., Feizizadeh, B., Sharifi, A., & Vogdrup-Schmidt, M. (2020). A GIS-Based Approach for Spatially-Explicit Sustainable Development Assessments in East Azerbaijan Province, Iran. *Sustainability, 12*(24), 10413. doi:10.3390/su122410413

Mohanty, A. (2018). Education for Sustainable Development: A Conceptual Model of Sustainable Education for India. *International Journal of Development and Sustainability*, *7*(9), 2242–2255.

Moisio, S., & Paasi, A. (2013). Beyond State-Centricity: Geopolitics of Changing State Spaces. *Journal of Geopolitics*, *18*(2), 255–266. doi:10.1080/14650045.2012.738729

Mokgalaka, H. (2014). *Measuring Access to Primary Health Care: Use of A GIS-based Accessibility Analysis*. CONFERENCE paper.

Moktadir, M. A., Ahmadi, H. B., Sultana, R., Tuj-Zohra, F., Liou, J. J. H., & Rezaei, J. (2020). Circular economy practices in the leather industry: A practical step towards sustainable development. *Journal of Cleaner Production*, *251*, 119737. doi:10.1016/j.jclepro.2019.119737

Molefe, N & Schellnack-Kelly, I (2019). Users' perceptions of services at the National Archives and Records Service of South Africa (NARSSA). *Innovation: Journal of Appropriate Librarianship and Information Work in Southern Africa*, *58*, 3 – 15.

Moorcroft, H., Ignjic, E., Cowell, S., Goonack, J., Mangolomara, S., Oobagooma, J., Karadada, R., Williams, D., & Waina, N. (2012). Conservation planning in a cross-cultural context: The Wunambal Gaambera Healthy Country Project in the Kimberley, Western Australia. *Ecological Management & Restoration*, *13*(1), 16–25. doi:10.1111/j.1442-8903.2011.00629.x

Moraes, V., & Locatelli, C. (2012). Vinho: uma revisão sobre a composição química e benefícios à saúde. *Evidência - Ciência e Biotecnologia - Interdisciplinar, 10*(1-2), 57-68.

Morales-Barquero, L., Lyons, M. B., Phinn, S. R., & Roelfsema, C. M. (2019). Trends in remote sensing accuracy assessment approaches in the context of natural resources. *Remote Sensing*, *11*(19), 1–16. doi:10.3390/rs11192305

Morel, A., Schertenleib, R., & Zurbruegg, C. (2003). *Conceptos Alternativos de Saneamiento Ambiental para Países en Desarrollo.* Instituto Federal Suizo de Ciencias del ambiente y Tecnología.

Moreton-Robinson, A. (2007). Introduction. In *Sovereign Subjects: Indigenous Sovereignty Matters*. Allen & Unwin.

Morgan, N., & Pritchard, A. (2004). Meeting the destination branding challenge. In Destination Branding: Creating the unique destination proposition. Butterworth-Heinemann.

Moroni, S. (2015). Complexity and the inherent limits of explanation and prediction: Urban codes for self-organising systems. *Planning Theory*, *14*(3), 248–267. doi:10.1177/1473095214521104

Mota, M. (2006). Princípio da precaução no direito ambiental: uma construção a partir da razoabilidade e da proporcionalidade. *Revista brasileira de direito do petróleo, gás e energia, 2*, 1 – 42.

Mouillot, D., Villéger, S., Scherer-Lorenzen, M., & Mason, N. W. (2011). Functional structure of biological communities predicts ecosystem multifunctionality. *PLoS One*, *6*(3), e17476. doi:10.1371/journal.pone.0017476 PMID:21423747

Moumen, Z., El Idrissi, N. E. A., Tvaronavičienė, M., & Lahrach, A. (2019). Water security and sustainable development. *Insights into Regional Development*, *1*(4), 301–317. doi:10.9770/ird.2019.1.4(2)

Moutinho, L., Rate, S., & Ballantyne, R. (2013). Futurecast: an exploration of key emerging megatrends in the tourism arena. In C. Costa, E. Panyik, & D. Buhalis (Eds.), *Trends in European Tourism Planning and Organisation* (pp. 313–325). Channel View Publications. doi:10.21832/9781845414122-026

Muchaonyerwa, N., & Khayundi, F. (2014). The Management of Digital Records in the Office of the Premier of the Eastern Cape Province, South Africa. *African Journal of Library Archives and Information Science*, *24*(1), 41–52.

Mueller, E. A., & Larkin, R. P. (1985). Insects observed using dual-polarization radar. *Journal of Atmospheric and Oceanic Technology*, *2*(1), 49–54.

Mugge, R., Jocking, B., & Bocken, N. (2017). How to sell refurbished smartphones? An investigation of different customer groups and appropriate incentives. *Journal of Cleaner Production*, *147*, 284–296. doi:10.1016/j.jclepro.2017.01.111

Mukherji, N. & Morales, A. (2010). *Zoning for urban Agriculture*. Zoning Practice 3.

Müller, F., & Burkhard, B. (2007). An ecosystem based framework to link landscape structures, functions and services. In *Multifunctional land use* (pp. 37–63). Springer. doi:10.1007/978-3-540-36763-5_3

Muller, S. (2014). Co-motion: Making space to care for country. *Geoforum*, *54*, 132–141. doi:10.1016/j.geoforum.2014.04.011

Municipal, C. (2018). *Orçamento e Grandes Opções do Plano 2018*. Available at: https://www.cm-idanhanova.pt/institucional/financas-locais/documentos-previsionais/2018.aspx

Municipio de Idanha. (2021). *Official website*. Available at: https://www.cm-idanhanova.pt/

Muñoz, A., & Sánchez, S. (2013). Destinos Turísticos Inteligentes. *Harvard Deusto Business Review, 224*, 58-67. Available at: https://www.mincotur.gob.es/Publicaciones/Publicacionesperiodicas/EconomiaIndustrial/RevistaEconomiaIndustrial/395/LOPEZ%20DE%20AVILA%20y%20GARCIA.pdf

Munro, J., & Richards, B. (2011). Destination brand challenges: the digital challenge. In Y. Wang & A. Pizam (Eds.), *Destination Marketing and Management, Theories and Applications* (pp. 141–154). CAB International.

Murakami, E. (2020). *Climate Change and International Migration: Evidence from Tajikistan.* https://www.adb.org/publications/climate-change-international-migration-tajikistan

Murayama, Y., Simwanda, M., & Ranagalage, M. (2021). Spatiotemporal Analysis of Urbanization Using GIS and Remote Sensing in Developing Countries. *Sustainability, 13*(7), 3681. doi:10.3390/su13073681

Murillo, A. (2017). Análisis Comparativo de tecnologías para el tratamiento colectivo de las aguas residuales en poblaciones menores a 5000 habitantes equivalentes en Costa Rica. Trabajo de Graduación., Escuela de Ingeniería civil. Facultad de Ingeniería. Universidad de Costa Rica.

Murray, A., Skene, K., & Haynes, K. (2017). The Circular Economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, *140*(3), 369–380. doi:10.100710551-015-2693-2

Murray, H. A. (1938). *Explorations in Personality*. Oxford University Press.

Musacchio, L. R. (2008). Metropolitan landscape ecology: Using translational research to increase sustainability, resilience, and regeneration. *Landscape Journal*, *27*(1), 1–8. doi:10.3368/lj.27.1.1

Muzyka, S. M., Vinober, A. V., Shvetsova, S. V., Bondarenko, O. V., & Kozlova, S. A. (2019). Potential of rural tourism in the Tunkinsky National Park (Baikal region): Synergy of environmental and economic factors. *IOP Conference Series. Earth and Environmental Science*, *341*(1), 012016. Advance online publication. doi:10.1088/1755-1315/341/1/012016

Myers, F. (1986). *Pintupi Country, Pintupi Self: Sentiment, Place and Politics Among Western Desert Aborigines*. University of California Press.

Nabiyeva, G., & Wheeler, S. (2020). Geographic Information Systems as a Tool to Support the Sustainable Development Goals. *International Journal of Computer and Information Engineering*, *14*(3), 78–85.

Naeem, S., Duffy, J. E., & Zavaleta, E. (2012). The functions of biological diversity in an age of extinction. *Science, 336*(6087), 1401-1406.

Nathaniel, S., & Khan, S. A. R. (2020). The Nexus Between Urbanization, Renewable Energy, Trade, and Ecological Footprint in ASEAN Countries. *Journal of Cleaner Production*, *272*, 122709. Advance online publication. doi:10.1016/j.jclepro.2020.122709

National Academy of Sciences. (1988). *BioDiversity*. Academy Press.

National Academy of Sciences. (2013). *Resilience and Ecosystem Services*. National Academy of Sciences.

National Biodiversity Authority. (2013). *Guidelines for operationlization of biodiversity management committees (BMCs).* Retrieved June 01, 2021, from nbaindia: http://nbaindia.org/uploaded/pdf/Guidelines%20for%20BMC.pdf

National Geographic Institute of Spain. (2007). Necesidad de un Nuevo "Datum". ETRS89, Working Group for the Transition to ETRS89; Higher Geographic Council of Spain.

National Land Use Database. (2000). *Previously Developed Land (PDL): Vacant Sites and Derelict Sites, and Other Previously Developed Land and Buildings that May be Available for Redevelopment, Data Specification*. NLUD.

Nations, U. (2015). *Transforming our world: The 2030 agenda for sustainable development*. United Nations, Department of Economic and Social Affairs.

Naveh, Z. (2000). The total human ecosystem: Integrating ecology and economics. *Bioscience*, *50*, 357–361.

Nazeer, M. Tabassum, U., & Alam, S. (2016). Environmental pollution and sustainable development in developing countries. *The Pakistan Development Review*, *55*(4), 589-604.

Neagu, C. (2016). The importance and role of small and medium-sized businesses. *Theoretical and Applied Economics*, *23*(3), 331–338.

Neef, M. M. (1995). Economic growth and quality of life: A threshold hypothesis. *Ecological Economics*, *15*(2), 115–118. doi:10.1016/0921-8009(95)00064-X

Nelson, A., & Liegey, V. (2020). *Coronavirus and degrowth*. https://theecologist.org/2020/apr/03/coronavirus-and-degrowth

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environment and Resources*, *32*, 395–419.

Nengomasha, T. C. (2013). The past, present and future of records and archives management in sub-Saharan Africa. *Journal of the South African Society of Archivists*, *46*, 2–11.

Nengomasha, T. C., & Nyanga, H. E. (2015). Access to Archives at the National Archives of Namibia. *ESARBICA Journal*, *34*, 88–103.

Netshakhuma, N. S. (2020). The role of archives in documenting African National Congress Women's League that impacted the development of their records: 1960 – 1990. *Global Knowledge, Memory and Communication, 70*(1/2),44-59.

Netshakhuma, N. S. (2021). The impact of climate change on the Mpumalanga Provincial Archives and records management activities. Records Management Journal. doi:10.1108/RMJ-09-2020-0031

Netshakhuma, N. S. (2018). *Capacity building through digitisation: Case of the ANC archives*. *The RIM Quarterly*.

Netshakhuma, N. S. (2019). Analysis of the role and impact of the Mpumalanga Provincial Archives. *Mousaion: South African Journal of Information Studies*, *36*(4), 1–18. doi:10.25159/2663-659X/5642

Netshakhuma, N. S. (2020). Analysis of archives infrastructure in South Africa: Case of Mpumalanga provincial archives. Global Knowledge. *Memory and Communication*, *69*(4/5), 221–239.

Neumann, W. R. (2008). Interaction. In W. Donsbach (Ed.), *The international encyclopedia of communication* (Vol. 5, pp. 2305–2309). Blackwell. doi:10.1002/9781405186407.wbieci040

Neves, L. (2019). *Going "Digital with Purpose" to Achieve Climate Goals and 2030 Agenda.* https://sdg.iisd.org/commentary/guest-articles/going-digital-with-purpose-to-achieve-climate-goals-and-2030-agenda/

New York City Mayor's Office of Sustainability. (2020). *Inventory of New York greenhouse gas emissions.* https://nyc-ghg-inventory.cusp.nyu.edu/#:~:text=The%20City%20of%20New%20York,achieve%20carbon%20neutrality%20by%202050

New, T. R. (2009). *Insect Species Conservation. Ecology, Biodiversity and Conservation*. Cambridge University Press. doi:10.1017/CBO9780511626876

New, T. R. (2018). *Forests and Insect Conservation in Australia*. Springer International Publishing. doi:10.1007/978-3-319-92222-5

Ngulube, P. (2001). Strategies for managing digital records and documents in the public sector in Sub Saharan Africa. *Records Management*, *22*(3), 198–211.

Ngulube, P. (2002a). Challenges to preservation of our archival heritage. *Archives*, *42*, 27.

Ngulube, P. (2002b). The future of the past: Access to public archives in Southern Africa and challenges to historical research. *Historia (Wiesbaden, Germany)*, *47*(2).

Niemann, E. (1977). Eine Methode zur Erarbeitung der Funktionsleistungsgrade von Landschaftselementen. *Archiv fur Naturschutz und Landschaftsforschung*.

Niemeyer, S., & Spash, C. L. (2001). Environmental valuation analysis, public deliberation, and their pragmatic syntheses: A critical appraisal. *Environment and Planning. C, Government & Policy*, *19*(4), 567–585. doi:10.1068/c9s

Nikraftar, T., & Hosseini, E. (2016). Factors affecting entrepreneurial opportunities recognition in tourism small and medium sized enterprises. *Tourism Review*, *71*(1), 6–17. doi:10.1108/TR-09-2015-0042

Nisha, J., & Chen, S. (2017). A study on the relationship of environmental regulations and economic performances. *IOP Conference Series. Earth and Environmental Science*, *94*(1), 012035. doi:10.1088/1755-1315/94/1/012035

NISO Framework Working Group. (2007). A framework of Guidance for Building Good Digital Collections (3rd ed.). Baltimore: National Information Standards Organization (NISO).

Nolan, J. (2018). *What makes smart cities, smart?* ITProPortal. https://www.itproportal.com/features/what-makes-smart-cities-smart/

Nooripoor, M., Khosrowjerdi, M., Rastegari, H., Sharifi, Z., & Bijani, M. (2020). The role of tourism in rural development: Evidence from Iran. *GeoJournal*. Advance online publication. doi:10.100710708-020-10153-z

North, D. O. (1963). An analysis of the factors which determine signal/noise discrimination in pulsed-carrier systems. *Proceedings of the IEEE*, *51*(7), 1016–1027.

Noskov, A., Bendix, J., & Friess, N. (2021). A Review of Insect Monitoring Approaches with Special Reference to Radar Techniques. *Sensors (Basel)*, *21*(4), 1474.

Not haft, H. (2016). A framework for strategic communication research: A call for synthesis and consilience. *International Journal of Strategic Communication, 10*(2), 69-86. doi:10.1080/1553118X.2015.1124277

Novelli, A., & Tarantino, E. (2015). Combining ad hoc spectral indices based on LANDSAT-8 OLI/TIRS sensor data for the detection of plastic cover vineyard. *Remote Sensing Letters*, *6*(12), 933–941. doi:10.1080/2150704X.2015.1093186

Nsibirwa, Z., Hoskins, R., & Stilwell, C. (2014). Building the South African Nation through Legal Deposit: The Impact of Legislation on Preservation of Digital Materials. *African Journal of Library Archives and Information Science*, *24*(1), 53–65.

Nunes, L. G. P., Almeida, A. A. S., & Targa, M. S. (2020). Gestão da água para a efetividade dos Objetivos do Desenvolvimento Sustentável. *Revista Técnica Ciências Ambientais, 1*(2), 1-6. Recuperado de http://agro.unitau.br/repositorio/index.php/rca/article/view/53

Núñez, J. M., Medina, S., Ávila, G., & Montejano, J. (2019). *High-Resolution Satellite Imagery Classification for Urban Form Detection*. Satellite Information Classification and Interpretation. IntechOpen. doi:10.5772/intechopen.82729

Nurse, K. (2006). Culture as the fourth pillar of sustainable development. Paper prepared for the Commonwealth Secretariat.

Nußholz, J. L. K. (2017). Circular business models: Defining a concept and framing an emerging research field. *Sustainability*, *9*(10), 1810–1826. doi:10.3390u9101810

Nußholz, J. L. K., Rasmussen, F. N., & Milios, L. (2019). Circular building materials: Carbon saving potential and the role of business model innovation and public policy. *Resources, Conservation and Recycling*, *141*, 308–316. doi:10.1016/j.resconrec.2018.10.036

Nwankwo, C. F., Arduino, R., Ali, A., & Made, I. A. (2020). Farmer-herder conflict: The politics of media discourse in Nigeria. *II Ponte*, *76*(1), 191–221. doi:10.21506/j.ponte.2020.1.13

Nyström, M., & Folke, C. (2001). Spatial resilience of coral reefs. *Ecosystems (New York, N.Y.)*, *4*(5), 406–417. doi:10.100710021-001-0019-y

O'Bowman, A. M., & Pagano, M.A. (2004). Terra Incognita: Vacant Land and UrbanStrategies. Georgetown University Press.

O'Toole, J. M. (1993). The symbolic significance of archives. *The American Archivist*, *56*(2), 234–255. doi:10.17723/aarc.56.2.e481x55xg3x04201

Obata, O. R., Cabral Júnior, M., & Sintoni, A. (2005). *Águas minerais orientação para regularização e implantação de empreendimentos*. Instituto de Pesquisas Tecnológicas.

ODEPA. (2020). *Solicitud Transparencia AR004T0001934 y AR004T0001935*. ODEPA.

Odum, E. P. (1971). *Fundamentals of Ecology* (3rd ed.). W. B. Saunders.

OECD. (2002). *Sustainable development strategies: A resource book*. Earthscan Publications Ltd.

OECD. (2016). OECD Tourism Trends and Policies 2016. *Tourism Trends and Policies*, *2016*. Advance online publication. doi:10.1787/tour-2016-en

OECD. (2017). *Getting Governments Organised to Deliver on the Sustainable Development Goals*. Available at: https://www.oecd.org/gov/SDGs-Summary-Report-WEB.pdf

OECD. (2020). *OECD Tourism Trends and Policies 2020*. OECD Publishing. Retrieved from http://www.oecd.org

OECD. (2020a). *From containment to recovery: Environmental responses to the COVID-19 pandemic*. https://unece.org/DAM/RCM_Website/OECD_Covid_env_responses_brief_April_2020.pdf

OECD. (2020b). *Environmental health and strengthening resilience to pandemics*. https://unece.org/DAM/RCM_Website/OECD_Covid_env_health_brief_April_2020.pdf

OECD. (2020c). *Making the green recovery work for jobs, income and growth. OECD Policy Responses to Coronavirus (Covid-19).* https://www.oecd.org/coronavirus/policy-responses/making-the-green-recovery-work-for-jobs-income-and-growth-a505f3e7/

OECD. (2021). *Building energy efficiency in cities and regions*. https://www.oecd.org/cfe/cities/energy-efficiency-cities.htm

Oepen, M., & Hamacher, W. (Eds.). (2000). *Communicating the environment*. Peter Lang.

Oficina de Estudios y Políticas Agrarias (ODEPA) del Ministerio de Agricultura. (2019). Panorama de la agricultura Chilena [Chilean agriculture overview]. ODEPA.

Oghazi, P., & Mostaguel, R. (2018). Circular business model challenges and lessons learned -An industrial perspective. *Sustainability*, *10*(3), 739–758. doi:10.3390u10030739

Olatokun, M. W. (2008). A survey of Preservation and Conservation Practices and Techniques in Nigerian University Libraries. *LIBRES Library and Information Science Research Electronic Journal*, *18*(2), 1–18.

Oliva, P., Alexianu, M., & Nasir, R. (2019, December). Suffocating prosperity: Air pollution and economic growth in developing countries. IGC, Growth Brief. *Energy*.

Oliveira, P. d., Shih, W.-y., Moreno-Peñaranda, R., & Phillips, A. (2014). *Integrating Biodiversity with Local and City Planning*. UNU-IAS. Retrieved from https://www.niua.org/csc/assets/pdf/key-documents/phase-2/Up-GreenC-and-BIO/Integrating-Biodiversity-with-Local-and-City-Planning.pdf

Oliveira, P., & Teixeira, A. (2011). *The Internationalization Profiles of Portuguese SMEs*. FEP working paper, n. 439, nov./2011. Porto: Faculdade de Economia da Universidade do Porto.

Oliveira, J. A., Doll, C. N., Moreno-Peñaranda, R., & Balaban, O. (2014). *Urban Biodiversity and Climate Change*. Springer.

Oliveira, O., & Pal, L. (2018). New frontiers and directions in policy transfer, diffusion and circulation research: Agents spaces, resistance, and translations. *Brazilian Journal of Public Administration*, *52*(2), 199–220. doi:10.1590/0034-761220180078

Oliveira, P. d., & Doll, J. A., N.H., C., Moreno-Peñaranda, Balaban, R. A., & Osman. (2014). Urban biodiversity and climate change. *Global Environmental Change*, 461–468.

Omerzel, D. G. (2015). Innovativeness in tourism: Model development. *Procedia Economics and Finance*, *23*, 750–756. doi:10.1016/S2212-5671(15)00550-X

Öncü, M., Yıldırım, S., Bostancı, S., & Erdoğan, F. (2021). The Effect of COVID-19 Pandemic on Health Management and Health Services: A Case of Turkey. *Duzce Medical Journal*, *23*(Special Issue), 61–70.

Ophoff, J., & Miller, S. (2019). Business Priorities Driving BYOD Adoption: A case study of a South African Financial Services Organisation. *Issues in Information Science Information Technology*, *16*, 165–196. doi:10.28945/4303

Opschoor, J. B. (1992). Institutional change and development towards sustainability. In R. Costanza & O. Segura (Eds.), *ISEE getting down to earth: Practical applications of ecological economics*. Island Press.

Orth, R. J., Lefcheck, J. S., McGlathery, K. S., Aoki, L., Luckenbach, M. W., Moore, K. A., Oreska, M. P. J., Snyder, R., Wilcox, D. J., & Lusk, B. (2020). Restoration of seagrass habitat leads to rapid recovery of coastal ecosystem services. *Science Advances*, *6*(41), eabc6434. doi:10.1126ciadv.abc6434 PMID:33028530

Ortigara, A., Kay, M., & Uhlenbrook, S. (2018). A Review of the SDG 6 Synthesis Report 2018 from an Education, Training, and Research Perspective. *Water, 10*(10), 1353. doi:10.3390/w10101353

Osio, L. (2015). Salud y seguridad en el teletrabajo. *Redalyc, 2*(2), 410–426.

Ost, F., & van de Kerchove, M. (2002). *De la pyramide au réseau? Pour unethéorie dialectique du droit*. Facultés Universitaires Saint Louis.

Ostrom, E. (2002). Reformulating the commons. *Ambiente & Sociedade*, *5*(10), 1–22.

Ostrom, E. (2010). Beyond Markets and States: Polycentric governance of complex economic systems. *The American Economic Review*, *100*(3), 641–672. doi:10.1257/aer.100.3.641

Otte, A., Simmering, D., & Wolters, V. (2007). Biodiversity at the landscape level: Recent concepts and perspectives for multifunctional land use. *Landscape Ecology*, *22*(5), 639–642. doi:10.100710980-007-9094-6

Otto, I. M., Reckien, D., Reyer, C. P., Marcus, R., Le Masson, V., Jones, L., Norton, A., & Serdeczny, O. (2017). Social vulnerability to climate change: A review of concepts and evidence. *Regional Environmental Change*, *17*(6), 1651–1662. doi:10.100710113-017-1105-9

Oweru, J. P., & Mnjama, N. (2014). Archival preservation practices at the Records and Archives Management Department in Tanzania. *Mousaion: Journal of Information Science in South Africa*, *32*(3), 136–165. doi:10.25159/0027-2639/1680

Ozdemir, B. K., & Koc, K. (2020). Türkiye’de Karbon Emisyonları, Yenilenebilir Enerji ve Ekonomik Büyüme. *Ege Stratejik Araştırmalar Dergisi*, *11*(1), 66–86. doi:10.18354/esam.665191

Ozdenerol, E. (2021). The Global Problem in Gender Inequality - Putting Gender on the Map with GIS. CRC Press.

Ozturk, S., & Kusmez, T. (2019). Elektrik Tüketimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisi (1995-2014). *Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *12*(2), 316-327.

Pagano, M. A., & Bowman, A. (2000). Land in Cities: An Urban Resource. Brookings Institution, Center on Urban and Metropolitan Policy.

Pakzad, P., Osmond, P., & Philipp, C. (2015). Review of Tools for Quantifying the Contribution of Green Infrastructure to Carbon Performance. *ICUC9 - 9th International Conference on Urban Climate jointly with 12th Symposium on the Urban Environment*. 10.13140/RG.2.1.1858.4083

Pala, A. (2018). Gelişmekte Olan Ülkelerde Enerji Tüketimi, Karbon Emisyonu ve Ekonomik Büyüme İlişkisinin ARDL Yaklaşımı İle İncelenmesi. *Ekonomik ve Sosyal Araştırmalar Dergisi*, *14*, 1–29.

Palma, A., & Mattos, U. A. O. (2001). Contribuições da ciência pós-normal à saúde pública e a questão da vulnerabilidade social. *Historia, Ciencias, Saude—Manguinhos*, *8*(3), 567–590. doi:10.1590/S0104-59702001000400004 PMID:11949695

Panayotou, T. (2016). Economic growth and the environment. *The environment in anthropology,* 140-148.

Pan, B., MacLaurin, T., & Crott, J. C. (2007). Travel blogs and the implication for destination marketing. *Journal of Travel Research*, *46*(1), 35–45. doi:10.1177/0047287507302378

Parker, S. (2003). *McGraw-Hill Dictionary of Scientific and Technical Terms*. McGraw Hill Dictionary of Scientific and Technical Terms. McGraw-Hill Education.

Parthasarahty, D. (2005). Taking Participation Seriously. A Critique of Good Governance. In Droit, gouvernance et développement durable,numéro spécial des Cahiers d'Anthropologie du Droit. Karthala.

Pascoal, R. M. (2020). *Acceptance of Online Education in Portugal and in the World: Before and During Covid-19*. Academic Press.

Pascoal, R., Alturas, B., de Almeida, A., & Sofia, R. (2018, June). A survey of augmented reality: Making technology acceptable in outdoor environments. In *2018 13th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-6). IEEE.

Pascoal, R. M., de Almeida, A., & Sofia, R. C. (2019, September). Activity recognition in outdoor sports environments: smart data for end-users involving mobile pervasive augmented reality systems. In *Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers* (pp. 446-453). 10.1145/3341162.3349299

Pascoal, R. M., & Guerreiro, S. L. (2017). Information overload in augmented reality: The outdoor sports environments. In *Information and Communication Overload in the Digital Age* (pp. 271–301). IGI Global. doi:10.4018/978-1-5225-2061-0.ch012

Pascoal, R., Almeida, A. D., & Sofia, R. C. (2020). Mobile pervasive augmented reality systems - MPARS: The role of user preferences in the perceived quality of experience in outdoor applications. *ACM Transactions on Internet Technology*, *20*(1), 1–17. doi:10.1145/3375458

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R. T., Başak Dessane, E., Islar, M., Kelemen, E., Maris, V., Quaas, M., Subramanian, S. M., Wittmer, H., Adlan, A., Ahn, S. E., Al-Hafedh, Y. S., Amankwah, E., Asah, S. T., ... Yagi, N. (2017). Valuing nature's contributions to people: The IPBES approach. *Current Opinion in Environmental Sustainability*, *26*, 7–16. doi:10.1016/j.cosust.2016.12.006

Pascual, U., Termansen, M., Hedlund, K., Brussaard, L., Faber, J. H., Foudi, S., Lemanceau, P., & Jørgensen, S. L. (2015). On the value of soil biodiversity and ecosystem services. *Ecosystem Services*, *15*, 11–18. doi:10.1016/j.ecoser.2015.06.002

Pata, U. K., & Yurtkuran, S. (2018). Yenilenebilir Enerji Tüketimi, Nüfus Yoğunluğu Ve Finansal Gelişmenin Co2 Salımına Etkisi: Türkiye Örneği. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, 303-318.

Paudyal, K., Baral, H., Bhandari, S. P., Bhandari, A., & Keenan, R. J. (2019). Spatial assessment of the impact of land use and land cover change on supply of ecosystem services in Phewa watershed, Nepal. *Ecosystem Services*, *36*, 100895. doi:10.1016/j.ecoser.2019.100895

Paulson, S. (2017). Degrowth: culture, power and change. *Journal of Political Ecology, 24, 425-666*. doi:10.2458/v24i1.20882

Pedregal, B., Laconi, C., & del Moral, L. (2020). Promoting Environmental Justice through Integrated Mapping Approaches: The Map of Water Conflicts in Andalusia (Spain). *ISPRS International Journal of Geo-Information, 9*(2), 130. doi:10.3390/ijgi9020130

Peng, J., Tian, L., Liu, Y., Zhao, M., & Wu, J. (2017). Ecosystem services response to urbanization in metropolitan areas: Thresholds identification. *The Science of the Total Environment*, *607*, 706–714. doi:10.1016/j.scitotenv.2017.06.218 PMID:28711000

Peng, M. W. (2006). *Global Strategy*. South-Western.

Peng, T., Kellens, K., Tang, R., Chen, C., & Chen, G. (2018). Sustainability of additive manufacturing: An overview on its energy demand and environmental impact. *Additive Manufacturing*, *21*, 694–704. doi:10.1016/j.addma.2018.04.022

Peralta, Á., Bilous, A., Flores, J., & Bombón, C. (2020). El impacto del teletrabajo y la administración de empresas. *RECIMUNDO: Revista Científica de La Investigación y El Conocimiento, 4*(1), 326–335.

Pereira, A. (1988). *O Contrato de «Joint-Venture»* (1st ed.). ICEP.

Perey, R., Benn, S., Agarwal, R., & Edwards, M. (2018). The place of waste: Changing business value for the circular economy. *Business Strategy and the Environment*, *27*(5), 631–642. doi:10.1002/bse.2068

Pérez-Chacón, R., Luna-Romera, J. M., Troncoso, A., Martínez-Álvarez, F., & Riquelme, J. C. (2018, March 18). Big data analytics for discovering electricity consumption patterns in smart cities. *Energies*, *11*(683), 683. Advance online publication. doi:10.3390/en11030683

Perilla, G. A., & Mas, J. F. (2019). High-resolution mapping of protected agriculture in Mexico, through remote sensing data cloud geoprocessing. *European Journal of Remote Sensing*, *52*(1), 532–541. doi:10.1080/22797254.2019.1686430

Perlya, Y. (1955). *How radiolocator works (Kak rabotaet radiolokator)*. Gosudarstvennoe Izdatelstvo Oboronnoy Promyshlennosti.

Perry, J. N., Woiwod, I. P., & Hanski, I. (1993). Using response-surface methodology to detect chaos in ecological time series. *Oikos*, *68*(2), 329–339.

Pesce, M., Tamai, I., Guo, D. Y., Critto, A., Brombal, D., Wang, X. H., Cheng, H. G., & Marcomini, A. (2020). Circular economy in China: Translating principles to practice. *Sustainability*, *12*(3), 832. doi:10.3390u12030832

Peterson, G., Allen, C.R., & Holling, C.S. (1998). Ecological resilience, biodiversity, and scale. *Ecosystems, 1*, 6–18.

Pham-Duc, B., Sylvestre, F., Papa, F., Frappart, F., Bouchez, C., & Crétaux, J.-F. (2020). The Lake Chad hydrology under current climate change. *Scientific Reports*, *10*(1), 5498. doi:10.103841598-020-62417-w PMID:32218517

Pheifer, A. G. (2017). *Barriers & Enablers to Circular Business Models.* Retrieved from: https://www.circulaironderne-men.nl/uploads/4f4995c266e00bee8fdb8fb34fbc5c15.pdf

Pickett, S. T. A., Burch, W. R. Jr, Dalton, S., & Foresman, T. (1997). Integrated urban ecosystem research: Themes, needs, and applications. *Urban Ecosystems*, *1*(4), 183–184. doi:10.1023/A:1018579628818

Pickett, S. T. A., & Cadenasso, M. L. (2002). Ecosystem as a multidimensional concept: Meaning, model and metaphor. *Ecosystems (New York, N.Y.)*, *5*(1), 1–10. doi:10.100710021-001-0051-y

Pickett, S. T. A., Cadenasso, M. L., & Grove, J. M. (2004). Resilient cities: Meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms. *Landscape and Urban Planning*, *69*(4), 369–384. doi:10.1016/j.landurbplan.2003.10.035

Pickett, S. T. A., Groffman, P. M., Brush, G. S., Galvin, M. F., Grove, J. M., ... Troy, A. R. (2008). Exchanges across land-water-scape boundaries in urban systems: Strategies for reducing nitrate pollution. *Annals of the New York Academy of Sciences*, *1134*(1), 213–232. doi:10.1196/annals.1439.012 PMID:18566096

Pickover, M. (2009). *Contestations, ownership, access, and ideology: Policy development challenges for the digitization of African heritage and liberation archives*. Paper presented at the First International Conference on African Digital Libraries and Archives (ICADLA-1), Addis Ababa.

Pickover, M. (2014). *Power and politics: Selecting, constructing and preserving digital heritage content in South Africa and Africa*. Paper presented at IFLA, Lyon.

Pickover, M., Dale, A., & Peters. (2002). DISA: An African perspective on digital technology. *Innovation: Journal of Appropriate librarianship and Information Work in Southern Africa, 24*, 14–20.

Picuno, P., Tortora, A., & Capobianco, R. L. (2011). Analysis of plasticulture landscapes in Southern Italy through remote sensing and solid modelling techniques. *Landscape and Urban Planning*, *100*(1–2), 45–56. doi:10.1016/j.landurbplan.2010.11.008

Pike, S. (2004). *Destination Marketing Organisations*. Elsevier.

Pimentel, P., Oliveira, A., Couto, G., Crispim Ponte, J., & Castanho, R. A. (2020). *The Azores Archipelago as a Region with Vast Potential for the Development of Adventure and Slow Tourism*. IntechOpen. doi:10.5772/intechopen.94411

Pinos Navarrete, A., & Mínguez García, C. (2017). El conocimiento científico de la Alta Velocidad Española y su relación con el turismo a través del análisis bibliográfico. *Revista de Estudios Andaluces*, *34*(1), 321–349. doi:10.12795/rea.2017.i34.11

Piragnolo, M., Masiero, A., Fissore, F., & Pirotti, F. (2015). Solar Irradiance Modelling with NASA WW GIS Environment. *ISPRS International Journal of Geo-Information, 4*(2), 711–724. doi:10.3390/ijgi4020711

Pires, R. (2017). Cidades Criativas de Pequena Dimensão e Contextos Rurais: A Perspectiva da Cidade de Ponte de Sor. *V CongresoInternacional de Ciudades Creativas*. Available at: https://www.researchgate.net/publication/311401396_Cidades_Criativas_de_Pequena_Dimensao_e_Contextos_Rurais_A_Perspectiva_da_Cidade_de_Ponte_de_Sor/stats

Pires, A. P., Soto, C. R., & Scarano, F. R. (2021). Strategies to reach global sustainability should take better account of ecosystem services. *Ecosystem Services*, *49*, 101292. doi:10.1016/j.ecoser.2021.101292

Pittock, J., Cork, S., & Maynard, S. (2012). The state of the application of ecosystems services in Australia. *Ecosystem Services*, *1*(1), 111–120. doi:10.1016/j.ecoser.2012.07.010

Pla-Julián, I., & Guevara, S. (2019). Is the circular economy the key to transitioning towards sustainable development? Challenges from the perspective of care ethics. *Futures*, *105*, 67–77. doi:10.1016/j.futures.2018.09.001

Planelles, D. (2011). *Internacionalización*. Nuevo Entorno, Nuevas Reglas.

Pliscoff, P. & Luebert, F. (2006). *Sinopsis Bioclimatica y Vegetacional de Chile*. Editorial Universitaria.

PNUD. (2020). *Atlas de Desarrollo Humano Cantonal de Costa Rica.* https://www.cr.undp.org/content/costarica/es/home/atlas-de-desarrollo-humano-cantonal.html

Poe, M. R., Norman, K. C., & Levin, P. S. (2014). Cultural dimensions of socioecological systems: Key connections and guiding principles for conservation in coastal environments. *Conservation Letters*, *7*(3), 166–175. doi:10.1111/conl.12068

Poeplau, C., & Don, A. (2013). Sensitivity of soil organic carbon stocks and fractions to different land-use changes across Europe. *Geoderma*, *192*, 189–201. doi:10.1016/j.geoderma.2012.08.003

Ponte, J., Couto, G., Pimentel, P., & Oliveira, A. (2018). Tourism activities and companies in a sustainable adventure tourism destination: The Azores. *Tourism & Management Studies*, *14*(4), 25–38. doi:10.18089/tms.2018.14403

Ponte, J., Couto, G., Pimentel, P., Sousa, Á., & Oliveira, A. (2019). Tourist satisfaction with the Municipality of Ponta Delgada (Azores). *Revista de Gestão e Secretariado*, *10*(3), 192–217. doi:10.7769/gesec.v10i3.896

Ponte, J., Couto, G., Pimentel, P., Sousa, Á., & Oliveira, A. (2020). Municipal Tourism Planning in an Island Territory: The Case of Ribeira Grande in the Azores. *Tourism Planning & Development*. Advance online publication. doi:10.1080/21568316.2020.1816567

Popp, J. N., & Boyle, S. P. (2017). Railway ecology: Underrepresented in science? *Basic and Applied Ecology*, *19*, 84–93. doi:10.1016/j.baae.2016.11.006

Popp, J., Lakner, Z., Harangi-Rákos, M., & Fári, M. (2014). The Effect of Bioenergy Expansion: Food, Energy, and Environment. *Renewable & Sustainable Energy Reviews*, *32*, 559–578. doi:10.1016/j.rser.2014.01.056

Porporato, A., D'Odorico, P., Laio, F., Ridolfi, L., & Rodríguez-Iturbe, I. (2002). Ecohydrolgy of water-controlled ecosystems. *Advances in Water Resources*, *25*(8-12), 1335–1348. doi:10.1016/S0309-1708(02)00058-1

Porter-Bolland, L., Ellis, E. A., Guariguata, M. R., Ruiz-Mallen, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, *268*, 6–17. doi:10.1016/j.foreco.2011.05.034

Porter, M. (1986). *Estratégia Competitiva: Técnicas para análise das indústrias e da concorrência*. Editora Campus.

Porter, M. E. (2005). *Estratégia Competitiva*. Campus.

Portugal 2020. (2019). Available at: https://www.portugal2020.pt/

Portugal Júnior, P. S. (2016). *A controvérsia sobre as águas: uma proposta de integração institucional e de políticas públicas para o segmento de águas minerais no âmbito da gestão de recursos hídricos*. Tese de Doutorado, Universidade Estadual de Campinas.

Portugal Júnior, P. S. (2018). Rompendo a controvérsia das águas: uma proposta de novo arranjo institucional para as águas minerais no Brasil. In A. P. L. Souza & R. Viana (Eds.), *Clamor das águas: a busca por nova identidade para as águas minerais no Brasil*. CAXIF/UFSC.

Pothukuchi, K., & Kaufman, J. (1999). Placing the food system on the urban agenda: The role of municipal institutions in food systems planning. *Agriculture and Human Values*, *16*(2), 213–244. doi:10.1023/A:1007558805953

Pothukuchi, K., & Kaufman, J. (2000). The food system: A stranger to the planning field. *Journal of the American Planning Association*, *66*(2), 112–124. doi:10.1080/01944360008976093

Potter, R., & Lloyd-Evans, S. (1998). *The City in the Developing World*. Routledge.

Pouri, A., & Inglesi-Lotz, R. (2017). The contribution of copyright-based industries to the South African economy. *South African Journal of Science*, *113*(11/12), 64–70. doi:10.17159ajs.2017/20160286

Powers, M. C. F., & Peeters, J. (2019). Sharing to flourish: A degrowth approach to provisioning for prosperity. In M. Rinkel & M. Powers (Eds.), Social work promoting community and environmental sustainability: A workbook for social work practitioners and educators (pp.172-193). International Federation of Social Workers (IFSW).

Powers, M. C., Rambaree, K., & Peeters, J. (2019). Degrowth for transformational alternatives as radical social work practice. *Critical and Radical Social Work*, *7*(3), 417–433. doi:10.1332/204986019X15688881497178

Preciado, J. M. S., Arilla, M. J. A., Uribeondo, M. P. B., & Yanci, M. P. G. (2006). La Movilidad Interurbana en la Línea de Alta Velocidad Madrid-Sevilla: Rasgos Definitorios a los 10 Años de su Implantación [The intercity mobility in the high speed line Madrid-Seville: defining features after ten years of its implementation]. In *Anales de geografía de la Universidad Complutense* (Vol. 26, p. 147). Universidad Complutense de Madrid.

Prendeville, S., & Bocken, N. (2017). Sustainable Business Models through service design. *Procedia Manufacturing*, *8*, 292–299. doi:10.1016/j.promfg.2017.02.037

Prendeville, S., Sanders, C., Sherry, J., & Costa, F. (2014). *Circular Economy. Is it enough?* EcoDesign Centre.

Prieto-Sandoval, V., Jaca, C., & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, *179*, 605–615. doi:10.1016/j.jclepro.2017.12.224

Propastin, P. (2012). Problems of Water Resources Management in the Drainage Basin of Lake Balkhash with Respect to Political Development. In W. Leal Filho (Ed.), *Climate Change and the Sustainable Use of Water Resources*. Springer. doi:10.1007/978-3-642-22266-5_28

Psychoudakis, D., Moulder, W., Chen, C., Zhu, H., & Volakis, J. L. (2008). A portable low-power harmonic radar system and conformal tag for insect tracking. *IEEE Antennas and Wireless Propagation Letters*, *7*, 444–447.

Pyle, R. M. (2012). The Origins and History of Insect Conservation in the United States. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Qiao, X. J., Liao, K. H., & Randrup, T. B. (2020). Sustainable stormwater management: A qualitative case study of the Sponge Cities initiative in China. *Sustainable Cities and Society*, *53*, 101963. doi:10.1016/j.scs.2019.101963

Qi, J., Chehbouni, A., Huete, A. R., Kerr, Y. H., & Sorooshian, S. (1994). A modify soil adjust vegetation index. *Remote Sensing of Environment*, *126*(2), 119–126. doi:10.1016/0034-4257(94)90134-1

Queiroz, J. T. M. (2011). *O campo das águas envasadas: determinantes, políticas públicas, consequências socioambientais, qualidade das águas e percepções*. Tese de Doutorado, Universidade Federal de Minas Gerais.

Qu, H., Kim, L. H., & Im, H. H. (2011). A model of destination branding: Integrating the concepts of the branding and destination image. *Tourism Management*, *32*(3), 465–476. doi:10.1016/j.tourman.2010.03.014

Quincerot, R., & Weil, M. (2009). *Genève 2020: Plan di-recteur communal de la Ville de Genève*. Ville de Genève.

Quispe, A., & Fernández, G. (2021). Teletrabajo en las entidades públicas, una necesidad y prioridad en la actualidad. *Ciencia Latina Revista Científica Multidisciplinar*, *5*(3), 3513–3533. doi:10.37811/cl_rcm.v5i3.547

Quivy, R., & Van Campenhoudt, L. (1998). *Manual de Investigação em Ciências Sociais* (2nd ed.). Gradiva.

Raento, M., Oulasvirta, A., & Eagle, N. (2009). Smartphones: An emerging tool for social scientists. *Sociological Methods & Research*, *37*(3), 426–454. doi:10.1177/0049124108330005

Rahman, H. (2019). *Fundamental Principles of Radar*. Taylor & Francis. doi:10.1201/9780429279478

Rahman, M. M., & Kashem, M. A. (2017). Carbon emissions, energy consumption and industrial growth in Bangladesh: Empirical evidence from ARDL cointegration and Granger causality analysis. *Energy Policy*, *110*, 600–608. doi:10.1016/j.enpol.2017.09.006

Rahnema, M. (1997). Participation. In *The Development Dictionary. A Guide to Knowledge as Power*. Zed Books.

Ram, S.C.V.S., & Prusty, S.A.K. (2020). *Covid-19 and its impact on environment*. Members Reference Service LARRDIS, No. 25/RN/Ref./May/2020.

Ramakrishna, S., Ngowi, A., Jager, H. D., & Awuizie, B. O. (2020). Emerging industrial revolution: symbiosis of industry 4.0 and circular economy: the role of Universities. *Science, Technology & Society*, *25*(3), 505–525. doi:10.1177/0971721820912918

Ramirez, E., & Chuquillanqui, O. (2016). El Teletrabajo en el Perú: Comentarios al Nuevo Marco Normativo. *Derecho & Sociedad*, *46*, 111–120.

Ramirez, P., Salazar, C., & Camacho, L. (2020). Explorando El Efecto Mediador Del Conflicto De Trabajo Hogar Entre La Sobrecarga Y El Agotamiento En Teletrabajo. *Proceedings of the 36th International Business Information Management Association (IBIMA)*, 11670–11672.

Ramos, V., Ramos-Galarza, C., & Tejera, E. (2020). Teleworking in times of COVID-19. *Revista Interamericana de Psicología*. *Interamerican Journal of Psychology*, *54*(3), e1450–e1450. doi:10.30849/ripijp.v54i3.1450

Ramsay, S. (2020). Let's not return to business as usual: Integrating environmental and social wellbeing through hybrid business models post COVID-19. *International Social Work*, *63*(6), 798–802. doi:10.1177/0020872820944996

Ranta, V., Aarikka-Stenroos, L., & Mäkinen, S. J. (2018). Creating value in the circular economy: A structured multiple-case analysis of business models. *Journal of Cleaner Production*, *201*, 988–1000. doi:10.1016/j.jclepro.2018.08.072

Ranta, V., Aarikka-Stenroos, L., Ritala, P., & Mäkinen, S. J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*, *136*, 70–82. doi:10.1016/j.resconrec.2017.08.017

Rao, Y. S., Venkataraman, G., & Rao, K. S. (2004). Sar interferometry for dem generation and movemnet of Indian glaciers. *IGARSS 2004. 2004 IEEE International Geoscience and Remote Sensing Symposium*, 2, 1128-1131.

Raposo, M., Castanho, R. A., Machado, M., Castro, C., Santos, P., & Pinto-Gomes, C. (2018). The Relevance of Vegetation Series on the Maintenance and Sustainability of Public Spaces in the South-west Iberian Peninsula. In Landscape Architecture: The Sense of Places, Models and Applications. InTech.

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R., & Swart, R. (2002). *Great transition: The promise and lure of the times ahead* (Vol. 1). Stockholm Environmental Institute.

Rasmussen, U. W. (1988). *Holding e Joint Ventures: Uma análise transacional de consolidações e fusões empresariais*. Aduaneiras.

Rauf, A., Zhang, J., Li, J., & Amin, W. (2018). Structural changes, energy consumption and carbon emissions in China: Empirical evidence from ARDL bound testing model. *Structural Change and Economic Dynamics*, *47*, 194–206. doi:10.1016/j.strueco.2018.08.010

Recio, S. G., & Colella, C. (2020). *The world of higher education after COVID-19. How COVID-19 has affected young universities*. YERUN. Available at: https://www.yerun.eu/wpcontent/uploads/2020/07/YERUN-Covid-VFinal-OnlineSpread.pdf

Redman, C., Grove, J. M., & Kuby, L. (2000). *Toward a unified understanding of human ecosystems: Integrating social sciences into long-term ecological research*. White Paper of the Long-Term Ecological Research. Albuquerque, NM: LTER Network.

Redwood, M., & Bahri, A. (2010). *Wastewater Irrigation and Health: Assessing and Mitigation Risks in Low-income Countries*. Earthscan/IDRC/IWMI.

Reinicke, W. (1998). *Global Public Policy- Governing without Government?* Brookings Institution Press.

Remaud, H. (2006). *What makes small wine companies more competitive in their export markets? Market orientation and innovativeness influence.* In Third Annual International Wine *Marketing* Symposium, France.

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.a). *6.7- Municipal Water Supply*. https://cevreselgostergeler.csb.gov.tr/belediye-icme-ve-kullanma-suyu-kaynaklari-i-85745

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.b). *2.4- Environmental Expenditures*. https://cevreselgostergeler.csb.gov.tr/cevre-koruma-harcamalari-i-85708

Republic of Turkey Ministry of Environment and Urbanisation. (n.d.c). *6.8-Municipalities Served by Wastewater Treatment Plant*. https://cevreselgostergeler.csb.gov.tr/atiksu-aritma-tesisi-ile-hizmet-verilen-belediyeler-i-85746

Republic of Turkey Ministry of Foreign Affairs. (n.d.). *Turkey's Policy on Water Issues*. https://www.mfa.gov.tr/turkey_s-policy-on-water-issues.en.mfa#:~:text=Contrary%20to%20the%20general%20perception,North%20America%20and%20Western%20Europe

Resch, B., Sagl, G., Törnros, T., Bachmaier, A., Eggers, J.-B., Herkel, S., & Narmsara, S. (2014). GIS-Based Planning and Modeling for Renewable Energy: Challenges and Future Research Avenues. *ISPRS International Journal of Geo-Information, 3*(2), 662–692. doi:10.3390/ijgi3020662

Research & Degrowth. (2010). Degrowth Declaration of the Paris 2008 conference. *Journal of Cleaner Production*, *18*(6), 523–524. doi:10.1016/j.jclepro.2010.01.012

Resonance Consultancy. (2019). *World's Best Cities 2019. A Ranking of Global Place Equity*. Retrieved from https://media.resonanceco.com/uploads/2018/11/Resonance-2019-Worlds-Best-Cities-Report.pdf

Reyer, C. P., Otto, I. M., Adams, S., Albrecht, T., Baarsch, F., Cartsburg, M., ... Mengel, M. (2017). Climate change impacts in Central Asia and their implications for development. *Regional Environmental Change*, *17*(6), 1639–1650. doi:10.100710113-015-0893-z

Reynolds, J. F. (2007). Global Desertification: Building a Science for Dryland Development. *Science, 316*(5826), 847-851.

Reynolds, D., & Riley, J. (2002). Remote-sensing, telemetric and computer-based technologies for investigating insect movement: A survey of existing and potential techniques. *Computers and Electronics in Agriculture*, *35*(2), 271–307.

Reza Shirazi, M., & Keivani, R. (2017). Critical Reflections on the Theory and Practice of Social Sustainability in the Built Environment – A Meta Analysis. *Local Environment*, *22*(12), 1526–1545. doi:10.1080/13549839.2017.1379476

Richards, M., Melvin, W., Scheer, J., Scheer, J., & Holm, W. (2014). *Principles of Modern Radar: Radar Applications*. Electromagnetics and Radar. Institution of Engineering and Technology.

Richter, J. H., Jensen, D. R., Noonkester, V. R., Kreasky, J. B., Stimmann, M. W., & Wolf, W. W. (1973). Remote radar sensing: Atmospheric structure and insects. *Science*, *180*(4091), 1176–1178.

Ricketts, T. H., Watson, K. B., Koh, I., Ellis, A. M., Nicholson, C. C., Posner, S., Richardson, L. L., & Sonter, L. J. (2016). Disaggregating the evidence linking biodiversity and ecosystem services. *Nature Communications*, *7*(1), 1–8. doi:10.1038/ncomms13106 PMID:27713429

Ricketts, T., & Imhoff, M. (2003). Biodiversity, urban areas, and agriculture: Locating prior-ity ecoregions for conservation. *Conservation Ecology*, *8*(2), 1. http://consecol.org./vol8/iss2/art1. doi:10.5751/ES-00593-080201

Rielli, L. E. (2018). *Sustainable development and the digital economy: new opportunities for access to markets.* http://noviconsult.com.br/wp-content/uploads/2018/12/Sustainable-development-and-the-digital-economy-new-opportunities-for-access-to-markets.pdf

Rijal, S., Rimal, B., & Sloan, S. (2018). Flood hazard mapping of a rapidly urbanizing city in the foothills (Birendranagar, Surkhet) of Nepal. *Land (Basel)*, *7*(2), 60. doi:10.3390/land7020060

Riley, J. (1980). Radar as an aid to the study of insect flight. *A Handbook on Biotelemetry and Radio Tracking*, 131–140.

Riley, J. R. (1985). Radar cross section of insects. *Proceedings of the IEEE*, *73*(2), 228–232.

Riley, J. R., Reynolds, D. R., & Rainey, R. C. (1979). Radar-based studies of the migratory flight of grasshoppers in the middle niger area of mali. *Proceedings of the Royal Society of London. Series B, Biological Sciences*, *204*(1154), 67–82.

Riley, J. R., Smith, A. D., Reynolds, D. R., Edwards, A. S., Osborne, J. L., Williams, I. H., Carreck, N. L., & Poppy, G. M. (1996). Tracking bees with harmonic radar. *Nature*, *379*(6560), 29–30.

Riley, J., & Smith, A. (2002). Design considerations for an harmonic radar to investigate the flight of insects at low altitude. *Computers and Electronics in Agriculture*, *35*(2-3), 151–169.

Rimal, B., Keshtkar, H., Sharma, R., Stork, N., Rijal, S., & Kunwar, R. (2019). Simulating urban expansion in a rapidly changing landscape in eastern Tarai, Nepal. *Environmental Monitoring and Assessment*, *191*(4), 1–14. doi:10.100710661-019-7389-0 PMID:30923960

Rinkel, M., & Powers, M. (Eds.). (2019). Social work promoting community and environmental sustainability: A workbook for global social workers and educators. International Federation of Social Workers (IFSW).

Risse, N. (2017). *Getting up to speed with to implement the SDGs: Facing the Challenges*. SDG Knowledge Hub. Available at: http://sdg.iisd.org/commentary/policy-briefs/getting-up-to-speed-to-implement-the-sdgs-facing-the-challenges/

Ritchie, H., & Roser, M. (2018). *Urbanization. Published online at OurWorldInData.org*. Retrieved from: https://ourworldindata.org/urbanization

Rivera, D., Godoy-Faúndez, A., Lillo, M., Alvez, A., Delgado, V., Gonzalo-Martín, C., Menasalvas, E., Costumero, R., & García-Pedrero, Á. (2016). Legal disputes as a proxy for regional conflicts over water rights in Chile. *Journal of Hydrology (Amsterdam)*, *535*, 36–45. doi:10.1016/j.jhydrol.2016.01.057

Rizos, V., Behrens, A., van der Gaast, W., Hofman, E., Ioannou, A., Kafyeke, T., Flamos, A., Rinaldi, R., Papadelis, S., Hirschnitz-Garbers, M., & Topi, C. (2016). Implementation of Circular Economy Business Models by Small and Medium-Sized Enterprises (SMEs): Barriers and Enablers. *Sustainability*, *8*(11), 1–18. doi:10.3390u8111212

Roberts, P. (2000). Strategic connectivity. In *The new regionalism: Strategies and governance*. Centre for Local Economic Strategies.

Rodell, M., Famiglietti, J. S., Wiese, D. N., Reager, J. T., Beaudoing, H. K., Landerer, F. W., & Lo, M.-H. (2018). Emerging trends in global freshwater availability. *Nature*, *557*(7707), 651–659. doi:10.103841586-018-0123-1 PMID:29769728

Rodríguez-Iturbe, I. (2000). Ecohydrology: A hydrologic perspective of climate-soil-vegetation dynamics. *Water Resources Research, 36*(1), 3-9.

Rodriguez, L. S., Cruzado, C. F., Mejía, C., & Diaz, M. A. A. (2020). Aplicación de ISO 27001 y su influencia en la seguridad de la información de una empresa privada peruana. *Propósitos y Representaciones*, *8*(3), 786. doi:10.20511/pyr2020.v8n3.786

Roetzel, P. G. (2019). Information overload in the information age: a review of the literature from business administration, business psychology, and related disciplines with a bibliometric approach and framework development. *Business Research, 12*(2), 479-522.

Rogers, E. M. (1997). *A history of communication study, a biographical approach*. The Free Press.

Roggema, R. (2012a). *Swarm planning: the development of a spatial planning methodology to deal with climate adaptation* (PhD thesis). Delft University of Technology.

Roggema,, R. (2012c). Shifting paradigms. In R. Roggema (Ed.), *The design charrette: ways to envision sustainable futures*. Springer.

Roggema, R. (2014). Towards enhanced resilience in city design: A proposition. *Land (Basel)*, *3*(2), 460–481. doi:10.3390/land3020460

Roggema, R. (2015). Three urbanisms in one city: Accommodating the paces of change. *Journal of Environmental Protection*, *6*(09), 946–956. doi:10.4236/jep.2015.69084

Roland, J., McKinnon, G., Backhouse, C., & Taylor, P. D. (1996). Even smaller radar tags on insects. *Nature*, *381*(6578), 120–120.

Romeiro, A. R. (2003). Economia ou economia política da sustentabilidade. In P. H. May, M. C. Lustosa, & V. Vinha (Eds.), *Economia do meio ambiente*. Campus.

Rosengren, K. E. (2000). *Communication, an introduction*. SAGE.

Rowse, T. (2001). Democratic systems are an alien thing to Aboriginal culture.... In M. Sawer & G. Zappala (Eds.), *Speaking for the People: Representation in Australian Politics*. Melbourne University Press.

Rubel, F. & Kottek, M. (2010). Observed and projected climate shifts 1901–2100 depicted by world maps of the Koppen-Geiger climate classification. *Meteorologische Zeitschrift, 19*(2), 135-141.

Rudd, J. W. M., Kelly, C. A., Schindler, D. W., & Turner, M. A. (1988). Disruption of the nitrogen cycle in acidified lakes. *Science*, *240*(4858), 1515–1517. doi:10.1126cience.240.4858.1515 PMID:17798981

Rume, T., & Islam, S. M. D.-U. (2020). Environmental effects of Covid-19 pandemic and potential strategies. *Heliyon*, *6*(9), e04965. doi:10.1016/j.heliyon.2020.e04965 PMID:32964165

Rusk, D. (1993). *Cities without Suburbs*. The Woodrow.

Saadat, S., Rawtani, D., & Hussain, C. M. (2020, August 1). Environmental perspective of Covid-19. *The Science of the Total Environment*, *728*, 138870. doi:10.1016/j.scitotenv.2020.138870 PMID:32335408

Saadoun, M. K. I. (2015). *Impact of Oil Spills on Marine Life*. Emerging Pollutants in the Environment - Current and Further Implications. doi:10.5772/60455

Saboori, B., & Sulaiman, J. (2013). Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. *Energy Policy*, *60*, 892–905. doi:10.1016/j.enpol.2013.05.099

Sabre Hospitality Solutions. (2016). *Europe & Middle East Consumer Mega-Trends Impacting Hospitality*. Trendwatching Premium.

Sacchi, A., Galvão, G., Gamboa, L., & Carvalho, M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, *175*, 525–543. doi:10.1016/j.jclepro.2017.11.064

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G., & Woelm, F. (2020). *The Sustainable Development Goals and COVID-19. Sustainable Development Report 2020*. Cambridge University Press. https://s3.amazonaws.com/sustainabledevelopment.report/2020/2020_sustainable_development_report.pdf

Saiz, I., & Donald, K. (2017). Tackling Inequality Through the Sustainable Development Goals: Human Rights in Practice. *International Journal of Human Rights*, *21*(8), 1029–1049. doi:10.1080/13642987.2017.1348696

Sala, O. E., Chapin, F. S. I., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., Leemans, R., Lodge, D. M., Mooney, H. A., Oesterheld, M., Poff, N. L., Sykes, M. T., Walker, B. H., Walker, M., & Wall, D. H. (2000). Global biodiversity scenarios for the year 2100. *Science*, *287*(5459), 1770–1774. doi:10.1126cience.287.5459.1770 PMID:10710299

Salehi, F., & Ahmadian, L. (2017). The Application of Geographic Information Systems (GIS) in Identifying the Priority Areas for Maternal Care and Services. *BMC Health Services Research*, *17*(1), 482. doi:10.118612913-017-2423-9 PMID:28701226

Salet. (2003). *Metropolitan Governance and Spatial Planning: Comparative Case Studies of European City-Regions*. Spon Press.

Sallustio, L., Munafò, M., Riitano, N., Lasserre, B., Fattorini, L., & Marchetti, M. (2016). Integration of land use and land cover inventories for landscape management and planning in Italy. *Environmental Monitoring and Assessment*, *188*(1), 1–20. doi:10.100710661-015-5056-7 PMID:26687091

Samarasinghe, S. (2021). *Top 10 smart cities worldwide*. Businesschief. https://businesschief.com/top10/top-10-smart-cities-worldwide

Samways, M. J. (2005). *Insect Diversity Conservation*. Cambridge University Press. doi:10.1017/CBO9780511614163

Sanches, F. O., Fialho, E. S., & Quina, R. R. (2017). Evidências de Mudanças Climáticas em Viçosa (MG). *Revista Do Departamento De Geografia*, *34*, 122–136. doi:10.11606/rdg.v34i0.138581

Sanders, W. (2004). *Thinking about Indigenous community governance.* CAEPR Discussion Paper No. 262, CAEPR, ANU.

Sankar, U. (1998). *Laws and Institutions relating to Environmental Protection in India*. Occasional Paper, Madras School of Economics. www.mse.ac.in

Sanneving, L., Trygg, N., Saxena, D., Mavalankar, D. & Thomsen, S. (2013). Inequity in India: The Case of Maternal and Reproductive Health. *Global Health Action, 6*(1). doi:10.3402/gha.v6i0.19145

SANTAG (Kwazulu-Natal Sanitation Task Group). (2000). ELET: An NGO in school and sanitation education. *OUTLET Newsletter for SANTAG, 32*.

Santa, S., & Herrero-Solana, V. (2010). Cobertura de la ciencia de América Latina y el Caribe en Scopus vs. Web of Science [Latin America and Caribbean Science Coverage in Scopus vs. Web of Science]. *Investigación Bibliotecológica*, *24*(52), 13–27. doi:10.22201/iibi.0187358xp.2010.52.27451

Santopietro, L., & Scorza, F. (2021). *A Methodological Framework for the Comprehensive Assessment of Actions and Territorial Target for the "Sustainable Energy and Climate Action Plan" (SECAP) of Potenza Municipality. Lecture Notes in Civil Engineering, 146*. Springer. doi:10.1007/978-3-030-68824-0_45

Santos, S. M., Carvalho, F., & Mira, A. (2017). Current knowledge on wildlife mortality in railways. In *Railway ecology* (pp. 11–22). Springer. doi:10.1007/978-3-319-57496-7_2

Sanz, I., Sainz, J., & Capilla, A. (2020). *Efectos de la Crisis del Coronavirus en la Educación*. https://www.flacsi.net/wp-content/uploads/2020/04/EFECTOS-DE-LA-CRISIS-DEL-CORONAVIRUS-EN-EDUCACIÓN.pdf

Sarathy, R., & Terpstra, V. (1991). International Marketing (5th ed.). Dryden Press.

Sarricolea, P., Herrera-Ossandon, M., & Meseguer-Ruiz, Ó. (2017). Climatic regionalisation of continental Chile. *Journal of Maps*, *13*(2), 66–73. doi:10.1080/17445647.2016.1259592

Sassen, S. (1991). *The Global City*. Princeton University Press.

Saur, K. G. (2004). *Digital resources from cultural institutions for use in teaching and learning*. A report of the America/German Workshop. Munchen: K.G. Suar Verlag.

Scheffer, M. & Carpenter, S. R. (2003). Catastrophic regime shifts in ecosystems: linking theory to observation. *Trends in Ecology and Evolution, 18*(12), 648-656.

Scheffer, M., Carpenter, S. R., Lenton, T. M., Bascompte, J., Brock, W., Dakos, V., ... & Vandermeer, J. (2012). Anticipating critical transitions. *Science, 338*(6105), 344-348.

Scheffer, M., Carpenter, S., Foley, J. A., Folke, C., & Walker, B. (2001). Catastrophic shifts in ecosystems. *Nature*, *413*(6856), 591–596. doi:10.1038/35098000 PMID:11595939

Schindler, D. W. (1990). Experimental perturbations of whole lakes as tests of hypotheses concerning ecosystem structure and function. *Oikos*, *57*(1), 25–41. doi:10.2307/3565733

Schmidt, S., Manceur, A. M., & Seppelt, R. (2016). Uncertainty of monetary valued ecosystem services–value transfer functions for global mapping. *PLoS One*, *11*(3), e0148524. doi:10.1371/journal.pone.0148524 PMID:26938447

Schneegans, S., Lewis, J., & Straza, T. (2021). *UNESCO Science Report: the race against time for smarter development; executive summary*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000377250

Schneider Electric. (2021). *Bridging progress and sustainability for all*. 2021 -2025 Sustainability Report. Retrieved from: https://download.schneider-electric.com/files?p_Doc_Ref=SustainabilityReport2020EN

Schneider, F., Kallisa, G., & Martinez-Alier, J. (2010). Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. *Journal of Cleaner Production*, *18*(6), 511–518. doi:10.1016/j.jclepro.2010.01.014

Schoeneborn, D., Blaschke, S., Cooren, F., McPhee, R. D., Seidl, D., & Taylor, J. R. (2014). The three schools of CCO thinking: Interactive dialogue and systematic comparison. *Management Communication Quarterly*, *28*(2), 285–316. doi:10.1177/0893318914527000

Scholte, S. S., Van Teeffelen, A. J., & Verburg, P. H. (2015). Integrating socio-cultural perspectives into ecosystem service valuation: A review of concepts and methods. *Ecological Economics*, *114*, 67–78. doi:10.1016/j.ecolecon.2015.03.007

Scholz, S.M., Rescalvo, M., Sugar, L., Lasa, M., D'Silva, N., Barrios, R., Mata, J., Gallegos, J.B., & Perry, J. (2014). *The low carbon city development program (LCCDP) guidebook- A systems approach to low carbon development in cities*. The World Bank & DNV KEMA Energy & Sustainability.

Schröder, P., Lemille, A., & Desmond, P. (2020). Making the circular economy work for human development. *Resources, Conservation and Recycling*, *156*, 104686. doi:10.1016/j.resconrec.2020.104686

Schröter, M., Ring, I., Schröter-Schlaack, C., & Bonn, A. (2019). The Ecosystem Service Concept: Linking Ecosystems and Human Wellbeing. In Atlas of Ecosystem Services (pp. 7-11). Springer.

Schröter, M., Koellner, T., Alkemade, R., Arnhold, S., Bagstad, K. J., Erb, K. H., Frank, K., Kastner, T., Kissinger, M., Liu, J., López-Hoffman, L., Maes, J., Marques, A., Martín-López, B., Meyer, C., Schulp, C. J. E., Thober, J., Wolff, S., & Bonn, A. (2018). Interregional flows of ecosystem services: Concepts, typology and four cases. *Ecosystem Services*, *31*, 231–241. doi:10.1016/j.ecoser.2018.02.003

Schulte, U. G. (2013). New business models for a radical change in resource efficiency. *Environmental Innovation and Societal Transitions*, *9*, 43–47. doi:10.1016/j.eist.2013.09.006

Schultz, M. J. (2013). Supporting Capacity Building For Archives in Africa: Initiatives of the Cooperative Africana Materials Project (Camp) Since 1995. *African Research & Documentation*, *121*, 3–12.

Schwartz, M. (1956). A coincidence procedure for signal detection. *I.R.E. Transactions on Information Theory*, *2*(4), 135–139.

Scott, G., & Rajabifard, A. (2017). Sustainable Development and Geospatial Information: A Strategic Framework for Integrating a Global Policy Agenda into National Geospatial Capabilities. *Geo-Spatial Information Science*, *20*(5), 1–18. doi:10.1080/10095020.2017.1325594

SDGs- Inter-Agency and Expert Group on SDG Indicators. (2017). *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development*. United Nations Statistical Commission.

Seana I., Johnson, L. & Peters, K. (1999). Community gardens and sustainable land use planning: A case-study of the Alex Wilson community garden. *Local Environment*, *4*(1), 33-46. doi:10.1080/13549839908725579

Searns,, R.M. (1995). The evolution of greenways as an adaptive urban landscape form. *Landscape and Urban Planning*, *33*(1), 65–80.

Segittur. (2015). *Smart Destination Report: building the future*. A pedido da Secretaria de Estado das Telecomunicações de Espanha. Obtido de https://www.segittur.es/opencms/export/sites/segitur/.content/galerias/descargas/documentos-en/Smart-Destination.pdf

Segittur. (2015). *Smart Destination Report: building the future*. Available at: http://www.millennium-destinations.com/uploads/4/1/9/7/41979675/smart-destination_segittur.pdf

Sehring, J., & Giese, E. (2011). Global Environmental Change and Conflict Potential in Central Asia. In *Coping with Global Environmental Change, Disasters and Security* (pp. 525–534). Springer. doi:10.1007/978-3-642-17776-7_27

Sekulova, F., Kallis, G., Rodríguez-Labajos, B., & Schneider, F. (2013). Degrowth: From theory to practice. *Journal of Cleaner Production*, *38*, 1–6. doi:10.1016/j.jclepro.2012.06.022

Semanario Universidad. (2017). *Tárcoles: a la espera de un milagro*. Disponible en https://semanariouniversidad.com/pais/httpsemanariouniversidad-ucr-crtarcoles/

Seneviratne, S. (2010). Investigating soil moisture–climate interactions in a changing climate: A review. *Earth-Science Reviews, 99*(3-4), 125-161.

Serra, S. H. (2009). *Águas minerais do Brasil: uma nova perspectiva jurídica*. Millennium.

Serway, R. A. & Vuille, C. (2017). *College physics.* Brooks Cole.

Seto, K. C., De Groot, R., Bringezu, S., Erb, K., Graedel, T. E., Ramankutty, N., & Skole, D. L. (2010). Stocks, flows, and prospects of land. In T. E. Graedel & E. van der Voet (Eds.), *Linkages of sustainability* (pp. 72–96). MIT Press.

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699–1710. doi:10.1016/j.jclepro.2008.04.020

Sevin, A.E., Bektaş Otman, B., Çelen, E., Kozikoğlu, E., Oğuz, K.B., Kavak, K., Bitlis, M., Şalgam, S., & Çınar, Ş. (2020). *Covid-19 pandemic as an ecosocial crisis and sustainability*. ESCARUS, TSKB.

Sgauke, T. D., & Chabikwa, S. (2012). *Beyond the digitisation horizon: Prospects and Issues for archivists and the digitisation of historical records in Zimbabwe*. Paper presented at the South Africa Society of Archivists (SASA) conference, UNISA, Pretoria, South Africa.

Shafiea,, F.A., Dasimah,, O., & Karuppannanb,, S. (2013). Urban metabolism: a research methodology in urban planning and environmental assessment. *Proceedings of the 1st international conference on research methodology for built environment and engineering.*

Shahbazi, S., Wiktorsson, M., Kurdve, M., Jöonsson, C., & Bjelkemyr, M. (2016). Material efficiency in manufacturing: Swedish evidence on potential, barriers and strategies. *Journal of Cleaner Production*, *127*, 438–450. doi:10.1016/j.jclepro.2016.03.143

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and $CO_2$ emissions in Indonesia. *Renewable & Sustainable Energy Reviews*, *25*, 109–121. doi:10.1016/j.rser.2013.04.009

Shan, Y., Guan, D., Zheng, H., Ou, J., Li, Y., Meng, J., Mi, Z., Liu, Z., & Zhang, Q. (2018). China CO 2 emission accounts 1997–2015. *Scientific Data*, *5*(1), 1–14. doi:10.1038data.2017.201 PMID:30482902

Sharifi, A. (2016). From garden city to eco-urbanism: The quest for sustainable neighborhood development. *Sustainable Cities and Society*, *20*, 1–16. doi:10.1016/j.scs.2015.09.002

Sharifi, A., & Yamagata, Y. (2018). Resilience-Oriented Urban Planning. In Y. Yamagata & A. Sharifi (Eds.), *Resilience-Oriented Urban Planning. Lecture Notes in Energy, 65*. Springer. doi:10.1007/978-3-319-75798-8_1

Sharma, A. (2020, April 15). *Ningún país ha de escudarse en el coronavirus para revertir sus políticas medioambientales*. Noticias ONU. https://news.un.org/es/story/2020/04/1472912

Sharma, D., & Johanson, J. (1987). Technical Consultancy in Internationalisation. *International Marketing Review*, 4.

Shen, Y., Silva, J. D. A., & Martínez, L. M. (2014). Assessing High-Speed Rail's impacts on land cover change in large urban areas based on spatial mixed logit methods: A case study of Madrid Atocha railway station from 1990 to 2006. *Journal of Transport Geography*, *41*, 184–196. doi:10.1016/j.jtrangeo.2014.09.007

Sherif, A. (2007). *Towards Spatial Justice in Urban Health Services Planning*. Ph.D. Thesis, University of Utrecht, Utrecht, The Netherlands.

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In *Festschrift in honor of Peter Schmidt* (pp. 281–314). Springer. doi:10.1007/978-1-4899-8008-3_9

Shiru, M. S., Shahid, S., Chung, E.-S., & Alias, N. (2018). Changing characteristics of meteorological droughts in Nigeria during 1901-2010. *Atmospheric Research*. doi:10.1016/j.atmosres.2019.03.010

Shuai, S., & Fan, Z. (2020). Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model. *Journal of Environmental Management*, *261*, 110227. doi:10.1016/j.jenvman.2020.110227 PMID:32148297

Shukla, M., & Jharkharia, S. (2013). Agri-fresh produce supply chain management: A state-of-the-art literature review. *International Journal of Operations & Production Management*, *33*(2), 114–158. doi:10.1108/01443571311295608

Siegfried, T., Bernauer, T., Guiennet, R., Sellars, S., Robertson, A. W., Mankin, J., Bauer-Gottwein, P., & Yakovlev, A. (2012). Will climate change exacerbate water stress in Central Asia? *Climatic Change*, *112*(3-4), 881–899. doi:10.100710584-011-0253-z

Silva, A. S., Babo, E. P., & Guerra, P. (2013). Cultural policies and local development: The Portuguese case. *Portuguese Journal of Social Science*, *12*(2), 113–132. doi:10.1386/pjss.12.2.113_1

Silva, E. R. A. (2018). *ODS – metas nacionais dos objetivos de desenvolvimento sustentável*. Brasília: IPEA.

Silva, G., & Li Bonilla, F. (2020). Factores clave del Teletrabajo que inciden en la relación ganar-ganar entre el trabajador y la empresa costarricense. *Revista Nacional de Administración*, *11*(1), 69–82. doi:10.22458/rna.v11i1.3009

Simões, V. (1997). Estratégias de internacionalização das empresas portuguesas. In *Comércio e Investimento Internacional*. ICEP – Investimentos, Comércio e Turismo de Portugal.

Sinclair, M. T. (1998). Tourism and economic development: A survey. *The Journal of Development Studies*, *34*(5), 1–51. doi:10.1080/00220389808422535

Singh, R. L., & Singh, P. K. (2017). Global environmental problems. In R. Singh (Ed.), Principles and applications of environmental biotechnology for a sustainable future. Applied Environmental Science and Engineering for a Sustainable Future. Springer. doi:10.1007/978-981-10-1866-4_2

Singh, A., Seitz, F., & Schwatke, C. (2012). Inter-annual water storage changes in the Aral Sea from multi-mission satellite altimetry, optical remote sensing, and GRACE satellite gravimetry. *Remote Sensing of Environment*, *123*, 187–195. doi:10.1016/j.rse.2012.01.001

Small, N., Munday, M., & Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environmental Change*, *44*, 57–67. doi:10.1016/j.gloenvcha.2017.03.005

Smil, V. (2014). *Making the modern world: materials and dematerialization*. Wiley.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282–292. doi:10.1016/j.gloenvcha.2006.03.008

Smith, D. E. (2005). *Researching Australian Indigenous governance: a methodological and conceptual framework*. CAEPR Working Paper No. 29, CAEPR, ANU.

Smith, D. E. (Ed.). 2000. Indigenous Families and the Welfare System: Two Community Case Studies. CAEPR Research Monograph No. 17, CAEPR, ANU.

Smith, R. (2015). *SMART Tourism Tools: Linking Technology with the Touristic Resources of City Destinations*. Tese de Bacharelado, Universidade NHTV Breda de Ciências Aplicadas. Available at: https://documents.nhtv.nl/load.aspx?doc=thesis%5C2015%5CAT%5CITMC%5CSmithR.pdf

Smith, A. C., Harrison, P. A., Soba, M. P., Archaux, F., Blicharska, M., Egoh, B. N., ... De Echeverria, V. W. (2017). How natural capital delivers ecosystem services: A typology derived from a systematic review. *Ecosystem Services*, *26*, 111–126. doi:10.1016/j.ecoser.2017.06.006

Smith, A., & Riley, J. (1996). Signal processing in a novel radar system for monitoring insect migration. *Computers and Electronics in Agriculture*, *15*(4), 267–278.

Smyth, D. (2015). Indigenous protected areas andICCAs: Commonalities, contrasts and confusions. *Parks*, *21*(2), 73–84. doi:10.2305/IUCN.CH.2014.PARKS-21-2DS.en

Soares, C. C. (2004). *Introdução ao comércio exterior: fundamentos teóricos do comércio internacional*. Saraiva.

Soe, R.-M. (2017). *Data-based energy provision for smart cities*. *Conference Paper*. 10.1007/978-3-319-69784-0_27

Solomon, M. R. (2013). Consumer behavior: Buying, having and being (10th ed.). Pearson Education.

Somani, M., Srivastava, A. N., Gummadivalli, S. K., & Sharma, A. (2020, September). Indirect implications of Covid-19 towards sustainable environment: An investigation in Indian context. *Bioresource Technology Reports*, *11*, 100491. doi:10.1016/j.biteb.2020.100491 PMID:33521605

Sonmez, N. K., & Koc-San, D. (2016). Plastic and glass greenhouses detection and delineation from WorldView-2 satellite imagery. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, 41*(July), 257–262. doi:10.5194/isprsarchives-XLI-B7-257-2016

Sorg, A., Bolch, T., Stoffel, M., Solomina, O., & Beniston, M. (2012). Climate change impacts on glaciers and runoff in Tien Shan (Central Asia). *Nature Climate Change*, *2*(10), 725–731. doi:10.1038/nclimate1592

Soto, V., Frias-Martinez, V., Virseda, J., & Frias-Martinez, E. (2011). *Prediction of Socio-economic Levels Using Cell Phone Records BT - User Modeling, Adaption and Personalization* (J. A. Konstan, R. Conejo, J. L. Marzo, & N. Oliver, Eds.). Springer Berlin Heidelberg.

Sousa, S. P. (2011). *Caldas Novas (GO): o uso das águas termais pela atividade turística – das aparências à realidade*. Dissertação de Mestrado, Universidade Federal da Goiás, Catalão, GO.

Sovocool, K. A., Morgan, M., & Bennett, D. (2006). An in-depth investigation of Xeriscape as a water conservation measure. *Journal - American Water Works Association*, *98*(2), 82–93. doi:10.1002/j.1551-8833.2006.tb07590.x

Spangenberg, J. (1995). Towards Sustainable Europe, A Study from the Wuppertal Institute for Friends of the Earth Europe. Luton.

Spangenberg, J. (2000). *Sustainable Development – Concepts and Indicators*. Colonia.

Spangenberg, J. H., Görg, C., Truong, D. T., Tekken, V., Bustamante, J. V., & Settele, J. (2014). Provision of ecosystem services is determined by human agency, not ecosystem functions. Four case studies. *The International Journal of Biodiversity Science, Ecosystem Services & Management*, *10*(1), 40–53. doi:10.1080/21513732.2014.884166

Speier, C., Valacich, J. S., & Vessey, I. (1999). The influence of task interruption on individual decision making: An information overload perspective. *Decision Sciences*, *30*(2), 337–360. doi:10.1111/j.1540-5915.1999.tb01613.x

SPI. (2014). *Estratégia de Investigação e Inovação para a Especialização Inteligente da Região Autónoma dos Açores – RIS3 Açores*. Governo Regional dos Açores.

Spitsyna, A. T. (2007). *Preliminary sustainability assessment of water resources management in the Ili-Balkhash Basin of Central Asia* [Unpublished doctoral dissertation]. Royal Institute of Technology, Stockholm, Sweden.

Ssali, M. W., Du, J., Mensah, I. A., & Hongo, D. O. (2019). Investigating the nexus among environmental pollution, economic growth, energy use and foreign direct investment in 6 selected sub-saharan african countries. *Environmental Science and Pollution Research International*, *26*(11), 11245–11260. doi:10.100711356-019-04455-0 PMID:30796658

Staddon, C., & Scott, C. A. (2018). Putting water security to work: Addressing global challenges. *Water International*, *43*(8), 1017–1025. doi:10.1080/02508060.2018.1550353

Stenou, K. (2004). Cultural diversity and dialogue: an interface. In *Cultural Diversity and Globalization –The Arab-Japanese Experience*. UNESCO Publishing.

Stone, D. (2008). Global Public Policy, Transnational Policy Communities, and their Networks. *Policy Studies Journal: the Journal of the Policy Studies Organization*, *36*(1), 19–38. doi:10.1111/j.1541-0072.2007.00251.x

Su, K., Li, J., & Fu, H. (2011). Smart city and the applications. *Electronics, Communications and Control (ICECC), 2011 International Conference on IEEE*, 1028–1031.

Su, B., Heshmati, A., Geng, Y., & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*, *42*, 215–227. doi:10.1016/j.jclepro.2012.11.020

Sukopp, H., Hejny, S., & Kowarik, I. (Eds.). (1990). *Urban ecology: Plants and plant communities in urban environments*. SPB Academic Publishing.

Sukopp, H., Trautmann, W., & Korneck, D. (1979). The soilflora and vegetation of Berlin'swastelands. In I. Laurie (Ed.), *Nature in Cities*. John Wiley.

Suryani, A. S. (2020, July). The impact of Covid-19 pandemic on the global environment. *Info Sinkat*, *XII*(13), 13–18.

Sutton, P. (1998). Families of polity: post-classical Aboriginal society and native title. In *Native Title and the Descent of Rights. National Native Title Tribunal, Perth. Yarnteen Aboriginal and Torres Strait Islanders Corporation (YATSIC) 2005. Annual Report*. YATSIC.

Sutton, P. C., Anderson, S. J., Costanza, R., & Kubiszewski, I. (2016). The ecological economics of land degradation: Impacts on ecosystem service values. *Ecological Economics*, *129*, 182–192. doi:10.1016/j.ecolecon.2016.06.016

Suvantola, J. (2002). *Tourist's Experience of Place*. Ashgate Publishing Limited.

Su, X., Tong, H., & Ji, P. (2014). Activity recognition with smartphone sensors. *Tsinghua Science and Technology*, *19*(3), 235–249. doi:10.1109/TST.2014.6838194

Swerling, P. (1960). Probability of detection for fluctuating targets. *I.R.E. Transactions on Information Theory*, *6*(2), 269–308.

Talpau, A., & Vierasu, T. (2012). Online Marketing Strategies - UK and Romania. *Bulletin of the Transilvania University of Brasov, 5*(2), 31-34. Available at: http://ezproxy.snhu.edu/login?url=http://search.proquest.com/docview/1418210443?accountid=3783

Tamburini, G., Bommarco, R., Wanger, T. C., Kremen, C., van der Heijden, M. G., Liebman, M., & Hallin, S. (2020). Agricultural diversification promotes multiple ecosystem services without compromising yield. *Science Advances, 6*(45), eaba1715.

Tan, D. (2014). *Fla Singapore*. Available at: http://www.flasingapore.org/info_branding.php

Tansley, A. G. (1935). The use and abuse of vegetational concepts and terms. *Ecology*, *16*(3), 284–307. doi:10.2307/1930070

Tao, Y., Li, F., Wang, R., & Zhao, D. (2015). Effects of land use and cover change on terrestrial carbon stocks in urbanized areas: A study from Changzhou, China. *Journal of Cleaner Production*, *103*, 651–657. doi:10.1016/j.jclepro.2014.07.055

Tarantino, E., & Figorito, B. (2012). Mapping Rural Areas with Widespread Plastic Covered Vineyards Using True Color Aerial Data. *Remote Sensing*, *4*(7), 1913–1928. doi:10.3390/rs4071913

Tatchell, G. (1991). Monitoring and forecasting aphid problems. In *Proceedings of the Conference on Aphid–Plant Interactions: Populations to Molecules*. USDA – Agricultural Research Service and Oklahoma State University.

Tatem, A. J. J., Bird, T. J. J., Bjelland, J., Bengtsson, L., Alegana, V. A. A., Iqbal, A. M. M., & ... . (2017). Mapping Poverty Using Mobile Phone and Satellite Data. *Journal of the Royal Society, Interface*, *14*(127), 20160690. doi:10.1098/rsif.2016.0690 PMID:28148765

Tavitiyaman, P., Qu, H., Tsang, W., & Lam, C. (2021). The influence of smart tourism applications on perceived destination image and behavioral intention: The moderating role of information search behavior. *Journal of Hospitality and Tourism Management*, *46*, 476–487. doi:10.1016/j.jhtm.2021.02.003

Tawalbeh, M., Al-Othman, A., Kafiah, F., Abdelsalam, E., Almomani, F., & Alkasrawi, M. (2020). Environmental Impacts of Solar Photovoltaic Systems: A Critical Review of Recent Progress and Future Outlook. *The Science of the Total Environment*, *759*, 143528. Advance online publication. doi:10.1016/j.scitotenv.2020.143528 PMID:33234276

Taylor, J. D. (2016). Introduction to advanced ultrawideband radar systems. In *Advanced Ultrawideband Radar* (pp. 19–36). CRC Press.

Taylor, J. D., Boryssenko, A., & Boryssenko, E. (2016). Signals, targets, and advanced ultrawideband radar systems. In *Advanced Ultrawideband Radar* (pp. 83–122). CRC Press.

Taylor, J. R., & Van Every, E. J. (2000). *The emergent organization: Communication as its site and surface*. Erlbaum.

Tecchio, P., McAlister, C., Mathieux, F., & Ardente, F. (2017). In search of standards to support circularity in product policies: A systematic approach. *Journal of Cleaner Production*, *168*, 1533–1546. doi:10.1016/j.jclepro.2017.05.198 PMID:29200663

Teixeira, S., & Krings, A. (2015). Sustainable social work: An environmental justice framework for social work education. *Social Work Education*, *34*(5), 513–527. doi:10.1080/02615479.2015.1063601

Tekinay, S. (1998). Wireless geolocation systems and services. *IEEE Communications Magazine*, *36*(4), 28–28. doi:10.1109/MCOM.1998.667408

Terborgh, J., Lopez, L., & Nunez, P. (2001). Ecological meltdown in predator-free forest fragments. *Science*, *294*(5548), 1923–1926. doi:10.1126cience.1064397 PMID:11729317

TERI. (2017, March 10). *Facilitate the preparation of People's Biodiversity Register (PBR) documentation for Chorao - Madel Village*. Retrieved June 01, 2021, from https://www.teriin.org/project/facilitate-preparation-peoples-biodiversity-register-pbr-documentation-chorao-madel-village

Termeer, C. J. A. M., & Metze, T. A. P. (2019). More than peanuts: Transformation towards a circular economy through a small-wins governance framework. *Journal of Cleaner Production*, *240*, 240. doi:10.1016/j.jclepro.2019.118272

Termorshuizen, J. W., & Opdam, P. (2009). Landscape services as a bridge between landscape ecology and sustainable development. *Landscape Ecology*, *24*(8), 1037–1052. doi:10.100710980-008-9314-8

Thaung, N. N. (2019). *Regional Capacity Development Resource Book on Monitoring SDG4-Education 2030 in Asia-Pacific*. United Nations Educational, Scientific and Cultural Organization.

The Climate Transparency Report 2020. (2020). https://www.climate-transparency.org/wp-content/uploads/2020/11/Turkey-CT-2020-WEB.pdf

The degrowth.info editorial team. (2020). *A degrowth perspective on the coronavirus crisis*. https://www.degrowth.info/en/2020/03/a-degrowth-perspective-on-the-coronavirus-crisis/

The International Institute for Sustainable Development (IISD). (2020). *Digital Cooperation Must Connect, Respect, Protect*. UN Secretary-General. http://sdg.iisd.org/news/digital-cooperation-must-connect-respect-protect-un-secretary-general/

The open letter working group. (2020). *More than 1,000 experts call for Degrowth as post-COVID-19 path*. https://www.degrowth.info/en/2020/05/more-than-1000-experts-call-for-degrowth-as-post-covid-19-path/

The World Bank. (2021). *Pollution*. https://www.worldbank.org/en/topic/pollution

The World Bank. 2020). *Urban Development.* (https://www.worldbank.org/en/topic/urbandevelopment/overview#)

Thorson, K. (2013). *Strategic communication*. Retrieved from https://www.oxfordbibliographies.com/view/document/obo-9780199756841/obo-9780199756841-0007.xml

Thuiller, W. (2007). Climate change and the ecologist. *Nature*, *448*(7153), 550–552. doi:10.1038/448550a PMID:17671497

Tidball, G. K., Krasny, E. M., Svendsen, E., Cambell, L., & Helphand, K. (2010). Stewardship, learning and memory in disaster resilience. *Environmental Learning Research*, *16*(5–6), 591–609. doi:10.1080/13504622.2010.505437

Tidball, K. G., & Krasny, M. E. (2009). *From risk to resilience: what role for community greening and civic ecology in cities?* Wageningen Academic Publishers.

Tikka, P. M., Högmander, H., & Koski, P. S. (2001). Road and railway verges serve as dispersal corridors for grassland plants. *Landscape Ecology*, *16*(7), 659–666. doi:10.1023/A:1013120529382

Tilbury, D., & Wortman, D. (2004). Engaging people in sustainability. Commission on Education and Communication, IUCN.

Tinker, D. B., & Knight, D. H. (2001). Temporal and spatial dynamics of coarse woody debris in harvested and unharvested lodgepole pine forests. *Ecological Modelling*, *141*(1-3), 125–149. doi:10.1016/S0304-3800(01)00269-1

TMMOB Cevre Mühendisleri Odasi. (2019). *Dünya Çevre Günü Türkiye Raporu, Haziran 2019*. https://www.cmo.org.tr/resimler/ekler/10504079d7e9ced_ek.pdf?tipi=72&turu=X&sube=0

Todeschini, B. V., Cortimiglia, M. N., & de Medeiros, J. F. (2020). Collaboration practices in the fashion industry: Environmentally sustainable innovations in the value chain. *Environmental Science & Policy*, *106*, 1–11. doi:10.1016/j.envsci.2020.01.003

Tolessa, T., Senbeta, F., & Abebe, T. (2017). Land use/land cover analysis and ecosystem services valuation in the central highlands of Ethiopia. *Forests, Trees and Livelihoods*, *26*(2), 111–123. doi:10.1080/14728028.2016.1221780

Tolessa, T., Senbeta, F., & Kidane, M. (2017). The impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. *Ecosystem Services*, *23*, 47–54. doi:10.1016/j.ecoser.2016.11.010

Torres, A., Jaeger, J. A., & Alonso, J. C. (2016). Assessing large-scale wildlife responses to human infrastructure development. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(30), 8472–8477. doi:10.1073/pnas.1522488113 PMID:27402749

Tough, A. G. (2009). Archives in Sub–Saharan Africa Half a century after independence. *Archival Science*, *9*(3-4), 3–4, 187–201. doi:10.100710502-009-9078-1

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207–222. doi:10.1111/1467-8551.00375

Triantafillidou, E., & Tsiaras, S. (2020). Exploring entrepreneurship, innovation and tourism development from a sustainable perspective: Evidence from Greece. *Journal for International Business and Entrepreneurship Development*, *86*(1), 53–64. doi:10.1504/JIBED.2018.090020

Tsetsi, E., & Rains, S. A. (2017). Smartphone Internet access and use: Extending the digital divide and usage gap. *Mobile Media & Communication*, *5*(3), 239–255. doi:10.1177/2050157917708329

TUIK. (2021). *Greenhouse Gas Emissions Statistics, 1990-2019*. https://data.tuik.gov.tr/Bulten/Index?p=Sera-Gazi-Emisyon-Istatistikleri-1990-2019-37196

Tundisi, J. G. (2008). Recursos hídricos no futuro: Problemas e soluções. *Estudos Avançados*, *22*(63), 7–16. doi:10.1590/S0103-40142008000200002

Turan, A., & Guler, M. (2013). Türkiye'de sürdürülebilir çevre politikaları: iklim değişikliği örneği. Internatıonal Conference On Eurasıan Economıes.

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., & Valkokari, P. (2019). Unlocking circular business: A framework of barriers and drivers. *Journal of Cleaner Production*, *212*, 90–98. doi:10.1016/j.jclepro.2018.11.202

Turc, L. (1961). Estimation of irrigation water requirements, potential evapotranspiration: A simple climatic formula evolved up to date. *Annales Agronomiques*, *12*, 13–49.

TURKSTAT (Turkish Statistical Institute). (2019a). *Sectoral Water and Wastewater Statistics, 2018, Press Release, Number: 30673*. https://data.tuik.gov.tr/Bulten/Index?p=Sektorel-Su-ve-Atiksu-Istatistikleri-2018-30673

TURKSTAT. (2018). *Environment and Energy, Environmental Expenditure of Municipalities*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1ÇevreselHarcamaları

TURKSTAT. (2019b). *Water Abstraction for Municipal Water Supply Network*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2019c). *Disposal/Recovery Methods and Amount of Municipal Waste*. Author.

TURKSTAT. (2019d). *Amount of Wastewater Discharged From Municipal Sewerage to Receiving Bodies*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2019e). *Water Indicators of Municipalities*. https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

TURKSTAT. (2021a). *The Results of Address Based Population Registration System, 2020, Press Release, Number: 37210*. https://data.tuik.gov.tr/Bulten/Index?p=The-Results-of-Address-Based-Population-Registration-System-2020-37210

TURKSTAT. (2021b). *Şehir-Köy Nüfus Oranı*. https://data.tuik.gov.tr/Kategori/GetKategori?p=nufus-ve-demografi-109&dil=1

Turner, K. G., Anderson, S., Gonzales-Chang, M., Costanza, R., Courville, S., Dalgaard, T., Dominati, E., Kubiszewski, I., Ogilvy, S., Porfirio, L., Ratna, N., Sandhu, H., Sutton, P. C., Svenning, J.-C., Turner, G. M., Varennes, Y.-D., Voinov, A., & Wratten, S. (2016). A review of methods, data, and models to assess changes in the value of ecosystem services from land degradation and restoration. *Ecological Modelling*, *319*, 190–207. doi:10.1016/j.ecolmodel.2015.07.017

TutorialsPoint. (n.d.). *Radar Systems Tutorial*. https://www.tutorialspoint.com/radar_systems/radar_systems_tutorial.pdf

UAGro. (2020, June). *Ciclo de paneles en línea: Repensar los objetivos de desarrollo sostenible para tiempos PostCovid-19*. http://posgradoderecho.uagro.mx/?page_id=4585

Ulucak, R., Yücel, A., & Koçak, E. (2019). *The process of sustainability: From past to present. Environmental Kuznets Curve*. EKC. doi:10.1016/B978-0-12-816797-7.00005-9

UN DESA. (2013). *World Economic and Social Survey 2013*. United Nations Department of Economic and Social Affairs (UN DESA). https://www.un.org/en/development/desa/policy/wess/wess_current/wess2013/WESS2013.pdf

UN SDG. (2020). *The 17 Goals – Sustainable Development Goals*. United Nations Department of Economic and Social Affairs (UN DESA). https://sdgs.un.org/goals

UN. (2018). *World Urbanization Prospects: The 2018 Revision*. United Nations, Department of Economic and Social Affairs, Population Division. https://population.un.org/wup/DataQuery/

UN. (2018, May 16). *68% of the world population projected to live in urban areas by 2050, says UN*. Retrieved June 01, 2021, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UN. (2021a). *Cities and pollution*. https://www.un.org/en/climatechange/climate-solutions/cities-pollution

UN. (2021b). *Climate change.* Department of Economic and Social Affairs Sustainable Development. https://sdgs.un.org/topics/climate-change

UN. (2021c). *National Sustainable Development Strategies (NSDS) Department of Economic and Social Affairs Sustainable Development*. https://sdgs.un.org/topics/national-sustainable-development-strategies

Unal, E., & Shao, J. (2019). A taxonomy of circular economy implementation strategies for manufacturing firms: Analysis of 391 cradle-to-cradle products. *Journal of Cleaner Production*, *212*, 754–765. doi:10.1016/j.jclepro.2018.11.291

UNCCD. (2020). *Supporting the global response to the Covid-19 pandemic: Land-based solutons for healthy people and healthy planet*. UNCCD.

UNDP Turkey. (n.d.). *Background on the goals*. https://www.tr.undp.org/content/turkey/en/home/sustainable-development-goals/background.html

UNDP/OCHA. (2018). *Resilience for sustainable development in the Lake Chad basin*. Retrieved 8 April 2019 from https://www.undp.org/content/dam/rba/docs/UNDP-OCHA-Lake-Chad-%20Resilience_spreads-EN.pdf

UNECE. (2018). *Strategic communications framework. The United Nations Economic Commission for Europe (UNECE)* Secretariat.

UNEP. (2015a). *City-level Decoupling: Urban Resource Flows and Governance of Infrastructure Transitions*. UNEP.

UNEP. (2015b). *Sustainable Consumption and Production Global edition. A Handbook for Policymakers*. UNEP.

UNESA. (2018). *68% of the world population projected to live in urban areas by 2050, says UN.* Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UNESCO. (2012). *Directories of National Commissions*. Available at: https://en.unesco.org/countries/national-commissions#:~:text=Presently%2C%20there%20are%20199%20National,within%20the%20United%20Nations%20system

UNESCO. (2019). *What does it mean to be a UNESCO Creative City?* Available at: https://en.unesco.org/creative-cities/sites/creative-cities/files/uccn_faq-en.pdf

UNESCO. (2020). *Creative Cities Network*. Available at: https://en.unesco.org/creative-cities/home

Ungerman, O., & Dedková, J. (2019). Model of the circular economy and its application in business practice. *Environment, Development and Sustainability*, *22*(4), 3407–3432. doi:10.100710668-019-00351-2

UNICEF. (2021). *The Climate Crisis is a Child Rights Crisis*. https://www.unicef.org/reports/climate-crisis-child-rights-crisis

UNICEF. (n.d.). *Water scarcity, Addressing the growing lack of available water to meet children's needs*. https://www.unicef.org/wash/water-scarcity

United Nations (UN). (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. General Assembly Seventieth session. Agenda items 15 and 116. A/RES/70/1.

United Nations Department of Economic and Social Affairs Sustainable Development. (n.d.). *The 17 Goals*. https://sdgs.un.org/goals

United Nations Development Program. (2020, March 25). *What are the Sustainable Development Goals?* https://www.tr.undp.org/content/turkey/en/home/sustainable-development-goals.html

United Nations Development Programme. (1997). *Good governance for sustainable human development*. http://magnet.undp.org/policy/chapter1.htm

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2004). *The UN Decade of Education for Sustainable Development (2005-2014): International Implementation Scheme*. UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2005a). Convention of the Protection and Promotion of the Diversity of Cultural Expressions. Paris: UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2008a). Background Note. A Review of Education for Sustainable Development (ESD) Policies from a Cultural Diversity and SOCIO-INTERCULTURAL Dialogue Perspective. Unpublished document. UNESCO/CLT/CPD/CPO20/11/2008. Paris: UNESCO.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2008b). UNESCO Concept Note. Towards a New Cultural Policy Profile. UNESCO/CLT/CPD 01/08/2008. Paris: UNESCO.

United Nations Environment Programme (UNEP). (2019). *Global Resource Outlook – natural resources for the future we want.* UNEP.

United Nations World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. Oxford University Press. Retrieved from https://www.environmentandsociety.org/mml/un-world-commission-environment-and-development-ed-report-world-commission-environment-and

United Nations. (2011). *The Green Economy: Trade And Sustainable Development Implications.* United Nations Conference on Trade and Development. https://unctad.org/en/Docs/ditcted2011d5_en.pdf

United Nations. (2015). *The Paris Agreement.* https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.* https://sustainabledevelopment.un.org/post2015/transformingourworld

United Nations. (2015, March 24). *Transforming our world: The 2030 agenda for Sustainable Development*. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

United Nations. (2017). *UN resolution A/RES/71/313. Resolution adopted by the General Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development*. Author.

United Nations. (2018). *Goals for Sustainable Development*. Retrieved from https://www.un.org/sustainabledevelopment/ru/about/development-agenda/

United Nations. (2020). *Informe de los Objetivos de Desarrollo Sostenible.* Report.

United Nations. (2020). *The Sustainable Development Goals Report 2020*. https://unstats.un.org/sdgs/report/2020/

United Nations. (2020a, March 24). *Goal 2: Zero hunger*. https://www.un.org/sustainabledevelopment/hunger/

United Nations. (2020b, March 24). *Goal 4: Quality education*. https://www.un.org/sustainabledevelopment/education/

United Nations. (2020c, March 24). *Goal 5: Achieve gender equality and empower all women and girls.* https://www.un.org/sustainabledevelopment/gender-equality/

United Nations. (2020d, March 24). *Goal 6: Ensure access to water and sanitation for all.* https://www.un.org/sustainabledevelopment/water-and-sanitation/

United Nations. (2020e, March 24). *Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all.* https://www.un.org/sustainabledevelopment/economic-growth/

United Nations. (2020f, March 24). *Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation.* https://www.un.org/sustainabledevelopment/infrastructure-industrialization/

United Nations. (2020g, March 24). *Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.* https://www.un.org/sustainabledevelopment/biodiversity/

United Nations. (2020h, March 24). *Goal 13: Take urgent action to combat climate change and its impacts.* https://www.un.org/sustainabledevelopment/climate-change/

Unterhalter, E. (2019). The Many Meanings of Quality Education: Politics of Targets and Indicators in SDG4. *Global Policy*, *10*(1), 39–51. doi:10.1111/1758-5899.12591

USAAF. (1945). *Graphic Survey of Radio and Radar Equip.* Used by the Army Air Forces [Sec. 1] Countermeasures Equipment, volume Section One. USAAF.

Vaezi, A. R., Ahmadi, M., & Cerda, A. (2017). Contribution of raindrop impact to the change of soil physical properties and water erosion under semi-arid rainfalls. *The Science of the Total Environment*, *583*, 382–392. doi:10.1016/j.scitotenv.2017.01.078 PMID:28119004

Vainio, A., Ovaska, U., & Varho, V. (2019). Not so sustainable? Images of bioeconomy by future environmental professionals and citizens. *Journal of Cleaner Production*, *210*, 1396–1405. doi:10.1016/j.jclepro.2018.10.290

Vale, M. M., Berenguer, E., de Menezes, M. A., de Castro, E. B. V., & de Siqueira, L. P. (2021). The Covid-19 pandemic as an opportunity to weaken environmental protection in Brazil. *Biological Conservation*, *255*, 108994. doi:10.1016/j.biocon.2021.108994 PMID:33568834

Valencia, A. (2018). Aspectos regulatorios del teletrabajo en el Perú: Análisis y perspectivas. *Revista IUS*, *12*(41). Advance online publication. doi:10.35487/rius.v12i41.2018.319

Valerio, F., Carvalho, F., Barbosa, A. M., Mira, A., & Santos, S. M. (2019). Accounting for connectivity uncertainties in predicting roadkills: A comparative approach between path selection functions and habitat suitability models. *Environmental Management*, *64*(3), 329–343. doi:10.100700267-019-01191-6 PMID:31372805

Valero, I., & Riaño, M. (2020). Teletrabajo: Gestión de la Seguridad y Salud en el Trabajo en Colombia. *Archivos de Prevencion de Riesgos Laborales*, *23*(1), 22–33. doi:10.12961/aprl.2020.23.01.03 PMID:31991075

Van Bohemen, H. D. (1998). Habitat fragmentation, infrastructure and ecological engineering. *Ecological Engineering*, *11*(1-4), 199–207. doi:10.1016/S0925-8574(98)00038-X van de Berg, L., & van Veenhuizen, R. (2005). Multiple functions of urban Agriculture. *Urban Agriculture Magazine*, 14.

Van den Bergh, J. C. J. M. (2009). The GDP paradox. *Journal of Economic Psychology*, *30*(2), 117–135. doi:10.1016/j.joep.2008.12.001

Van der Ree, R., Smith, D. J., Grilo, C., & van der Ree, R. (2015). *Handbook of Road Ecology*. Wiley. doi:10.1002/9781118568170

van Loon, B. (2005). Radar 101: Celebrating 101 years of development. *Proceedings of the IEEE*, *93*(4), 844–846.

Van Ruler, B. (2018). Communication theory: An underrated pillar on which strategic communication rests. *International Journal of Strategic Communication*, *12*(4), 367–381. doi:10.1080/1553118X.2018.1452240

van Soest, H. L., van Vuuren, D. P., Hilaire, J., Minx, J. C., Harmsen, M. J. H. M., Krey, V., Popp, A., Riahi, K., & Luderer, G. (2019). Analysing Interactions Among Sustainable Development Goals with Integrated Assessment Models. *Global Transitions*, *1*, 210–225. doi:10.1016/j.glt.2019.10.004

Van Wee, B., Van Den Brink, R., & Nijland, H. (2003). Environmental impacts of high-speed rail links in cost–benefit analyses: A case study of the Dutch Zuider Zee line. *Transportation Research Part D, Transport and Environment*, *8*(4), 299–314. doi:10.1016/S1361-9209(03)00017-8

van Weelden, E., Mugge, R., & Bakker, C. (2016). Paving the way towards circular consumption: Exploring consumer acceptance of refurbished mobile phones in the Dutch market. *Journal of Cleaner Production*, *113*, 743–754. doi:10.1016/j.jclepro.2015.11.065

VandenBos, G., Knapp, S., & Doe, J. (2001). *Role of reference elements in the selection of resources by psychology undergraduates*. http://jbr.org/articles.html

VanSnick, A., & Ntanos, K. (2018). On digitisation as a Preservation Measure. *Studies in Conservation*, *63*(1), 282–287. doi:10.1080/00393630.2018.1504451

Vargo, D., Zhu, L., Benwell, B., & Yan, Z. (2021). Digital technology use during COVID-19 pandemic: A rapid review. *Human Behavior and Emerging Technologies*, *3*(1), 13–24. doi:10.1002/hbe2.242

Varotto, A., & Spagnolli, A. (2017). Psychological strategies to promote household recycling. A systematic review with meta-analysis of validated field interventions. *Journal of Environmental Psychology*, *51*, 168–188. doi:10.1016/j.jenvp.2017.03.011

Vasquez, L. J. (2009). *Comércio Exterior Brasileiro 9ª Edição*. Editora Atlas.

Vaughn, C. R. (1985). Birds and insects as radar targets: A review. *Proceedings of the IEEE*, *73*(2), 205–227.

Vautin, D. A., & Walker, J. L. (2011). *Transportation impacts of information provision & data collection via smartphones* (No. 11-3500). Academic Press.

Vaz, D., & Reis, L. (2017). From City-States to Global Cities: The Role of Cities in Global Governance. *E-Journal of International Relations.* Available at: https://www.redalyc.org/html/4135/413553386002/

Vegas-Gallo, E. (2003). *Hacia un Perú Sustentable*. http://biblioteca.unp.edu.pe/cgi-bin/koha/opac-detail.pl?biblionumber=50940

Vegas-Gallo, E. (2018). Biodiversidad de la macroregión norte del Perú: Estado y estrategia para su conservación y uso sustentable. *Repositorio Institucional de UNP*. https://repositorio.unp.edu.pe/handle/UNP/1580

Vega, W. (2012). *Politicas Y Seguridad De La Informacion*. Revista de Difusión Cultural y Científica de La Universidad La Salle En Bolivia.

Verheyen, F. (2013). Interest rate pass-through in the EMU–new evidence using the nonlinear ARDL framework. *Economic Bulletin*, *33*(1), 729–739.

Veugelers, R. (2012). Which policy instruments to induce clean innovating? *Research Policy*, *41*(10), 1770–1778. doi:10.1016/j.respol.2012.06.012

Viana, C., & Hortinha, J. (2005). *Marketing Internacional* (2nd ed.). Sílabo.

Vicedo-Cabrera, A. M., Scovronick, N., Sera, F., Royé, D., Schneider, R., Tobias, A., Astrom, C., Guo, Y., Honda, Y., Hondula, D. M., Abrutzky, R., Tong, S., Coelho, M. de S. Z. S., Saldiva, P. H. N., Lavigne, E., Correa, P. M., Ortega, N. V., Kan, H., Osorio, S., … Gasparrini, A. (2021). The burden of heat-related mortality attributable to recent human-induced climate change. *Nature Climate Change 2021, 11*(6), 492–500. doi:10.1038/s41558-021-01058-x

Vickerman, R. (2018). Can high-speed rail have a transformative effect on the economy? *Transport Policy*, *62*, 31–37. doi:10.1016/j.tranpol.2017.03.008

Victor, P. A. (2020). Büyüme. In Küçülme yeni bir çağ için kavram dağarcığı (pp. 162-166). Metis Publishing.

Vieira de Jesus, D. S. (2017). A arte do encontro: A paradiplomacia e a internacionalização das cidades criativas. *Revista de Sociologia e Politica*, *25*(61), 51–76. doi:10.1590/1678-987317256104

Vila, J. S., & Linde, D. V., Pascual, A. L., & Palom, A. R. (2006). Conceptos y métodos fundamentales en ecología del paisaje (landscape ecology). Una interpretación desde la geografía. *Documents d'Analisi Geografica*, (48), 151–166.

Vivekananda, J., Fetzek, S., Mobjorrk, M., Sawas, A., & Wolfmaier, S. (2017). Action on climate and security risks: Review of progress 2017. Amsterdam: The Centre for Climate and Security (SIPRI).

Vivekananda, J., Wall, M., Nagarajan, C., Sylvestre, F. & Brown, O. (2019). *Shoring up stability: Addressing climate and fragility risks in the Lake Chad region*. Berlin: Adelphi.

Volo, S. (2010). Bloggers' reported tourist experiences: Their utility as a tourism data source and their effect on prospective tourists. *Journal of Vacation Marketing*, *16*(4), 297–311. doi:10.1177/1356766710380884

Vossen, V. W. (2013). *Feasibility Study Sustainable Material and Energy Recovery from Landfills in Europe*. Istanbul International Solid Waste, Water and Wastewater Congress, Istanbul.

Vrontis, D., & Papasolomou, I. (2007). Brand and product building: The case of the Cyprus wine industry. *Journal of Product and Brand Management*, *16*(3), 159–167. doi:10.1108/10610420710751537

Wahba, G. (1990). *Spline Models for Observational Data. University of Wisconsin*. University of Wisconsin. doi:10.1137/1.9781611970128

Walker & Salt. (2012). *Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function.* Island Press.

Walker, B. H., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society, 9*(2), 5. http://www.ecologyandsociety. org/vol9/iss2/art5/

Wall, D. H., Nielsen, U. N., & Six, J. (2015). Soil biodiversity and human health. *Nature*, *528*(7580), 69–76. doi:10.1038/nature15744 PMID:26595276

Wang, B., Zhang, Q., & Cui, F. (2021). Scientific research on ecosystem services and human well-being: A bibliometric analysis. *Ecological Indicators*, *125*, 107449. doi:10.1016/j.ecolind.2021.107449

Wang, H. J. (2015). A new approach to network analysis for brand positioning. *International Journal of Market Research*, *57*(5), 727–742. doi:10.2501/IJMR-2015-060

Wang, H., & Drake, V. (2004). Insect monitoring radar: Retrieval of wingbeat information from conical-scan observation data. *Computers and Electronics in Agriculture*, *43*(3), 209–222.

Wang, P. C., Che, F., Fan, S. S., & Gu, C. (2014). Ownership governance, institutional pressures and circular economy accounting information disclosure: An institutional theory and corporate governance theory perspective. *Chinese Management Studies*, *8*(3), 487–501. doi:10.1108/CMS-10-2013-0192

Wang, X., Li, D., & Li, L. (2009). Adding value of food traceability to the business: A supply chain management approach. *International Journal of Services Operations and Informatics*, *4*(3), 232–237. doi:10.1504/IJSOI.2009.026951

Watson, R. (2009). *Radar Origins Worldwide: History of Its Evolution in 13 Nations Through World War II*. Trafford Publishing.

Watts, C., Stringer, I., & Gibbs, G. (2012). Insect Conservation in New Zealand: An Historical Perspective. In T. New (Ed.), *Insect Conservation: Past, Present and Prospects*. Springer.

Watts, S. (1987). Radar detection prediction in k-distributed sea clutter and thermal noise. *IEEE Transactions on Aerospace and Electronic Systems*, *AES-23*(1), 40–45.

Watzlawick, P., Beavin, J., & Jackson, D. (1967). *Pragmatics of human communication: A study of interactional patterns, pathologies, and paradoxes*. Norton.

WCED. (1987). *Our Common Future. World Commission on Environment and Development*. Oxford University Press.

Webster,, C., & Lai,, L.W.C. (2003). *Property rights, planning and markets*. Edward Elgar.

Webster, K. (2015). *The Circular Economy: A Wealth of Flows*. Ellen MacArthur Foundation.

Weissbrod, I., & Bocken, N. (2017). Developing sustainable business experimentation capability-A case study. *Journal of Cleaner Production*, *142*, 2663–2676. doi:10.1016/j.jclepro.2016.11.009

Welch, L. S., & Loustarinen, R. K. (1988). Internacionalization: Evolution of a Concept. *Journal of General Management*, *14*(2), 34–55. doi:10.1177/030630708801400203

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171–180. doi:10.1002mj.4250050207

Werner, W. L. (1993). Aspects of ecological problems and environmental awareness in South Asia. *European Conference on Modern South Asian Studies 1990*.

Westbury, N. & Dillon, M. (2006, Dec. 8). Australia's institutionalised second class. *The Australian Financial Review*.

Westman, W. E. (1977). How much are nature's services worth? *Science*, *197*(4307), 960–964. doi:10.1126cience.197.4307.960 PMID:17784115

White, P. (2010). Creative industries in a rural region: *Creative West:* The creative sector in the Western Region of Ireland. *Creative Industries Journal*, *3*(1), 79–88. doi:10.1386/cij.3.1.79_1

WHO. (2018). *Millennium Development Goals (MDGs)*. https://www.who.int/news-room/fact-sheets/detail/millennium-development-goals-(mdgs)

WHO. (2019). *Air pollution*. https://www.who.int/health-topics/air-pollution#tab=tab_1

WHO. (2020). *Commitment and call to action: Global collaboration to accelerate new COVID-19 health technologies*. https://www.who.int/news/item/24-04-2020-commitment-and-call-to-action-global-collaboration-to-accelerate-new-covid-19-health-technologies

Williams, N. M. (1986). *The Yolngu and Their Land: A System of Land Tenure and Its Fight for Recognition*. Australian Institute of Aboriginal Studies Press.

Williams, N. M. (1987). *Two Laws: Managing Disputes in a Contemporary Aboriginal Community*. Australian Institute of Aboriginal Studies.

Williamson, P. (2002). Successful Strategies for Export. *Long Range Planning, 24*(1), 57-63.

Willis, C. (2004). *Review of Governance Training for Indigenous Organisations and Communities in the Northern Territory: Final Report to the Department of Community Development, Sport and Cultural Affairs*. NT Government.

Wilson, D. C. (2015). *Global Waste Management Outlook*. United Nations Environment Programme (UNEP). https://digitallibrary.un.org/record/1324051

Winkler, I., & Williams, C. (2017). The sustainable development goals and human rights: A critical early review. *International Journal of Human Rights*, *21*(8), 1023–1028. doi:10.1080/13642987.2017.1348695

Withers, D. (2017). Ephemeral Feminist Histories and the Politics of Transmission within Digital Culture. *Women's History Review*, *26*(5), 678–691. doi:10.1080/09612025.2016.1166887

Woiwod, I. P., & Hanski, I. (1992). Patterns of density dependence in moths and aphids. *Journal of Animal Ecology*, *61*(3), 619–629.

Wolff, C. (2009a). *Radar tutorial.* https://www.radartutorial.eu/druck/Book1.pdf

Wolff, C. (2009b). *Radartutorial: Book 2 - radar sets.* https://www.radartutorial.eu/druck/Book2.pdf

Wolff, C. (2016). *Radartutorial: Book 7 - intrapulse modulation.* https://www.radartutorial.eu/druck/Book7.pdf

Wolman,, A. (1965). The metabolism of cities. *Scientific American*, *213*(3), 179–190. PMID:14338520

Woo, H., Acuna, M., Moroni, M., Taskhiri, M., & Turner, P. (2018). Optimizing the Location of Biomass Energy Facilities by Integrating Multi-Criteria Analysis (MCA) and Geographical Information Systems (GIS). *Forests, 9*(10), 585. doi:10.3390/f9100585

Wood, P. (2012). *Socio-intercultural Placemaking, socio-intercultural cities.* www.coe.int/socio-interculturalcities

Woodhead, A. J., Hicks, C. C., Norström, A. V., Williams, G. J., & Graham, N. A. (2019). Coral reef ecosystem services in the Anthropocene. *Functional Ecology*, *33*(6), 1023–1034. doi:10.1111/1365-2435.13331

Woods, E. T., Schertzer, R., Greenfeld, L., Hughes, C., & Miller-Idriss, C. (2020). COVID-19, Nationalism, And The Politics Of Crisis: A Scholarly Exchange. *Nations and Nationalism*, 1–19. PMID:32837223

World Bank. (2011). *Chile: Diagnóstico de la gestión de los recursos hídricos 88*. Author.

World Bank. (2019). *Data for Nigeria, Niger, Chad, Cameroon*. Retrieved 8 April 2019 from https://data.worldbank.org/?locations=NG-NE-CM-TD

World Bank. (2020, March 23). *Poverty and shared prosperity.* https://www.worldbank.org/en/publication/poverty-and-shared-prosperity

World Bank. (2021). *Banco Mundial Datos*. Obtenido de https://datos.bancomundial.org/indicator/ER.H2O.INTR.PC?end=2017&locations=CR&start=1962&view=chart

World Bank. (2021, April 20). *Poverty.* https://www.worldbank.org/en/topic/poverty/overview#1

World Commission on Environment and Development. (1987). *Our common future, Chapter 2: Towards sustainable development.* https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.

World Health Assembly. (2018). *Health, environment and climate change Road map for an enhanced global response to the adverse health effects of air pollution Report by the Director-General*. https://apps.who.int/iris/handle/10665/276321

World Meteorological Organization. (2021, May 27). *New climate predictions increase likelihood of temporarily reaching 1.5 °C in next 5 years*. https://public.wmo.int/en/media/press-release/new-climate-predictions-increase-likelihood-of-temporarily-reaching-15-c-next-5

World Resources Institute. (n.d.a). *Baseline Water Stress*. https://www.wri.org/applications/aqueduct/country-rankings/

World Resources Institute. (n.d.b). *Drought Risk*. https://www.wri.org/applications/aqueduct/country-rankings/?country=TUR&indicator=drr

World Resources Institute. (n.d.c). *Riverine Flood Risk*. https://www.wri.org/applications/aqueduct/country-rankings/?indicator=rfr

World Tourism Organization (UNWTO). (2013). *Sustainable Tourism for Development Guidebook - Enhancing capacities for Sustainable Tourism for development in developing countries*. Madrid: UNWTO. doi:10.18111/9789284415496

World Tourism Organization (UNWTO). (2019). *International Tourism Highlights. 2019 Edition.* World Tourism Organization. doi:10.18111/9789284421152

World Tourism Organization (UNWTO). (2020). *World Tourism Barometer*. Retrieved from https://webunwto.s3.eu-west-1.amazonaws.com/s3fs-public/2020-01/UNWTO_Barom20_01_January_excerpt_0.pdf

World Tourism Organization and United Nations Development Programme. (2017). *Tourism and the Sustainable Development Goals – Journey to 2030, Highlights*. UNWTO. doi:10.18111/9789284419340

World Travel & Tourism Council (WTTC) & Wyman, O. (2020). *To Recovery & Beyond: The Future of Travel & Tourism in the Wake of COVID-19.* Retrieved from https://wttc.org/Portals/0/Documents/Reports/2020/To%20Recovery%20and%20Beyond-The%20Future%20of%20Travel%20Tourism%20in%20the%20Wake%20of%20COVID-19.pdf

World Travel & Tourism Council. (2018). *Travel & Tourism Economic Impact. 2018 Portugal.* Author.

World Wide Fund for Nature. (2020, March 23). *Dünya liderleri, 2030'a kadar biyolojik çeşitlilik kaybını tersine çevirmeyi taahhüt etti*. https://www.wwf.org.tr/?10260/dunya-liderleri-2030a-kadar-biyolojik-cesitlilik-kaybini-tersine-cevirmeyi-taahhut-etti

Worldometer. (2021, April 20). *Covid-19 coronavirüs pandemic.* https://www.worldometers.info/coronavirus/

Wu, C. F., Deng, J. S., Wang, K., Ma, L. G., & Tahmassebi, A. R. S. (2016). Object-based classification approach for greenhouse mapping using Landsat-8 imagery. *International Journal of Agricultural and Biological Engineering*, *9*(1), 79–88. doi:10.3965/j.ijabe.20160901.1414

Wu, H., Shi, Y., Xia, Q., & Zhu, W. (2014). Effectiveness of the policy of circular economy in China: A DEA-based analysis for the period of 11th five-year-plan. *Resources, Conservation and Recycling*, *80*, 163–175. doi:10.1016/j.resconrec.2013.10.003

Wu, J., Deng, Y., Huang, J., Morck, R., & Yeung, B. (2013). *Incentives and outcomes: China's environmental policy (No. w18754)*. National Bureau of Economic Research.

Wu, J., & Wu, T. (2013). Ecological resilience as a foundation for urban design and sustainability. In S. T. A. Pickett, M. L. Cadenasso, & B. McGrath (Eds.), *Resilience in ecology and urban design: Linking theory and practice for sustainable cities* (pp. 211–229). Springer. doi:10.1007/978-94-007-5341-9_10

Wu, P., Christidis, N., & Stott, P. (2013). Anthropogenic impact on Earth's hydrological cycle. *Nature Climate Change*, *3*(9), 807–810. doi:10.1038/nclimate1932

WWF. (n.d.). https://www.worldwildlife.org/threats/water-scarcity

Xie, M., Jean, N., Burke, M., Lobell, D., & Ermon, S. (2015). Transfer learning From Deep Features for Remote Sensing and Poverty Mapping. *Proceedings 30th AAAI Conference on Artificial Intelligence*, *30*(1).

Yañez, L. (2018). Región de Valparaíso: Información Regional 2018. *Oficina de Estudios y Politicas Agrarías*, 3–15. Available at: https://www.odepa.gob.cl/wp-content/uploads/2018/03/Valparaiso.pdf

Yañez, L. (2019). *Región de Valparaíso: Información Regional 2019*. Available at: https://www.odepa.gob.cl/wp-content/uploads/2019/07/Valparaiso.pdf

Yang, D., Chen, J., Zhou, Y., Chen, X., Chen, X., & Cao, X. (2017). Mapping plastic greenhouse with medium spatial resolution satellite data: Development of a new spectral index. *ISPRS Journal of Photogrammetry and Remote Sensing*, *128*(December), 47–60. doi:10.1016/j.isprsjprs.2017.03.002

Yang, M. Y., Smart, P., Kumar, M., Jolly, M., & Evans, S. (2018). Product-service systems business models for circular supply chain. *Production Planning and Control*, *29*(6), 498–508. doi:10.1080/09537287.2018.1449247

Yang, Q. Z., Zhou, J., & Xu, K. (2014). A 3R Implementation Framework to Enable Circular Consumption in Community. *International Journal of Environmental Sciences and Development*, *5*, 217–222. doi:10.7763/IJESD.2014.V5.481

Yang, X., Lin, S., Li, Y., & He, M. (2019). Can high-speed rail reduce environmental pollution? Evidence from China. *Journal of Cleaner Production*, *239*, 118135. doi:10.1016/j.jclepro.2019.118135

Yang, Y., Wang, K., Liu, D., Zhao, X., & Fan, J. (2020). Effects of land-use conversions on the ecosystem services in the agro-pastoral ecotone of northern China. *Journal of Cleaner Production*, *249*, 119360. doi:10.1016/j.jclepro.2019.119360

Yan, H., Liu, J., Huang, H. Q., Tao, B., & Cao, M. (2009). Assessing the consequence of land use change on agricultural productivity in China. *Global and Planetary Change*, *67*(1-2), 13–19. doi:10.1016/j.gloplacha.2008.12.012

Yaseef, N. R., Yakir, D., Rotenberg, E., Schiller, G. & Shabtai, C. (2010). Ecohydrology of a semi-arid forest: partitioning among water balance components and its implications for predicted precipitation changes. *Ecohydrology, 3*(2), 143–154.

Yayar, R., Kaplan, Ç., & Simsek, Ü. (2014). Awareness on Economic, Social, and Environmental Effects of the Global Warming: Experimental Findings from Turkey. *Business and Economics Research Journal*, *5*(3), 81–95.

Yener, D. (2007). *Importance of Environmental Policy in Turkey for a Sustainable Future.* http://www.unaturkey.org/dergiler-bulletins/51-say-15-number-15-spring-2007/149-importance-of-enviromental-policy-in-turkey-for-a-sustainable-future-.html

Yigitcanlar, T., Dur, F., & Dizdarogluc, D. (2015). Towards prosperous sustainable cities: A multiscalar urban sustainability assessment approach. *Habitat International: A Journal for the Study of Human Settlements,* 36-46.

Yıldırım, S., & Bostancı, S.H. (2021), The efficiency of e-government portal management from a citizen perspective: evidences from Turkey. *World Journal of Science, Technology and Sustainable Development*. doi:10.1108/WJSTSD-04-2021-0049

Yıldırım, D. Ç., Yıldırım, S., Erdoğan, S., Demirtaş, I., Couto, G., & Castanho, R. A. (2021c). Time-Varying Convergences of Environmental Footprint Levels Between European Countries. *Energies*, *2021*(14), 1813. doi:10.3390/en14071813

Yildirim, S. (2020). The Consumer Role for Sustainable Development: How Consumers Contribute Sustainable Development Goals. In V. Chkoniya, A. Madsen, & P. Bukhrashvili (Eds.), *Anthropological Approaches to Understanding Consumption Patterns and Consumer Behavior* (pp. 325–341). IGI Global. doi:10.4018/978-1-7998-3115-0.ch018

Yıldırım, S., Bostancı, S. H., & Erdogan, S. (2017). Environmental sustainability in local governments: A case of Turkish municipalities. *Journal of Geography and Regional Planning*, *10*(12), 330–339. doi:10.5897/JGRP2017.0668

Yıldırım, S., Bostancı, S. H., Yıldırım, D. C., & Erdogan, F. (2021a). *Rethinking mobility of international university students during COVID-19 pandemic*. Higher Education Evaluation and Development., doi:10.1108/HEED-01-2021-0014

Yıldırım, S., & Kaplan, M. (2020). The profile of Turkey's sea and seafood in the context of sustainable development. *Gaziantep University Journal of Social Sciences*, *19*(3), 853–866.

Yıldırım, S., & Yıldırım, D. Ç. (2020). Achieving Sustainable Development Through a Green Economy Approach. In S. Patti & G. Trizzino (Eds.), *Advanced Integrated Approaches to Environmental Economics and Policy: Emerging Research and Opportunities* (pp. 1–22). IGI Global. doi:10.4018/978-1-5225-9562-5.ch001

Yıldırım, S., & Yıldırım, D. C. (2021). Achieving seafood security in the Mediterranean Region: A case of Turkey. In R. Castanho & J. Martín Gallardo (Eds.), *Management and Conservation of Mediterranean Environments* (pp. 173–193). IGI Global. doi:10.4018/978-1-7998-7391-4.ch011

Yıldırım, S., Yıldırım, D. Ç., Aydın, K., & Erdogan, F. (2021b). Regime-dependent effect of tourism on carbon emissions in the Mediterranean countries. *Environmental Science and Pollution Research International*. Advance online publication. doi:10.100711356-021-14391-7 PMID:34014485

Yohe, G., & Tol, R. S. J. (2002). Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. *Global Environmental Change*, *12*(1), 25–40. doi:10.1016/S0959-3780(01)00026-7

Yong, R. (2007). The circular economy in China. *Journal of Material Cycles and Waste Management*, *9*(2), 121–129. doi:10.100710163-007-0183-z

Youssef, M., Yosef, M. A., & El-Derini, M. (2010, December). GAC: Energy-efficient hybrid GPS-accelerometer-compass GSM localization. In *2010 IEEE Global Telecommunications Conference GLOBECOM 2010* (pp. 1-5). IEEE.

Yuan, Z., Jiang, W., Liu, B., & Bi, J. (2008). Where Will China Go? A Viewpoint Based on an Analysis of the Challenges of Resource Supply and Pollution. *Environment and Progress*, *27*(4), 503–514. doi:10.1002/ep.10300

Yu, D., & Hang, C. C. (2010). A reflective review of disruptive innovation theory. *International Journal of Management Reviews*, *12*(4), 435–452. doi:10.1111/j.1468-2370.2009.00272.x

Yudkin, M., & Stork, H. (2014). *The Benefits of Branding*. Available at: http://www.namedatlast.com/branding3.htm

Yunus, A. P., Masago, Y., & Hijikoka, Y. (2020, August 20). Covid-19 and surface water quality: Improved lake water quality during the lockdown. *The Science of the Total Environment*, *731*, 139012. doi:10.1016/j.scitotenv.2020.139012 PMID:32388159

Yu, R., Deng, X., Yan, Z., & Shi, C. (2013). Dynamic evaluation of land productivity in China. *Zhongguo Renkou Ziyuan Yu Huanjing*, *11*(3), 253–260. doi:10.1080/10042857.2013.835547

Zaelke, D., Orbuch, P., & Housman, R. (Eds.). (1993). *Trade and the Environment: Law, economics, and policy*. Island Press.

Zaid, Y., & Abioye, A. (2010). Museums, Libraries, and Archives; Collaborating for the Preservation of Heritage Materials in Nigeria. *African Research & Documentation*, *114*, 59–70.

Zambrano-Monserrate, M. A., Ruanob, M. A., & Sanchez-Alcalde, L. (2020). Indirect effects of Covid-19 on the environment. *The Science of the Total Environment*, *728*, 138813. doi:10.1016/j.scitotenv.2020.138813 PMID:32334159

Zanoni, P., & Janssens, M. (2009). Sustainable DiverCities. In M. Janssens, D. Pinelli, D. C. Reyman, & S. Wallman (Eds.), *Sustainable Cities. Diversity, Economic Growthand Social Cohesion* (pp. 3–25). Edward Elgar.

Zemp, D. C. (2017). Self-amplified Amazon forest loss due to vegetation-atmosphere feedbacks. *Nature Communications, 8*(14681), 1-10.

Zhang, K. Z. K., Wang, S., & Zhao, S. J. (2014). Effect of brand pereffect of brand personality on brand loyalty in companies' microblogs. *PACIS 2014 Proceedings*. Available at: https://aisel.aisnet.org/pacis2014/203

Zhang, Y., Liang, S., & Yang, L. (2019). A Review of Regional and Global Gridded Forest Biomass Datasets. *Remote Sensing, 11*(23), 2744. doi:10.3390/rs11232744

Zhang, H., Liu, G., Hao, H., & Liu, S. (2014). Review, assessment and recommendations on environmental policies in Western China. *Zhongguo Renkou Ziyuan Yu Huanjing*, *12*(1), 42–51. doi:10.1080/10042857.2013.874521

Zhang, H., Lu, L., & Sun, F. (2020). Changing role of lifestyle in tourism entrepreneurship: Case study of Naked Retreats Enterprise. *Tourism Management*, *84*, 104259. Advance online publication. doi:10.1016/j.tourman.2020.104259

Zhang, S. X., & Babovic, V. (2012). A real options approach to the design and architecture of water supply systems using innovative water technologies under uncertainty (PDF). *Journal of Hydroinformatics*, *488*. www.frontiersinecology.org

Zhang, X. P., & Cheng, X. M. (2009). Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics*, *68*(10), 2706–2712. doi:10.1016/j.ecolecon.2009.05.011

Zhang, X., Liu, Y., & Zhou, L. (2018). Correlation analysis between landscape metrics and water quality under multiple scales. *International Journal of Environmental Research and Public Health*, *15*(8), 1606. doi:10.3390/ijerph15081606 PMID:30060594

Zhao, J., Yan, Y., Deng, H., Liu, G., Dai, L., Tang, L., Shi, L., & Shao, G. (2020). Remarks about landsenses ecology and ecosystem services. *International Journal of Sustainable Development and World Ecology*, *27*(3), 196–201. doi:10.1080/13504509.2020.1718795

Zhao, Y., Feng, D., Yu, L., Wang, X., Chen, Y., Bai, Y., Hernández, H. J., Galleguillos, M., Estades, C., Biging, G. S., Radke, J. D., & Gong, P. (2016). Detailed dynamic land cover mapping of Chile: Accuracy improvement by integrating multi-temporal data. *Remote Sensing of Environment*, *183*, 170–185. doi:10.1016/j.rse.2016.05.016

Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. *International Journal of Remote Sensing*, *24*(3), 583–594. doi:10.1080/01431160304987

Zhu, Q., Geng, Y., & Lai, K. (2010). Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications. *Journal of Environmental Management*, *91*(6), 1324–1331. doi:10.1016/j.jenvman.2010.02.013 PMID:20223586

Zhu, Q., Geng, Y., & Lai, K. (2011). Environmental Supply Chain Cooperation and Its Effect on the Circular Economy Practice-Performance Relationship Among Chinese Manufacturers. *Journal of Industrial Ecology*, *15*(3), 405–419. doi:10.1111/j.1530-9290.2011.00329.x

Zimov, S. A., Chuprynin, V. I., Oreshko, A. P., Chapin, F. S. III, Reynolds, J. F., & Chapin, M. C. (1995). Steppe–tundra transition: An herbivore-driven biome shift at the end of the Pleistocene. *American Naturalist*, *146*(5), 765–794. doi:10.1086/285824

Ziter, C. (2016). The biodiversity–ecosystem service relationship in urban areas: A quantitative review. *Oikos*, *125*(6), 761–768. doi:10.1111/oik.02883

Žižek, S. (2020). *Pandemic! COVID-19 Shakes the World*. OR Books. doi:10.2307/j.ctv16t6n4q

Zrnic, D. S., & Ryzhkov, A. V. (1998). Observations of insects and birds with a polarimetric radar. *IEEE Transactions on Geoscience and Remote Sensing*, *36*(2), 661–668.

zu Ermgassen, P. S., Baker, R., Beck, M. W., Dodds, K., zu Ermgassen, S. O., Mallick, D., ... Turner, R. E. (2021). Ecosystem services: Delivering decision-making for salt marshes. *Estuaries and Coasts*, 1–8.

Zucchella, A., & Previtali, P. (2019). Circular business models for sustainable development: A “waste is food restorative ecosystem”. *Business Strategy and the Environment*, *28*(2), 274–285. doi:10.1002/bse.2216

Zucchella, A., & Urban, S. (2019). *Circular Entrepreneurship – Creating Responsible Enterprise*. Springer Nature Switzerland AG. doi:10.1007/978-3-030-18999-0

Zufall, J., Norris, S., Schaltegger, S., Revellio, F., & Hansen, E. G. (2020). Business models patterns of sustainability pioneers -Analizing cases across the smartphone life cycle. *Journal of Cleaner Production*, *244*, 118651. doi:10.1016/j.jclepro.2019.118651

ZWE. (2019). *Zero Waste Hierarchy, Press Release: A Zero Waste hierarchy for Europe.* Zero Waste Europe. https://zerowasteeurope.eu/2019/05/press-release-a-zero-waste-hierarchy-for-europe/

# About the Contributors

**Rui Alexandre Castanho** holds an International Ph.D. on Sustainable Planning in Borderlands. Nowadays, he's a Professor at the WSB University, Poland, and the Coordinator of International Relations on the Research Institute on Territorial Cooperation and Inter-Organizational Cooperation. Also, he is a pos-doc researcher on the GREAT Project, University of Azores, Ponta Delgada, Portugal. Furthermore, he collaborates with the Environmental Resources Analysis Research Group (ARAM) - University of Extremadura (UEx); VALORIZA - Research Center for the Enhancement of Endogenous Resources, Polytechnic Institute of Portalegre (IPP), Portugal; CITUR - Madeira - Centre for Tourism Research, Development and Innovation, Madeira, Portugal; and AQUAGEO Research Group - University of Campinas (UNICAMP), Brazil. Moreover, he has Graduated in Green Spaces Engineering and Agricultural Engineering and holds a Master's Degree in Planning, Audit, and Control in Urban Green Spaces.

* * *

**Nassir Abba-Aji**, PhD, is a senior lecturer and former Head of Department at the Department of Mass Communication, University of Maiduguri, Nigeria. Also, he is a former Chairman, Jere Local Government Area of Borno State as well as former Commissioner for Religious Affairs, Borno State, Nigeria. He has published a number of research articles, book chapters and presented papers at conferences.

**Bilge Abukan** is a Dr. Lecturer at Ondokuz Mayis University, Faculty of Health Sciences, Department of Social Work. She received her bachelor and master degree at Ankara University Faculty of Health Sciences, Department of Social Work. She received her doctorate degree in the field of clinical social work at Ankara Yıldırım Beyazıt University. Her main research interests include clinical social work, child welfare, foster family, traumatic experiences, traumatic stress, aging, early (child) marriage, sustainable development, ecology. She is also studying Law at Erciyes University, Faculty of Law.

**Ignacio Aguirre** holds a degree in geography from the Pontificia Universidad Catolica de Chile. In 2021, he began his graduate studies in the Department of Geography and Planning and the Centre of Hydrology at the University of Saskatchewan, Canada. He has worked as a consultant for several projects on water resources. His current research interests include ecohydrology, wetlands, hydrological modeling, hydroinformatics, remote sensing, and nature-based solutions for hazards. He has presented at European Geosciences Union (EGU) General Assembly, Biohydrology meeting, and Chilean conferences of geography and agronomic studies.

**Ahmet Altın** received his MS and PhD in Environmental Engineering from the Cumhuriyet University in 1997 and 2002, respectively. In 2005 he was hired as the Asistant Professor by the Department of Environmental Engineering at Zonguldak Bülent Ecevit University and is currently the Professor at the same department. He writes and presents widely on issues of basin management, soil/groundwater pollution, remediation processes in soil and groundwater, and water/wastewater treatment.

**Süreyya Altın** received her MS and PhD in Environmental Engineering from the Cumhuriyet University in 1997 and 2003, respectively. In 2005 she was hired as the Asistant Professor by the Department of Environmental Engineering at Zonguldak Bülent Ecevit University and is currently the Professor at the same department. She writes and presents widely on issues of waste management, water/wastewater treatment, and membrane processes.

**Atul Bamrara** received his PhD in Business Management from HNB Garhwal University. He has shared his expertise in Research Methodology, Project Management, Information Security, and Education Technology with students of Business Management, Computer Science and Education in India and abroad. He is currently working with Department of School Education, Government of Uttarakhand - India. His responsibilities include training to various in-service teachers in ICT Inclusion, Mathematics & Science Pedagogy, e-content development etc. He has received Young Scientist Award 2018, Commonwealth of Learning Award, Teacher Innovation Award and Nation Builder Award for his extraordinary performance. He has widely published his research papers in reputed journals of Information Security, Education Technology and Operations Management.

**Seda H. Bostancı** is head of Political Science and Public Administration Department in Tekirdağ Namık Kemal University, Turkey. She graduated from Public Administration in 2020 from Eskişehir Anadolu University. And her PhD. is from Istanbul Technical University in Urban and Regional Planning Department in 2008. She worked for 6 years in a district municipality and work 6 years at Okan University. Since 2016 she is Associated Prof Dr. in Political Science and Public Administration Department, Economics and Administrative Sciences Faculty at Tekirdağ Namık Kemal University. She has may international articles and book chapters and national publications and editorial books. Her research areas are local governments, urbanization, sustainable development, urban design, and e-governments.

**Andreia Carvalho** is a Lecturer in Portuguese and English in the Undergraduate Course in Tourism Lecturer in Business English in the Undergraduate Course in Business Management. Member of ISAL Department of Languages. Member of ISAL Research Centre.

**Gualter Couto** has a degree in Business Management from the University of the Azores in 1995, a Master in Business Management / MBA from the Higher Institute of Economics and Management at the University of Lisbon in 1999, and a PhD in Management / Finance from the Higher Institute of Economics and Management at the University of Lisbon, since 2006. He is currently Professor of Finance at the School of Business and Economics at the University of the Azores since 1996 and researcher at the Center for the Study of Applied Economics in the Atlantic since 2003. Specialist in corporate finance, he was director of the Master in Business Administration from the University of the Azores.

**Işıl Demirtaş** was born in 1980. She earned her bachelor's degree in Economics from Kocaeli University and her master's degree in Economic Development and International Economics at the same university in 2010. While pursuing graduate studies, she began to work Giresun University as a teaching assistant. In 2015 she earned her PHD in Economic Policy from Marmara University. At the same year she began to work as an assistant professor at Giresun University in the department of economics. In 2016 she earned a scholarship from TUBİTAK and worked as a visiting scholar at The University of Michigan between October 2016 - September 2017. She is still working as an assistant professor at Giresun University. Her research interests include energy economics, economy policy, green economy, sustainable development.

**Meenakshi Dhote** has about 30 years of teaching, research and professional experience in the field of Environmental Planning with special interest in biodiversity conservation in urban areas and planning for hill areas.

**Roxana Durán Sosa** holds an International Master on Environmental Engineering and Management (Own title). Nowadays, she's a professor at the National University, Costa Rica, and researcher. Also, she has a Master of Business Administration with an emphasis on Human Resources, a Degree in Environmental Education, a Bachelor of Planning, and a Diploma in Social Promotion.

**Bhavya Kavitha Dwarapureddi** completed M.Sc, M.Tech and Ph.D in Environmental Science and Management. She has 6 years of research and 3 years of teaching experience in addressing environmental issues through sustainable solutions.

**Deborah Estima** is Project Manager - FRCT and Coordinator of the Management Team of RIS3 Azores – DRCTD.

**Rodrigo Frogeri** has a PhD in Information Systems and Knowledge Management. Master in Administration. Bachelor in Computer Science. Professor of the Master in Management and Regional Development of the Centro Universitário do Sul de Minas - UNIS.Main lines of research: Information Technology Governance in small and medium enterprises;Information Security Management; Knowledge Management; Organizational Ambidexterity.

**Sema Genç** was born in Istanbul on 25/07/1980. She graduated from Kocaeli University, Department of Economics, in 2002. In 2004, she completed her master's degree at Kocaeli University, Department of Economic Policy, completing her thesis titled "Capital Accumulation Problem in Turkey Perspectives of Capital Accumulation Models." In 2008, she graduated from Marmara University, Institute of Social Sciences, Department of Economic History Ph.D. Program, preparing her thesis titled "An Assessment on the Contributions of Galbraith to Economic Thought." She started her academic career as an assistant professor at Kocaeli University in 2009. Since 2010, she has been working as the Head of the Department at Kocaeli University, Ali Riza Veziroğlu Vocational School, Marketing and Advertising Department. In 2018, she was awarded the title of the associate professorship in the field of Economic Thought. Her academic fields of study are economic methodology, economic thought, economic sociology, institutional economics, and economic history. She has articles in SSCI, ESCI, Scopus, and

Ulakbim indexed journals, book chapters in internationally recognized publishing houses, and papers at international congresses in these fields.

**Adamkolo Mohammed Ibrahim** received his MSc degree in Development Communication from Universiti Putra Malaysia (UPM) in 2017 and had his first degree, BA Mass Communication from University of Maiduguri in 2007. Currently, Malam Adamkolo is pursuing a PhD programme in mass communication at Bayero University, Kano. Also currently, he teaches and conducts research for development in mass communication studies at the Department of Mass Communication, University of Maiduguri. In line with his MSc degree, ever since he met his former MSc Supervisor Prof. Dr. Md. Salleh Hassan in 2014, Malam Adamkolo has delved into researching and publishing papers and book chapters in the areas of ICT adoption for agribusiness and small and medium enterprises development. In the last couple of years, he was inspired by one of his mentors Prof. Umaru Pate of Bayero University, Kano to do research in journalism specifically in the areas of fake news, misinformation and hate speech. Adamkolo's other research interests include social media; cyberbullying; cyber terrorism; media, peace and conflict; media and gender; ICT and gender; and online shopping. To his credit, Malam Adamkolo has a total of over 60 publications (including journal articles, book chapters, conference papers and a couple of books). In 2014, he served as Sub-Editor for Get Involved magazine published by the Universiti Putra Malaysia Students' Association (UPMISA). Since 2013, Adamkolo has received several merit awards related to social work, intellectual excellence and so on including the award he received in 2018 from Publons, the greatest global network of academic peer reviewers as Top Reviewer, for being among the top 1% of global peer reviewers in Psychiatry/Psychology of communication. Since 2014, Malam Adamkolo has been reviewing for several academic research journals prestigious among which are Computers in Human Behaviour (CHB) and Children and Youth Services Review (CYSR) both published by Elsevier, which is one of the global publishing giants as well as Journal of Systems and Information Technology (JSIT) which is published by Emerald which, also, is a one of the renowned global publishing companies and SAGE Open Access published by SAGE and Jurnal Komunikasi Ikatan Sarjana Komunikasi Indonesia (the Communication Journal of the Indonesian Association of Communication Scholars). Details on his research can be accessed here: https://unimaid.academia.edu/AdamkoloMohammedIbrahim. To his credit, since 2014, Adamkolo has peer reviewed not less than 56 academic research papers. Much earlier, from 2000 to 2010, he worked as a broadcast presenter, producer and journalist at Yobe Broadcasting Corporation (YBC) Damaturu, and from 2008 to 2010 was deployed to Sahel FM (formerly Pride FM), a subsidiary of YBC Damaturu as DJ-cum-producer/presenter/journalist. From 2008 to 2010, Adamkolo worked as YBC's focal person on UNICEF and Partnership for the Revival of Routine Immunisation in Northern Nigeria-Maternal, New-born and Child Health (PRRINN-MNCH) and other partnering NGOs' matters. From September to October 2018, he served as a consultant to ManienDanniels (West Africa Ltd.) regarding the assessment of organisational capacity building for MNCH2 programme in Damaturu, Yobe State. Malam Adamkolo was born in Geidam town of Geidam Local Government Area of Yobe State some 42 years ago. He is married and has children. Finally, he is available for consultancy services in media and strategic communication, content development and management including research, writing, editing and proofreading research, political and official documents.

**Sérgio António Neves Lousada** holds an International Ph.D. in Civil Engineering - Hydraulics. He teaches at the University of Madeira, field of Hydraulics, Environment and Water Resources and Construction. Furthermore, he collaborates with the Environmental Resources Analysis Research Group

(ARAM) - University of Extremadura (UEx); VALORIZA - Research Center for the Enhancement of Endogenous Resources, Polytechnic Institute of Portalegre (IPP), Portugal; CITUR - Madeira - Centre for Tourism Research, Development and Innovation, Madeira, Portugal; and Institute of Research on Territorial Governance and Inter-Organizational Cooperation, Dąbrowa Górnicza, Poland. Moreover, he holds an International Master's Degree in Ports and Coasts Engineering.

**Francisco J. Moral** is a Professor at the University of Extremadura (Spain) where one of his research lines focuses on the use of different techniques and models in agriculture and other topics. He earned a Master of Agricultural Engineering at the University of Córdoba (Spain) and also earned a doctorate in Agricultural Engineering at the same University. He has supervised some doctoral theses and is author of some articles related to different statistical methods applied to agriculture and environment.

**José Manuel Naranjo Gómez** is a PhD in Geodesy and Cartography (2015); an Engineer in Geodesy and Cartography (2002) and an Engineer Surveying (1999) by the University of Extremadura. He works as professor at the University of Extremadura since 2002 and researches in the fields of sustainability, transport infrastructure and territorial accessibility.

**Julijana Nicha Andrade** holds a Doctorate in Political Science from the Federal University of Minas Gerais, Master's in Public Policies and Development from the Institute of Social Studies and University of York, part of the Erasmus Mundus Master Program, and Undergraduate in IR from the American College of Thessaloniki. Her research circles around the topics of development, arts and culture, IR, and policies.

**Mariana Nóbrega** has a bachelor's degree in Management and Planning in Tourism from the University of Aveiro, Portugal, and is currently a student of the Master's Program in Management and Planning in Tourism, also at the University of Aveiro. Some of her areas of interest are tourism and sustainability.

**Alexey Noskov** is a postdoctoral researcher at the Laboratory for Climatology and Remote Sensing (Faculty of Geography, Philipps University of Marburg, Germany) involved in the Nature 4.0 Sensing Biodiversity project. His previous postdoctoral position was at the GIScience research group of Heidelberg University (2016-2019). 2012-2016: Ph.D. at Israel Institute of Technology (Technion). In 2002-2011: Research Assistant and MSc at Lomonosov Moscow State University.

**André Oliveira** is a BSc in Business Management, Universidade dos Açores, and MSc in Business Management, Universidade dos Açores. PhD student in Management/Finance, Universidade dos Açores. Finance Assistent Professor at School of Business and Economics, Universidade dos Açores since 2020 and researcher. Expert in corporate finance.

**Elsa Patricia Orozco Quijano** has been teaching at Laurentian University over the past 15 years marketing and overall management courses. She leads the development of experiential learning components of the BBA, HBCom and MBA curriculums at the Faculty of Management, additionally she has acted as academic advisor in other institutions nationally and internationally. Her research spanned different areas of Management and business overall.

**Hatice Ozturk** is a research assistant at Aksaray University, Faculty of Health Sciences, Department of Social Work. She received her master degrees on Peer Bullying and School Social Work from the Ankara Yıldırım Beyazıt University. She is a PhD candidate in the Department of Social Work at the University of Ankara. Her main research interests include peer bullying and conflict resolution, intergroup relations, youth and social policy, ecological social work.

**Himanshhu Panwar** is an architect and environmental planner, working in the field of urban biodiversity, air pollution, and environmental management.

**Rui Pascoal** is currently an Ph.D. student of ISCTE-IUL, Lisbon, and a researcher of ISTAR-IUL. He is also a teacher at ISTEC, where he teaches several curricular units focused on Big Data, IoT, computer architecture, mathematical analysis, and techniques of graphic animation. Rui has an M.Sc. from University Lusófona (2017), entitled "Augmented Reality in Outdoor Sports". He also holds an BEng in Informatics Engineering by Autonomous University of Lisbon. Before, Rui has pursued an engineering career at HP (1998-2000) focused on UNIX and NT servers' configuration; at IBM (2004-2014) operating Mainframes Z/OS in Critical Recovery, software distribution, and fix management systems of biometric identity; at CTT (2015-2018) focused on planning and Management Control, Business Intelligence, Executive Information System and SAP Business Warehouse. Rui's research interests are data mining, mobile pervasive augmented reality systems, information overload, activity recognition, and speech recognition. Rui Pascoal explores current methods and technologies that can assist Augmented Reality (AR) technology in outdoor sports environments. However, the question of how to provide adequate information in real-time to end-users in uncontrolled environments and in an efficient and effective way is still an issue. Smart Data must be collected, sorted, processed, and distributed in real-time, the information must be useful for the end-user. If decontextualized information is provided or the end-user is flooded with information, then the AR technology is not adopted. The aim is to provide meaningful feedback to specific sports activities preventing information overload and improve the quality of experience.

**Pedro Pimentel** is a BSc in Business Management, Universidade dos Açores, 1999. MSc in Business Management/MBA, Instituto Superior de Economia e Gestão da Universidade de Lisboa, 2002. PhD in Management/Finance, Instituto Superior de Economia e Gestão da Universidade de Lisboa, 2009. Finance Professor at School of Business and Economics, Universidade dos Açores since 2000 and researcher at Center of Applied Economics Studies of the Atlantic since 2003. Expert in corporate finance, is director of the Master in Business Administration program at Universidade dos Açores since 2009.

**Alessia Pisoni** is Associate Professor at the Department of Economics - University of Insubria, where she teaches Innovation Management. She holds a Ph.D. in Economics of Production and Development, and coordinates the research unit of the Research Centre for Innovation and Life Sciences Management (CRESIT). Since 2010, she has also been collaborating with Mind the Bridge Foundation's research activities on European ICT startup ecosystems. Nowadays, her research interests are in the area of innovation, internationalization and entrepreneurship. She is author of an extensive list of articles and books in the fields of innovation, entrepreneurship, corporate governance and international business.

**João Crispim Ponte** holds a bachelor's degree in Business Management from the University of the Azores. MSc in Environmental Sustainability, University of the Azores. Ph.D. in Business Administration from the University of the Azores, 2020. Consultant and researcher. Specialist in tourism.

**João Ribeiro** has a bachelor's degree in Marketing Management from IPAM Marketing School, Porto, Portugal. His main interests are related to sustainability in general. He believes in sustainability in any area as long as duly recognized and supported.

**Carlos Santos** is President of the Azores Tourism Observatory (OTA).

**Fabio Sirigu** earned his Bachelor's Degree in Naval Engineering from the University of Genoa in 2016. After several experiences in the nautical sector, he decided to broaden his knowledge and opportunities by attending a Master in the Management field. He earned a Master's Degree in "Global Entrepreneurship Economics and Management" from the University of Insubria in 2021, with a specialization in "International Business and Entrepreneurship". He's passionate about Circular Economy themes and more in general about environmental sustainability related issues.

**Mariana Sousa** has a bachelor's degree in Management and Planning in Tourism from the University of Aveiro, Portugal, and is currently a student of the Master's Program in Management and Planning in Tourism at the University of Aveiro. She is interested in tourism, entrepreneurship, and sustainability.

**Nina Szczygiel** is a professor in the Department of Economics, Management, Industrial Engineering and Tourism, University of Aveiro, Portugal, and an effective member of the Research Unit on Governance, Competitiveness and Public Policies. Her research interests comprise quality of life, happiness and well-being in societies, organizations and individuals. She has been working on intersectoral, inter-organizational and social networks, partnerships, integration and mobility in diverse contexts.

**Saritha Vara** completed M.Sc, M.Tech and Ph.D in Environmental Science and Management. She holds 17 Years of experience in teaching and research. Her research areas include water and wastewater treatment, epidemiological studies, and corrosion studies.

**José G. Vargas-Hernández**, M.B.A., Ph.D., Member of the National System of Researchers of Mexico and a research professor at University Center for Economic and Managerial Sciences, University of Guadalajara. Professor Vargas-Hernández has a Ph. D. in Public Administration and a Ph.D. in Organizational Economics. He has undertaken studies in Organisational Behaviour and has a Master of Business Administration, published four books and more than 200 papers in international journals and reviews (some translated to English, French, German, Portuguese, Farsi, Chinese, etc.) and more than 300 essays in national journals and reviews. He has obtained several international Awards and recognition.

**Edwin Vegas-Gallo** is a Doctor of Political Science, Doctor of Environmental Sciences, Master of Science, Mention in Zoology, Biologist. Specialist in public policies for sustainable development, public management, research on biological diversity. With extensive experience in Senior Management positions in the public sector (15 years).

**Phuong Thi Vi** (MSc), is an Assistant Professor at the Faculty of Journalism, Communications and Literature, TNU – Thai Nguyen University of Science in Vietnam. She has a strong passion for journalism and sustainable development and has published many news articles. Currently, she is doing her PhD in Journalism and Communication at TNU.

**Durmuş Çağrı Yıldırım** was born in 1981. After graduating from Kocaeli University, Department of Economics in 2005, he started to study for a master's degree in Economics. In 2007, he received a master's degree in Economic Policy. In 2011, he received his PhD in Economics. While working as a doctoral student, he worked at the University of Almeria-Spain for a while. He worked as a research assistant at Kocaeli University between 2006-2012. He worked as an Assistant Professor at the Department of Banking and Finance at Recep Tayyip Erdoğan University between 2013-2015. Since April 2015, he has been working as Professor at Tekirdag Namık Kemal University. His current research interests are current and emerging issues such as sustainable development, energy, health, employment, and Islamic economics.

**Filiz Yildirim** is an associate professor at Ankara University, Faculty of Health Sciences, Department of Social Work. She was awarded a "Doctorate Research Scholarship" from TUBITAK to carry out a part of her doctorate research at the Department of Sociology, Criminology & Law at the University of Florida, the USA in 2011. She received the "International Young Scholar Award" from the Society for Research on Adolescence in Canada in 2012. Her main research interests include love, early (child) marriage, social policy, sustainable development, ecology. She is also a post-doctoral fellow at Hacettepe University, Department of Sociology.

**Seda Yıldırım** currently works at Tekirdag Namık Kemal University in Turkey. She studies on sustainable development, 2030 sustainable development goals, sustainable consumption patterns, Islamic finance and banking, consumption patterns, environmental quality and food security. She is a married and has one child.

# Index

# D



# E

# F



# G



# H



# I



# L

## M



## N



## O



## P

## Q



## R



## S

# T



# U



# V



# W