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Mapping, Managing, and Crafting Sustainable Business Strategies for the Circular Economy

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and Nuno Miguel Castanheira Almeida

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This chapter analyses the guiding principles that companies in the tourism sector should follow to implement a management model that conforms to the new paradigm of the circular economy. To do this, the authors contextualise this new model in the important sector of tourism, creating the concept of circular tourism, and they argue that many of the innovations being incorporated in this sector are oriented to eco-innovation. They also discuss the case of a Spanish urban hotel that has opted for circularity and sustainability, and finally, they propose, in line with the British Standard BS 8001:2017, that the application of the principles of system thinking, innovation, stewardship, collaboration, value optimization, and transparency will help companies in the tourism sector to focus on the new paradigm of the circular economy.

In the last decades, the concern over natural resources, sustainability, and the current linear economic model based on continuous growth is one of the great challenges of our time. The assumption that there is an unlimited supply of natural resources and that the environment has an unlimited capacity to absorb waste and pollution is no longer a current trend, and growing attention has been paid to it worldwide. This chapter represents a contribution to the continuous conceptual development of circular economy and sustainability, and it also reviews how these two concepts have evolved over the past decades. An extensive literature review was conducted, employing bibliometric analysis to scrutinise the state of the art, the perspectives, the agreements and disagreements among these concepts and their correlation.

The 2030 Agenda is comprehensive, universal, and ambitious. To reach its goals, the world needs to invest US$5 to 7 trillion/year. To finance it, the private sector must be involved. This chapter considers the motivations of business and corporations to incorporate the SDG in their investment agenda and the role DFIs can play in providing financing to their projects. It acknowledges that the private sector is a key element for long-term sustainable development and highlights the difficulties of DFI in assessing impact in risk analysis and therefore financing private investments for sustainable development. Finally, it finds that the international community and developing countries need to work together to improve the business environment on those countries, and concludes that the international community and the banking system do not know how to assess the role and impact of business and corporations projects in the agenda, and that the risk mitigation policy does not consider the nature of DFIs. Looking into the future, the authors present future research topics needed on this subject.

This chapter aims to describe how the alignment of organizational competencies with the dimensions of the triple bottom line (TBL) in companies of the Brazilian chemical sector are integrated in the business strategy. This study used a methodological approach to qualitative research, the multiple case study strategy, covering three major producing companies in the Brazilian chemical industry: Braskem, Solvay, and Beta (fictitious name). As regards the scale interactions of organizational competence between the environmental pillars, economic, and social TBL, the analysis was done taking as a basis the properties of eco-efficiency, environmental justice, and social justice. Besides the three skills characterized by TBL interaction model for sustainable development, the competence of eco-innovation was evident, with the internal factors that influence: strategic dimension of eco-innovation, collaboration networks, support of management leadership and top management.

This chapter has the objective to analyze the elements of urban green innovation based on the guarantee of the public interest to decentralize the infrastructure to democratize the territory and innovate the institutional design to address the complexity of the challenges in the city. The method employed is the critical analysis supported by a review of the literature and consultation of experts in the field. It is concluded that the urban green innovation capacity planning has a critical role in urban innovation development in specific areas of economic growth, social inclusion and equality, environmental sustainability, health, education, business, etc. To achieve these aims, urban green innovation requires one to guarantee the public interest, the democratization of the territory, and the new institutional design.

Digitalization is a topic of circular economy in the context of the ReSolve framework. The use of information and communication technologies (ICT) in the context of social organizations can provide added value in order to foster integrative solutions. The aim of this chapter is aligned with the literature about ICT, circular economy, and sustainability to present the design of a prototype that fits homeless person integration strategies and addresses concerns in the various dimensions of sustainability supported by ICT. The authors use the design science research methodology in order to communicate the prototype results for the integration of homeless people. The prototype will be developed under the assumption of use in an organizational context by a multidisciplinary team, aiming to allow the cooperation of the various entities involved. This is a contribution to achieving the Sustainable Development Goals. The main results of this research suggest how to develop, in partnership with local organizations, solutions to solve social problems supported by a sustainable perspective.

Section 2
Applied Perspectives: Products, Contexts, Consumers, and Strategies

This chapter gives a good grounding in view of the development of innovative technological solutions that enhance the valorisation and efficient use of marine resources through the integration of value chains, in a logic of circular economy, articulating food industry, biotechnology, and fisheries. Economy is a business model that extends the circular economy principles of sustainability and reuse to activities influencing the world's aquatic ecosystems, not only seas, oceans, and coastlines, but rivers and lakes, too. Both combine concepts of design out waste and pollution, keep products and materials in use, regenerate natural systems, sustainability, and share economy. However, the blue economy goes further to strengthen competitiveness by lowering costs and pursuing a more effective economy of scale. Consequently, the circular economy is becoming increasingly tinged with blue. The aim of this chapter was to present two case studies on sustainable business strategies for the circular blue economy.

This chapter aims to analyze the main factors of the production and consumption of organic products, as well as their policies and strategies. The analysis is based on the premise of the sustainable development of the production, distribution, and consumption systems of organic products that have the potential to improve the quality of life levels of producers, consumers, and society. It is concluded that the production and consumption of organic food is based on a more favorable agriculture of the ecological and the environment, as well as by providing more nutritious and healthy food for consumption.

This chapter is a unique case study that aims to present the evolution of non-financial reporting in Nestlé Portugal from 2007 to 2016 with the aim to study in-depth the Nestlé sustainability report practices. This study proposes to identify the key milestones in the evolution of this type of report, to compare with the disclosure strategy of Nestlé international, to understand if this company follow the IIRC guidelines, to identify the contribution of the audit by an independent entity, to conclude if Nestlé contributes to the achieving of United Nations Sustainable Development Goals, and to identify if the awards Nestlé received matter in its sustainability initiatives. Public institutional information was preferably used, particularly the sustainability report and integrated report, processed with various work tools using the technique of content analysis. The conclusions made it possible to understand that Nestlé emerges as a company that integrates these issues into its strategy and can be a model for companies that wish to follow this report path towards sustainability.

The agroforest sector plays a leading role as a biomass supplier to obtain bio-based products that allowed an acceleration in the circular bioeconomy transition. This chapter applied a mixed-methods review to identify new attractive bio-based products and to evaluate its market potential in Portugal. Forest biomass was identified as an excellent raw material for (1) low-carbon building materials, (2) biotextiles, and (3) bioplastics. The potential of agro-food waste to obtain new bio-based materials was also emphasised. The new bioproducts identified have high potential and attractive markets. It was estimated that a 5% market share of these bioproducts in the global construction, textiles, and plastics markets in 2030 corresponds to an aggregate increase in revenues of 260-579 million € per year in Portugal. The environmental sustainability implications arising from the diffusion of these new biomaterials are also highlighted, focusing on the decarbonisation of the economy.

Preface

Business strategy defines how a company uses its competencies and resources to competitively operate in its markets. As planet resources are limited, environmental awareness has grown over the recent decades. Businesses of all forms are being forced to incorporate more sustainable approaches to carrying out their activities. Organizations cannot maintain existing practices without placing future resources at risk. Organizations that develop sustainable business strategies that deliver enhanced value by radically reducing material inputs and engaging consumers on circular economy will be well-positioned for success. organizations would be called to innovate; to implement new business models; to redesign waste, to reduce pollution, to redefine products by extending its life-cycle and services; to reduce costs; to develop and implement reuse, repair, remanufacture and recycling strategies and to improve environmental performance. This book attempts to make a major contribution by sharing sustainable business strategies of implemented circular economy principles. It attempts to show that is possible and feasible to implement circular economy regardless the type of organization. It attempts to encourage other firms to implement sustainable business strategies, creating a major and worldwide snow ball effect of circularity knowledge dissemination.

This book provides concepts and examples of sustainable business strategies for the circular economy. Sustainable business strategies for the circular economy has been gaining gradual attention from researchers, and there are some conceptual and theoretical contributions. However, it has been studied mostly in large firms. Though, it can be applied in any organization: medium, small enterprises, social organizations, etc. To broadly disseminate sustainable business strategies for the circular economy, it is crucial to extend it to all kinds of organizations. All kind of organizations are important providers of circular solutions. This book will provide empirical, conceptual and theoretical contributions to the area of sustainable business strategies for the circular economy in all kind of organizations. It will illustrate facts, trends, concepts, strategies and practices of organizations' circular solutions. It will provide examples of new business models, innovation, technology and digital economy (e-business, e-services, e-government and e-society), networks and collaborative best practices applied in all kind of organizations. It will describe consumers' and enterprises' perception of sustainable business strategies for the circular economy principles. It will debate and promote design strategies to waste use and pollution save, to keep products and materials in use and to regenerate natural systems in organizations. It will provide insights of the skills and competences required, as well as economic policies to sustainable business strategies for circular economy implementation. This book will share relevant information to scale up sustainable business strategies for circular solutions activities in all kind of organizations. It attempts to help and inspire businesses and consumers to make the transition to a stronger and more circular economy where resources are used in a more sustainable way.

This book has fifteen chapters and is organized into two major sections, which we will now present below. The first major section presents the conceptual and theoretical perspectives to conceptualize the theme in question and build a theoretical framework that allows us to understand the importance of producing research and knowledge in this area.

In chapter one the aim of this chapter is to present a research agenda that can help to advance in the generation of scientific knowledge intended to support the implementation of circular economy initiatives in the tourism industry. In this line, a dialogue was used as a starting point, which was checked with academics and professionals in this field in order to refine the initial proposal and enrichen it with new research opportunities and challenges. As a result, a research framework has been created organized in four sections, according to their nature: economic/business, social, environmental and cross-sectional. Nevertheless, in spite of the particular character of each of them, their interconnections are also underlined in order to contribute to the progressive development of a more circular tourism economy.

The second chapter analyses the guiding principles which companies in the tourism sector should follow to implement a management model that conforms to the new paradigm of the circular economy. To do this, the authors contextualize this new model in the important sector of tourism, creating the concept of circular tourism, and they argue that many of the innovations being incorporated in this sector are oriented to eco-innovation. They also discuss the case of a Spanish urban hotel that has opted for circularity and sustainability, and, finally, they propose, in line with the British Standard BS 8001:2017, that the application of the principles of system thinking, innovation, stewardship, collaboration, value optimization and transparency will help companies in the tourism sector to focus on the new paradigm of the circular economy.

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The 2030 Agenda is comprehensive, universal and ambitious. To reach its goals the World needs to invest US$5 to 7 trillion/year. To finance it, private sector must be involved. This fourth chapter considers the motivations of business and corporations to incorporate the SDG in their investment agenda, and the role DFIs can play in providing financing to their projects. It acknowledges that private sector is a key element for long-term sustainable development and highlights the difficulties of DFI in assessing impact in risk analysis and therefore financing private investments for sustainable development. Finally, it finds that the International Community and developing countries need to work together to improve the business environment on those countries, and concludes that the International Community and the Banking System do not know how to assess the role and impact of business and corporations projects in the Agenda and, that the risk mitigation policy does not consider the nature of DFIs. Looking into the future the authors present future research topics needed on this subject.

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Digitalization is a topic of circular economy in the context of the ReSolve framework. The use of Information and Communication Technologies (ICT) in the context of social organizations can provide added value in order to foster integrative solutions. The aim of this seventh chapter is aligned with the literature about ICT, Circular Economy and Sustainability, to present the design of a prototype that fits homeless person integration strategies and addresses concerns in the various dimensions of sustainability supported by ICT. We use the Design Science Research methodology in order to communicate the prototype results for the integration of homeless people. The prototype will be developed under the assumption of use in an organizational context by a multidisciplinary team, aiming to allow the cooperation of the various entities involved. This is a contribution to achieving the Sustainable Development Goals. The main results of this research suggest how to develop, in partnership with local organizations solutions to solve social problems supported by a sustainable perspective.

The second major section of this book presents the Applied Perspectives: Products, Contexts, Consumers and Strategies. today it is increasingly sought to boost all knowledge produced through its applicability in society and the economy. Sharing this knowledge is part of the social responsibility that many higher education institutions and researchers must promote. Innovating with new products, understanding social and economic contexts, defining strategies based on market studies, developed, enhancing opportunities thus contributing to people's well-being is fundamental to the planet's sustainability.

The eighth chapter gives a good grounding in view of the development of innovative technological solutions that enhance the valorization and efficient use of marine resources through the integration of value chains, in a logic of Circular Economy, articulating: food industry, biotechnology and fisheries. Economy is a business model that extends the Circular Economy principles of sustainability and reuse to activities influencing the world's aquatic ecosystems, not only seas, oceans and coastlines but rivers and lakes too. Both combine concepts of design out waste and pollution, keep products and materials in use, regenerate natural systems, sustainability, and share economy. However, the Blue Economy goes further to strengthen competitiveness by lowering costs and pursuing a more effective economy of scale. Consequently, the Circular Economy is becoming increasingly tinged with blue. The aim of this chapter was to present tow case studies on sustainable business strategies for the circular blue economy.

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Designing circular economy implying the adoption of a set of circular principles that support a society for future. Understanding how CE principles influence attitudes to consume green products is a key factor aligned with the consumer trends. This twelfth chapter aims to study how CE principles influence attitudes to consume green products in a particular case of fashion industry. According to Ellen MacArthur Foundation “clothing represents more than 60% of the total textiles used and in the last 15 years, clothing production has approximately doubled, driven by a growing middle-class population across the globe and increased per capita sales in mature economies. At the same time, clothing use has declined by almost 40%. Both developments are mainly due to the ‘fast fashion’ phenomenon, with quicker turnaround of new styles, increased number of collections offered per year, and often, lower prices”. This chapter aims to cover aims a gap and contributes to improve applied studies about this topic.

This thirteenth chapter talks about plastics. Plastic is an indispensable material for modern society. However, plastic waste is at the center of the current debate due to its presence and persistence in aquatic ecosystems. The literature recognizes that this problem is mainly due to the traditional linear economic model. The circular economy is a model based on the practices of reduction, reuse, recovery and recycling of materials and energy. Circular economy solutions for plastic could hold the key to its present and future sustainability. Investigating the studies already done about plastic in the context of a circular economy is fundamental to understand where we are and where we can go.

The fourteenth chapter analyses Repair Café Porto (RCP) through the lens of a SWOT (strengths, weaknesses, opportunities, threats) method. Based on the event-RCP held for three hours on a Saturday every 2 months from June 17, 2017 until April 28, 2018 and on a new economics approach of circular economy. It is intended to examine the potentialities and challenges of RCP. Repair Cafés are 'workshops' for people to bring consumer products in need of repair where they with volunteer fixers learn repair, maintain their broken or faulty products, or try product modification. It is a RCP-requirement that visitors who bring products participate in repairs undertaken. Regular repair stations include: Bike, Electrical and Electronic, Clothing and Jewellery. The SWOT method is used to assess internal and external aspects of RCP. It is concluded that the success of RCP is dependent on financial support, the maturity of repair notion, and the alteration of consumers and producers' attitude to see waste as a resource and to extend the life of a product.

And we have reached the fifteenth and final chapter of this book. Humanity and planet Earth have no long-term future unless there is a commitment to respect and to live within its ecological boundaries, which demands a transition from the prevailing economic system, the linear economic system, to another that is circular. One that is focused on resource management. There is a need for society to implement the circular economy principles. Principles that are expressed with words start with the letter "r" as a guide for resource management. Several are the researchers that have studied and extended the Circular Economy principles, i.e. the R's. Some have outlined the "7 R's", they are: Reduce, Repair, Reuse, Refurbish, Recycle, Recover, Rethink. The construction sector is one of the sectors that mostly impacts directly and indirectly on the environment throughout the buildings' life cycle. During construction, occupancy, renovation, demolition processes as well as their use of energy, water, and raw materials, waste and harmful atmospheric emissions are generated. Taking these considerations into account the need to pursue for more sustainable paradigms have materialized. Therefore, implementing circular models, which would allow to create green building standards, certifications, and rating systems to promote the mitigation of the construction industry on the environment through a sustainable design has been gaining momentum. Developed and developing economies are adopting the concept of Circular Economy (CE) as an approach that can lead to the development and enhancement of markets for recovered materials. This chapter aims to analyze awareness, challenges, enablers that the implementation of Circular economy has in the perspective of consumers, architects and builders (building companies). How aware are consumers, architects and building companies about the circular economy concept and the 7R's circular economy principles; what challenges do they face to apply it; is there a lack of knowledge, operating systems, or government legislation that are creating obstacles? what could boost its implementation; what could stimulate, consumers and companies to apply circular economy? and the attitude do they have to implement it; are they willing to sacrifice comfort or price to implement them? are they applying the 7'Rs ?

Data were collected using a hybrid research strategy. Different research strategies and data collection methods were used to achieve the research objectives and to respond to the research questions. Secondary data, as well as primary data in the form of interviews and questionnaires were applied to the construction sector in Panama. Secondary data were used by analyzing surveys and statistical information. The interviews were conducted to understand the circular economy aspects in general and worldwide. Through a critical analysis of the literature, in in-depth interviews and semi-structured interviews with, architects, consumers, engineers and managers of building companies', key factors were identified by consumers, architects and building companies regarding awareness, attitudes, challenges involving the implementation of circular economy in the construction sector in Panama. Based on the interviews a survey instrument was designed and applied. Data were collected between December 2018 and January of 2019. Six hundred and fifty valid questionnaires were collected. The results showed that consumers are aware of the circular economy concept. However, they only acknowledge some of the circular economy principles. Several challenges were also highlighted, bringing to light the importance of the role of policymakers for CE implementation. The architects are very aware of the concept of the circular economy, as well as the 7R's principles. Most of the challenges identified were lack of finance support, lack of legislation, lack of supervision, lack of punishment from the government, and lack of knowledge from the society.

Throughout these 15 chapters we have tried to make readers aware of the importance and opportunity of the circular economy as the basis for the social and economic sustainability of society. We cannot continue to waste resources and put pressure on the production chain to produce more and more. We do have to educate for sustainability, for minimal waste, for circularity and collective well-being.

In conclusion, we cannot fail to thank all the authors who made the organization of this book possible. Your collaboration has allowed us to learn more about this very important topic, it has enabled us to sensitize more authors to research and produce for the circular economy. Thank you for your inspiration and you have our recognition!

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Section 1

Conceptual and Theoretical Perspectives

Chapter 1
Tourism Circular Economy:
Proposal for a Research Agenda

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ABSTRACT

The aim of this chapter is to present a research agenda that can help to advance the generation of scientific knowledge intended to support the implementation of circular economy initiatives in the tourism industry. In this line, a decalogue was used as a starting point, which was checked with academics and professionals in this field in order to refine the initial proposal and enrich it with new research opportunities and challenges. As a result, a research framework has been created and organized into four sections, according to their nature: economic/business, social, environmental, and cross-sectional. Nevertheless, in spite of the particular character of each of them, their interconnections are also underlined in order to contribute to the progressive development of a more circular tourism economy.

INTRODUCTION

The aim of this chapter is to present the results and conclusions from a survey carried out with the participation of a panel of experts (academics and professionals) in the intersection between the tourism industry and the circular economy (CE), with the intention to contribute to the establishment of a research agenda in this still insufficiently explored domain.

As a previous step to the recommendation of future research avenues in this field, a systematic literature review is required to clarify what has been done so far. Very few works with that focus have been published till this moment, and very recently, specially Vargas-Sánchez (2018, 2019). The paper by Pan et al. (2018) is also considered a review work, although with a different scope (it provides an overview of the interrelationships between tourism and sustainability from a cross-disciplinary perspective). For this reason, the former contributions will be used as the foundation of the research presented here.

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The relevance of this document rests on its novelty, as, to the best of the author's knowledge, this is the first attempt of this type done in this field of study, with the creation of a research framework intended to contribute to the progressive development of a more circular tourism economy. Although its implications are mainly academic, the participation of a number of tourism professionals in the formation of the proposed agenda also helps to match their concerns and, therefore, to secure its practical implications.

Beyond recycling and other R's present in the literature (reuse, reduce, etc.), the CE model is inspired by the cycles of ecological systems and, therefore, intended to eliminate waste generation. In this line, in the Circular Economy Package Report issued in Brussels on 4 March 2019 by the European Commission, it is said that: "In a circular economy the value of products and materials is maintained for as long as possible; waste and resources use are minimised, and they are kept within the economy when a product has reached the end of its life, to be used again and again to create further value"[1]. In addition, according to Ten Brink et al. (2017):"This requires actions ranging from upstream product innovation to downstream waste and recycling infrastructure, as well as engagement by governments, businesses and citizens", that is, a greater collaboration among all these actors (known as industrial symbiosis) able to lead to the creation of circular ecosystems integrated, for example, by firms in sectors such as tourism, agriculture, energy generation, etc., interconnecting them for the creation of synergies in this area.

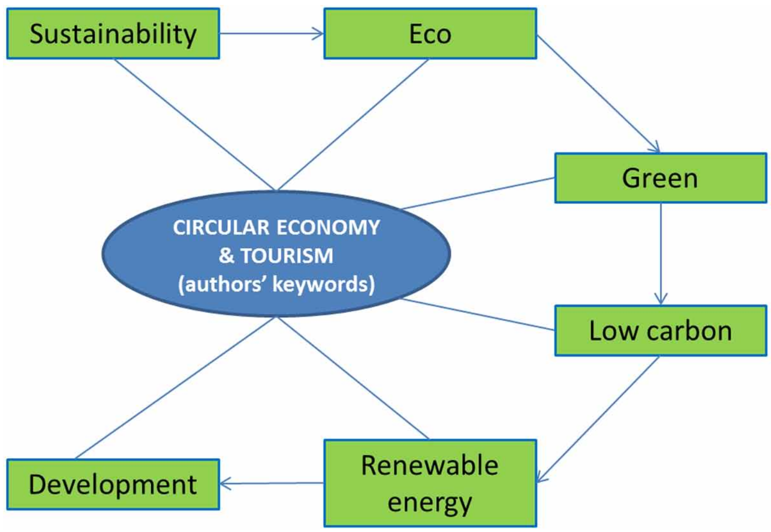
Under these bases, this chapter is organized as follows: firstly, the antecedents of the current research are presented; secondly, the methodology used to reach the abovementioned aim is explained; finally, results and conclusions complete this document.

ANTECEDENTS

Although CE is not a new concept -for Hens et al. (2018) it dates back to late 1970s-, its application to the tourism industry is still in an early stage of development. Originally applied to the environmental sustainability of industrial activities, the CE approach is also being spread into service sectors such as tourism (Hens et al., 2018). Nevertheless, in spite of its relatively late arrival to this model shift, it is important to note the potentially significant role that tourism companies and destinations can play in the transition from a linear (unsustainable) economy to a circular (sustainable) economy, since the tourism industry is, undoubtedly, one of the most impactful socio-economic activities at the global level.

Similarly in the academic field, Vargas-Sánchez (2018, 2019) has recently begun to address the challenge to systematize the state of the art of scientific research in the intersection between Circular Economy and Tourism, through the identification of the topics and methodological approaches used by researchers when studying the implementation of circular economy initiatives in the tourism sector. Thereby, the connections among the keywords utilized by authors, displayed in Figure 1, can show how the intersection between CE and tourism has been mostly addressed in the academic literature, from a conceptual point of view. Thus, the most numerous keywords are those related to sustainability issues, followed by eco and green topics; low carbon, renewable energy and development matters are next in quantitative importance.

Figure 1. Keywords association
Note: Eco refers to Eco-agricultural tourism or Eco-tourism, Eco-costs, Eco-efficient value creation, Eco-industrial system, Eco-innovations, Ecological benefits/environment.
Source: own elaboration.



As a result, a number of research lines have been characterized, at the same time that, in an attempt to contribute to bridging some significant gaps in a domain still in its infancy, an initial research agenda has been proposed with a decalogue of new lines (to be added to those already in motion) to guide the future research efforts (Vargas-Sánchez, 2019). That decalogue of new research avenues in this field of study follow:

1. Business implications of the transition to a circular economy in tourism.
2. Design and implementation of new circular business models and new entrepreneurial opportunities.
3. Holistic planning, strict impact assessments, and effective management of circular economy initiatives.
4. Identification and dissemination of good practices.
5. The insertion of Circular Economy initiatives within the framework of Corporate Social Responsibility (CSR) policies.
6. The creation of metrics for monitoring the progress of circular economy initiatives within a framework of smart tourism.
7. From a public policy perspective, the effectiveness analysis of the diverse instruments for stimulating the adoption of circular economy initiatives.
8. The interplay between the collaborative economy and the circular economy in tourism.
9. A better understanding of the factors capable of facilitating (accelerators) and hindering (brakes) the implementation of circular economy strategies.
10. Impacts of the application of circular economy principles in major tourism segments, such as sun & beach, urban tourism, etc.

The methodology utilized to check this proposal and, eventually, confirm and improve it, is explained in the next section.

METHODOLOGY

To confirm and add value to the initially proposed research agenda, refining it and prioritising their working lines, a consultation to experts was designed and implemented. Thereby, the required experts' insight was gained via a consultation process executed during the month of November 2019 via TRINET (Tourism Research Information Network, http://www.tim.hawaii.edu/trinet), the largest international tourism research and education community, and other groups of academics and professionals on tourism and circular economy in social networks (Facebook and LinkedIn).

For this exploratory study, an online questionnaire using the "Google Docs" tool was created in the English language, which was divided into three sections. In the first one, respondents were asked to assess the level of importance of each proposed research line in a scale from 0 to 10 (that is, from not at all important to extremely important), according to their experience and understanding of its relevance for the tourism industry in its transition to a CE. In the second section, with the purpose to identify research gaps and refine our research agenda, they were asked to propose other relevant research lines (up to three). The last part is set up by three questions intended to characterize the respondents' profile: occupational context (academic and/or professional), years of experience in the tourism sector, and affiliation (country).

A total of 52 valid responses were collected. The results obtained are detailed next.

RESULTS

In the characterization of the participating experts, with regard to their occupational context, almost three-quarters of them are academics (73.1%), 11.5% are tourism professionals, and the remaining 15.4% perform both roles. Concerning the number of years of experience in the tourism sector, the dispersion is very pronounced, with a mean of 16.85 years (standard deviation of 9.965) and a median of 15 years. Finally, the most frequent countries of affiliation are Portugal and Spain (with 10 and 8 respondents, respectively), followed by the US, UK, Japan, Poland and Bulgaria with 3 each on them.

Concerning the importance attributed (from 0 to 10) to the ten research lines proposed in the agenda, the results, in terms of descriptive statistics, are synthesized in Table 1.

Even though there are no big differences among the lines in this decalogue and all of them have been conferred a relatively high level of importance, which can be considered a confirmation of the adequacy of this proposal (although open to newlines), it is clear that academics and professionals are eager to know good practices in tourism circular economy, thereby its identification and dissemination has been considered by the panel of experts as the highest priority.

In addition, beyond the usual focus on its environmental implications, the analysis of business implications of the transition to a circular economy in tourism has been given the second highest importance. Its application in major tourism segments (such as sun & beach or urban tourism), together with the investigation of new circular business models and new entrepreneurial opportunities, are the lines leading this pack. Concerning the latter, it is worth to note that those informants with a professional career

Table 1. Importance of research lines (descriptive statistics)

Research Lines	Median	Mode	Mean	Standard Deviation
01.-Business implications of the transition to a circular economy in tourism.	9	10	8.50	1.365
02.-Design and implementation of new circular business models and new entrepreneurial opportunities.	9	10	8.45	1.629
03.-Holistic planning, strict impact assessments, and effective management of circular economy initiatives.	8	9	8.12	1.478
04.-Identification and dissemination of good practices.	9	10	8.78	1.501
05.-The insertion of Circular Economy initiatives within the framework of Corporate Social Responsibility policies.	8	9	7.76	2.329
06.-The creation of metrics for monitoring the progress of circular economy initiatives within a framework of smart tourism.	8	8	8.26	1.454
07.-From a public policy perspective, the effectiveness analysis of the diverse instruments for stimulating the adoption of circular economy initiatives.	8	8	7.94	1.618
08.-The interplay between the collaborative economy and the circular economy in tourism.	8	9	8.10	1.652
09.-A better understanding of the factors capable of facilitating (accelerators) and hindering (brakes) the implementation of circular economy strategies.	8	8	8.20	1.600
10.-Impacts of the application of circular economy principles in major tourism segments, such as sun & beach, urban tourism, etc.	8	8	8.47	1.270

Source: own elaboration.

(not pure academics) value even higher the importance of doing research on new business models and entrepreneurial opportunities in the context of a circular tourism economy. In fact, this has been the only statistically significant difference found after the application of Kruskal-Wallis' (non-parametrical) test, based on respondents' occupational profiles.

Conversely, there are two lines where the levels of assigned importance are the lowest, although still high: at the bottom of this decalogue is the connection between CE initiatives and CSR policies (it could be argued that CE initiatives are seen as business practices that go beyond usual CSR actions), followed by the analysis of the effectiveness of public policy measures for stimulating circularity within the tourism industry (a certain background on this matter already exists in other sectors).

When asked about other relevant research lines in order to identify research gaps and refine the initial research agenda, the most repeated topics have been "sharing economy" (its contribution to a CE) and "waste" (in reference to food, water, energy, plastic…and its management towards the desideratum of its elimination). In fact, they had been already identified in Vargas-Sánchez (2019).

The social dimension of CE has been also emphasized, underlining the need to approach this subject from the guest's and the host's points of view, promoting a dialogue with them and learning from circular cultures.

Other referred topics have been the following, although some of them are not new and, in fact, are being already tackled (Vargas-Sánchez, 2019): incentives (pricing, subsidies…to stimulate the implementation of CE initiatives); benefits, but also challenges and obstacles (for companies and destinations, for instance in the case of the transformation from community-based tourism into circular community-based tourism); certifications (of the circular character of tourist products, routes and destinations, such as zero waste certifications); implications for economic growth (linked to the innovations required in business models -entrepreneurship-, production processes -quality management-, consumption patterns –for different target groups-); circular destinations design (planning); CE and Sustainable Development Goals; the roles of the public sector (at central, regional and local level) in the promotion of circularity in tourism; CE and smart tourism (with the support of big data).

Therefore, as our main conclusion, the research agenda initially proposed will be enrichened accordingly, as detailed in the next section.

CONCLUSION

Within the paradigm of sustainability, the transition from a linear to a circular economy is an ongoing process, and, unavoidably, the tourism industry is part of it. According to Mathews' (2011), naturalising capitalism is the next great transformation ahead, preventing the destruction of humankind's resource base and its biosphere. To this respect, the tourism industry not only cannot be an exception, but it has to play a significant role in this model shift.

Consistently, further research in the intersection between the circular economy and tourism is clearly needed, since the development of this domain in the academic literature is still in an incipient phase. To promote it, new lines of research should be cultivated, and the intention of the survey carried out was to identify those more relevant or with higher priority based on the existing opportunities and challenges for circular economy implementation in the tourism sector.

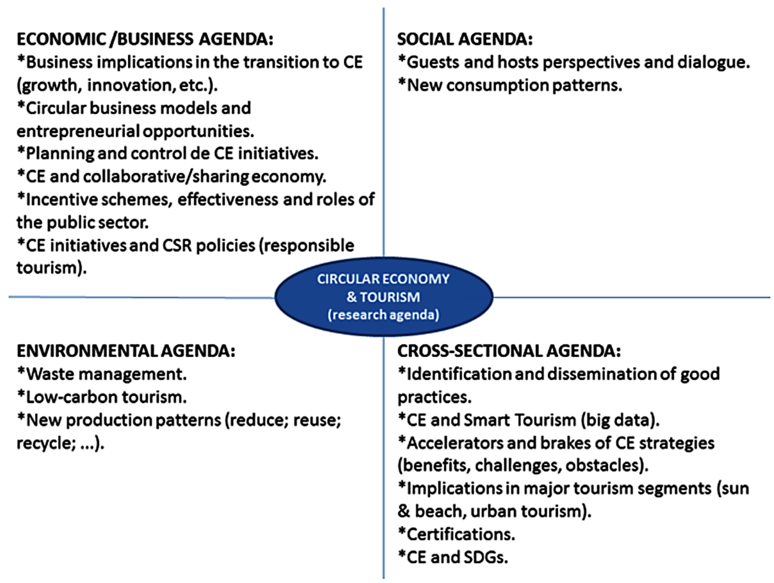
Tourism professionals and academics familiar with this specific field have participated, in a number of 52 in total.

The discussion of the results obtained leads to the proposal of a richer agenda, which is displayed in figure 2 organized in four sections, according to their nature: economic/business, social, environmental and cross-sectional.

Notwithstanding the particular focus of each agenda section, they can not be considered as silos. By the contrary, there are interconnections between lines in different sections. For instance:

- The interplay between environmental and economic/business axes. The identification of new forms of providing tourist services based on the R principles of a circular economy, mitigating the carbon footprint and waste generation, will require, to certain extent, the reconfiguration of tourism services providers' value chains (hotels, restaurants, etc.), the ability to manage change within their organizations as a result of the innovations to be incorporated in the corresponding internal processes, or even update traditional business models (value proposition, key resources and activities, etc.).
- The interplay between environmental and social axes. The new production patterns, with an improved environmental record, have to meet the new consumption patterns and lifestyles (Kjaer, 2015). Anticipating hosts and guests reactions to CE initiatives is a must for their right implementation, which demands a dialogue with them. The depth of this understanding will allow the design of sensibilization and educational activities intended for the removal of social barriers that could exist.

Figure 2. Research agenda
Source: own elaboration.



- The interplay between social and economic/business axes. New patterns of consumption are in the foundations of new (circular) business models and entrepreneurial opportunities.
- The interplay among the three backbone axes of the agenda. The transition from a linear to a circular tourism economy has implications in all these dimensions, not environmental only (where the spotlight has been mainly pointing), but also social and economic (including business management repercussions). The contribution of tourism, and the application of circularity in it, to the achievement of the UN's Sustainable Development Goals (SDGs) is a clear example. Likewise, the concept of smart tourism (CE can be pushed forward by it) has in its core the pillar of sustainability, with the three referred dimensions.

The significant reference in our survey to the sharing economy is noteworthy. Certainly, in the tourism supply chain is present everywhere, including how to get around, where to stay, what to eat, what to do, etc., but its role as a driver or contributor to a more circular tourism economy is controversial. On the one hand, defined as "a socio-economic model where the access to goods and services with excess capacity is provided to users through Internet-based platforms" (Kosintceva, 2016), product sharing platforms are usually considered circular business models (Larsson, 2018). The increased number of business models that promote sharing, instead of owning, where, through this kind of platforms, people may lease, rent or simply borrow things, instead of buying them, respond to a necessity which technology has helped enormously to address, particularly linked to goods and services which are infrequently used (vehicles, garments, electric gadgets, storage, etc.). But, on the other hand, going beyond the grass-roots initiatives that, thanks to this technology, allow people to directly interact and share with their peers in an almost unlimited way, the question is if models such as Airbnb and Uber (as iconic global examples) are genuinely circular or help to promote circularity. In this sense, the critical point of this discussion is not if a monetary transaction occurs, but if they represent "ways to collectively cut down on resource consumption, instead of helping in the financing of a continuation of existing consumption patterns" (Larsson, 2018), which would be their real contribution towards a circular economy. In many occasions, the difference between what sharing economy should be and what really it is -between, therefore, normative and descriptive approaches- is applicable here.

Finally, in spite of the exploratory nature of this piece of research, it is evident that it has its limitations. Although the population of experts in this field is undetermined, the representativeness of the panel of respondents are far to be claimed, and it was not the intention from a research design perspective, but to gather a preliminary insight, with global scope, from knowledgeable people, as part of a process aimed to guide research efforts in an still underexplored field of study.

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KEY TERMS AND DEFINITIONS

Circular Economy: An economic model oriented to eliminate waste generation, reuse/recycle products and materials, reduce as much as possible resources consumption as well as other actions to close material loops, and in sum, minimize the environmental impact.

Circular Economy Principles: Originally known as the 3R's (Reduce, Reuse, and Recycle), others have been added over time, such as Redesign, Repair, Refurbish, Recover, and others.

Circular Tourism Economy (or Tourism Circular Economy): The application of circular economy principles to tourism companies and destinations.

Exploratory Research: A type of research aimed to understand and describe, in a preliminary way, a mostly unknown subject of study, increasing the level of knowledge on it.

Linear Economy: An economic model based on the sequence take (raw material), make (products), use (consume), dispose (of non-recyclable waste), which has demonstrated to be unsustainable for both its resources consumption and its environmental impact.

Research Agenda: The proposal of research lines to guide researchers' efforts towards certain priorities aligned to opportunities and challenges that have been identified in the area under study.

Sharing Economy: A peer to peer model of socio-economic interaction that has extended its reach to non-members of a certain community (such as a family, group of friends, etc.) and even to physically distant people through Internet-based platforms, which allow the access (use) to goods and services with excess capacity. It is based on shared access to them instead of their ownership.

ENDNOTE

1. Available at: https://europa.eu/rapid/press-release_MEMO-19-1481_en.htm (accessed 30th November 2019).

Chapter 2
Guiding Principles of Design for Circular Tourism

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ABSTRACT

This chapter analyses the guiding principles that companies in the tourism sector should follow to implement a management model that conforms to the new paradigm of the circular economy. To do this, the authors contextualise this new model in the important sector of tourism, creating the concept of circular tourism, and they argue that many of the innovations being incorporated in this sector are oriented to eco-innovation. They also discuss the case of a Spanish urban hotel that has opted for circularity and sustainability, and finally, they propose, in line with the British Standard BS 8001:2017, that the application of the principles of system thinking, innovation, stewardship, collaboration, value optimization, and transparency will help companies in the tourism sector to focus on the new paradigm of the circular economy.

INTRODUCTION

Nowadays, governments, economists, activists and other voices are putting on the table the necessity of driving a new economic paradigm in which resources are better used, reused and recycled. In fact, increasing global demand for some resources such as petrol or food, growing population and consuption worldwide, and the price volatility of raw materials, among other things, are putting pressure on future access to resources (Whalen et al., 2017).

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In the case of tourism, the pressure is stronger because statistics show that tourists consume more resources and produce more waste and pollution than the destination population. In addition, transportation is one of the fastest-growing industries in all its categories and contributes in a not-small or best sustainable way to tourism.

Therefore, the circular economy (CE) is postulated as a possible solution to these problems. The CE supports the design of economic solutions according to ecological principles. It includes everything from the initial design to the final business solutions that can help satisfy the needs of the environment without causing major imbalances.

Thus, taking into account CE considerations during tourism planning deployment – design, planning, development – implies rethinking the current principles of design in tourism organisations with a holistic view of involvement and operations.

The three main objectives involved in a CE, according to Szita (2017), are protecting environmental capital, optimising resource extraction (use and reuse) and minimising negative externalities. These objectives also are valid for circular tourism (CT).

In this sense, the protection of the natural enviroment has been widely studied by previous researchers with a number of recommendations and success cases. In a lesser measure, how the human hand regenerates natural enviroments also has been studied, but more emphasis is needed on this issue to understand the best practices involved from a CE viewpoint.

Optimisation of resources in tourism is a relevant issue in industries such as hospitality or transportation where different green-friendly business practices have been adopted to reduce and recycle resources (e.g. Alonso-Almeida et al., 2017; Peeters et al., 2006). Nevertheless, research about reuse and practices such as circular redesign, remanufacturing and recovering remain underdeveloped. Some authors advocate for the development of eco-innovations in a wide sense as a way to approach a CE. For that reason, Alonso-Almeida et al. (2016, p. 8) suggest that 'eco-innovations could include numerous activities that affect businesses and tourist destinations in areas such as energy; recycling; water; new construction development; interior design; engineering projects; responses to external environmental degradation; new products, processes, and business models; adaptations of products and existing materials; new materials; the use of eco-biological products; spatial planning' and other ideas.

Finally, with regard to minimising tourism's negative externalities, some research also has been developed from the stakeholders' perspective, although other issues such as the increase of waste and the reduction of water reserves during high occupation periods (e.g. summer in sun and sand destinations) has been analysed less often.

Therefore the main questions that this book chapter will try to answer are:

- How could the main principles of CE apply to tourism?
- What is the role of eco-innovations to push CE?
- What design principles are the most relevant to drive CT?

BACKGROUND

Circular Tourism

At the end of the 1990s, Pearce and Turner (1990) mentioned the need to create a harmonious system between the environment and the economy, making the latter a part of the environmental ecosystem. They proposed to close the circle of the production-consumption-waste recycling chain, returning to use recycled products. As Murray et al. (2017) affirm, however, other scientists suggested this idea a long time ago. In 1848, von Hofmann, a German chemist, said it would be ideal if chemical factories could produce goods without generating waste. Similarly, Boulding (1966) advocated that humans should find their place in a cyclical ecological system that plays continuously, and based on these ideas, Stahel and Reday-Mulvey (1976) were the first to talk about a closed economic cycle.

As Rodriguez-Anton and Alonso-Almeida (2018, p. 5) say, 'since the beginning of industrialization people have followed an economic model that has served to increase the wealth average of the economy of the planet – but with large and serious inequalities, although at a cost very high: the deterioration and depletion of our planet's resources. This model, known as linear, supposed to extract raw materials – which means to go low, gradually, our resources, manufacture – what it means to go low energy factors and generating emissions of harmful gases-, consume and, lastly, disposal -what implies generate huge amounts of waste-'.

Because this model is unsustainable, the application of a new paradigm or economic model, known as the circular economy (CE), is required, prompting businesses to get products, once consumed, incorporated into the production process through recycling and reuse of the material.

The CE aims to close the loop of the flow of materials and energy and to contribute to the sustainability of the planet in the long term, improving the use of energy and resources, protecting the environment and promoting economic development (Rodriguez-Anton, 2018). It does this through implementation of the 3R rule: reduce, reuse and recycle:

- Reduce: Cut the level of consumption of resources and generation of waste throughout extraction, processing, production and consumption of materials.
- Reuse: Directly use waste as a product or as a component of other products.
- Recycle: Use waste as raw material directly after passing a specific process.

Other rules have been added more recently to these 3Rs; they are oriented in the same direction but expand the nuances. Rules such as renew, restore, replace, rework or reinstate go in this line, although other authors add repair to extend the service life of products, redesign to facilitate products' reuse or recycling after end of their useful life, rethink to make production processes more creative so they do not consume so many resources or generate as much waste and reinvent in the sense of search eco-innovations to make more efficient and sustainable both the processes and the offered products.

Therefore, the CE aims to reconcile economic development with protection of the environment in such a way as to ensure the planet's sustainability in the long term while maintaining adequate levels of productivity and economic efficiency. As a result, the CE 'directly affects both economic and social growth through the care of the environment, the maintenance and the creation of new jobs and the acquisition of new skills, new products and new businesses that boost the economy, promoting a sustainable future supported in the balance between the social, economic, and it respects the environment' (Rodriguez-Anton & Alonso-Almeida, 2018, p. 3).

For this new economic model to be efficient globally, it must be applied at both the geographical and sectoral levels. At a geographical level, it would serve little to have a few countries, aware of the importance of this new paradigm for their future, implement it if neighbouring countries did not. Hence it is important that large global institutions (e.g. the United Nations) or large political spaces (e.g. the European Union) encourage and promote the full implementation of this model. At the sectoral level, all economic sectors must implement the CE, specifically its underlying principles. Economic sectors are not isolated from the economic world; on the contrary, they are interconnected and must work together to achieve global economic objectives.

Most countries have experienced an outsourcing of their economy, and within the services sector, tourism is the main industry of employment and economic development. Its importance is such that, according to the United Nations World Tourism Organization (UNWTO, 2017), tourism contributes about 10% of the global gross domestic product (GDP) and accounts for approximately 7% of the world's services exports. It also is the fourth largest export sector after oil, chemicals and automotive industries, generating 235 million jobs, or one in ten jobs in the world. These data have been reinforced by the development of tourism in recent years. The tourism industry reached 1.322 million international tourists in 2017, an increase of 7% over the previous year (UNWTO, 2018). According to the latest data (United Nations Environment Programme, 2011), however, the tourism industry is responsible for 5% of global CO^2 emissions, direct water use in tourism varies between 100 and 2000 litres per guest nigt, and tourism sites generate much food waste and, in many cases, performed inadequate management of the waste.

In addition, tourism is changing worldwide, driven in part by the unsustainability of traditional tourism of the masses, according to authors such as Aguila et al. (2005). It also is adapting in part because of changes in consumption patterns which are causing tourism to turn to a model characterized by demand for quality and respect for the environment. In this sense, the application of CE principles to the tourism sector is referred to as circular tourism (CT). "By applying principles of circular economy, hospitality and tourism companies can contribute to the achievement of sustainable tourism. Hospitality industry (hotels and other accommodation facilities) are strictly engaged in sustainable initiatives, so they should implement and increase sustainability measure." (Girard & Nocca, 2017: 68).

The concept of CT, although recent and not yet widespread, is not new and has been cited in the literature. Thus, works like those of Qing-lei & Qing-zhong (2007), Feng-sheng & Li-peng (2007), Yingren (2008), Bin (2010), Guan-ping and Yong (2010), Lihong, Zhu and Qiang (2010), Ying-tao (2011), Ying (2011), Bin-bin, Dan and Yong-jin (2012), Ren, Hongmei and Kun (2012), Song et al. (2009), Xiaohong et al. (2016), Girard and Nocca (2017) and Vargas-Sanchez (2018), have analyzed the application of the CE to the tourism sector, especially the multiple papers carried out by Chinese researchers, to analyze specific cases of touristic áreas and tourism companies that are already implementing the principles of the CE. This is due, in line with pointed out by Vargas-Sanchez (2018), the Chinese government has based its strategy of sustainable development on the CE (Su et al., 2013).

As indicated by Xuemei and Cong (2015: 91)"Using concepts of circular economy, tourism circular economy is to strengthen recycling of tourism resources and enhance sustainable development of environment according to analysis of the tourism market, developing and training, tourism product design and development, enterprise management and tourism management, Tourism circular economy mode is following the principles of circular economy with tourism, to make resources cycle run, environmental improvement and sustainable develop of the tourism economy. Many scholars generally believe that tourism circular economy includes three aspects: tourism internal circulation; social circulation regional and tourism cycling."

As a result, we can define CT as an economic system that tries to make the tourism sector, in all its manifestations, capable of supporting the economic development of tourist destinations without putting the sustainability of the planet at risk by reducing the use of energy factors and natural resources, reusing the waste generated in the activities carried out, either as products directly or as components of other products, and using waste as direct raw material after of a recycling process.

Every enterprise, organization and agent involved in any of the stages or phases that make up the tourism industry must commit themselves to this new model. Companies, tourist intermediation, transportation, tourist accommodation, catering, entertainment and tourist animation, and a wide range of institutions and organizations that lend their support to tourism must act to achieve a model of CT based on reducing consumption of resources and generation of waste, reusing the waste generated either directly as products or components of other products and using properly the waste once it is recycled.

In addition to these three classic stages, companies and institutions in the tourism sector should implement new initiatives based on the other Rs outlined previously. It is necessary to repair damaged equipment to lengthen its useful life and to reinvent, in the sense of seeking eco-innovations that make processes and products more efficient and sustainable, both the facilities and services offered.

There is no doubt that the variety of subsectors comprising the tourism sector makes it difficult to propose general circular performances for all of them. Although ultimately the goal is the same, the initiatives of CT that can be developed into a hotel cannot be exactly the same as those that applied to an airline company or a travel agency. Therefore, negative externalities generated by each of these subsectors should be tested to propose a series of incentives that could be applied to make their business model more circular, because "in order to be a sustainable sector, tourism needs to transform its processes from linear (take-make-dispose) to circular (takemake-use-remake) ones." (Girard & Nocca, 2017: 67).

Ecoinnovations and Circular Tourism

The strong increase of global competition in the tourism sector in recent years makes the application of innovations a differentiator for both destinations and companies in the sector, and thus quality management and its contribution to sustainable development are increasingly valued (Sancho et al., 2007). This view is endorsed by the COTEC report (2007), which defends that, at the strategic level, innovation in the tourism sector is closely related to concern for differentiation while also indicating that these innovations increasingly are considering environmental issues. The latter is evidenced by the growing number of certifications of environmental management systems for hotels.

Therefore, although any kind of innovation in business management can be translated into a competitive advantage for the agents involved, eco-innovation benefits not only the company but also the community and the environment (Tejada & Moreno, 2013). It also generates distinctive custom competences which are difficult to imitate, at least in the short term.

Following Miret et al. (2011), an eco-innovation is 'a new series of processes and products that should increase value to customers and businesses, but with a significant reduction in the impact on the environment and pollution'. For García-Granero et al. (2018), the implementation of eco-innovations is positioned as an objective that the companies set to be more sustainable, to reduce the negative externalities of their activity and to meet governments' environmental requirements, as well as consumer demand.

Eco-innovation seeks to reconcile development and productivity with the ecology and environmental respect so that natural resources are, in this type of production, an ally in conservation and efficiency of use. As a result, care of the environment directly affects both economic and social growth through maintenance and creation of new jobs, acquisition of new skills, and new products and new businesses that boost the economy. Thus, in opinion of the Escuela de Organización Industrial (EOI, 2015), 'ecological innovation (eco-innovation) is the introduction of a product (good or service), new or significantly improved process, organisational changes or a marketing strategy through the which reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances throughout their life cycle'.

As one can see, the concept of eco-innovation has different dimensions, where often it is not enough to have an individual effort; to achieve business models of an ecological nature, a mix of innovations is required so organizations can pursue not only the launch and development of eco-friendly products but achieve a more sustainable economy (OECD, 2013). In addition, such innovations can contribute to the establishment of networks, the formation of social capital, business cooperation and the creation of new models of relationships between the public and the private sector.

Therefore, new design parameters and new organisational models are needed to incorporate effective capabilities, routines and processes of organizational learning that enable businesses and tourist destinations to create, adopt and improve a culture of innovation so they can achieve competitive advantages and develop strategies of value not based on low prices (Bowman & Faulkner, 1997). Along this line, Rodriguez-Anton (2002, 2008, 2010), Rodríguez-Antón and Oliva (2002), Bueno, Rodriguez-Antón, and Salmador (2008) have explored the role that the new organizational designs have in all phases of the process of business innovation.

An insufficient commitment to the environment and a weak innovative capacity of firms in this field of action will mean, in the medium and long term, a great loss of competitiveness in the market because the future will be governed by those who follow an eco-efficient strategy that enables them to adapt and stay ahead of the environment in which they develop their activities. Even today, eco-innovations favour more radical changes to traditional innovations, with stronger effects on the efficiency of the processes and on economic and social outcomes. Given the importance of reduction in environmental impact, conservation of the environment and local development have on tourism and the development of its activities, it seems more than logical that the presence of eco-innovations in the tourism sector should increase their importance. Otherwise it could only lead to the sector facing a loss of competitiveness, lower prices for tourism services and widespread losses in wealth and employment. Miret et al. (2011) point out, however, that 'eco-innovation appears as one of the great challenges of the tourist industry today' because although some companies have adopted environmental management measures, these have been low importance, as evidenced by various research (a review of them is collected in Pereira-Moliner et al., 2012).

Research on eco-innovations is very recent and had its origins in the manufacturing sector. Studies detected that both regulations and the mechanisms of the market are the main drivers for the generation, development and dissemination of eco-innovations. In the food industry in Spain, a recent study highlighted that the extent of external knowledge sources has a positive effect on the adoption of eco-innovations by sector enterprises (Green et al., 2018). These eco-innovations were aimed mainly at the most efficient use of materials and energy – assuming no radical innovations – and market pressures and regulatory issues have emerged.

Regarding the services sector, more drivers are coming from the environment in which the company develops its activity than from inside the sector (Del Val & Peiro-Signes, 2013; Triguero et al., 2013). In the case of tourism, research about the development of eco-innovations remains very limited. In fact, the sector that has developed more eco-innovations has been restaurants, both in their products (Alonso-Almeida, 2012; Rodgers, 2007) and in hotels (Alonso-Almeida, 2012; Bastic & Gocjic, 2012) as they look to change the design of restaurants and distribution to create an innovative atmosphere (Horng et al., 2013).

It should not be forgotten, however, that 'eco-innovations include numerous activities that affect businesses and tourist destinations in areas such as energy; recycling; water; new construction development; interior design; engineering projects; responses to external environmental degradation; new products, processes, and business models; adaptations of products and existing materials; new materials; the use of eco-biological products; spatial planning; and the wellness industry, which, in some regions, may also include the development and transformation of organic products, eco-tourism, and therapeutic tourism' (Alonso-Almeida et al., 2016, pp. 4).

The authors studied eco-innovations in different tourism sub-industries and found that hospitality and restaurants are the leaders in eco-innovations, although their development remains scarce because tourism is a traditional industry with low levels of research. In fact, eco-innovations in the tourism sector mainly involve the implementation and adaptation of innovations adopted in other sectors. The adoption of a social or environmental management system can be a starting point to generate new eco-innovations because, although a management system of this type may not be, by itself, an eco-innovation, it can contribute to generating learning mechanisms and capabilities that, in turn, lead to a process of continuous improvement (see Horbach et al., 2012).

Accordingly, eco-innovation will be an angular CT piece as long as its guidance both to the profitability of companies in the tourism sector adopting them and to the sustainability of the environment in which they operate make them integrate perfectly in the new paradigm of the CE. Moreover, the Rs referring to reinvent, rethink and redesign are which better together the concepts of eco-innovation and CT. When companies in the tourism sector are committed to reinventing business towards a more sustainable-approach model – thinking about new systems of management and more efficient production, generating less waste, and redesigning facilities by providing them with technologies that incorporate a decrease in the level of consumption – they are making a commitment for implementation of a model of CE.

Although there are many examples of companies in the tourism sector that have opted to follow the principles of CT, following is a case study of a four-star hotel in Madrid, Spain. This case was chosen because the sub-sector of tourist accommodation generates the largest volume of tourism employment; Spain has led recent reports of the World Economic Forum (WEF, 2015, 2017, 2019), occupying the top spot in tourism competitiveness globally; Madrid is the second Spanish destination in tourist attraction; and four-star hotels are numerous in Madrid.

CIRCULAR TOURISM CASE STUDY: CLARIDGE HOTEL, MADRID

The Claridge Hotel, founded in 1967, is a four-star hotel in Madrid. It belongs to the Moratiel family with a clear profile as an urban business hotel. It has 114 rooms, including two 45 m^2 suites with three rooms adapted for people with disabilities, five professional rooms with capacity for up to 100 persons and fully equipped with audio-visual resources, parking for 160 vehicles and a 1,500 m^2 gym. In total, it has a constructed area of 5,879 m^2. After a long period of operation as a mid-level hotel, it underwent a major remodel in 2012, incorporating new technologies to improve comfort, efficiency and security, and with a clear commitment to sustainability, circularity and respect the environment.

The remodel involved a series of structural changes of enormous importance. For example, the new facade is ventilated and coated externally with a ceramic material that significantly improves thermal and acoustic insulation, resulting in about a 40% savings in energy. In addition, new woodworking was configured through aluminium windows with double glazing, reducing heat transmittance by more than 50%.

Hotel facilities also were renovated to adapt to new regulatory requirements in terms of safety and comfort and to seek greater efficiency and energy saving. The managers acted in the main aspects related to energy consumption, particularly on issues related to air conditioning, the production of hot water, lighting, kitchen and lifts (http://alojamiento.ahorraenenergia.com/los-alojamientos-turisticos-tienen-plazo-31-marzo-solicitar-informe-gratuito-eficiencia-energetica/). General heating of the building, rooms and public areas was carried out using direct expansion heat recovery equipment, which can provide heat and air conditioning as demand drives terminals, limiting the range of temperatures.

Production of domestic, hot sanitary water was turned to cogeneration equipment, which produces electric energy in low tension and uses the heat generated to boil water, and to a geothermal energy collaborative process. The latter was done thanks to an agreement with the owners of a building next door, who installed a geothermal system to air condition their offices. Thus, in the summer, instead of the system directing heat to the ground, it uses it to heat water for boiler and micro-cogeneration system support. This project was recognised by ASPRIMASIMA in 2015 for its ground-breaking initiative in the buildings' energy rehabilitation.

Between 2016 and 2017, the hotel equipped faucets and showers with aerators that mix air with water, reducing water consumption and the associated cost of heating it. In 2015, the hotel launched a plan to replace existing conventional, halogen and low-consumption lighting with LED lighting. In the kitchens, much energy is consumed by having a lot of high-wattage equipment such as smoke extractors; for this reason, the hotel has set this equipment on frequency variators and a time control system so that they can become operational on demand.

After the interior renovation, the hotel installed five lifts with high energy efficiency, a modern security system and two stands for electric bikes. In the garage, the hotel dedicated two spaces to mobility with two separate standard electric chargers and Tesla chargers.

Thanks to all these actions, the Claridge Hotel annually used 41.5% less water per customer than the average of four-star hotels in the region of Madrid and 36% less than energy than hotels of the same category, and it reduced CO^2 emissions by 25% per year compared to these same hotels (Hotel Claridge, 2018). Information on these efforts was produced by Benchotelmark Madrid, a tool developed by the Hotelier Technological Institute for the comparison and evaluation of energy data of hotels in Madrid.

In summary, with all these activities, the hotel's energy consumption comes from three sources: 72% from renewable electric power, which has a certificate of origin guarantee from the GdOs of the National Commission on Markets and Competition; 26% from natural gas; and 2% from collaborative geothermal sources.

In addition, the Claridge Hotel's sustainability commitment led it to participate in the EcoLeaders program developed by TripAdvisor in partnership with the United Nations Environment Programme, the International Tourism Partnership and the Spain Green Building Council, which recognises hotels and hostels that apply environmentally friendly practices. Membership in the program is voluntary and free of charge, but hotels must request membership. To achieve the distinction of EcoLeader, the property must meet basic program requirements, have seven mandatory eco-practices and achieve a minimum score of 30% in a survey of eco-practices. An establishment can earn the distinction of TripAdvisor EcoPartner by meeting the necessary seven eco-practices, but unlike the EcoLeader designation, no minimum score is needed to become an EcoPartner.

Also, EcoLeader establishments can reach different levels of recognition. Those with a bronze logo must meet the minimum requirements and achieve a 30% EcoPractice survey score. To obtain a silver logo, hotels must achieve a 40% score, those with a gold logo must achieve a 50% score, and those with a platinum logo must score at least 60%. Establishments which achieve recognition as either EcoLeaders or EcoPartners can place a logo reflecting that status on its TripAdvisor page. To continue as an EcoLeader or EcoPartner, hotels must reapply for the corresponding evaluation every two years[1].

To participate in this program, the Claridge Hotel was evaluated on its environmental performance in eight areas that are customised to fit the characteristics of the establishment. There were compulsory questions as well as questions on energy consumption, water consumption, procurement, waste, site, education and innovation.

In the region of Madrid, only 24 hotels are EcoLeaders. Of those, one is a one-star establishment, another has two stars, five have three stars, 15 have four stars and two have five-star ratings. As EcoLeaders, one is at the Platinum level, three at gold, 12 at silver, and 8 at bronze (Table 1).

The Claridge Hotel achieved a silver level in the EcoLeaders program by scoring at least 40% in the following areas:

- have plans for reuse of linens and towels
- regularly monitor energy consumption
- recycle
- use low-energy consumption bulbs
- provide information about eco-practices to personnel and customers
- adequately purify wastewater (either through its own or a municipal purification system)

Following are the eco-practices promoted in the field of sustainability by the program[2]:

A. General actions
   - A.1 Control the use of energy, measuring and recording it on a regular basis (at least four times a year)
   - A.2 Implement a towel reuse program including training of regular checks and cleaning staff
   - A.3 Implement a bed linen reuse program including training of regular checks and cleaning staff
   - A.4 Recycle at least two types of waste (e.g. paper, glass, plastic, cardboard)
   - A.5 Have recycling containers in the public areas
   - A.6 Perform staff training at least once a year on the hotel's implementation of ecological measures
   - A.7 Enable guests to review€€hotel's ecological measures during their or before.
   - A.8 Have at least 75% of the interior light bulbs be energy efficient.

B. Energy-related actions
   - B.1 Use energy-efficient dryers
   - B.2 Set the temperature inside the building to a minimum of 22° C in the summer
   - B.3 Set the temperature inside the building to a maximum of 22° C in the winter

Table 1. EcoLeader Hotels in the region of Madrid

Hotels	Stars	Ecoleader Levels
Ibis Madrid Centro Las Ventas	2	Platinoum
Ibis Budget Madrid Centro Las Ventas	1	Gold
NH Collection Madrid Abascal	4	Gold
Radisson Blu Hotel, Madrid Prado	4	Gold
Madrid Centro managed by Meliá	3	Silver
NH Alonso Martínez	3	Silver
Tryp Madrid Airport Suites	3	Silver
Artiem Madrid	4	Silver
Claridge	4	Silver
Exe Madrid Norte	4	Silver
ME Madrid Reina Victoria	4	Silver
NH Collection Madrid Eurobuilding	4	Silver
NH Madrid Zurbano	4	Silver
Plaza España by Meliá	4	Silver
Vincci The Mint	4	Silver
InterContinental Madrid	5	Silver
Ibis Budget Madrid Vallecas	3	Bronze
NH Madrid Atocha	3	Bronze
Meliá Barajas	4	Bronze
Tryp Madrid Atocha Hotel	4	Bronze
Vincci Capitol	4	Bronze
Vincci Soma	4	Bronze
Vincci Vía 66	4	Bronze
Santo Mauro Autograph Collection	5	Bronze

Source: Own elaboration from the TripAdvisor website: https://www.tripadvisor.es/Hotels-g187514-zff24-Madrid-Hotels.html (data of access: 2019/02/15)

B.4 Use boilers, refrigeration systems, ovens or efficient heat pumps
B.5 Have a preventive maintenance plan with regular checks to ensure the effective operation of energy and water equipment
B.6 Perform evaluations to identify ways to save energy
B.7 Have sensors that automatically turn off lights when not needed to save energy in common areas
B.8 Use combined heat and power systems to generate electricity and heat for the building at the same time, which improves efficiency
B.9 Have sensors in more than 90% of the guest rooms that adjust the temperature when a room is empty
B.10 Have sensors in more than 90% of the guest rooms that turn off electronic devices when a room is empty

- B.11 Have sensors in more than 90% of the guest rooms that turn off lights when a room is empty

C. Actions related to the consumption of water
  - C.1 Have more than 90% of the taps in rooms use a maximum of 6 litres per minute
  - C.2 Have more than 90% of the toilets in rooms use a maximum of 4.5 litres per flush.
  - C.3 Have more than 90% of public and private staff faucets use 6 litres per minute or less

D. Actions related to purchases
  - D.1 At least 90% of toiletries should have packaging that is more than 50% recycled
  - D.2 Use organic dry cleaning
  - D.3 Organic dry cleaning should use alternatives to traditional perchloroethylene (PERC)

E. Actions related to waste
  - E.1 Perform a safe disposal of hazardous materials such as paint, printer cartridges, batteries and fluorescent light bulbs
  - E.2 Recycle at least 90% of the flooring when it is replaced with new material
  - E.3 Recycle at least 90% of furniture when it is replaced with new pieces
  - E.4 Recycle at least 90% of mattresses when they are replaced with new ones
  - E.5 Recycle or use for biodiesel fuel at least 90% of the used cooking oil
  - E.6 Have at least 90% of the crockery and cutlery be reusable

F. Actions related to education and innovation
  - F.1 Measure and document carbon emissions of the building as a form of control
  - F.2 Possess a charging point for electric vehicles for guests to use up to 2 km from the establishment

Looking at the orientation of each of these 33 actions undertaken by the Claridge Hotel, one can see that 20 of them are intended to meet the first objective of the CE or CT, which is to reduce the consumption of raw materials as the consequent generation of waste; 7 are actions designed to recycle or turn waste into raw materials; and 4 are oriented to reuse waste either as main products or components of other products. Not all actions undertaken by the hotel in the area of sustainability were clearly aimed at achieving a path to a circular economy; in particular A.6, A.7, E.1 and E.5 have a clear orientation towards two objectives of CT: reuse and recycling (Table 2).

The clear orientation of the Claridge Hotel towards one R (reduce) at the expense of the other two Rs is due to its commitment to reduce energy and water consumption and other factors to be more efficient from an economic point of view, which leads it to also reduce the generation of waste. To a lesser extent, the hotel recycles much of its waste such as flooring materials, furniture, mattresses, crockery and cutlery, and cooking oil. It also offers recycling in public areas for other waste such as paper, glass, plastic or cartons with items. Finally, the unfinished hotel reuses towels, bed linen, crockery, cutlery and cooking oil. In conclusion, the Claridge Hotel can be considered a good example of a company that applies a management model that follows the principles of CT.

Table 2. Orientation of the performances of the Claridge Hotel to a circular economy

Performance	Reduce	Reuse	Reclycling
A. GENERAL	2	2	2
A.1			
A.2			
A.3			
A.4			
A.5			
A.6			
A-7			
A.8			
B. ENERGY	11	0	0
B.1			
B.2			
B.3			
B.4			
B.5			
B.6			
B.7			
B.8			
B.9			
B.10			
B.11			
C. WATER	3	0	0
C.1			
C.2			
C.3			
D. PURCHASES	2	0	1
D.1			
D.2			
D.3			
E. WASTES	0	2	4
E.1			
E.2			
E.3			
E.4			
E.5			
E.6			
F. EDUCATION AND INNOVATION	2	0	0
F.1			
F.2			
TOTALS	20	4	7

continues in next column

Table 2. Continued

Source: Own elaboration

SOLUTIONS AND RECOMMENDATIONS: A PROPOSAL OF FRAMEWORK FOR CIRCULAR TOURISM. CIRCULAR GUIDING PRINCIPLES IN TOURISM ORGANIZATIONS

To design a framework that serves as a reference for the creation of a CT model, we propose that all agents in the tourism sector assume a series of guiding principles which enable and promote the full implementation of this model. In this sense, the Pact for the Circular Economy, prepared by the Ministries of Agriculture and Fishing, Food, and Environment, and the Ministry of Economy, Industry and Competitiveness of Spain, is a good starting point to achieve the desired circularity in the tourism sector. This pact, initially signed in September 2017 by 55 organisations, now has the support of 294 organisations. The pact includes 10 actions:

A1 Progress in the reduction of the use of non-renewable natural resources, reusing materials contained in waste as secondary raw materials provided it ensures the health of people and protection of the environment.

A2 Boost analysis of the lifecycle of products and the incorporation of eco-design criteria, reducing the introduction of harmful substances in manufacturing, facilitating the repairability of produced goods, extending products' useful life and enabling their valuation at the end of their life.
A3 Promote the effective implementation of the principle of the waste hierarchy, promoting the prevention of the generation of waste, promoting reuse, strengthening recycling and encouraging goods' traceability.
A4 Promote guidelines that increase the overall efficiency of production processes through the adoption of measures such as the implementation of environmental management systems and innovation
A5 Promote innovative forms of sustainable consumption
A6 Promote a model of responsible consumption through the use of measures such as the use of the eco-label
A7 Facilitate and promote the exchange of information and coordination with administrations, the scientific and technological community, and economic and social stakeholders to facilitate this transition
A8 Disseminate the importance of moving forward from a linear economy towards a circular economy
A9 Promote the use of common, transparent and accessible indicators that enable us to know the degree of implementation of the circular economy
A10 Promote the incorporation of indicators of social and environmental impacts arising from the operation of the CE

To date, no company in the tourism sector, in a strict sense, has joined the pact, although some suppliers of the sector have. This lack of institutional commitment, although not real as seen in the case studied, shows that most companies in the tourism sector are not applying a series of principles that should set the framework of their circular strategy.

In this sense, Niero and Schmidt (2018) propose that organisations should follow the recommendations contained in the British Standard BS 8001:2017 'Framework for implementing the principles of the circular economy in organizations', a standard that provides companies with a guide to follow in their transition towards a model of circular and sustainable organisation. The authors analysed how the six principles in this standard – system thinking, innovation, stewardship, collaboration, value optimisation and transparency – can guide businesses towards sustainability. In this line, in this book chapter intends that companies in the tourism sector should apply these principles to achieve a proper orientation towards circularity:

1. System thinking. First, companies in the tourism sector must possess global thinking that enables them to see the influence that an action, such as any of the contained in the Pact for the Circular Economy, will have on both the environment in which it operates and the planet in general.
2. Innovation. Tourist organizations must be able to incorporate eco-innovations both in their service delivery processes and offered services, which can lead to the creation of new business models to boost positioning in the market.
3. Stewardship. The managers of companies in the tourism sector must be able to properly manage the potential economic, social and environmental impacts, both direct and indirect, which could lead to the development of their activities.
4. Collaboration. Because the tourism sector requires the participation of multiple companies and organisations – transport, accommodation, catering, etc. – it is necessary to have intense collabo-

ration among them to enhance circular tourism as several of them will be providers of others and vice versa.

5. Value optimisation. Value optimisation is trying to keep all products, components and materials used in the tourist industry at their maximum value and utility for as long as possible.
6. Transparency. Companies in the tourism sector must be transparent when it comes to communication (both internal and external), decisions and initiatives that the implement to become a circular company.

It seems essential that companies in the tourist sector adopt these principles if people want the sector to continue to be a source of satisfaction for tourists and a source of wealth for the destinations. These principles would guide their management teams to implement the actions contained in the Pact for the Circular Economy. Thus, the principle of system thinking could help implement actions A1 and A6; the principle of innovation could help enact A4 and A5; the principle of stewardship could promote actions A1, A2 and A3; the principle of collaboration could help implement action A7; the principle value optimisation could propel actions A1, A2, A3 and A4; and, finally, the principle of transparency could help launch actions A8, A9 and A10 (Table 3).

Table 3. Relationship between CE guiding principles and CT Actions

Circular Economy Guiding Principles	Circular Tourism Actions
System thinking.	A1,A6
Innovation	A4,A5
Stewardsship	A1, A2, A3
Collaboration	A7
Value optimisation	A1, A2, A3, A4
Transparency	A8, A9,A10

Source: Own elaboration

FUTURE RESEARCH DIRECTIONS

There is no doubt in the minds of the authors that the new paradigm of the CE will be implemented in an unstoppable and progressive manner in all sectors of the economy. Although initially the industrial sector faced more pressure and had to endure to align itself on the path of the CE, the services sector is making great efforts to be more circular and sustainable. In this sense, a future line of research could be based on analysing the degree of relative progress all sectors of the economy are making toward a CE and their degree of compliance with the objectives of sustainable development.

Equally, it would be interesting to analyse how member countries of the European Union are legislating in this area to meet the 2030 agenda for sustainable development, approved on 25 September 2015 by the United Nations General Assembly, and the report titled ‘Closing the Circle: a Plan of Action from the EU for the Circular Economy’, prepared on 2 December 2015 by the European Commission in asking for a commitment to implement the CE in all possible areas: member states, regions, cities, businesses and citizens.

CONCLUSION

This chapter was written to put into evidence how goverments, economists, activists and other voices are highlighting the necessity of driving a new economic paradigm called CE as opposed to continued use of the traditional linear model. The CE advocates closing the loop of the flow of materials and energy and contributing to the sustainability of the planet in the long term by improving the use of resources and energy. It aims to protect the environment and promote economic development through a reduction in the consumption of resources and generation of waste throughout the lifecycle of goods and services – extraction, processing, production and consumption – through direct reuse of waste materials as a product or as a component of other products and through recycling, or using waste as a raw material directly after passing a specific process.

If in all sectors it is urgent to promote this change of paradigm or economic model, the pressure is stronger in the case of tourism because data show that tourists consume more resources and produce more waste and pollution than the destination population. In addition, transportation is one of the fastest-growing industries and it contributes to tourism but not in the best sustainable way. Accordingly, the application of the CE to the tourism sector, what could be called circular tourism, may be a solution to these problems, ensuring the sustainability of the sector and of the planet.

All companies, organizations and agents involved in any of the stages of the tourism industry must commit themselves to this new model. Companies, tourist intermediation, transportation, tourist accommodation, catering, entertainment and tourist animation, and a wide range of institutions and organizations that support tourism must act to achieve a CT model by reducing their consumption of resources (energy, equipment, food, drinks, etc.) and generation of waste, and by reusing this waste, either directly as products or as a component of other products once it is properly recycled.

The strong growth of the existing global competition in the tourism sector has led companies to make a special effort to innovate, either using new processes or offering new services to customers and, as the COTEC (2007) report indicates, innovation in the tourism sector increasingly is considering environmental issues, as evidenced by the growing number of certified environmental management systems. Although any kind of innovation in business management can be translated into a competitive advantage, eco-innovations benefit not only the company but also the community and the environment (Tejada & Moreno, 2013); they also generate distinctive custom competences that will be difficult to imitate, at least in the short term.

This study analysed the case of a company in the tourism sector that has been implementing a CT model, the four-star Claridge Hotel in Madrid, Spain. After a full refurbishment process, this hotel opted to implement a circular management model supported in facilities that incorporate new technologies that improved the comfort, efficiency and security of the hotel, with a clear commitment for sustainability, circularity and respect for the environment.

Specifically, the Claridge Hotel has undertaken initiatives related to the facade of the building, carpentry, facilities, air conditioning, production of domestic hot water, lighting, kitchen and lifts, and use of cogeneration and geothermal energy collaborative processes. These changes, as well as others related to energy and water consumption, procurement, waste management, education and innovation, have earned the hotel the silver level in the TripAdvisor EcoLeader program.

Finally, enterprises in the tourism sector, to achieve implementation of a true CE model, should follow, as noted by Niero and Schmidt (2018), the six guiding principles set out in the British Standard BS

8001:2017: system thinking, innovation, stewardship, collaboration, value optimisation and transparency. These principles can orient them towards sustainability.

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KEY TERMS AND DEFINITIONS

3R Model: The basic model of the circular economy based on reducing the level of consumption and waste generation, reusing waste directly as a product or as a component of other products, and recycling or using waste as raw material directly after passing through a recycling process.

BS 8001:2017: A British standard drawn up by the British Standard Institution that is a voluntary guide for reaching the circular economy.

Circular Economy: A new economic paradigm that consists of extracting raw materials; transforming them; and producing, consuming, and returning the materials to integrate in the process so that they turn into new raw material or new elements of production.

Circular Tourism: An economic system that tries to make the tourism sector, in all its manifestations, capable of supporting the economic development of tourist destinations without putting the sustainability of the planet at risk by reducing the use of energy factors and natural resources, reusing the waste generated in the activities carried out, either as products directly or as components of other products, and using waste as direct raw material after of a recycling process.

Hotel Claridge: A four-star hotel in Madrid, Spain that can be considered an example for the implementation of a circular economy model.

Linear Economy: A traditional economic paradigm that consists of extracting raw materials; transforming them; producing and consuming goods and services; and discarding the resulting waste.

Principles of Design for Circular Tourism: Standards of performance that should apply to tourism companies to adequately implement a model of circular economy.

ENDNOTES

1 https://www.tripadvisor.es/GreenLeaders

2 https://www.tripadvisor.es/Hotel_Review-g187514-d228475-Reviews-Hotel_Claridge-Madrid.html

Chapter 3
Circular Economy and Sustainability:
Concepts, Perspectives, and (Dis)Agreements

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ABSTRACT

In the last decades, the concern over natural resources, sustainability, and the current linear economic model based on continuous growth is one of the great challenges of our time. The assumption that there is an unlimited supply of natural resources and that the environment has an unlimited capacity to absorb waste and pollution is no longer a current trend, and growing attention has been paid to it worldwide. This chapter represents a contribution to the continuous conceptual development of circular economy and sustainability, and it also reviews how these two concepts have evolved over the past decades. An extensive literature review was conducted, employing bibliometric analysis to scrutinise the state of the art, the perspectives, the agreements and disagreements among these concepts and their correlation.

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INTRODUCTION

In this context of transition to a more sustainable future where renewable energy, biomaterials, toxic chemicals and emissions of waste (Lacy and Rutqvist, 2015) are gaining momentum, the concept of circular economy as a new approach to sustainability, is emerging and materialising as a restorative and alternative strategy in industrial economy to face environmental and economic challenges (Lacy and Rutqvist, 2015; Hobson, 2015), as well as to enhance sustainable development and a balanced society (Feng and Yang, 2007; Geng and Doberstein, 2008; Ness, 2008; Mathews and Tan, 2011; Lett, 2014).

Circular Economy strives to harmonize economy, environment, technology and social approaches (Ren *et al.*, 2013), so as to promote a more harmonized use of natural resources as well as the implementation of a greener economy. This unique business model steps up innovative employment opportunities (EMF, 2012; Stahel, 2014, 2019) and seeks future generations' wellbeing regarding resource access and purpose. It also represents a more effective alternative to the prevailing economic system, referred to as the "take, make, dispose" (Ness, 2008) model, which is endangering the equilibrium of the economies and the integrity of resource ecosystems that are fundamental to humanity's existence.

This sustainable development question has echoed globally and new approaches to limit the depletion of resources, the processing of certain raw materials, and the use of less polluting and contaminating products (McDonough & Braungart, 2002) had been put on the global agenda decades ago, by the WCED 38/161 resolution, in December 1983.

Sustainability is a global challenge and the transition to a more sustainable economic system (Meadow et al., 2004; WSCSD, 2010; Seiffert, 2005; Markard, 2012) has been receiving growing attention both in the political sphere (Rio Summit, 1992; OECD, 2011; UNEP, 2011) as well as in the social-science academia level (Smith *et al*., 2005; Frantzeskaki and Loorbach, 2010; Grin *et al*., 2010).

The world population growth and prosper, global warming, biodiversity loss, the escalation in the production of greenhouse gases, increasing urban and industrial growth, natural resource depletion, pollution and waste, are leading to resource scarcity increase, price inflation and environmental deterioration (Rockstrom *et al*., 2009; Jackson, 2009; Meadows *et a*l., 2004; WWF, 2014).

Indeed, the levels of consumption will more than double by 2060, and it is imperative to choose a strategic path towards efficient resources management - *decoupling,* concept applied in a wide range of areas (electronics, cosmology or algebra), which consider the usage of fewer resources in production processes, and consequently reduce the impact on the environment of the economic activities performed (The Ellen MacArthur Foundation (EMF), 2013; United Nations Environment Programme (UNEP), 2019).

The prevailing economic model, based on extracting resources, using them in manufacture and production processes, sell them in large scale and finally discard them after usage, presupposes that natural resources are abounding, available and there is no need to concern about waste. Nonetheless, this assumption has led to environmental deterioration and ecological scarcity, putting the "planetary sink" (Lacy and Rutqvist, 2015:7) at risk, and unless this alarming situation is accounted for it will considerably mitigate "the benefits that future generations obtain from ecosystems" (Lacy and Rutqvist, 2015:8).

Global natural resources have physical boundaries and limits that need to be understood and addressed in achieving human welfare and sustainable environmental resources. Currently we are using the equivalent to 1.5 planets in order to provide for all our basic needs, the resources necessary to assist all our economic activities and to absorb the waste produced (Lacy and Rutqvist, 2015). The environmental footprint, which designates the biomass that humanity needs to produce goods, to live in and to absorb waste, is currently showing a tendency of excessive consumption by more than 50 per cent and it means that by 2050, and based on the current trend, we will need the equivalent to three planets per year to meet our needs (World Wild Fund for Nature, 2006).

The World Business for Sustainable Development (WBSD) states that "*we are moving beyond our planetary boundaries"* (2012:2) and depletion concerning biological diversity is already in progress. By closely analysing the data available on the world population growth, it is possible to estimate that the world population will increase from 9.7 billion until 2050 and could reach a peak of almost 11 billion people around 2100, which means that the global population is foreseen to increase by 2 billion in the coming 30 years (United Nations, *World Population Prospects,* 2019). Furthermore, competition for natural resources exploitation and the concentration of supplies in certain countries, have been expanding, which makes industry susceptible to high and volatile market prices. As Lacy and Rutqvist (2015) show the prevalent linear economic model is growing at an astonishing average rate of 3%, which means it doubles every 25 years. At the moment there are no indicators that the correlation between growth and consumption will be discontinued.

Consequently, policies and new approaches concerning the traditional economic model should be undertaken, as it is shown, the prevailing economic model is not viable in the future, even considering all the technological evolution we are experiencing.

CIRCULAR ECONOMY

The Concept and Its Origins

The concept of Circular Economy was firstly delineated and introduced to academia by Pearce and Turner (1990), as noted by Su *et al*., (2013); Ghisellini *et al*., (2016) and Geissdoerfer *et al*., (2017). These authors also acknowledge that natural resources play a key role on economic systems and that the existing linear economic system, in which it is believed that natural resources thrive and that planet Earth has an unlimited capacity as a waste sink (Cooper, 1990), is no longer sustainable.

In this context, a CE perspective is proposed as a means to promote circularity within the economy, by reducing the energy inputs and raw materials consumption, which are indispensable for sustaining future resource preservation (Hilsop and Hill, 2011).

Feng *et al*. (2007), Geng and Doberstein (2008), Yang and Feng (2008), Hu *et al*., (2010), consider CE a vital economic approach to attain economic development, enhancement in resource productivity, equipment optimization and revitalization, and management improvement, as it mimics the ecological circulation of materials, in closed cycles, with regard for the ecological laws and the unflawed usage of natural resources.

CE is also a general term that encloses the diverse activities related to the processes of reducing, reusing, and recycling supplies, and also to the allocation of these materials. It is common sense that natural resources ought to be processed in cycles, through biogeochemical processes or by means of human interference (one of the CE principles), otherwise environment and consequently the humanity life-support system will deteriorate at an overwhelming rhythm (Robèrt, 1991).

Cooper (1994) also argues that governments have implemented recycling goals for domestic waste, but failed in introducing practical measures to encourage production and marketing of longer lasting products, in spite of the raising awareness concerning activities that comprise reducing, reusing and recycling were increasing.

Drawing on different solutions was imperative regarding the nature of the products disposed of, as some consumables undergo intricate processes of construction and may contain hazardous substances. To sum up, little attention was and still is paid to the durability of products and the focus has mainly been on recycling. Although Circular Economy is generally associated with recycling it is fundamental to explain that this approach may be the least sustainable solution, when compared to the remaining R – imperatives, to tackle sustainability efficiently and profitably (Stahel, 2013, 2014, 2019). Some residual materials can only be recycled to a certain extent and others are not recyclable at all. For example, fibbers can undergo a recycling process 4-6 times, whilst some metals cannot be recycled at all (Reh, 2013). Some varieties of plastic cannot be recycled due to the existence of impurities as ink or metals in its formulation (Prendiville, *et al.*, 2014).

It is also acknowledged that CE cannot perpetuate recycling, as in a certain stage recycling may become too difficult and onerous, because the amount of waste produced is not at the same level of the resources depleted, i.e. the economic system is open-ended. In a circular economic system, the ultimately goal is to produce goods that at the end of life re-enter the circular flow of materials in new production processes in an industrial cycle, i.e., a closed system (Cardoso, 2018).

CE cannot guarantee that products or their components are 100% recyclable, as there is a certain degree of impracticability of an economic system to be totally circular with waste, residues and energy, as a consequence of the entropy law (Daly, 1977; Andersen, 2007).

McDonough and Braungart (2002), argue that profound adjustments must be made to the world's industrial and manufacturing system, as the current model is depleting natural resources. For the purpose of achieving environmental balance, environmentalists, industrialists, and designers ought to harmonize strategies and rethink the 'eco-friendly' concept, and what it stands for in manufacturing processes. McDonough and Braungart (2002) and the EMF (2012) consider that the Circular Economy approach should target a new scientific and design oriented strategy, coined as 'eco-effectiveness', as a technique to minimize and dematerialize the material flow system. This strategy would allow a balanced exchange between environment and economy and renounce to the existing manufacturing practice of 'eco-efficiency'.

CE has also been associated with an economic approach to relevant waste management strategies, which stands out as a very reductive perspective. Geng *et al*. (2014) consider that a preventive and regenerative eco-industrial development ought to be implemented. This strategy along with the use of 'green' technologies, the design of alternative solutions, and the synergies between manufacturing processes, the environment and the economic system in which it is enclosed, will regenerate material, and recover energy, achieving the long-awaited sustainability (Annarelli *et al*., 2016).

In addition, McDonough and Braungart (2002) bring to light some misinformation on 'good' recycling environmental practices and suggest that manufacturers exploit a 'cradle-to-cradle' design concept, rather than a 'cradle-to-grave' life cycle, i. e., the lifespan of a product mustn't end in a 'grave', in a landfill. Drawing on a 'cradle-to-cradle' manufacturing model, products undergo long lasting design and manufacture processes, as well as a waste-free industrial process (Geissdoerfer *et al*., 2017).

From this point of view, CE does not stand out as a merely preventive approach (McDonough, 2002) with the purpose to mitigate resource depletion and waste emissions (Cooper, 1999; Nakajima 2000). It goes far beyond the concept of sustainability and the articulation of the link between environment and industry, emphasizing that efficiency through design and service supply allowing a reduction in inputs, upgrading resource usage and economic growth. To achieve this target, strategies and policies have to consider and focus on three approaches 'low energy consumption', 'low emission of pollutants', and 'high efficiency', (UNEP Paris Report on CE, 2006), and unless essential changes and joint action discourage the excessive exploitation of natural resources, global commodities consuming will more than double by 2060 (UNEP/OCDE, 2019).

According to Andersen (2007) the environment performs four fundamental functions that interact amidst each other. It caters for amenity values, it is an economic resource base, it is a waste sink, and it is an essential life-support system. In this context, the author considers that the implementation of CE principles will be valuable to the economy, as they will not only reduce the use of raw materials within the economic activity, but also lessen the use of environment as a waste sink.

Andersen (2007) also reiterates *The First Law of Thermodynamics*, which states that the amount of energy and matter prevail constant in a closed system, where the volume of waste generated ought to be equivalent to the amount of resources drained, and part of the waste would be converted into raw material. By doing so, economy becomes circular, which implies that material outflows as well as economic assets need to be taken into consideration.

In this light, Feng *et al*. (2007), Geng and Doberstein (2008), Yang and Feng (2008), Hu *et al*. (2011), refer to CE as a model of economic development which mimics the ecological circulation of raw materials, 'closed materials cycle or resources circulated economy', respecting the ecological laws and the flawless utilization of natural resources in order to accomplish economic development, improvements in resource productivity, optimization or equipment revitalization and management upgrade.

Mathews and Tan (2011) also recommend eco-industrial initiatives as an approach in dealing with sustainable industrial businesses. It is fundamental to consider circularity within the production chain by transforming waste into a valuable input. The Ellen MacArthur Foundation (2010) also considers that the growing demand for rethinking, redesigning, and building a positive and sustainable future have been gaining traction as the prevailing linear economic model based on the 'take-make-dispose' approach is leading to resource depletion, and sharp increases in both pricing levels and related volatility of raw materials supply.

In this respect, CE represents a new perspective beyond the current 'take-make-waste' extractive industrial model. Economic growth should be redefined in order to target positive benefits to society and decouple economic activity from the consumption of finite natural resources and converge to renewable energy sources handling.

One of the principles underlying the concept of Circular Economy is that it is restorative and regenerative by design, with the purpose to attain the highest utility and value of products, components and materials. In order to do so, it is essential to enhance an economic system where long lasting design, reuse, refurbishment, remanufacturing and recycling are considered. Toxic materials and waste are eliminated without waste emissions, as debris represent valuable resource in reducing the use of natural resources consumption and its impact on the environment (EMF, 2012), a precept also considered by Liu *et al*., (2009).

This approach reiterates the conviction that an economic and industrial system based on the 'reuse' imperative of products and components, stating that remanufacturing is the pathway to reinforce the environment natural capability to restore itself (EMF, 2013; Bastein *et al*., 2013).

It has also been demonstrated that the implementation of a circular Economy strategy should consider system thinking as decision making of the stakeholders engaged in manufacturing processes have a vast impact in the value chain. In a restorative by intention and design industrial system, the central point should be the use and reuse of products rather than discard them before their value is completely explored (Wijkman and Skânberg, 2015; Waste Resource Action Programme (WRAP), (2016).

In today's economy, where high and volatile resource prices are consistent, CE offers considerable business opportunities. But to do so, stakeholders have to concentrate on collecting and sharing date, exchange good and preventive practices, invest in innovation and research, and above all promote collaboration among the different actors (governments, businesses, companies, etc.). Stakeholders play a key role in accelerating the transition to a Circular Economy model in a period of time compatible with the response to global challenges as climate change, water and resource scarcity, pollution, and take responsible decisions that may contribute to achieving sustainable development within a reasonable timescale.

In this perception, natural resources can no longer be attained by means of a linear model, as it implies that as long production processes increase, a boost in resources extraction and consequently waste production will also intensify.

Finally, as an attainable solution, Circular Economy, stands out as a fundamental strategy to upgrade the sustainability performance, life of products, and a closed circular flow of materials (Mesa *et al*., 2018). Table 1 provides a general overview of the concept of circular economy and its intrinsic R-Principles.

Table 1. The concept of circular economy and its R-Principles

Definitions / R-Principles	References
• A restorative and alternative strategy in industrial economy to face environmental and economic challenges.	Lacy and Rutqvist, 2015 Hobson, 2015
• A strategy to enhance sustainable development and a balanced society.	Feng and Yang, 2007 Geng and Doberstein, 2008 Ness, 2008 Mathews and Tan, 2011 Lett, 2014
• It balances economy, environment, technology, and social approaches.	Ren *et al*., 2013
• It promotes a balanced use of natural resources and the implementation of a greener economy; • It steps up innovative employment opportunities; • It seeks future generations' wellbeing considering resource access and purpose.	EMF, 2012 Stahel, 2014
• It promotes circularity within the economy by reducing the inputs of energy and raw materials consumption.	Hilsop and Hill, 2011
• §n economic approach that mimics the ecological circulation of materials, in closed cycles. • **CE R-Principle: Refuse**	Feng *et a*l., 2007 Geng and Doberstein, 2008 Yang and Feng, 2008 Hu et al., 2010 Miller and Spoolman, 2002; Clapp and Swanston, 2009; Black and Cherrier, 2010; Alwood *et al*., 2011, Bilitewski, 2012; Kasidoni *et al*., 2015
• It encloses the diverse activities related to the processes of reducing, reusing, and recycling supplies, and also to the allocation of these materials. • **CE R-Principles: Reduce, reuse, and recycle**	Robèrt, 1991 Daly, 1977; Karl-Henrik Robèrt, 1991; Cooper, 1994; Yoshida, 2007; Larson and Taylor, 2000; Andersen, 2007; Clapp and Swanston, 2009; Bilitewski, 2012; Hassini *et al*., 2012; Jiao and Boons, 2014; Ghisellini *et al*., 2014; Yan and Feng, 2014; Diener and Tillman, 2015; Kasidoni *et al*., 2015; Reike *et al*., 2018.
• It targets a new scientific and design oriented strategy, coined as "eco-effectiveness", in order to minimize and dematerialize the material flow system.	McDonough and Braungart, 2002 EMF, 2012

continues on following page

Table 1. Continued

Definitions / R-Principles	References
• It emphasizes that efficiency through design and service supply allowing a reduction in inputs, upgrading resource usage and economic growth; • Strategies and policies consider and focus on three approaches: 'low energy consumption, 'low emission of pollutants' and 'high efficiency'. • **CE R-Principles: Rethink, refurbishment, remanufacture, repair**	McDonough, 2002 Cooper, 1999 Nakajima, 2000 UNEP, 2006 Thierrry *et al*., 1995; De Brito & Dekker, 2003; Fernández and KeKale, 2005; King *et al*, 2006; Gehin *et al*., 2008; EMF, 2010, 2013; Liu *et al*., 2009; Stahel, 2010; Hultman and Corvellec, 2012; Bastein *et al*., 2013; Wijkman and Skânberg, 2015; Lieder and Rashid, 2015; Reike *et al*., 2018
• Its implementation will reduce the use of raw materials within the economic activity and lessen the use of environment as a waste sink.	Andersen, 2007
• In a circular economic system, the main goal is to produce goods that at the end of life re-enter the circular flow of materials in new production processes - a closed system. • It is restorative and regenerative by design, with the purpose to attain the highest utility and value of products, components and materials. • **CE R-Principles: Redesign/ Rethink, Repurpose, Recover, Cradle-to-cradle, Long- lasting Product**	Cardoso, 2018 Daly, 1977 Andersen, 2007 Cooper, 1999; Nakajima 2000; McDonough and Braungart, 2002; McDonough, 2002; EMF, 2012; Stahel, 2013, 2014, Reh, 2013; Prendiville, *et. al*, 2014; Geissdoerfer *et al*., 2017, Li, 2011; Stahel, 2010; Yan and Feng, 2014; Reike *et al*., 2018
• It stands out as a new economic model, where products, components, services and energy are managed in closed loops or cycles, mimicking the natural ecosystems. Toxic materials and waste are eliminated without waste emissions, as debris represent valuable resource in reducing the use of natural resources consumption and its impact on the environment.	EMF, 2012 Liu *et al*., 2009 Feng *et al*., 2007 Geng and Doberstein, 2008 Yang and Feng, 2008 Hu *et al*., 2011
• An important goal of a circular economic system is the decoupling of the economic system from resource consumption; • The emphasis has to be on value retention, stock optimization and product life extension.	EMF, 2013 Stahel, 2013
• It is a fundamental strategy to upgrade the sustainability performance, life of products, and a closed circular flow of materials.	Mesa *et al*., 2018

FROM LINEAR TO CIRCULAR ECONOMY

The existing economy model is based on a linear paradigm of production and consumption, in which products are used for a brief period of time and afterwards disposed, resulting in enormous amounts of waste.

According to the Ellen MacArthur Foundation (EMF) (2013), the linear economic model has its origins in the formerly irregular distribution of wealth geographically. Considering that resource consumers are predominantly centralised in the most developed and developing areas, industrialised countries have experimented both raw material abundance and energy. Consequently, manufacturers are driven and stimulated to embrace business models which depend on the heavy use of raw materials. This approach implies that an economic system based on a consumption model at the expenses of an unsustainable use of natural resources has effective and impressive costs along the supply chain.

Furthermore, the rapid growth and development of an economic model based on consumption and extraction since the mid of the 20th century has originated an expansion of negative external effects (Stephen *et al*., 2004) and is one of the main factors which triggered natural depletion.

Considering the material flow in a conceptual model of value creation in which only raw materials are used in production processes, redundant losses along the chain materialize: massive waste is generated, disproportionate energy use and depletion of ecosystems (EMF, 2012). Taking into account these resource depletion indicators, academics, practitioners, economists, environmentalists and politicians are seeking for a new paradigm of development and economic growth that is beneficial within the natural boundaries of planet Earth (EMF, 2014).

Steffen *et al*., (2004) point out that during the second half of the twentieth century it was visible the accelerated transformation concerning the relationship of mankind with nature. The price of raw materials escalated erasing a century's of real price decline. At the same time the price of metals, food, and non-food agricultural production was higher than ever in any decade of the 20th century. This price volatility is mainly due to the population growth and urbanisation, the growth of output and consumption per capita, the unprecedented resource extraction and exploitation in even more remote locations, and the environmental expenditure of natural resources depletion.

According to the Ellen MacArthur Foundation (2012) many different companies have recently concluded that this linear economic system which follows a 'take-make-dispose' pattern, may be the real cause to resource price inflation. Therefore, businesses face a double-edge sword, with higher resource prices on one edge and stagnating demand in consumer markets on the other. Thus, in a context of socioeconomic development, with a growing world population, especially middle-class, the crusade for resources increases promptly. And as, Meadows *et al*., (1972) put it, natural resources are not unbounded, which means that this exponential economic growth, the raw material resources and energy, and humanity's metabolism is unsustainable and represents an environmental and economic challenge.

In this scenario and considering the modern environmental and economic trends of the dominant economic model, the linear economy, circular economy stands out as an element of a circular production process. It means that resources are collected from the environment but at a subsequent stage waste is turned into a resource and continuously recycled in the economic process, as illustrated by Figure 1.

Figure 1. Author unknown.
Source: https://www.instarmac.co.uk/linear-vs-circular-economy/

So, implementing a circular economy would imply the reduction and afterward elimination of the existing throw away society. This would also mean the abandonment of the "take, make, use, dispose" pattern, transitioning to a "re-use and recycle" process.

As circular economy alludes to the activities undertaken in an economy, its operationalization should start with the design of products, services and processes. Products ought to be designed to be durable, repairable and upgradable, so that their life cycle could be extended in order to enable remanufacturing and recycling within the same business or for other industries. In this way, the central feature that allows the distinction between these two concepts, linear economy and circular economy, lies in the fact that in the latter, products, services and industrial manufacturing are formulated and produced to allow them a more extended life cycle and the potential to be restored, improved or remanufactured, and even inputs for other businesses (Bonciu, 2014).

Table 2 presents an overview of these two concepts: linear economy and circular economy.

Ultimately, the current economic model, the linear economy, has been revealing its inadequacy to meet the future needs of mankind, as it is inherently related to the excessive waste output, and also to the environmental insufficient capacity to sustain the current level of resource overutilization.

Table 2. Overview of the concept of linear economy and of the concept of circular economy.

	Linear Economy	**Circular Economy**
Business Model	**Production-consumption-disposal:** ● The linear economic model is based on a linear paradigm of production and consumption.	**Production-consumption-reuse:** ● The circular economy model is based on a circular production process.
Products	**Short life cycle** ● Products are used for a brief period of time and afterwards disposed.	**Long life cycle** ● Products, services and industrial manufacturing are formulated and produced to allow them a more extended life cycle and the potential to be restored, improved or remanufactured, and even inputs for other businesses;
Resources	**Unlimited use** ● Considering the material flow in a conceptual model of value creation, only raw materials are used in production processes.	**Looping use** ● Resources are collected from the environment but at a subsequent stage waste is turned into a resource and continuously recycled in the economic process; ● Recognises decoupling of the economic system from resource consumption.
Energy	**Fossil energy** ● Disproportionate energy use and of pricing levels, and volatility of raw materials supply.	**Renewable energy** ● It promotes circularity by reducing the energy inputs and raw materials consumption.
Economy	**Linear economic model** ● A linear economic system, which follows a 'take-make-dispose' pattern; ● Open-ended economic model.	**Circular economic model** ● "Re-use and recycle" process; ● It is restorative and regenerative by design; ● It emphasises value retention, stock optimization and product life extension. ● A closed economic model, which mimics the ecological circulation of raw materials.
Energy	**Fossil energy** ● Natural resources thrive, and planet Earth has an unlimited capacity as a waste sink.	**Renewable energy:** ● It associates environment and industry and minimises waste emissions.
Environmental impact	**Ecosystems overexploitation** ● It has depleted natural resources.	**Ecosystems conservation** ● It alleviates resource depletion. ● It focus on the social, economic and eco-conscious perspectives.
Manufacturing model	● 'Cradle-to-grave' manufacturing model.	● 'Cradle-to-cradle' manufacturing model.

SUSTAINABILITY

Concerns over sustainability and environmental protection and the increasing inequality along with enduring deprivation of a great part of mankind have become a major challenge in the 1990s and have been flourishing in the last decades (Rockstrom *et al*., 2009; Piketty, 2014; Steffen *et al*., 2015). Consequently, it is important to consider the broad roots from which the concept came to light.

According to Geissdoerfer *et al*., (2017) the concept of sustainability emerged from the French verb "soutenir", meaning "to hold up or support" (Brown *et al*., 1987) and its contemporary definition is based on forestry (Du Pisani, 2006; Grober, 2012; Caradonna, 2014) On its basis is the silviculture principle which establishes that the quantity of wood harvested ought not to overcome the amount that is cultivated, (von Carlowitz, 1713). In the course of time, this concept was adopted by a broader area, ecology, regarding the capacity that nature holds to restore itself (Duden, 2015).

Of particular relevance is also the former political economist Malthus (1879), who, outshined by the industrial revolution, discussed the limits of both economic and demographic progress, showing his concerns on the world's population flourishing effects, attesting that a population boost could eventually endanger the world's function of food supplier. Furthermore, in the 19th and early 20th centuries, naturalists and ecologists already promoted the separation between the anthropocentric conservationists on one side and, who encouraged the preservation of natural resources and their sustainable usage, and the biocentric preservationists, who stood for conservation of nature on account of its intrinsic value (Callicott and Mumford, 1997).

The modern approach of this concept and the discourse around sustainability in a broad understanding was only brought to light in the 20th century, when the debate on resource depletion and sustainability concluded that natural resources exploitation ought to be regulated, as the rate of utilization and consequently their cheap value, was leading to a wasteful consumption (Hotelling, 1931).

Following a period of discussion on unprecedented ecological turbulence (food shortage, ozone depletion, crisis in climate, biodiversity loss), which resulted from inadequate management policies, the Organisation for Economic Cooperation and Development (OECD) (1960), sought to promote policies to ensure sustainable economic growth and employment in signatory countries, to enhance employment and life standards.

These were the first steps of the debate on the way industry interacts with the environment and how it should promote the reduction of its environmental negative impacts, and on the search for changes in industrial behaviour and technology.

Following this line of thought, Kenneth Boulding (1966), presented planet Earth as a spaceship with a long journey ahead. It had solar energy as the only external source of energy and all the resources available were put aboard before take-off. As time goes by, resources are spent and time in space diminishes, unless astronauts succeed in recycling goods and producing food. With this allegory, Boulding acknowledged that Earth should be considered a closed economic system, where economy and environment are interfolded.

This initial discussion was taken to another level and a number of international debates on sustainability and on the dynamics between nature/environment, society and economy (Kates *et al*., 2005) were launched.

The Stockholm Conference (1972) and the report *Limits to Growth* (Club of Rome, 1972) had significant implications, as it recognised the need to reduce the ecological footprint per unit of consumption so as to avoid surpassing the limits of nature. It also triggered an international debate on the planet's capacity to sustain continuous human and economic growth.

In 1980, the World Conservation (WC) policy was published by the International Union for the Conservation of Nature (IUCN), defining the essence of sustainable development as the preservation of life-support system of planet Earth.

The conception of sustainable development introduced by the Brundtland Commission (1987) arose as a demonstration of the increasing environmental awareness which accentuated during the 1980s, and has been put on the agenda of different stakeholders (policymakers, academia, businesses). It stood out as a pathway towards economic development while maintaining the ecological processes necessary for life and health of future generations (McMichael *et al*., 2003; Ehrenfeld, 2005), without undermining the generations to come potential to provide for themselves (*Our Common Future* - World Commission on Environment and Development, 1987),

The United Nations World Commission for Environment Development (UNWCED) (1983), delineated a global agenda to achieve sustainable development. The report "Our Common Future" (1987) aimed to set clear goals which enabled sustainable development by 2020 and onward; it also advocated cooperation among develop and developing countries, by establishing common and beneficiary goals considering people, natural resources and consequently environment, and economic development; how to address environmental constrains; and finally to establish joint goals in protecting, enhancing and rehabilitating the environment, i.e., an overtime agenda for the years to come.

Developing in a sustainable way, eradicating poverty, reducing environmental degradation and waste are the essential parts of the process to allow social, economic, and environmental sustainable growth. There is also the common knowledge that economic and environmental questions shouldn't be separated as development may stand for environmental constrains and the latter may also sabotage economic development (UNWCED, 1987). The commission concluded that a new route is essential to support human progress not only during a few years to come, but in the future and set 'sustainable development' as the ultimate goal and central issue of the challenge (UNWCED,1987).

So, in 1992, in the Rio – 92 Summit, which joined at the same table Heads of State, diplomats, government officials, international organisations, delegates from United Nations agencies, nongovernmental organisations (NGO) representatives and Chiefs of Government from different countries, establishing as first preamble "…the beginning of a global partnership" (1992:7), concluded that environment, and social and economic development cannot be seen as fragmented areas. In addition, *The Declaration of Rio* (1992) established clear principles for dealing with future environmental policies and decisions concerning of socio-economic development and its agenda aimed "to reconcile the twin requirements of a high quality environment and a healthy economy for all people of the world, while identifying key areas of responsibility as well as offering preliminary cost estimates for success" (1992:6). This was a noticeable breakthrough that would lead to international agreement on achieving sustainable development.

Afterward, environmental summits (Istanbul, 1996; Johannesburg, 2002) accelerated the international programme on environmental conservation through sustainable resource management and the main focus became poverty in developing countries rather than wealth in developed countries. (Martinez-Alier, 2002). By doing so, the economic growth and development framework was adjusted as the imperative pathway in attaining a solution to environmental degradation (Gómez-Baggthun and Naredo, 2015).

The disclosure of Agenda 21 (United Nations, 1992), as the final programme of action in the environment field and its subsequent acceptance by different governments, confirms the importance given by the international community to sustainable development.

Since the 1980s a lot was produced to set forth environmental challenges to academia policies, and important documents were issued: the Magna Carta of European Universities (1988); the Talloires Declaration of University Presidents for a Sustainable Future (1990); the Halifax document "Creating a Common Future: An Action Plan for Universities'' (1991); the "Urgent Appeal from the CRE" to the Preparatory Committee of UNCED (1991); the "Universities Charter for Sustainable Development" (1994); and the Lund Declaration (1999) (Leal, 2000).

At the Rio+20 Summit (2012) the construct of 'Green Economy' (GE) represented the core of sustainable development and the main directive of the multilateral talks. Accounting for this Summit, in the United Nations Environmental Programme (UNEP, 2011) report 'Towards a green economy: pathways for sustainable development and eradication of poverty', GE is displayed as an economical model that meets fundamental human needs, and social and economic equity growth, whilst minimizing environmental depletion, principle also recalled in the Rio+20 Summit final declaration.

Geissdoerfer *et al*., (2017) state that Johnston *et al*., (2007) point out that a wide range of disparate interpretations and applications of sustainability have emerged within this period of time (Munda, 1997). According to D'Amato *et al*., (2017) diverse sustainability definitions have been proposed in different fields as research, politics, and in the private sector so as to justify their businesses and proceedings, and that each societal actor interpreters these various meanings in different forms, granting graduations of diversity.

Taking the above into consideration, Geissdoerfer *et al*., (2017), suggest a new interpretation to the term sustainability, as "the balanced and systemic integration of intra and intergenerational economic, social, and environmental performance". Based on this description, these authors conclude that a reflection on how to accomplish intragenerational prosperity whilst sustaining essential life-support systems has arisen.

Along the global debate concerning the sustainability concept, a new framework to access the corporations performance was brought into the discussion, the 'triple bottom line' (Elkington, 1994, 1997). This model exceeded the traditional estimate of profits, return on assets, and stock value to take into account the environmental and the social dimensions. Therefore, intersecting the dimension of profit (economy), people (social) and the planet (environment) is a noteworthy approach to promote sustainability goals.

The economic dimension focus on the bottom line and on the capital inflow, expenditures, taxes, employment, and the business context. The social measures prioritize the community social dimension and may comprise educational measurements, equity and access to social assets. The environmental variable considers environmental actions and their feasibility. It ought to take into consideration air and water quality, energy use, resource systems, and waste. The interactions within these three elements are consistently, significantly related, and reciprocally affect each other (Mckelvey, 2002), being considered "interdependent and mutually reinforcing pillars" (UN General Assembly, 2005).

As the concern over environment became progressively important as an imperative global concern, sustainability has been considered a key-word concerning global research and a common political goal (Garud and Gehman, 2012; Markard *et al*., 2012). A general concern whether present prosperity policies are maintainable in the future to come (Clark and Crutzen, 2005; Rockström *et al*., 2009), along with the limited capacity to stock resources and their inconsistent geographical spread and allocation (Georgescu-Roegen, 1977), and concerns over the ability of lie-systems to assimilate waste beyond economic growth (Daly and Townsend, 1993), constitute a global and local challenge.

Considering the strengths and weaknesses of this concept, efforts are being made to transition from research, academia, and independent stakeholders programmes, to projects that promote tangible and sustainable initiatives.

CIRCULAR ECONOMY AND SUSTAINABILITY: AGREEMENTS AND DISAGREEMENTS (SIMILARITIES AND DIFFERENCES)

Agreements

The concepts of Circular Economy and Sustainability have been gaining increasing attention worldwide among stakeholders (academia, industry, policymakers). Both constructs focus on intra- and intergenerational principles based on the assumption that environmental hazards are the major cause of the existing development crisis (Geissdoerfer *et al*., 2017). Additionally, they emphasize a global approach to development, and equally highlight that an ecological collapse on a global scale ought to determine collective responsibility and enhance collaboration amongst stakeholders and cross-sectoral procedures, in order to create value.

These concepts rest upon regulation, i.e., governments regulations and industry codes of conduct demand that businesses consider sustainability. The violation of these regulations implies costs as penalties and fines. Incentives and/or rewards should also be considered as essential implementation tools to achieve and improve performance (Geissdoerfer et al., 2017).

Private companies play a key function amidst major stakeholders as they operate within a wider range of resource proficiencies, and hold appropriate structures and systems to enhance sustainability in the companies.

Technological solutions are also taken into account as the use of production technologies which are input efficient, allow a higher production per unit of input. Nevertheless, they frequently bring up implementation issues (Geissdoerfer *et al*., 2017).

Indeed, the search for sustainability is already transforming businesses, which is currently leading them to change the way they consider products, technologies, production processes, as well as business models. The path towards environmental goals, success, and progress is innovation and technological upgrade, (Nidumolu, 2009).

Disagreements (Differences)

The concept of circular economy and the concept of sustainability have a set of differences that go from backgrounds, designs, goals, incentives, to timelines.

Circular economy dates back to different schools of thought, to different authors and periods, which indicates that the principles underlying it have prevailed for hundreds of years though only a few decades ago were brought to public consideration.

It draws on epistemological fields as biology, economy, and ecology providing "umbrella constructs" (Hirsch and Levin, 1999:199) such as 'circular flow of income' (Quesnay,1758), 'industrial metabolism' (Simmonds,1862), the 'spaceman economy' (Boulding, 1966), 'limits to growth' (Meadows, Randers, Meadows, and Behrens, 1972), 'cradle-to-cradle' (Stahel and Ready-Mulvey, 1981; McDonough and Braungart, 2002), 'industrial ecology' (Frosh and Gallopoulos, 1989; Graedel and Allenby, 1995), 'regenerative design' (Lyle, 1996), 'remanufacturing' (Steinhilper, 1998), 'natural capitalism' (Hawken, Lovins and Lovins, 1999), biomimicry (Benyus, 2002), 'eco-effectiveness' and 'eco-efficiency', (McDonough and Braungart, 2002; EMF, 2012), 'steady state economy' (Daly, 2005), and 'performance economy' (Stahel, 2010). Nonetheless, its modern conceptualisation and one of the first definitions is allied to Pearce and Turner (1990) as stressed by Su *et al.*, (2013); Ghisellini *et al.*, (2016) and Geissdoerfer *et al.*, (2017).

The concept of sustainability emerged in the 1960s as a response to some concern over ecological collapse and environmental damage and later formalized by environmental movements and policymakers, mainly after the disclosure of the Brundtland Report (1987), and when society became aware that humanity could no longer maintain the current global path toward economic growth without exhausting Earth's finite resources.

Circular Economy targets the concept of circular flow, a closed loop system, based on continuous growth, in which resource inputs, waste are eliminated, promoting, this way, the reduction of natural resources usage and create effective societal and environmental results (Kraaijenhagen, 2016). An environmentally better and consistent use of resources is promoted, and waste emissions are reduced, by adopting a circular rather than linear 'take, make and dispose' model (Ness, 2008) that has dominated the economy so far. Circular business models require collaboration, communication and articulation among networks of stakeholders in order to achieve value within a closed material loop system (Mentik, 2014), which mimics natural life cycles (Benyus, 2002).

In turn, sustainability presupposes an open-ended system, in which the environment, economy and society play key roles and are the direct benefited (Elkington, 1997). This concept was primarily conceptualised as the three dimensional 'triple bottom line' (Elkington, 1997) considering the social, environmental, and economic elements, that allow sustainable outcome, as equal and uniform. If one of these components is more fragile than the others, the system as a whole becomes unsustainable, as it is extremely complex to contemplate an efficient management system that integrates the social and environmental perspectives (Geissdoerfer *et al.*, 2017).

The concept of circular economy promotes 'eco-effectiveness', in order to minimize and dematerialize the material flow, which promotes well-balanced swaps between environment and economy (McDonough and Braungart, 2002; EMF, 2012). On the contrary, sustainability, enhances 'eco-efficiency', the ultimate tool for achieving industrial cohesiveness (Hueseman, 2003).

As one of the beneficiaries, the environment profits from less resource depletion and pollution, and society, another dimension of the triple bottom line, gains from the environmental enhancements as well as from the additional advantages, like jobs and equitable taxation (Webster, 2015).

The CE beneficiaries are the parties involved in the system implementation, along with the environment, the societal welfare and development benefits are implicit.

Considering sustainability, it is also referred in specialised literature (Brundtland Report, 1987; Rashid *et al*, 2013) that it constitutes a wider concept as it can assume different meanings in different contexts. CE considers economic and environmental beneficial impacts comparatively to the ones of a linear system.

Geissdoerfer *et al.*, (2017) stress out that another fundamental difference lies in the parties involved in the system changes. Regarding sustainability, the areas of intervention are determined by the stakeholders engagement, along with the management acknowledgement that sustainability can generate value for businesses through the reinforcement of revenues and lower costs, even though the motivation for the implementation of sustainable strategies comes from governments' policies, economic demands, or even from NGOs (Epstein, 2009). On its side CE focus on governments and companies (Webster, 2015).

The chronological timeline is indefinite, as targets, goals, intentions can be adapted or reorganised in the course of time, as determinations of sustainability can only be made after the fact. As compared to sustainability, CE outlines theoretical and practical constraints when conducting the implementation of a CE strategy in a certain region (EMF, 2013).

Additionally, the allocation of competencies amid the two concepts is also different. With respect to sustainability competencies, goals and interests are shared among stakeholders, however they are not highlighted in obvious means. In CE private companies, regulators and decision makers have the responsibility, emphasise economic incentives for firms, and promote a reduction in resource consumption and environmental pollution.

Nevertheless, Gueissdoerfer *et al*., (2017) point out that the correlation between these constructs remains unclear as it is not obvious in literature, which is disadvantageous for progress in the sustainability science research.

Furthermore, Benson and Craig (2014) emphasize that the time to overcome the concept of sustainability has come. Although the appeal to sustainability principles in the academia, in international lectures and policy debates, the unprecedented and irreversible biodiversity loss (Wolinsky 2011; Sala, 2000), the increasing consumption rates per capita (Myers 1997), and the global climate change (Intergovernmental Panel on Climate Change [IPCC], 2007) are driving humanity towards unprecedented changes (Barnosky *et al*. 2012), towards a ‘‘no-analog future’’ (Fox 2007).

Table 3 presents an overview of the main differences between these two concepts.

Nevertheless, Gueissdoerfer *et al*., (2017) point out that the link between these constructs remains unclear as it is not obvious in literature, which is disadvantageous for progress in the sustainability science research.

CONCLUSION

In the last decades the demand for a transformational model of production and consumption, as well as a model that allows the mitigation of the inconsistencies between economic growth and environmental sustainability has gained relevance. Although, the implementation of Circular Economy strategies is at an initial phase of development, stakeholders and consumers, are, as never before, watchful concerning environmental sustainability and consider CE as an approach towards preventive and regenerative eco-industrial development.

The purpose of this study was to understand the abovementioned concepts, their evolution and the main similarities and differences based on the literature scrutiny. And after doing so, it can be concluded circular economy represents the diving force to attain sustainable development at the operation level.

Finally, similarities and differences between the two constructs were found, nevertheless, the linkage between these two constructs is not clearly explicit as most authors (EMF, 2013; Bakker *et al*., 2014, Rashid *et al*., 2013; Bocken *et al*., 2016) emphasize the environmental performance of CE, instead of taking into account the three dimensions of sustainability (Geissdoerfer *et al*., 2017). From this perspective, these constructs still need to be further refined, so that the relationship between them becomes clarified. Therefore, future research initiatives are conceivable in this area.

Table 3. Differences between the concept of circular economy and the concept of sustainability.

	Circular Economy	Sustainability
Origins	The CE construct draws on epistemological fields as biology, economy, and ecology: ● 'circular flow of income' (Quesnay,1758); ● 'industrial metabolism' (Simmonds,1862); ● the 'spaceman economy' (Boulding, 1966); ● 'limits to growth' (Meadows, Randers, Meadows, and Behrens, 1972); ● 'cradle-to-cradle' (Stahel and Ready-Mulvey,1981; McDonough and Braungart, 2002); ● 'industrial ecology' (Frosh and Gallopoulos, 1989; Graedel and Allenby, 1995); ● 'regenerative design' (Lyle, 1996), ● 'remanufacturing' (Steinhilper, 1998); ● 'natural capitalism' (Hawken, Lovins and Lovins, 1999); ● biomimicry (Benyus, 2002); ● 'eco-effectiveness' and 'eco-efficiency', (McDonough and Braungart, 2002; EMF, 2012); ● 'steady state economy' (Daly, 2005); ● 'performance economy' (Stahel, 2010).	● This concept is traced back to the 1960s and stands out as a response to some concern over ecological collapse and environmental damage; ● It was conceptualised as the 'triple bottom line' (Elkington, 1997); ● It was formalized by environmental movements and policymakers after the disclosure of the Brundtland Report (1987); ● Society became aware that humanity could no longer maintain the current global path toward economic growth without exhausting Earth's finite resources.
Main Purpose	**Circular Economy focus on:** ● circular flow; ● a closed loop system; continuous growth which eliminates waste resource inputs, creating effective societal and environmental outcomes (Kraaijenhagen, 2016); ● enhancing natural resource exploitation, by adopting a circular rather than linear 'take, make and dispose' model (Ness, 2008); ● mimicking natural life cycles (Benyus, 2002). ● Collaboration and communication are required among stakeholders to achieve value within a closed material loop system (Mentik, 2014).	**Sustainability presupposes:** ● an open-ended system, in which the environment, economy and society play key roles (Elkington, 1997);T
Target	● It promotes 'eco-effectiveness', ie to minimize and dematerialize the material flow; ● It promotes well-balanced swaps between environment and economy (McDonough and Braungart, 2002; EMF, 2012).	● It enhances 'eco-efficiency', the ultimate tool for achieving industrial cohesiveness (Hueseman, 2003).
Beneficiaries	● The environment ● Society ● The parties involved in the system implementation.	● The environment ● Society
Focus	● CE focus on governments and private companies (Webster, 2015).	● Stakeholders, governments, NGOs (Epstein, 2009); ● Non profit organisations at a global level.
Competencies	● Private companies, regulators and decision makers have the responsibility, emphasise economic incentives for firms, and promote a reduction in resource consumption and environmental pollution.	● Competencies, goals and interests are shared among stakeholders.
Timeline	● CE outlines theoretical and practical constraints when conducting the implementation of a CE strategy in a certain region (EMF, 2013).	● The chronological timeline is indefinite, as targets, goals, intentions can be adapted or reorganised in the course of time.

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KEY TERMS AND DEFINITIONS

Circular Economy: It is a holistic approach to reduce, reuse and recycle the production and consumption procedures so as to minimize energy consumption and consequently waste production.

Sustainability: It is a practice that combines economic growth and human activity in harmony with environmental preservation.

Chapter 4
Financing the Sustainable Development Agenda Goals:
Role and Challenges for the Private Sector and DFI

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ABSTRACT

The 2030 Agenda is comprehensive, universal, and ambitious. To reach its goals, the world needs to invest US$5 to 7 trillion/year. To finance it, the private sector must be involved. This chapter considers the motivations of business and corporations to incorporate the SDG in their investment agenda and the role DFIs can play in providing financing to their projects. It acknowledges that the private sector is a key element for long-term sustainable development and highlights the difficulties of DFI in assessing impact in risk analysis and therefore financing private investments for sustainable development. Finally, it finds that the international community and developing countries need to work together to improve the business environment on those countries, and concludes that the international community and the banking system do not know how to assess the role and impact of business and corporations projects in the agenda, and that the risk mitigation policy does not consider the nature of DFIs. Looking into the future, the authors present future research topics needed on this subject.

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INTRODUCTION

Until 2015, the mechanisms to support international development were a one-way street from developed countries into developing countries reserved to traditional actors, namely the States, International Organisations, NGOs and Third Sector Organisations. In 2015, The UN approved a new agenda for development that is a game changer. In fact, the 2030 Agenda is comprehensive - for it covers all the key elements of human progress; universal - for it sets goals for all the nations and all the people; and ambitious - by demanding a lot in a short period of time.

But to reach the general goals of environmental sustainability, social development and economic growth for all, the World needs to invest US$5 to 7 trillion every year and, according to the UN, the existing Official Development Aid totalled US$149 billion in 2018.

There are, indeed, significant challenges to financing the Sustainable Development Goals (SDG) agenda and it is no longer possible to rely on the traditional approach to development. New actors must be brought, as the International Community recognised in 2015 in the Addis Ababa Action Agenda, namely the Private Sector. Indeed, the Agenda is unique in the way the International Community decided to incorporate the private sector, which is called upon to work side-by-side with the States, the International Organisations, the NGOs and the Not-For-Profit Organisations.

This chapter considers the motivations of business and corporations to incorporate the SDG in their agenda, their investments and their impact. It recognises that, contrary to the traditional development actors, Business and Corporations, large and small, need to make money, for without profit the private sector fails. That is the nature of the private sector. But it also acknowledges that business and corporations are a key element for long-term sustainable development and that, regardless of their motivations - be that a modern understanding of Corporation Social Responsibility, or because legislation and consumers so impose it or even because there are profits to be made and financing available in sustainable business - the role of the private sector in SDG agenda is expected to become ever more relevant, though a methodology that allows business and corporations to identify and quantify the real impact of their investments in sustainable development is still under debate. In fact, as recognised by the UN, sustainable private investment in developing countries is still far from the desirable numbers, calling into question the ability to achieve the objectives set. UN IATF, among other agencies and international organisations, has been questioning this situation, seeking to find the causes for this reality. The chapter focuses on this effort, and the causes already identified, namely the role DFIs may play in helping increase sustainable investment in developing countries. The chapter argues that, due to the difficulties DFIs face in assessing impact in risk analysis and therefore financing private investments for sustainable development, a new approach is necessary that clearly separates Developing Banks from Commercial ones.

This study looks at the role of private sector in sustainable development. It starts by identifying the changes in the International Community vis-a-vis the actors for development and contribution that business and corporations are expected to give in for the implementation of the new 2030 Agenda. Later, the chapter consideres the reasons that drive the private sector and developing countries to incorporate the Sustainable Development Goals in their investment strategies and finally, the chapter considers the difficulties that business and corporations face when contributing to the SDG Agenda, in particular the issues surrounding the instruments for financing private investments. The Chapter closes by raising three further research areas, thus contributing to this new but ongoing conversation.

2030 Agenda's Challenge to the Private Sector

When the World looks back at 2015, it finds a seismic change on the way that Development Policy works. In fact, until then – including in the Millennium Development Goals launched in 2000 (UN, 2000), centered on addressing basic human needs throughout the developing world - Development was something for developing countries to benefit from and for the developed ones to provide; it was limited in its scope and it failed to catch the imagination of people across the Planet.

The new agenda, to be delivered by 2030 (UN, 2015) and composed by 3 international instruments (the UN 2030 Agenda, the Paris Agenda on Climate Change and the Adis Ababa Agenda for Action), is the opposite: it is comprehensive - for it covers all the key elements of human progress -; it is universal - for it sets goals for all the nations and all the people - and it is ambitious - by demanding a substantial and profound change in a short period of time. And this Agenda has captured the imagination of people and organisations across the globe.

The Sustainable Development Agenda - or the Sustainable Development Goals (SDG) as commonly referred to - covers the so called "5 Ps" of development (People, Planet; Prosperity, Peace and Partnership), organised in 17 goals and encompassing 169 targets. This massive and ambitious agenda basically argues that every country and each person are entitled to sustainable development, underlines that no country in the World can claim to have fulfil the development goals and considers that to achieve development, all the goals have to work together.

When one considers the full range of the Sustainable Development Agenda, one notices that the SDG for the post-2015 era can be clustered around the three main areas of economic growth, social inclusion and environmental protection as interconnected dimensions of broader global development (PAVONE, 2015), and, unlike the Millennium Development Goals, achieving this new set of ambitious goals calls for a new level of cooperation and bolder action not only from the traditional development actors, namely the International Organisations, States and the 3rd Sector, but it goes further and includes new actors across society. Chiefly among these new actors is the private sector, that plays an important role.

If the Agenda is ambitious, so too is the cost of delivering the 17 SDG by 2030. According to the UN, the annual cost of implementing the Sustainable Development Goals is US$ 5 to 7 trillion and the existing Official Development Aid totalled US$149 billion in 2018 (UN). Clearly, the 2030 Agenda needs new actors and new funding which may explain in part the rational of the Addis Ababa Agenda for Action (UN, 2015) where, for the first time, the private sector is called upon to join the efforts of bringing sustainable development to all, "leaving no-one behind", an expression used in the SDGs common lexicon and commonly used by UN agencies and others in official documents, e.g. (UN Committee for Development Policy, 2018).

Setting the Case for Private Sector as an Actor for Development

As mentioned previously, there are significant challenges to financing the SDG agenda, and one can no longer rely on a "business as usual" approach to development, and the International Community recognised in the 2015 Addis Ababa Action Agenda that new players are needed, in particular the Private Sector.

In fact, the Agenda is unique in many aspects and the way the International Community decided to incorporate the Private Sector, now called upon to work side-by-side with the States, the International Organisations, the NGOs and the Not-For-Profit Organisations, is one of those major changes.

As such, it has generated broad reactions, with mistrust on both sides but, as World Business Council for Sustainable Development and the International Business Leaders Forum have pointed out (WBCSD/IBLF, 2004). While there are still development organisations which are opposed to different aspects of business and corporate activities, there has been a clear increase in the number of developments organisations not only willing to work with the private sector, but actively seeking corporate partnerships. Similarly, while many companies remain unconvinced of the need for collaboration with non-traditional partners, a consensus is emerging among leading businesses that such alliances can be useful.

As Vaes and Huyse recall, (VAES & HUYSE, 2015) there has been a combination of factors that pushes and pulls private sector onto the development agenda. The shifting views on the role of private sector in development are visible in current development discourse, but insight in the scale and the modalities of the implementation on the ground remains limited. This idea of bringing the Private Sector as an actor to development cooperation policies is far from consensual in the economic world, and it is certainly not well accepted by, for example, Friedman's Chicago School. In fact, as (BANIK & MIKLIAN, 2017) have put it, "Friedman[1] would be livid" with these new approaches to the private sector's role in development policies, as "Friedman believed passionately that firms should steer clear of trying to improve society, leaving this weighty responsibility to governments and NGOs".

Over the last 25 years, however, many things have changed. Banik and Miklian (BANIK & MIKLIAN, 2017) point out three main interconnected trends that have driven this move: (1) companies have established deeper footprints in poor and fragile countries, both through their own expansion and by acquiring local competitors; (2) activist attention to corporate misdeeds in such places is much higher – and spreads faster and wider to consumers, also more attentive and concerned with issues related to the social and environmental impact of company activities; and (3) a new generation of activist CEOs and investors have come to the fore, embracing the belief that businesses should be not just profiteers but also positive social actors. The authors conclude that, taken together, these profit and reputational drivers have led the private sector to make a sustained collective effort for global development for the first time.

Adding to those trends, a new understanding on long-term business sustainability is driving the private sector to acknowledge the relevance of development cooperation and partnering with not-for-profit organisations to help spur development.

In fact, the private sector and development organisations have many long-term goals in common that provide a basis for partnership. As noted by the WBCSD and the IBLF (WBCSD/IBLF, 2004) both have an interest in a stable society; both want to foster income-generating activities and build the capacity of local entrepreneurs; both want to ensure that people are healthy and educated.

To address the still existing issues on potential collaboration between traditional development actors and private sector, there are best practices that are starting to facilitate further collaboration. To promote a better understanding of the different roles and expected outcomes, the OCDE has agreed a number of principles, known as the "Kampala Principles on effective Private Sector Engagement in Development Co-Operation" (OECD, 2016) that regulates (1) inclusive country ownership, (2) results and target impact, (3) inclusive partnership, (4) transparency and accountability and (5) leaving no one behind.

Regardless of the newfound role in sustainable development, one should not forget that the nature of business and corporations has not, as such, changed. Business and Corporations, large and small, need to make money, for without profit the private sector fails. But they have moved from short-term-only focus to long-term sustainability attention.

On the other side, there is also, on the development community, a growing recognition that private sector investment brings a range of benefits, including technology, employment, and access to markets, which are not core competencies of the development community, but which can be drawn on to help meet development needs (WBCSD/IBLF, 2004).

Therefore, incorporating for-profit organisations in the effort to attain the Agenda's goals by 2030 is not a small change for the development universe. Furthermore, the role of Business and Corporations is much wider than just to square the bill. In fact, they are a key element for sustainable development, for there is a clear impact in individual progress generated by a well-payed job, allowing children to go to school and not to work, to put food on the table and a roof over one's head. And there is equally a public interest in business paying their taxes, allowing governments to provide for public policies.

Furthermore, one should note that by creating well payed jobs, private sector impacts directly and indirectly on the goals of No Poverty (SDG 1), Zero Hunger (SDG 2) and Decent Work and Economic Growth (SDG 8). But business and corporations contributes to the SDG Agenda not only by creating jobs and paying its taxes, as private investment may also contribute to Gender Equality (SDG 5), Industry, innovation and infrastructures (SDG 9), Responsible Consumption and Production (SDG 12) - although impacts on SDG 5, 9 and 12 need to be considered carefully. Private investment has, thus, a significative impact on SDG and is key for the objectives of the Agenda 2030, not only as key actors in implementation but as important partners in financing it.

Why Are Business and Corporations Willing to Consider SDG Impact Investments?

The new Development Agenda agreed in 2015 demands new actors to contribute to the effort of leaving no one behind by 2030 and that the Private Sector plays an important role when investing in developing countries, as long as those investments may have a positive impact on environmental sustainability, social development and economic growth.

Some of the arguments development cooperation organisations' have pointed out on why the private sector could invest projects with an impact on the SDGs have been highlighted. But if the Private Sector must become a central actor in order to achieve the SDGs, it is essential that it incorporates objectives that it recognises as valid in the context of its corporate business strategies.

Let's consider a story on how some business are incorporating the SDG in their day-to-day:[2]

A few years ago, a major business working on a not-sustainable sector decided that it had to change its business model to become more aligned with SDG agenda. The first thing they did was a significant investment in a project with obvious sustainable impact in a developing country. And to do so, the business applied for a loan from a Sustainable Development Bank that was only too happy to agree but puzzled on the why would such a massive business need such a comparative small loan. The business explained that the market and consumers knew that this Bank only supported sustainable projects and it was important to be seen as a sustainable responsible organisation. The next steep of this business was to abandon any lobby activity that did not have a strong sustainability, again making it clear that the lack of sustainability credentials was the main reason to change its lobby policy. Finally, the business set-up a significant carbon compensation system closed connected to consumers using its products.

This tale illustrates the argument that there are basically 4 reasons why Business and Corporations are willing to consider SDG impact investments: (1) a modern understanding of Corporate Social Responsibility; (2) legislation and consumers pushing the private sector into the sustainability agenda; (3) envisioning of profits to be made in sustainable business; (4) financing available for sustainable business that do not consider non-sustainable investments and projects.

One can look at this from a more cynical viewpoint and argue that everything is motivated by profit, or one can be more benevolent and consider that businesses are incorporating the SDG in their investments mainly motivated by Corporate Social Responsibility. But there is also a case for arguing that companies are beginning to understand the benefits that impact driven investment can bring to their business and economic performance, keeping mind that business and corporations need to turn a profit in their investments and that investment in developing countries adds a significant risk that must also be considered. From a development viewpoint, one could even argue that the reason why business and corporations incorporate sustainable development policies in their day-today activity is ultimately indifferent. As long as they do it. Therefore, the Private Sector is not encouraged by the interest of the international community, but that the rational for business and corporations for investment decision is it that can benefit from sustainable invest.

Private Investment in Developing Countries

If there is an obvious interest on the International Community to incorporate the private sector in the sustainable development agenda, and there are arguments to support the role of business and corporations in that agenda, there is also interest from developing countries to attract foreign direct investment (FDI) to their countries. In fact, and according to (LOUNGANI & RAZIN, 2001), and adding to job creation and tax generation that has been mentioned before, FDI allows for transfer of technology, foster competition, promotes training and human capital development and represents a long term commitment from business and corporations into a particular developing country. Botsworth and Collins add that when compared to other forms of foreign investment, notably loans, FDI has a much stronger impact in domestic investment (LOUNGANI & RAZIN, 2001).

If FDI is desired by Developing Countries, one should not forget that the international competition for receiving good investments from good business and corporations is fearless, and one should consider that there is a direct relation between risk and reward in FDI. The riskier the investment, the bigger the return. If that is so, one would expect that FDI would be flowing into developing countries, as business and corporations would be looking for big returns in their investments. But that is not the case. In fact, data shows the exact opposite. According to the World Bank (World Bank (2)), the ten countries that attracted more FDI in 2018 were, in order of investment, the US, the UK, China, The Netherlands, Ireland, Brazil, Singapore, Germany, India and France. In other words, most of FDI was directed to developed countries or - with possible exception of Brazil that is, nonetheless, inline to join the OECD - countries that have little or no risk associated. Thus, private sector will choose where to invest based as much as on expected Return on Investment as on the overall foreign investment legal and administrative realities and that between greater return or safer investment, business and corporations will choose the latter and not the former.

This creates an added difficulty for the expected role of private sector in contributing to developing countries pursue of the SDG. In fact, if the international community relies, among other actors, on the contribution of business and corporations to support sustainable development in developing countries, it needs to work with those governments in the creation of investment conditions.

In this regard, the World Bank publishes an annual report on “Doing Business” (World Bank (1)) where it assesses the existence (or lack of) conditions to attract FDI. It compares items such as starting a business, dealing with bureaucracy, access to electricity and other infrastructure, access to credit, protection of investment and property rights, paying taxes, trading across borders, rule of law, resolving insolvency and workers’ rights.

Not surprisingly, the best places to do business are also the places where FDI flows more naturally, i.e. developed economies. In fact, and as the World Bank assessment makes clear, non-standing the improvement in Nigeria and Togo in Sub-Saara Africa, only the Mauritius in 13th and Ruanda in 38th position make into top 50 countries where it is easy for the private sector to invest. And not one Latin America economy makes the cut (World Bank (1)).

At this point, one is found in a conundrum regarding the role of private sector in sustainable development. It has been recognised that the new sustainable agenda agreed in 2015 is a massive and ambitious undertaking that calls upon the usual actors - International organisations, States, NGOs and the 3rd sector - as well as new actors, namely the private sector. In fact, in this new context, the private sector can have a significant impact in promoting key Sustainable Development Goals and it is believed that private sector has its own reasons to consider investments in developing countries. But when one considers the conditions necessary for private sector to engage in sustainable development investment, one finds that those conditions are mainly not there, in particular when looking at the level of risk and difficulties associated with doing business in countries where sustainable development investment is needed the most. It is not surprisingly, therefore, that most private investment targets developed markets and not developing ones, and the question, therefore, is how to create the right conditions for the private sector to invest in developing countries.

Financing Private Sector Investment for Sustainable Development

In any undertaking, the dynamics between risk and reward is always present, be that in politics, in business or even in one’s personal life. When deciding where to invest, private sector will necessarily consider, assess and control threats to the organisation’s capital and earnings. These threats, or risks, could stem from a wide variety of sources, including financial uncertainty, legal liabilities, strategic management errors, accidents and natural disasters. Managing the level of risk and balancing it with expected return is thus a major task for private sector when considering investing on other country.

Risk management provides with strategies of risk mitigation, but evidence referred earlier in this chapter suggests that there is a premium on avoiding a certain level of risk even if the reward could be more significative. As argued before, that implies that if one wants business and corporations to contribute to the SDG’s in developing countries, one needs to create specific models of risk mitigation for this purpose.

Although there are a significant number of risk mitigation strategies, in particular putting in place the legal and administrative framework that will facilitate business as prescribed and promoted by the World Bank and other International Organisations, this chapter will focus its attention on the role of the financial sector in mitigating FDI in developing countries’ risk, in particular the Development Financial Institutions or DFIs.

As defined by OECD (OECD, s.d.), DFIs are:

National and international development finance institutions (DFIs), (…) specialised development banks or subsidiaries set up to support private sector development in developing countries. They are usually majority-owned by national governments and source their capital from national or international development funds or benefit from government guarantees. This ensures their creditworthiness, which enables them to raise large amounts of money on international capital markets and provide financing on very competitive terms.

The European Development Finance Institutions follows this definition, and further specifies:

DFIs invest in private sector projects in low and middle-income countries to promote job creation and sustainable economic growth. They apply stringent investment criteria aimed at safeguarding financial sustainability, transparency, and environmental and social accountability.

DFIs can be bilateral, serving to implement their government's foreign development and cooperation policy, or multilateral, acting as private sector arms of International Finance Institutions (IFIs) established by more than one country.

DFIs source their capital from national or international development funds or benefit from government guarantees which ensures their credit-worthiness. (EDFI (1), s.d.)

In other words, DFIs are bilateral or multilateral institutions, normally owned or financed directly or indirectly by government, that provide loans, guarantees and equity funding for private sector investments that impact on sustainable development in developing countries. They fulfil, therefore, a role that commercial banks are less inclined to take, as the risk assessment regarding these investments discourages action from them. One should note that "the financial support (that DFIs) bring to relatively high-risk projects helps mobilising the involvement of private capital, bringing in such diverse actors as commercial banks, investment funds or private businesses and companies". (EDFI (1), s.d.). In other words, DFIs not only invest directly in private sector projects but also help mobilising other funding, normally in the form of commercial funding and other private funding.

Although one places a significant emphasis on the role of DFIs, and evidence shows significant impact on job creation across the supply chain and increase incomes for poor people and improve access for business and poor people to infrastructure, goods and services (ATTRIDGE, CALLEJA, GOUETT, & LEMMA, 2019), it must be equally highlighted that there is only modest evidence to inform the understanding of the distributional impacts of FDI investment on different segments of the population. In other words, the data and evidence of business and corporations' impact on Sustainable Development Goals is not clear, uniform or even available.

The issue of lacking of reliable data for assessing impact is also referred by OECD as a key element that limits the capacity of DFIs in fully supporting the private sector investment with SDG impact in developing countries (OECD, 2020).

On one hand, how can one assess an investment's true impact, if one does not have the necessary tools to do it? In fact, the lack of comparable data, metrics and information from business and corporations' impact in SDG in developing countries is a significative issue that has substantive repercussions on the role private sector can play in achieving the SDG. Without data, it becomes much more difficult, if not impossible, to make the case for private sector impact on Sustainable Development Goals.

On the other hand, the lack of comparable and credible information undermines the argument that DFIs fulfil a role that commercial banking does not. If one cannot truly assess the impact of business and corporations in promoting the United Nations' 2030 Agenda, it is harder to argue that the development agenda needs to create the necessary conditions to attract foreign direct investment with SDG impact into developing countries.

In other words, without information, the true role and impact of business and corporations in sustainable development is more a matter of expectation than it is a matter of fact. And therefore, it becomes harder to distinguish between the role of Development Finance Institutions from that of commercial banks.

Recognising the need to further work on these themes, the UN Secretary-General convened, in December 2015, the Inter-Agency Task Force on Financing for Development (IATF), to follow up on the Addis Ababa Action Agenda. This task force is coordinated by the Financing for Sustainable Development Office of the UN Department of Economic and Social Affairs, but comprises over 60 United Nations agencies, programs and offices, regional economic commissions and other relevant international institutions. Major institutional stakeholders of the Financing for Development process, the World Bank Group, IMF, WTO, UNCTAD and UNDP, are also engaged.

Following the 2008 world financial and economic crisis, the G20 launched the Data Gaps Initiative (DGI), aiming to address important data gaps in the financial sector that were revealed by the 2008 crisis. The second phase of the Initiative (DGI-2) commenced in 2015 and is focused on (i) monitoring risk in the financial sector; (ii) vulnerabilities, interconnections and spill overs; and (iii) data sharing and communication of official statistics. As DGI-2 is approaching its completion date in 2021, countries have moved closer to the goal of implementing regular collection and dissemination of reliable and timely statistics for policy use, but major difficulties persist.

As noted by the United Nations (UN IATF, 2020), important progress was made on the work on financial soundness indicators (FSIs); derivatives data, with ongoing work on governance arrangements for Unique Product Identifiers (UPI); actions to reduce barriers to over-the-counter derivatives trade data reporting; and on reporting on sectoral accounts, international investment position, securities statistics, international banking statistics, and government finance statistics.

There are, however, remaining challenges, including the full implementation of international banking statistics; improved periodicity and timeliness of financial stability indicators; and the complete reporting of quarterly general government debt and operations. While progress has been made in data sharing, further efforts are needed to improve it within and across countries.

The task force recognises that high-level political support will be essential to overcome these challenges. In its 2019 Financing for Sustainable Development Report, IATF stated that unless national and international financial systems are revamped, the world's governments will fail to keep their promises on such critical issues as combatting climate change and eradicating poverty by 2030.

Despite the work done and progresses made, mobilising enough financing remains a major challenge in implementing the 2030 Agenda for Sustainable Development, as recognised by UN Secretary-General (UN Secretary-General, 2019, p. 2): Regardless of signs of progress, investments that are critical to achieving the Sustainable Development Goals remain underfunded. Interest in sustainable financing is growing, but the transition to sustainability in the financial system is not happening at the required scale.

IATF 2019 Report is very clear on this, by stating that "Weaknesses in the global financial system could pose heightened risks to achievement of the Sustainable Development Goals" (UN IATF, 2019,

p. 131). The report restates that the achievement of the SDG is dependent on private investment in least developed countries and other vulnerable countries, where capital markets are less developed and investment profiles riskier. The Report thus stresses that "deliberate policy efforts are required to promote and facilitate investments that are linked to sustainable development. That fact also highlights the importance of international support to spur investment, for instance through carefully structured risk-sharing instruments or through a greater role for development banks."

The lack of comparable and agreed data on the impact of business and corporations in development impact not only the understanding of the role of the private sector, but also on creating the necessary conditions for the setting up of the tools that may attract private investment to developing countries

This becomes clearer when one looks at the key element that limits the capacity of finance sector, either development financial institutions or commercial banks, to support private sector investment with SDG impact. For that, one needs to look back at the financial crisis started in 2008, when Governments had to step in to save the global financing sector from collapsing and dragging the World economy with it.

The global financial crisis prompted the Finance Regulation Authorities across the World to take a long and hard look at the way that the finance sector did business and to impose a number of credit limit measures, to ensure that a crisis of that scale and magnitude cannot happen again, as it became only too obvious that a deregulated banking system is a World systemic risk.[3]

In fact, as (KAMINSKI & ROBU, 2016) stress, the post-2008 crisis tougher compliance environment "multiplied the various regulations that financial institutions must follow", noting that since 2009, "regulatory costs have increased dramatically relative to banks' earnings and credit losses" and represent a growing pressure on Banks activities. More important, the authors recall, the scope of regulators' focus continues to expand, with new issues emerging and getting more attention. They include conduct risk, the quality of banks' corporate and risk culture, the next generation of anti-money-laundering measures, and third-party risk management.

Ten years on from the financial crisis, it has become now very familiar the mantra of banks saying that there is lots of money available to support the private sector and business complaining that they have no access to commercial financing. And they are both right, for as much money the banks may have to finance business, the level of risk compliance in the finance sector is now much more demanding and so less investment projects meet those criteria.

Risk compliance in the finance sector has been transformed over the past decade, largely in response to regulations that emerged from the global financial crisis and the fines levied in its wake (HÄRLE, HAVAS, & SAMANDARI, 2016). This change has been profound, and deeply changed the banking system way of operating in risk-related projects.

The fact is that the understandable and, considering the consequences of the 2008 financial crisis, desirable reinforcement on risk assessment that regulators imposed on the financial sector, is impacting on the banking sector's capacity to support and invest in Sustainable Development relevant projects.

This happens because without the possibility of incorporating Sustainable Development impact on the inner works of the Development Finance Institutions, these are just another bank. In fact, if DFIs cannot consider the SDG impact when assessing the risk/return of a particular project, because they're are under the control of the Banking System Regulatory Authorities, then they're limited in their capacity to provide the finance instruments in the conditions that could attract business and corporations' direct investment into developing countries, even if the risk may be more considerable then investing in developed markets.

In fact, considering the legal structure of the 15 national DFIs that are members of the European Development Institutions, only 3 are banks. The remaining ones are limited companies, listed companies, or investment funds (EDFI (2)). One may argue that the variety of legal frameworks within the EDFIs and the fact that most DFIs in Europe decided for other than a bank model, could be linked to the impossibility of incorporating SDG impact when assessing business and corporation's investment projects. Let us explore that argument further.

If the banking sector, both DFI and commercial banking, are still looking for a formula that will allow to incorporate the SDG into their risk modelling, and that without those metrics and models, the banking system cannot include a business and corporation's Sustainable Development Impact into its risk analysis, as a consequence, the one true principle for risk assessment is basically the financial ratio between risk and return, even if a particular investment may have a significant SDG impact.

In this context, IATF has called for well-run national development banks (NDBs) to help countries develop financing options for SDG related investments, noting that NDBs should be considered in integrated national financing frameworks. Collaboration of NDBs and multilateral banks, through co-financing or on-lending arrangements, can enhance SDG-related finance through the complementarity of international resources and local market knowledge. But further work is needed to strengthen NDB risk management and further research needed to better understand how the regulatory frameworks applied to NDBs can be tailored to protect their financial sustainability while incentivising the sustainable development.

For the financial sector, due to regulations that were put in place after the 2008 crisis, Sustainable Development Impact is an aspirational goal but not a decision-maker element in risk assessment.

It is true that some elements of the SDG are already being incorporated. Investments on climate change resilience are easier to assess, and insurance companies do it all the time. But other areas of development, notably those more closely related to social development, are still very difficult to consider when assessing the risk involved in lending for private investments. And the same rules apply to all the banks, regardless of their commercial or development nature.

To overcome the limitations on financing riskier investments, DFIs have embarked on the so called "blending finance" (OECD, s.d.) that translates into adding different forms of financial support with different sources to the same project.

OECD has defined Blended Finance as "the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries." (OECD, s.d.)

In fact, as underlined by OECD, while understanding that Official Development Assistance (ODA) has an indispensable role in financing the SDGs, the need for significant additional development finance, has acknowledged by the international community, can only be met by according a prominent place to private sector participation in it. And as such, just as the vision underpinning the 2030 Agenda is broad and ambitious, so must the instruments to finance it.

This understanding lead OECD to call for a broad and ambitious financing strategy. In February 2016, OECD Development Assistance Committee (DAC) agreed to develop "an inclusive, targeted, results-oriented work program" on blended finance drawn upon three main principles: it should be evidence based (collate evidence and lessons learned on blended finance with a focus on targeting private finance and the use of blended finance across different regions); learn from best practices (develop best practices for deploying blended finance in key economic systems and sectors, such as sustainable infrastructure, and to address specific issues such as climate change) and provide for policy guidance (deliver policy guidance and principles on the use of blended finance to deliver development impact).

Several documents and guidelines have followed, and in 2018 a roadmap for Blended Finance (the Tri Hita Karana Roadmap (OECD, 2018)) was agreed upon, recognising the need for effective coordination and for a multilateral framework for delivering blended finance.

This means the need to involve multilateral actors, in order to widen engagement further. Building on the shared value system presented in the 2018 Roadmap, blended finance stakeholders have agreed to work towards turning this roadmap into reality, but the process is still under development.

Blended finance is now seen as a promising instrument in solving the limitations on financing riskier investments, by attracting commercial capital towards projects that benefit society while providing financial return to investors.

From the banking sector – commercial and development – point of view, blended finance is at the moment the only existing instrument available to overcome limitations opposed by financial regulatory authorities.

In fact, if a particular investment has a relevant development impact, but the risk assessment does not allow neither DFIs nor commercial banks to support it, a combination or blended of support may be considered, combining commercial and concessional funding (i.e. grants), thus reducing the payback element of the funding up to the level where banking risk is acceptable. Although Blending Finance has the potential to overcome the limitations that the Banking System Regulation imposes on financing private sector investments with impact on sustainable development, the fact that those limitations impact on DFIs on the same basis that impact on commercial banking limits the capacity of developing banking to consider investments with significant SDG repercussions, thus limiting the very role of Financial Development Institutions.

UN and the International Community – and DFIs – are, therefore faced with a new difficulty when considering the role of private sector investment with sustainable development impact: even when business and corporations are willing to take the risk involved in working in developing countries, the financial institutions cannot incorporate the full SDG impact of those projects and even when it does, one just do not know how to assess its impacts. In other words, and recognising that significant steps are being taken to address environmental sustainability - but not social development -, for the banking system, having or not SDG impact is irrelevant when assessing a given project.

CONCLUSION

This chapter looks at the role of business and corporations in sustainable development. The chapter underlines that, since 2015 the International Community has recognised a new role for the private sector in the Sustainable Development Goals Agenda and identifies some of the impacts that businesses and corporations have in SDG as well as the key motivations for private sector to consider sustainable development as a driver for investment.

However, the chapter finds that the level of risk involved in business and corporation investment with SDG impact in developing countries may be too high to have the substantial impact that one could expect. If one expects the private sector role to improve, then it is fundamental that the International Community and developing countries work together to improve the business environment on those countries.

The chapter also looks at the mechanisms to finance private investment with SDG impact in developing countries and concludes, on the one hand, the International Community and the Banking System does not know how to assess the role and impact of business and corporations in the Sustainable Development

Agenda and, on the other hand, that as a collateral result of the 2008 finance crisis, the risk mitigation policy that followed does not consider the different nature of Developing Finance Institutions when compared with commercial finance institutions, even though ownership, role and aims of the former are very different from the latter.

Although one recognises that Financial Regulation Authorities in Europe and elsewhere are moving into a new understanding of the role of financial institutions in combating climate change, one underlines that the same is not true when considering other sustainable development goals, in particular social development.

This is particularly relevant, as it has been argued that SDG impact must consider, support and promote environmental sustainability, social development and economic growth working as a system and that the three sides of this tripod must move together. In this case, and to misquote Meat Loaf, "Two out of Three is not Good Enough" (STEINMAN, 1977).

Looking into the future, the International Community must be creative if it is to find the US$ 5 to 7 trillion every year that it needs to finance the Sustainable Development Agenda by 2030. To understand if private sector will, indeed, be able to contribute to the Sustainable Development Goals, more research is necessary on:

1. Is the cooperation with SDG impact between all the actors working in development, including the States, International Organisations, Public Sector, Private Sector, Foundations, NGOs and, naturally, the Financial Sector improving? Is this enhanced relationship, developing and agreeing on the metrics and data availability that is necessary to have a clear understanding of the private sector impact on sustainable development in developing countries?
2. Are DFIs and other actors in Sustainable Development improving in combining different sources of financing, blending commercial and concessional funding to de-risk projects and have more impact with less resources from the Official Development Assistance funding?
3. Can we see a serious conversation between States, International Organisations, Financial Regulation Authorities, the Finance Sector and other actors, on how to incorporate the full SDG impact - environmental sustainability, social development and economic growth - into risk analysis, in such a way that investment with impact in sustainable development is both feasible and globally recognisable?

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ENDNOTES

1 Economist and Nobel laureate, member of Ronald Reagan's Economic Policy Advisory Board, Friedman's free-market fundamentalism taught during the 70´s and the 80´s influenced corporate activity for years. In his view, firms worked in impoverished parts of the world alongside – but almost never with – do-gooder aid and development actors, and their main – and only – focus was and should be profit.

2 Although this is a true story, the authors chose not to identify the business and ask, therefore, to readers to consider it as a tale.

3 Existing literature on the impact of the 2008 crisis in the banking sector regulation is abundant. A simple google search returns 221 million hits.

Chapter 5
Alignment of Organizational Competence for Sustainability With Dimensions of the Triple Bottom Line

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ABSTRACT

This chapter aims to describe how the alignment of organizational competencies with the dimensions of the triple bottom line (TBL) in companies of the Brazilian chemical sector are integrated in the business strategy. This study used a methodological approach to qualitative research, the multiple case study strategy, covering three major producing companies in the Brazilian chemical industry: Braskem, Solvay, and Beta (fictitious name). As regards the scale interactions of organizational competence between the environmental pillars, economic, and social TBL, the analysis was done taking as a basis the properties of eco-efficiency, environmental justice, and social justice. Besides the three skills characterized by TBL interaction model for sustainable development, the competence of eco-innovation was evident, with the internal factors that influence: strategic dimension of eco-innovation, collaboration networks, support of management leadership and top management.

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INTRODUCTION

Organizations are inserted in a context of social, economic, political and technological changes that affect the dynamics of their competitive environment. The interest of society, governments and organizations on the topic of sustainability is growing. This theme is present on the global problems agenda, presenting as discussions on climate change, scarcity of non-renewable resources, Human Development Index (HDI), and sustainable consumption, etc. Over the years, studies have been developed that focus on sustainability, emphasizing the complementarity of businesses and sustainable practices.

One of the challenges for industrial organizations is to demonstrate how they are decreasing their environmental and social impacts without compromising their economic sustainability (Demajorovic, 2003). Among these organizations is the chemical industry in Brazil, which maintains an important role. In 2016, occupying third place in the development of the Brazilian industrial Gross Domestic Product (GDP) and, in 2015, eighth place in terms of net sales in the world (ABIQUM, 2017). Although this industry develops essential products for humanity, chemical production has generated discussions regarding its role in relation to sustainability, primarily due to problems caused by the formation of toxic by-products, contamination of the environment, and risks presented by products and processes that generate volumes of toxic effluents. Thus, the sustainability theme has been highlighted in the chemical industry. (Prado, 2003; Ferreira, et al., 2013; ABIQUIM, 2017)

Some challenges and dilemmas present as specific to the chemical industry, regarding the development of a sustainability strategy: hazardousness of chemicals, climate change, greenhouse gases, water and energy consumption, use of non-renewable raw materials, post-consumption and strengthening of relationships. In view of these challenges, the adoption of sustainability by the chemical industries can be a great opportunity for the development of the sector (Soto, 2012).

Van Kleef and Roome (2007) understood organizational competence as the ability to collaborate and innovate for sustainability based on the integration of the economic, social and environmental dimensions while maintaining competitiveness, ultimately delivering value to the customer and other stakeholders.

When analyzing competencies at the organizational level, Munck and Borim-de-Souza (2012a) stated that sustainability can be achieved through the logic of competences. This is so that the development of competences by the organization can result in benefits in the Triple Bottom Line (TBL) dimensions, as the actions of organizations in the debate on sustainability seeks to develop new management methods and practices that contribute to systemic sustainable development.

Rapid mobilization of competencies in response to environmental changes that affect the company's business, characterized by dynamic capacity that constitutes the ability to integrate, build and reconfigure internal and external competencies to quickly respond to environmental changes and developing innovative forms of competitive advantage (Teece, et al., 1992), is in line with sustainability as studied by Amui et al. (2017). This shows that studies on this topic have been developed more thoroughly in developed countries. The study also showed that the topic has been arousing interest in the European, American, Asian and Oceania continents. With a concentration of studies on the European continent, this demonstrates a gap in terms of research developed in the context in Latin America. Among the sectors studied, manufacturing has aroused greater interest than that of other services.

Thus, this paper aims to describe how the alignment of organizational competencies with the Triple Bottom Line (TBL) dimensions in companies in the Brazilian chemical sector are integrated into the business strategy.

This study is justified by the need to fill theoretical gaps in the generation of competencies, aiming at sustainability in the context of companies in the Brazilian chemical sector, since this sector has a crucial representation in the development of national GDP. Moreover, its production has generated discussions regarding its action in relation to sustainability by environmental risks presented by products and processes. To achieve this goal, we sought to answer the question: How can the development of TBL-integrated organizational skills integrate organizational strategy in companies in the Brazilian chemical sector?

The following specific objectives were defined: a) to identify the dimensions of the Triple Bottom Line characterized in the companies studied; b) analyze the competences aligned with the Triple Bottom Line dimensions in companies; c) characterize the organizational skills aligned with the Triple Bottom Line that are part of the strategy of companies in the Brazilian chemical sector.

THEORETICAL BACKGROUND

The interests of society and the business world on the topic of sustainability is growing, and this topic is present on the global problems agenda and has generated interest in academic studies in associating sustainability with the performance of the manufacturing system (Jabbour & Santos, 2008; Junior et al, 2018; Ahmad et al., 2018; Ahmad & Wong, 2019). There is an intense debate in academia, with a theoretical diversity, about the concept of sustainability. One of the most widely adopted concepts was presented in the Brundtland report (1987): humanity has the capacity to meet its present needs without compromising the ability of future generations to meet their own needs.

The commonality that aligns the various concepts is the fact that sustainability must be considered from the perspective of the three pillars: economic, social and environmental, proposed by Elkington (1997), called Triple Bottom Line (TBL), or Planet, People. and Profit. The inclusion of environmental and social dimensions in concerns for future generations is increasingly present in organizations, requiring changes in business strategies and organizational culture (Claro; Claro & Amancio, 2008; Ehnert & Harry, 2012; Jabbour & Santos, 2008; Alhaddi, 2015).

Table 1 presents the aspects of the sustainability guidelines shown by Elkington (1997), Demajorovic (2003), based on research and work by the World Resources Institute (WRI) by Collins, Lawrence, Pavlovich and Ryan (2006,) used and validated in a New Zealand company survey instrument, as well as by the Global Reporting Initiative - GRI.

From these economic, social and environmental pillars, characterized by the performance achieved by the organization in each dimension, a model was developed that proposes the interactions between the pillars of sustainability, forming sustainable development (Elkington, 1997; Munck & Borim- De-Souza, 2012a). Figure 1 presents TBL interaction model.

The model shows that the eco-efficient logic involves the economic and social pillars, being characterized by the supply, at competitive prices, of products and services that meet human needs, reducing the ecological impacts and the resource intensity during the life cycle to a close to bearable level, without compromising future generations. Economic prosperity is sought through a more efficient use of natural resources by generating less environmentally harmful emissions, contributing to economic and environmental organizational sustainability (Elkington, 1997; Munck & Borim-De-Souza, 2012a; Munck; Galleli & Borim-de Souza, 2012). McWilliams et al. (2016) say in the strategic dimension, it is necessary to resolve economic compensations that are occasionally necessary when looking out for

Table 1. Sustainability Performance Aspects

TBL	Features	Performance
Economical	Extend the concept of economic capital from forms of financial and physical capital to human and intellectual capital. Consider the long-term sustainability of company costs, demand for products or services, pricing, and profitability.	Accounting practices; Investments; Economic performance; Market presence; Indirect Economic Impacts; Purchasing Practices. Financial viability, cash flow generation for the organization's liquidity, job offer, and market share. The organization develops its activities responsibly aiming at profitability.
Social	It is based on the prevalence of trust in a society or part of it that can be developed or destroyed at all levels, from the basic family unit to the institutions of international governments. It relates to the acquisition and maintenance of virtues such as faithfulness, honesty, ethics and dependence. It contemplates the impact of the organization's activities on the social system. Expectations from various groups of society are truly considered.	Labor Practices, Community Relations, Training and Education. Diversity and equal opportunities; Ethics; Social impact of the product. Assistance to employees in obtaining formal education. Have time or financial resources for local community projects. Consideration of diversity in hiring processes. Allow flexible hours; Stress management initiatives. Remuneration between men and women. Evaluation of labor practices of suppliers. Non-discrimination; Human Rights Investment. Health and safety at Work; Indigenous rights; Fight against corruption. Public policy; Unfair competition; Customer health and safety. Marketing communications; Customer Privacy. Grievance mechanisms related to labor practices, human rights and impacts on society.
Environmental	Understand natural capital in two main ways: critical natural capital, that which is essential for the life and integrity of the ecosystem; and renewable natural capital, which can be recovered or replaced. Prioritizes the prevention of environmental impact generated by the organization.	Use of materials; Energy consumption; Use of water; Biodiversity Effluents and waste; Pollutant emissions; Recycling programs. Environmental Impact Complaint Mechanisms. Participation in voluntary environmental program. Member of an environmental group. Supplier assessment with environmental focus. Have an environmental management system. Measurable goals for employee training. Considers product life cycle impact.

Source: the authors – adapted from Elkington (1997); Demajorovic (2003); Collins et al. (2006); Munck and Borim-de-Souza (2012a); Munck and Borim-de-Souza (2012b); Alhaddi (2015)

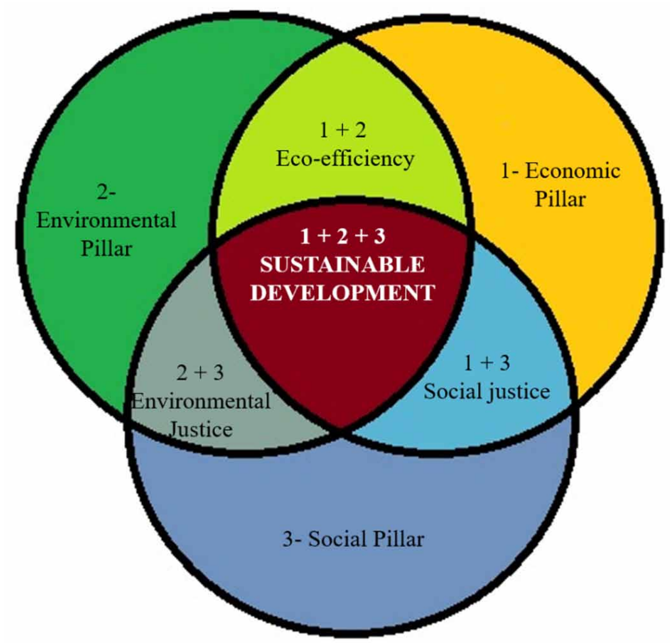
the environment and human well-being, needing tools that help to balance the expectations of various stakeholders.

Considering eco-efficiency as an organizational competence aligned with the economic and environmental dimension of sustainability, the authors Munck, Galleli and Borim-de-Souza (2012) and Cella-de-Oliveira and Munck (2014) define the competencies supporting the development of eco-efficiency. These competences are presented in Table 2.

The model of interactions of the TBL dimensions also presents the structure of environmental justice and evolves from the balanced relationship between the environmental and social pillars and is associated with intra and inter-generations equity, which considers equity between living people and the balance of advantages between different generations, even those yet to be born (Elkington, 1997; Munck and Borim-De-Souza, 2012a; Munck; Galleli and Borim-de-Souza, 2012). Thus, it contributes to the formation of social and environmental organizational sustainability.

To complete the interactions between sustainability pillars, the model describes the structure that forms from the optimal relationship between the social and economic pillars, and concerns the ethical business performance, also called social justice, which encompasses ethical investment not only of a company, but of an entire industry in which the product or service is made, as well as of markets in which it is used (Elkington, 1997; Munck & Borim-De-Souza, 2012a; Munck; Galleli & Borim-de-Souza, 2012).

Figure 1. TBL Interactions
Source: the authors - adapted from Elkington (1997)



Interactions between the dimensions of sustainability form organizational competencies that characterize the development of organizational sustainability. In investigating the factors that lead companies to respond to the challenges presented by aligning themselves with the demands required by sustainability, Van Marrewijk and Werre (2003) described six different levels of ambition that can lead the organization to develop organizational sustainability: pre-sustainability; compliance with legislation; profit orientation; consciousness, synergistic level and the holistic level, presented in Table 3.

Organizational competence is characterized by the ability to collaborate and innovate for sustainability, integrating the economic, social and environmental dimensions, while maintaining competitiveness and delivering value to customers and other stakeholders (Van Kleef & Roome, 2007). The managed competencies generate competitive advantages (Kabue & Kilika, 2016), so that the development of competencies by the organization can result in benefits in the TBL dimensions, as the action of organizations in the sustainability debate seeks to develop new management methods and practices that contribute to systemic sustainable development (Munck & Borim-de-Souza, 2012a). For Goh et al. (2019) joint construction practices involve evaluation and formulation of policies, collaborative platforms and needs balanced among stakeholders.

The concept of eco-innovation can be understood as the production, assimilation or exploitation of a product, production process, service or management or method of conducting business, which can be developed or adopted. These results in a reduction of environmental risk, pollution and resource use, including energy use, compared to existing alternatives (Kemp & Pearson, 2007). Eco-innovation can be influenced by contextual factors, both internal and external to the organization, as shown in Table 4.

The contextual factors presented in both its internal and external dimensions directly influence the development of eco-innovation competence in organizations, which may favor or hinder it depending

Table 2. Eco-efficiency Competency Support Competencies

Supporting Competency	Expected Delivery
Economic value added	Generation of capital for the organization due to the commercialization of products, by-products and savings resulting from organizational effectiveness.
Product marketing	Maximizing sales by placing products on the market.
Optimized material consumption in products and services	Reduction from pre-established standards of resource consumption in products and services.
Optimized energy consumption (all modalities) in products and services.	Minimization or elimination of energy consumption or use of alternative energy with low environmental impact.
Optimized water consumption.	Minimization or promotion of re-use of water consumption, promoting the efficient removal, use and disposal of water.
Infrastructure development	Realization of use of infrastructure that results in less environmental impact in the production and management of products and by-products.
By-product arrangement	Proper disposal of by-products, waste and effluents, treating them appropriately to not cause damage to the environment.
Reduction of greenhouse gas emissions	Minimization or elimination of emissions of gases or pollutants that may destroy the ozone layer and cause the greenhouse effect and be harmful to the atmosphere or human health.
Recycling culture	Promoting and carrying out the recycling of waste (solid, liquid and / or gaseous), both internally and externally, from the company's activity.
Maximizing the use of renewable resources.	Choose and buy the best environmental raw materials and maximize the use of renewable resources from pre-established standards.
Maximized product durability	Extension, from pre-established standards, of product durability.
Heavy use of products and services	Increased, from pre-established standards, the intensity of use of products and services.
Adaptation to new market demands	Matching products and processes to new market demands, such as new product requirements, new laws and regulations.
Research and Development effectiveness (R&D)	Conducting research and development of new technologies and products with an environmentally sound character, reducing environmental impacts and return to the organization.

Source: the authors - adapted from Munck, Galleli and Borim-de-Souza (2012) and Cella-de-Oliveira and Munck (2014).

on how the organization aligns its strategy in seeking to respond to these factors. From this perspective, eco-innovation strategies are considered in two approaches: reactive and proactive. The characteristics of each approach are presented in Table 5.

Considering the proactive approach, for Jacomossi et al. (2016), eco-innovation has a social dimension as it is associated with the emergence of new economic activities, and eco-innovation is considered in terms of its use, thus associating the social pillar of eco-innovation with governance, making it a tool for development sustainable.

Given these approaches, organizational competence for sustainability is defined as "effective organizational action underpinned by efficient technologies, individual competencies, dynamic organizational structures, and the institutionalization of organizational culture, which together provide sufficient return and the ability to add social value to directly or indirectly related individuals, without compromising the environment". Thus, systemic sustainable development is considered a meta-competence influenced by organizational actions (Munck & Borim-De-Souza, 2012a, p. 402).

Table 3. Levels of Sustainability Development Ambition

Level	Feature
Pre-sustainability	No ambition to develop organizational sustainability. Initial actions labeled sustainable are possible due to legal or consumer requirements.
Compliance with legislation	It is based on the welfare of society within the limits provided for in the legal regulations. The stimuli are the impositions, obligations of the norms that are admitted as correct behaviors.
Profit orientation	Integration of social, ethical and environmental aspects, as long as they contribute to the organization's financial return. Sustainable actions are promoted only if they are profitable.
Conscious	Economic, social and environmental issues are placed at the same level of importance. Sustainable actions are stimulated by human potential, corporate responsibility and care for the planet.
Synergistic	The organization seeks functional solutions that create value in economic, social and environmental scopes with a win-win approach in which all relevant stakeholders in the relationship chain participate. Sustainability at this level is recognized as an important phenomenon and inevitable for the company's progress.
Holistic	Sustainability is extremely integrated and embedded in each of the aspects involved in management processes, contributing to the quality, maintenance and continuation of life of all beings and institutions, both now and in the future. Understood as the only alternative response to the environmental crisis. Each person and organization have universal responsibility to all other living beings on the planet.

Source: the authors - adapted from Van Marrewijk and Werre (2003)

Table 4. Contextual factors influencing eco-innovation

	Factor	Features	Authors
Internal	Support from senior management	Participation, involvement and support of senior management in encouraging, defending and influencing the adoption of eco-innovative practices.	Maçaneiro and Cunha (2014; 2015) Jacomossi *et al.* (2016)
	Management Leadership Support	Management's potential to engage its team and foster an environment conducive to the development of eco-innovation.	Jacomossi *et al.* (2016)
	Technological competence	Improvement of the company's competency base, technological maturity and flexibility, capacity and engaging in collaboration and information flow on environmentally aligned opportunities and building alliances and strategic relationships.	Maçaneiro and Cunha (2014; 2015)
	Environmental Formalization	Effective organizational attitudes that can encompass environmentally friendly characterization.	Maçaneiro and Cunha (2014; 2015)
	Collaboration Networks	Existence of information sharing and learning networks that promote eco-innovations.	Jacomossi *et al.* (2016)
	Eco-innovation strategy	Strategic scope and organizational culture that favors the development of eco-innovation.	Jacomossi *et al.* (2016)
External	Environmental regulation	Action by the government and / or institutions to establish various legal standards mechanisms in relation to environmental performance, which imply eco-innovations.	Maçaneiro and Cunha (2014; 2015) Jacomossi *et al.* (2016)
	Environmental incentive	Economic incentives through credits or grants that fund eco-innovation activities through government influence.	Jacomossi *et al.* (2016)
	Reputation Effects	Pressure exerted by various groups that may influence the reputation of the organization.	Maçaneiro and Cunha (2014; 2015)
	User Acceptance	The users' perception regarding the valorization of the environmental benefits generated by the products.	Jacomossi *et al.* (2016)
	Technological demands	Frequency and / or level of orders for environmental quality products received by the organization.	Jacomossi *et al.* (2016)

Source: the authors - adapted from Maçaneiro and Cunha (2014); Maçaneiro and Cunha (2015); Jacomossi et al. (2016)

Table 5. Eco-innovation Approaches

Approach	Features
Reactive	Organization does not see environmental management as a priority. Predict pollution control posture at the end of the production process. Adopt actions aimed solely at compliance with environmental legislation. Investments in corrective technologies for end-of-pipe problem remediation. Considers the treatment of environmental issues as additional and high costs, threatening the survival of the organization.
Proactive	Voluntary actions to reduce environmental impacts enabling the creation of competitive advantage through the adoption of eco-innovative technologies. Adopt well-defined environmental objectives seeking to reduce pollution below legal requirements. Environmental issues are seen as stimulating the generation of innovations and technological, economic and competitive opportunities. Require the acquisition and installation of new technologies, involving learning and development of competitive organizational capabilities. Believes that dealing with environmental regulation can increase industrial competitiveness.

Source: the authors - adapted from Maçaneiro and Cunha (2014); Maçaneiro and Cunha (2015); Maçaneiro, Cunha, Kuhl and Cunha. (2015)

RESEARCH METHODOLOGY

The qualitative research approach was utilized, offering the possibility of studying the phenomenon through several research strategies (Mason, 1996). The research strategy adopted was the study of multiple cases, characterized by a thorough empirical investigation, of a contemporary phenomenon (Yin, 2018). The selection criteria of the cases were: to belong to the Brazilian chemical industry and to be a member of the Brazilian Chemical Industry Association (ABIQUIM); have the Management System of the Responsible Action Program of ABIQUIM; and to be a signatory of the Global Compact which is an initiative developed by the UN that aims to mobilize the international business community to adopt, in its business practices, fundamental and internationally accepted values in the dimensions of human rights, labor relations, environment and anti-corruption, based on ten principles established by the Global Compact. Based on these criteria, the companies studied were: Braskem, Solvay and Beta (fictitious name, as company did not authorize its identification). Table 6 lists the social subjects of the research and lists the sources of evidence accessed in each company.

The analysis of the results was guided by the constructs 'Triple Bottom Line dimensions' and 'organizational competence' from a theoretical reorganization in categories and dimensions in the literature, as demonstrated by the evidence described and analyzed.

PRESENTATION OF DATA AND DISCUSSION OF RESULTS

The Braskem Case

The analysis of the 'organizational competence for sustainability' category was based on the TBL interaction dimensions (economic, social and environmental) and the level of ambition to characterize sustainable development in its properties of eco-efficiency, environmental justice, social and holistic justice. The empirical evidence collected from Braskem through the interviews is presented in table 7 from selected interview excerpts.

Table 6. Characterization of sources of evidence of the companies in question

Companies That Participated in the Study			
	Braskem (C1)	**Solvay (C2)**	**Beta (Fictitious) (C3)**
Nature of capital	Brazilian public company	Foreign public company	Foreign public company
Size	Large	Large	Large
Year founded	2002, with the integration of six companies from the Odebrecht Organization and Mariani Group.	1863 by Ernest Solvay	Late 19th century
Area and markets	Adhesives, agribusiness, rubber, construction, automotive industry, lubricants, paint and retail	Automotive and aerospace, consumer and healthcare products, energy and environment, appliances, building and construction and industrial applications.	Transport, infrastructure, environment and final consumer.
Interviewees (I) (Total pages transcribed and analyzed: 187)	- Director of sustainable Development (I1) - Person in charge of environmental area at all Braskem sites (I2) - Safety and environment coordinator of the UNIPOL business units – SP (I3) - Environmental coordinator at UNI2 – RS (I4)	- Corporate safety and environment manager for Latin America (I1) - HR manager and person in charge of South America by area of learning and corporate university (I2)	- HSE Manager (I1) - Management system coordinator (I2) - Environmental safety engineer (I3) - HR analyst – in charge of training (I4)
Documents (D) (Total pages systematized and analyzed: 1,396)	- Presentation on environmental management 2015 (D1) - Model of environmental education lesson plan (D2) - Presentation used at leaders' sustainable development workshop (D3) - Annual report 2015 (D4) - Company website (D5)	- Global report 2015 (D1) - Complementary annual report 2015 (D2) - Global report 2013 (D3) - Competence maps (D4) - Company website (D5)	- Sustainability report 2014/5 (D1) - Update of sustainability report 2015 (D2) - Health, safety and environmental policy (D3) - Environment week program 2016 (D4) - List of environmental training programs (D5) - Company website (D6)
Videos (V) (Total pages transcribed and analyzed: 40)	- Video interview with Braskem's director of sustainable development at the IV Atlas Publishing Business Soiree (V1) - Video of Braskem's vice president of institutional relations and sustainable development's statement (V2) - Video of "Braskem Environmental Education Seminar" (V3)	- Video of presentation of Solvay way program (V1) -Video interview of Solvay CEO and company executive on sustainable management program tools (V2) - Video of Solvay CEO on carbon emission and credits (V3)	- Video of statements by three top executives on sustainable development (V1) - Video of company president on the environment (V2)

Source: the authors.

The pursuit of developing innovative products that meet human needs while at the same time seeking to reduce ecological impacts to characterize eco-efficiency (Elkington, 1997; Munck & Borim-de-Souza, 2012; Munck; Galleli & Borim- de-Souza, 2012), was evidenced in the statement by the vice president for institutional relations and sustainable development in video (V2) when he says: "what we called eco-indicators of actions linked to health and environment safety, but with a higher performance than the world average in terms of waste generation per ton of product, in terms of energy consumption per ton of product".

Table 7. Organizational competency category data aligned with company sustainability Braskem

Dimension	Properties	Description	Interview Fragments
TBL interactions	ECO-EFFICIENCY	Interaction between the economic and environmental pillars	"We are continually investing in new product development based on renewable raw materials because we believe this is the chemistry of the future" (I1). "Braskem is the best carbon management company in Brazil." (I2). "[...] the environmental bias is very strong because of the generation of waste, effluent, water and energy that are our eco-indicators" (I4). "The increasingly sustainable product portfolio" (I4).
	ENVIRONMENTAL JUSTICE	Interaction between the environmental and social pillars	"So, it is also a necessary competence to follow the fundamental impacts that happen in our upstream chain" (I1). "Another competence is mainly the company's power of influence in the chemical sector" (I2).. "Braskem proposes to be active through its professionals to work in committees that are, in fact, the pillars of ABIQUIM" (I4).
	SOCIAL JUSTICE	Interaction between the social and economic pillars	"The market sees that we are very transparent, everything we do is clear to the market" (I3). "Braskem strives to act by example both within and outside the association" (I3). "We also influence the industry when somehow our practices are improved, and those practices are somehow shared" (I1).
Ambition level	HOLISTIC	Sustainability extremely integrated with management processes. Understood as a response to the environmental crisis.	"Today I would say that we are in a phase that is no longer merely meeting legal requirements or more operational risk management, which would be the slightly more reactive phase for environmental and social dimensions that are integrated with the business strategy that complements the issue of strategy" (I1). "Braskem considers the environmental sustainability part with a business line, in fact, we have a business that is a business with leaders, with funds, etc. and such, to invest in this area and this is all about Braskem's strategy" (I3).

Source: the authors

In the documentary analysis, we found evidence that characterizes eco-efficiency in all annual and management reports, as well as data collected on the company's website and documents (D4, D5, D6, D7, D8 and D9). As an example of this evidence, it can be mentioned that eco-efficiency is characterized as an organizational competency, according to the deliverables reported by the company. For example, when it says in document (D4): "During the year, R$ 31 million were invested in environmental improvement projects, generating savings of R$ 144.4 million in 2015, as a result of process improvements that impact environmental and energy efficiency indicators".

Thus, elements of eco-efficiency ownership in organizational actions were strategically demonstrated for the business, aligning the economic and environmental dimensions of sustainability and corroborating the theoretical basis presented.

In the documentary base, Braskem's actions are aligned with the environmental justice competence, in data provided in document (D4) that presents the project "Wecycle": responsibility with the product and its post-consumption". This project seeks to develop the recycling of plastic waste through partnership with organizations that operate or want to operate in this segment of plastic recycling in different sectors and aligns with the Post Consumer macro objective. The macro objective of developing solutions is also associated with environmental justice.

Complementing the analysis of the interactions of the sustainability, economic and social pillars, there is the presence of social justice property, characterized by the ethical and transparent performance, not only of the company, but in its chain, according to the interviewee (E3), when reporting the transparent performance of the company. This evidence is corroborated by the interviewee (E1), saying that the company operates in national and international organizations, sharing its practices in an open and transparent manner.

Data collection shows, at Braskem, there is an interaction between the economic, social and environmental pillars of sustainability, characterizing eco-efficiency, environmental justice and social justice as competencies that support the competence of organizational sustainability, to guarantee its differential and competitiveness, corroborating the presented literature. Based on the analysis of the dimension of interactions of the TBL pillars, we begin to analyze the level of organizational ambition, characterized by Van Marrewijk and Werre (2003), as shown in table 3, based on the analysis of the interviews conducted with the professionals of the organization.

When examining the strategic pillars defined by the organization, in documents (D4, D6, D7 and D8), elements of sustainability are expressed in its guidelines. Renewable chemistry appears as a strategic component of the growth pillar, while sustainability and innovation make up the pillar of the organization's perpetuation. One can identify the proactive dimension of the company's performance regarding environmental sustainability that is the focus of this study, characterizing Braskem's level of holistic ambition regarding the development of sustainability.

The holistic dimension of the organizational competence of sustainability is characterized by the statement made in the video (V1) testimony of the director of sustainable development: "People, I participate a lot in international relations in the chemical industry that people look at Brazil with positive eyes, thanks to that kind of initiative."

By analyzing the properties of ambition with the presented classification of organizational competence of environmental sustainability, there is an alignment between the perception that such competence is considered vital to the survival and perpetuity of the organization, while being strategic. It is essential for the development of organizational competitiveness, with a holistic ambition approach, in which organizational competence is integrated in all management processes, being considered strategic for sustainable organizational development, in line with the theoretical basis of Van Marrewijk and Werre (2003).

Therefore, the following descriptive properties of Braskem's category 'organizational competency for sustainability' are summarized: a) eco-efficiency involves strategically organizing actions that seek the development of innovative products that meet market needs and also seek to reduce ecological impacts; b) environmental justice includes the voluntary action of the company in the pursuit of sustainable development of the sector, establishing a dialogue with stakeholders; c) environmental justice addresses the transparent performance of the company before its chain, with respect to its practices aligned with the development of environmental sustainability; and d) holistic ambition includes both the integration of environmental sustainability as a strategic pillar for the organization that is present in all its processes and a business unit regarding the production of green polyethylene.

The Solvay Case

Solvay is presented in Table 8, based on excerpts from interviews.

The logic of eco-efficiency is characterized by the interaction between the environmental and economic dimensions of sustainability, based on the provision of competitively priced products that meet human needs, while at the same time, have concerns about reducing environmental impacts (Elkington, 1997; Munck & Borim-de-Souza, 2012; Munck; Galeli & Borim-de-Souza, 2012). This theoretical basis was

Table 8. Organizational competency category data aligned with company sustainability Solvay

Dimension	Properties	Description	Interview Fragments
TBL interactions	ECO-EFFICIENCY	Interaction between the economic and environmental pillars	"A classification of the entire portfolio of products sold by the group was created, based precisely on the sustainability issue with a very strong focus on the environmental issue" (I1). "It will not develop a new product that will generate more pollution than the product that exists today" (I1). "Which in our case translated into CO2 emissions, so a medium- and long- term reduction of CO2 emissions" (I1).
	ENVIRONMENTAL JUSTICE	Interaction between the environmental and social pillars	"So much that it's part of development approval. One cool thing that the R&D people put in the approval criteria is the HSE issue, more formally, the development team is questioned, listen, this product here that you are thinking of launching, what is the effect on human health? It's no use showing me a great, innovative product, but it's a carcinogen, right, big deal? It solves nothing" (I1).
	SOCIAL JUSTICE	Interaction between the social and economic pillars.	"In the qualification of these suppliers, there is a series of agreements that can be reached until the training of drivers, the coordinators of these companies in our methodologies" (I2).0 "This corporate tool has a reasoning logic that takes that concept of sustainability stakeholders" (I1)
Ambition level	LEGAL COMPLIANCE	Actions limited to legal regulatory obligations.	"I would say that we are halfway, right, we had to evolve a little under the law, let's say this" (I1).
	HOLISTIC	Actions embedded in each of the management processes, contributing to the maintenance, quality of life of living beings and institutions.	"We are a chemical industry, so you know that our level of concern for environmental issues, we are very concerned, the group is very responsible for that issue and so one of the pillars is environmental education" (I2). "We treat sustainability as well as occupational safety as values" (I2).

Source: the authors

corroborated by the findings in the empirical research at Solvay, both in interviews and in video (V1) in which it is said to seek continuous improvements of the best solutions to reduce water consumption. Another video (V2) states that 40% of the product portfolio is positive for the environment and that the intention is to increase this percentage. In document (D1) it is highlighted as a pillar of the organization's strategic objectives to double the number of sales generated from sustainable solutions.

The properties of environmental justice characterize the concern with present and future generations. These elements are presented in the interviewees' statements, so they corroborate the theoretical basis presented and illustrate the company's concern with the bases that make up the competence of environmental justice. The document (D5) also shows such evidence by characterizing, in the social pillar, the emphasis on health, safety and social dialogue, as well as responsibility for responsible product management. From the collected data it can be stated that the properties that characterize environmental justice are present in the company, corroborating the theoretical basis.

Regarding the properties of social justice, both in interviews and in documents, as in documents (D1, D5), which shows the company's search to develop the engagement of its employees in social initiatives such as: Young Alchemy; Volunteer Friends Group; Friends Volunteer Association Encouraging Donations and Love Friends moved by Love so that they can share their knowledge and develop society. Participation is also reported by the company in associations, such as ABIQUIM, to share their practices to develop the chemical industry.

Regarding the analysis of the levels of ambition for the development of sustainability characterized by Van Marrewijk and Werre (2003), as shown in Table 3, there was evidence that came from a development in the search for legal compliance, according to the interviewee (I1). This is an important factor, especially due to the development of environmental legislation for the chemical sector, and the pursuit of compliance with the legislation. This provides the development of sustainability for many companies in the sector, regarding the holistic level in which sustainability is inserted in the business through five commitments to responsible chemistry by 2025: reducing greenhouse gas intensity by 40%, increasing energy efficiency; reduce accidents by 50% through safety management based on people involvement and improvement plans; double employee participation in social initiatives; double the share of net sales generated by sustainable solutions; and increases the level of employee engagement by 5%.The document (D6) permeates the entire organization as the only alternative response to the environmental crisis, as characterized by respondents (I1) and (I2) by documents (D1), (D2), (D3) and (D4), and in the video (V1) and (V3).

From these data, the following descriptive properties of Solvay's 'organizational competence for sustainability' category are summarized: a) eco-efficiency involves the pursuit of continuous improvement of environmental efficiency through the development and increase of sales of products aligned with positive solutions for the environment; b) environmental justice includes highlighting health and safety and responsible management with a focus not only on company employees, but on society; c) social justice addresses stakeholder dialogue and employee engagement in social initiatives; d) ambition for legal compliance states that compliance with environmental legislation is an important factor in the development of the chemical sector; and e) holistic ambition contemplates the insertion of sustainability in the business, permeating every organization, in response to the environmental crisis.

The Beta Case

The evidence that characterizes the interaction between the dimensions of sustainability, based on the TBL, and the ambition factors identified in Beta company in relation to the development of sustainability are presented, from the selected excerpts of the interviews, in table 9.

The quest to respond to the complexities of current and future environmental, economic and social problems, from regional to national and/or international scales, describes the relevance of the competence of organizational sustainability and the interaction between the dimensions of the TBL to generate competencies of eco-efficiency, environmental justice and social justice that support the competence of sustainability (Munck & Borim-de-Souza, 2012a). The data collected at Beta show the characterization of these supportive competencies, both in interviews and in documents.

As an example, we can highlight the characterization of eco-efficiency in document (D1, p.2) when it presents the environmental dimension bringing contribution to the environment while showing economic value for the company, having the environmental dimension as a business. "We have created products that support solutions to some of the world's most pressing environmental issues today, including air and water purification, flue gas treatment and safety and environmental risk mitigation in challenging oil, gas and drilling operations."

Evidence of competence aligned with environmental justice is found in the interviews that characterize an interaction between the company and its stakeholders aiming at the development of sustainability. In the video (V1) the executive vice president affirms the goal of the company being an innovative leader, consistent with the ways to engage customers, addressing sustainability concerns. The analyzed docu-

Table 9. Organizational competency category data aligned with company sustainability Beta

Dimension	Properties	Description	Interview Fragments
TBL interactions	ECO-FFICIENCY	Interaction between the economic and environmental pillars	“All water that becomes effluent, this effluent is treated and reintroduced in the process. Even rainwater is captured and used in the process. Because we use a lot of water in the process” (I1). “Safety is not just for the process, it has environmental issues as well, [...] not only regulatory issues, but Beta’s own issues, intrinsic to Beta’s own process” (I1).
	ENVIRONMENTAL JUSTICE	Interaction between the environmental and social pillars	“We have an event that we do that is more focused on health and safety, more of rapport with our customers” (I1).. “Beta is participating a lot to be able to involve the community more in both safety issues [...], but also involving the environmental part of raising awareness around the environment” (I3).
	SOCIAL JUSTICE	Interaction between the social and economic pillars.	“We have in our investment approvals controls, [...] there is one that is non-negotiable: health, safety and environment” (I1). “Rather than sometimes it’s increasing production capacity, increasing storage capacity, this is sometimes in the background because I need to first address the issue that if I don’t treat it, it’s going to be a nonconformity” (I3).
Ambition level	AWARENESS	Actions stimulated by human potential, the sense of responsibility of the organization and care for the planet.	“Beta further expands this concept of environmental non-compliance”“(I1). “If it is a small business, small not in terms of size but of awareness, if it puts this as a foundation, then…” (I2). “The company will not produce at any cost, leaving safety aside, this is far from us ” (I1).
	HOLISTIC	Extremely integrated sustainability embedded in all management processes, as the only alternative to respond to the environmental crisis.	“We treat sustainability as well as workplace safety as values” (I2). “For Beta, safety and the environment are non-negotiable, you can’t negotiate, it’s top-down, it’s bottom-up. What is important is number 1 - doing security”(I1). “This is in Beta’s DNA that goes from the president to the shop floor” (I3).

Source: the authors

ments also show organizational practices that are aligned with the dimension of environmental justice, such as the sponsorship of a popular television program that seeks to disseminate advances in engineering, technology and environmental science, in document (D1).

Social justice is evidenced in the interviews, which in addition to addressing the aspects of prioritizing the company’s investments in sustainability issues, also point out the actions of participation in associations and committees that seek to develop the chemical industry. In the video (V2) the CEO of the company claims to be grateful for the work he has done in many years seeking not only the long-term success of the business but also the success of many people’s lives.

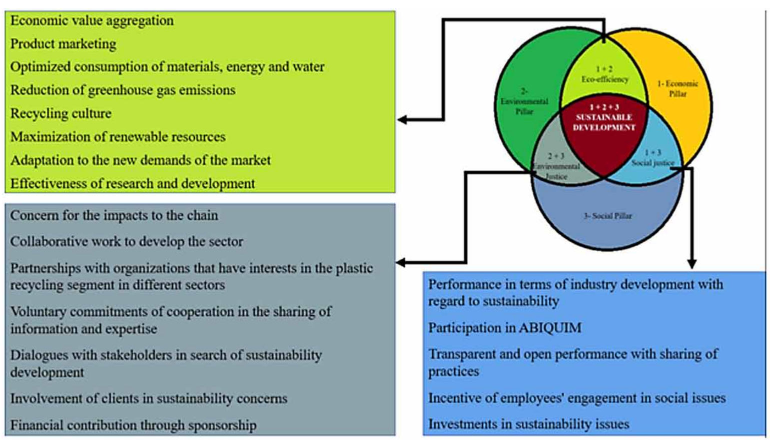
The interviews found evidence that points to properties that drive the company: awareness and the holistic dimension. In the opening statement of the document (D1), this motivation points out: “Every day we seek to take our sustainability journey one step further - to improve people, customers, communities and the environment”. The analyzed data corroborate these two dimensions characterized by Van Marrewijk and Werre (2003).

Therefore, the following descriptive properties of the category ‘organizational competence for sustainability’ in the Beta company are summarized: a) eco-efficiency involves contribution to the environment while showing economic value to the company; b) environmental justice includes customer engagement with sustainability concerns; c) social justice addresses prioritization of investments in sustainability issues and pursuit of the development of the chemical industry not only with concerns about business success, but with that of people; d) awareness establishes that the company adopts a slightly broader concept of environmental standards and does not relinquish its safety standards; and e) holistic ambition contemplates sustainability as a non-negotiable value for the company.

The Grouped Cases

Regarding the dimension of the interactions of organizational competence between the environmental, economic and social pillars of the TBL, the analysis was made based on the properties of eco-efficiency, environmental justice and social justice. The alignment of organizational skills based on these properties is evidenced in the three research companies from the support competencies synthesized in Figure 2:

Figure 2. Alignment of organizational competences with TBL
Source: the authors



In addition to the three competences characterized by the TBL interaction model for sustainable development, the competence of eco-innovation was also evidenced in the three organizations, which according to Jacomossi et al. (2016) also has a social dimension. In the three companies studied, eco-innovation can be characterized by the proactive approach as these companies show characteristics of eco-innovation deliveries aligned with what was described as requirements by Maçaneiro and Cunha (2014) and Jacomissi et al. (2016). The internal factors that influence the eco-innovation and that were identified in the three companies are: strategic dimension of the eco-innovation; collaboration networks; and support of management leadership and top management.

Regarding external factors influencing eco-innovation, they were: highlighted environmental regulatory factor; technological demand for more sustainable products with regard to environmental issues; and effects of reputation, for the three companies seek to be considered as a reference regarding their practices relating to the environment.

As for the competences formed from the interactions between the dimensions of the TBL with the establishment of convergence between the theoretical-empirical discussion with respect to eco-efficiency, environmental justice, social justice and eco-innovation with presentation of dimensions and their descriptive properties are presented from the comparison of empirical data (discussion of BRASKEM, SOLVAY and BETA cases) with the literature (table 10).

Table 10. Evidence of Organizational Competences for Sustainability in the cases investigated

	Evidences	**BRASKEM (C1)**	**SOLVAY (C2)**	**BETA (C3)**
Interactions with TBL	"We constantly invest in new product development based on renewable raw materials because we believe this is the chemistry of the future" (C1 - I1). "We're not going to develop a new product that causes more pollution than the product we have today" (C2 - I1) . "All the water, which becomes an effluent, this effluent is treated and reintroduced to the process. Even rainwater is captured and used in the process, because we use a lot of water in our process" (C3 - I1).	*Eco-efficiency*	*Eco-efficiency*	*Eco-efficiency*
	"So, it's also a necessary competence to monitor the fundamental impacts in our assembly chain" (C1 - I1). "There's no point in you showing me an excellent innovative product that causes cancer, right? No way! That doesn't solve a thing" (C2 - I1). "Beta is a serious participant so that it can really get involved in the community, in safety issues [...], but also on the environmental side, raising awareness of the population regarding environmental issues" (C3 - I3).	*Environmental justice*	*Environmental justice*	*Environmental justice*
	"Braskem really wants to serve as a shining example in and out of the association" (C1 - I3). "This corporate tool has a logic of reasoning that takes that concept of sustainability stakeholders" (C2 - I1). "We don't have this in our controls to approve investment [...] there is something that is not negotiable: health, safety and the environment" (C3 - I1).	*Social justice*	*Social justice*	*Social justice*
Ambition level	"I would say that we are halfway there. We had to evolve a little due to the legislation, let's put it that way" (C2 - I1).		*Compliance - driven*	
	"Beta expands this concept of environmental non-compliance a little more" (C3 - I1).			*Awareness*
	"Braskem views environmental sustainability as part of the business. Indeed, we have a business that is a business with leadership, with funds, etc., to invest in this area. This all has to do with Braskem's strategy" (C1 - I3). "We handle sustainability like safety in the workplace, as values" (C2 - I2). "For Beta, safety and the environment are not negotiable. You can't negotiate it. It's top-down, it's bottom-up. That is what's important, safety is number one" (C3 - I1).	*Holistic*	*Holistic*	*Holistic*

Source: the authors.

We conclude the discussions on the competences formed from the interactions between the dimensions of the TBL with establishing the convergence between the theoretical-empirical discussion regarding eco-efficiency, environmental justice, social justice and eco-innovation with the grouping of organizational competencies for sustainability which were mapped in the cases investigated and which may be the focus of attention by other companies operating in the Brazilian chemical sector (table 11).

Table 11. Organizational competencies for sustainability mapped in the cases investigated

Organizational Skills for Environmental Sustainability	Cases Investigated		
	BRASKEM	SOLVAY	BETA
Development of green products	X		
Carbon management	X	X	X
Development of sustainable products focused on the environmental issue	X	X	X
Treatment of hazardous waste	X	X	
Waste Management	X	X	X
Effluent generation management	X	X	X
Ability to influence the chemical industry	X	X	X
EHS management		X	X
Management of the consumption of water resources	X	X	X
Generating solutions against climate change	X	X	
Employees' ability to engage in social initiatives		X	
Processes management			X
Eco-Ability capacity	X	X	X

Source: the authors.

The results show that in the companies studied, environmental sustainability can be classified as an organizational competence. This competence is understood as a strategic factor of competitive advantage, recognized by the market and developed in an integrated manner. Companies recognize that sustainability develops their markets and contributes to leadership in their areas of activity, generating recognition in the global market.

Among the company, there was a search for integrated actions; sharing of practices, mainly through participation in national and international associations for the development of sustainability in the dimension of the chemical sector, favoring the development of skills aligned with sustainability.

These skills are sought both with respect to the internal organizational context and the external context of the chemical sector. This contributes to the chemical industry reaching its objectives of reducing the environmental impacts caused by its operation, through collaboration, from coding, sharing, possibility and search for transfers to other organizations.

The skills associated with sustainability are encouraged by the companies studied, demonstrating that the integration of the development of skills aligned to the TBL can integrate business strategies to develop competitive advantages.

CONCLUSION

By analyzing the organizational competences and dimensions of the Triple Bottom Line in the three major companies in the Brazilian chemical sector studied, it was possible to identify the dimensions of the Triple Bottom Line characterized in the companies studied as well as the interactions between the pillars of sustainability, forming the sustainable development through eco-efficiency, social justice and environmental justice. It was possible to analyze the organizational competences aligned with the dimensions of the TBL, as well as to characterize the organizational competences for sustainability that contribute to the strategy development of the Brazilian chemical companies studied.

From these specific objectives, the general objective can be reached and the answer to the research question is that in the companies studied, environmental sustainability can be classified as a organizational competence, understood as a strategic factor of competitive advantage. This is recognized by the market and developed in an integrated manner, recognizing that sustainability develops its markets and contributes to remaining a leader in its fields, generating recognition in the global market. The concern with the imitation of its practices associated with the environmental dimension of sustainability was not evidenced. What was found was the pursuit of integrated actions, sharing of practices, mainly by participation in national and international associations for the development of environmental sustainability in the chemical sector dimension. Proving itself favorable to the development of competences aligned with sustainability, regarding both respect to the internal organizational context as to the external context of the chemical sector. Thus contributing to the chemical industry achieving its objectives of reducing the environmental impacts caused by its operation, through collaboration. Sharing and the search for transfer of competencies associated with the environmental dimension of sustainability to other organizations is encouraged by the companies studied, demonstrating that integrating TBL-aligned competency development can integrate business strategies to develop competitive advantage.

Regarding academia, the contribution is presented in the deepening of studies focusing on the development of sustainability. A discussion was also presented as to a new paradox regarding the characterization of organizational competence when it comes to sustainability. We found a perspective of competition in terms of products, but a collaborative attitude among companies in terms of practices for developing sustainability competency, which all companies studied consider as strategic.

Concerning market contribution, mapping sustainability-aligned competencies from both the literature and the companies studied can help organizations develop their competency maps. For ABIQUIM, which has specific committees in both the environmental and people management areas, and also develops training for various chemical industries, this work can contribute knowledge for the development of the sector regarding sustainability competencies as well as for structuring of the phases of the process that seeks the alignment of competences with the dimensions of the TBL.

Regarding the contribution to the companies studied, the research process itself has already been highlighted as a contribution by the companies, as the interviewees observed that they are reflecting on the topic and view it as already important. They can also, from the consolidated results, identify the points at which they can seek improvements in competency development processes aligned with sustainability.

It is also worth highlighting the limitations found in this research. The impossibility of generalizing its results, due to the methodological approach adopted that can allow the subjectivity of the topic in the studied object. Conversely, this study opens as an agenda for future research: the possibility of expanding studies in the cases studied to units located in other countries, seeking to compare results in different cultural contexts; the development of studies that analyze the informal context in skills building for sustainability; the investigation of the theoretical base on communities of practice as elements for the development of competences for the Brazilian chemical sector, based on associations such as ABIQUIM.

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KEY TERMS AND DEFINITIONS

Eco-Efficiency: Balanced action of the economic and social pillars of sustainability through the pursuit of economic prosperity through more efficient use of resources and reduction of environmental degradation.

Eco-Innovation: Innovation of goods and/or services as well as in production, exploration, production, management or business processes that seeks to reduce both environmental risks and the use of natural resources.

Environmental Justice: Balanced action between the social and environmental dimensions of sustainability, associated with intra and intergenerational equity, seeking to balance the advantages between present and future generation.

Organizational Competence for Sustainability: Effective organizational action supported by human, physical and organizational resources that provide return to the organization, adding social value to individuals, without compromising the environment.

Proactive Approach: Organizational actions based on the determination of the necessary competences to the important changes that occur in the organization, in order to answer the fundamental requirements for developing competitive advantage for the organization.

Reactive Approach: Organizational actions based on the difference between the expected and the achieved result, not focusing on the link between the strategic objectives of the organization.

Social Justice: Integration of the social and economic dimensions of sustainability, characterized by an ethical performance not only of a company, but of an entire industry both in the market in which the product or service is produced as in what is used.

Triple Bottom Line: Model that characterizes sustainability through the interaction between three dimensions: economic, social, and environmental.

Chapter 6
Territory Democratization and Institutional Design in Urban Green Innovation

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ABSTRACT

This chapter has the objective to analyze the elements of urban green innovation based on the guarantee of the public interest to decentralize the infrastructure to democratize the territory and innovate the institutional design to address the complexity of the challenges in the city. The method employed is the critical analysis supported by a review of the literature and consultation of experts in the field. It is concluded that the urban green innovation capacity planning has a critical role in urban innovation development in specific areas of economic growth, social inclusion and equality, environmental sustainability, health, education, business, etc. To achieve these aims, urban green innovation requires one to guarantee the public interest, the democratization of the territory, and the new institutional design.

INTRODUCTION

Cities are very different lively ecosystems brooding places of urban innovation, imagination and creativity. Cities shape and are shaped by the vision of urban green innovation ecosystem elements that anchor investments into environmental and sustainable development. Larger cities generate more innovations because the interactions between people socially distant to each other and weak ties, aggregating information when they meet (Arbesman, Kleinberg and Strogatz, 2009; Granovetter 1973). Large cities have more educated and transient people (Arbesman et al. 2009).

Urban green innovation may have the objective to improve the high technology and services business labor market while restructuring old urban industrial and shrinking areas creating new urban development mixing economic, science, media, leisure and living activities. Green innovative technologies

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processes supporting the green urban environment may become more complex when affecting the pace of changing the city. Urban green innovation challenges sustainable and environmental development of the city at various scales and across sectors. The multi-level conceptual analysis of urban green innovation takes into consideration the micro, meso and macro niche levels the corresponding innovations, socio-technical regimes and landscapes.

The contribution made by this article is the realization of an analysis of the concept of urban green innovation from a social perspective of transformation of the planning creation structure, based on territorial democratization processes that are capable of evolving institutional design with the aim of defending the public interest.

Defining need of urban green innovation is a first step required to advocating investment in specific local spaces and areas and encouraging external funding support. The intention to introduce urban green innovation requires an enhanced level of corporate governance environmental responsibility and sustained level of implementation of the city's environmental strategies and policies to put urban green projects into practice and overcoming of environmental challenges and risks. Integrating environmental sustainability, economic growth and social development issues into urban green innovation into an in-depth approach represents a challenge. Other innovative urban green projects are related with alternative and renewable energy saving buildings, neighborhoods and spaces.

There are different approaches can be used, each one with different reasons and ends, for example: radical versus incremental, environmental performance, etc. Urban green innovation essentially intents to respond to the environmental changes and new societal expectations, integrate sustainability issues into the achievement of economic growth, social development, environmental sustainability, community welfare and good.

Urban green innovation practices contribute to sustainable urban planning of infrastructure and urban green areas. The cities and urban undertakings are innovation hubs for urban green areas with relevant impacts on economy, technology, social, organizational, etc. Urban green areas are a potential testing ground for innovations in several issues and disciplines. Urban green areas are hot spots for green innovation (Burch and De Luca, 1984; Krott, 1998). Innovation can be social, technical, socio-technical, ecological, socio-ecological and environmental.

Urban green innovation may contribute significantly to urban sustainable development providing an opportunity for research to define a new direction for green environments (Cronon 1991; Goudie 1994; Forman 1995).

DECENTRALIZE THE INFRASTRUCTURE TO DEMOCRATIZE THE TERRITORY

Public interest is related with the well-being and welfare of the general public where all the society has a stake in opposition to the private interest related to the welfare of a person or firm. Public interest covers a wide range of issues, principles and values of legitimate public concern in the best interest of the whole society. The public interest in green and sustainable urban planning cannot be defined in objective terms as it has unsatisfying results in terms of green innovation in urban green areas, aesthetic and social dullness, necessary urban infrastructure and services, etc. However, normative planning has the tool of descriptive science, evident in the notion of public interest or common benefits of planning solutions.

An elaboration of an operative concept of public interest in green urban sustainable planning as a political decision process must be the result of a debate on economic, socio-political and ecological priorities of the whole society. Defining the means and ends in planning is left to urban planners under the assumption that they know better what is the best for the citizens (Banfield 1973). Subjective motivation on participatory planning analysis may distort the objectivity of common good and the realization of public interest. Urban planners rely more on facts that have scientific basis and on rules based on his authority (Forester 1987).

Democracy is intricately intertwined within the state, society and economy. In contemporary societies, the major institutional forces are the economy, state, society and the media, which have crucial functions to create a democratic transformation and maintain a democratic social order. Urban community organizations advocating local environmental and sustainable development are catalyzing urban resilience my making regulatory procedures and monitoring institutions in their deliberations of public interests. Urban community greening innovation is a community-based tool able to strengthen resilience through social learning, adaptive management and urban green innovation ecosystems. Innovativeness in urban green areas have developed from motivations to engage in environmental and sustainable development performance issues, risks and challenges. This means producing and developing green innovation with environment impact.

The concept of public interest applicable to green urban sustainable planning afford awareness of values and the consequences in the planning analysis. In situations in which local governments want to be acting actors of independent public and private agencies, they are faced with harshness at higher levels of uncertainty in order to have knowledge and to confront their ability to manage in the public interest as well as to promote general welfare. The exercise of public management in environments of high complexity and uncertainty requires that managers and public executives have the tools of analysis for the treatment of various public issues concerned with the public interest of the society as a whole through the development of critical analytical skills and through training in applied heuristics.

Those who are users of public and social services from local government agencies and institutions do not always also have clarity about many interdependent and non-competitive structures when there is only one choice for public interest. Then, it is assumed that local government agencies also have to make more choices than the citizens as consumers of goods and services themselves. It is also relevant in this order of structural relationships, the analysis and determination of satisfaction levels for the client-consumer-final citizen, as well as the determination of what will be most appropriate for the public interest and general social welfare.

The research constructed properly consists of the evaluation of explanatory and comparative frames of reference, the proof of models centered on structures / cultures / organizations / spatial contexts and the comparison of different instruments to achieve the verification of the same results. The reference model defining the urban green innovation ecosystem must describe the characteristics taking into consideration the different characteristics of the cities to taylor the model of local urban green innovation accordingly. In addition, the new public management in local government organizations takes into account the organizational culture of the private sector, accountability for results rather than the traditional public sector, processes of accountability and the vocabulary of efficiency and service rather than the justice of the public interest.

If the efficiency of the private market economy is questioned on its own, then this argument implies that private companies need a more critical and differentiated analytical approach to public interest before they are recommended as models of organizational efficiency to public organizations. These concerns are often equated to the public interest with the same interest of the current government, this is the public interest is what the current government says it is. The society that is democratic is concerned about income disparities between citizens and their public interest in their well-being, so it has to make policy decisions that often involve questionable negotiations.

There is a genuine concern for the application of the entrepreneurial model from the perspective of the new public management of democratic ideals, either because the public entrepreneur is capable of abandoning self-interested behavior in favor of the public interest. It is worrying that the concept of public interest does not provide specifically enough guidance for ethical-centered behaviors. There is concern about the urgency of the behavior of public servants that to pursue the public interest may induce some of them to inject excessively their personal values into the decision-making processes, in such a way that they achieve their personal advantage instead of social benefit. The behavioral assumptions on the public interest involved in the new managerialism of the public entrepreneur is another area of concern.

An example of how the field of collaborative planning has evolved in recent decades is the northern European case. The schools of Versailles and even more that of Paris proposed a systematic way to qualify and quantify the spatial relations between the different elements. Ravetz (1980) highlights the opposition generated to this type of urbanization processes generated in Great Britain in the 70s. After the creation of numerous English cities around industrial activities, the new urban transformations required an approach that surpassed the modern architectural discourse to embrace the possibility of guaranteeing the inhabitants a space in which they could be identified, especially through conservation and restoration work.

Although the methods of quantitative spatial analysis supported by the new technological platforms certainly offer numerous advantages, the new challenge must consist in integrating the inhabitants into the decision-making processes, so as to allow the meeting of the parameters of efficiency with the quality of life, which is supported by identification mechanisms with the territory.

Negotiation in urban innovation processes among local authorities, city planners, land-use preservationists, communities, neighborhoods, developers, and any stakeholder with interests can contribute to find innovative solutions concerning public interest for urban planning, design and development of public open spaces, urban green areas and housing. The interests and expertise of each one of the stakeholders' steer and enable to reframe of the problems and the developments of innovative solutions. Freedom and independence of stakeholder's participation to address political sensitive problems, are relevant factors in contributing to collaborative planning to explore innovative solutions based on the public interest. The expertise of stakeholders contributes to facilitate the access to broader and innovative research networks of public interest.

In turn, urban governance harness networks of urban green innovation ecosystems to sustain services to the city, locate resources of and challenging the urban resilience. Urban innovation drives urbanization influencing negatively the resilience of ecosystems, which needs to be reinvigorated. Innovation is supported by resilience and transformative capacity systems human dominated. Society innovative capacity in urban green spaces is based upon resilience and sustainability of the city. Urban green spaces are essential components of cities (Husqvarna Group, 2012) to promote ecosystems and human health (Tzoulas et al., 2007).

Integration of environmental sustainability into green area innovation is a key challenge. Green innovation is the result of interaction between innovation, sustainable and environmental development, and economic growth. The green areas innovation model can be refined into urban green innovation ecosystem supported by the theory of systems to determine city processes.

Finding urban green innovative solutions do not necessarily come out of confrontations based on ideological clash, although conflict resolution or third-party negotiation processes between the participant parties and stakeholders can be used in specific disputes of diverse public interests. The concept of user-driven open urban innovation ecosystems are sustained by the urban needs and interests of stakeholders, such as citizens, local governments, social organizations, business. This concept of urban innovation ecosystems can bridge the gap between urban development priorities and technological research and experimentation based on public interest.

Popular mobilization on the street serves to produce political results in the street, because the institutions with their current configuration do not respond, they are co-opted, taken for other values and interests that are neither the interests of the population, nor the public interest. The development of forms of participatory democracy of organized and well-informed citizens who participate in decision-making processes will enhance social policies based on the public interest of the society as a whole.

The public interest is an ethical concept and an operative that is consubstantial essence of political discourse and a guide for political action attempting to justify the policies and acting of government on decision-making in the green urban sustainable planning and empirical evaluation processes. Public interest must be identified, demonstrable and the implementation process and results must be evaluable. Public interest is a basic premise for a territorial democratic process of green urban sustainable planning. The public interest emanates from the acting of the state because it can be demonstrated that it reflects that green urban sustainable planning. This is an instrument for the expression of territorial democratizing with the explicit objectives and consequences of decisions affecting all the individuals equally.

DECENTRALIZE THE INFRASTRUCTURE TO DEMOCRATIZE THE TERRITORY

The debate around the urban public space, the housing and urban justice revolve around the proper object of the struggles for the right to land, city infrastructure and territorial order. Public space emerges as a situation of paradigmatic spatial transition, from a space that is a box or vehicle, to a space that is an entity in itself. It is a collective presence rather than social movements in the city and in public spaces, it is a different type of claim to space.

The green urban resources and infrastructure for innovation, research and innovation networks between governments, business and higher education and research institutions are determinants of the city welfare. The position of the different actors in the innovation network facilitates the access to diverse information and knowledge flows and provides the potential to create and develop innovative opportunities (Burt 2002, 2005). For example, Green roofing is an innovative practice in design and wastewater technologies. The use of innovative practices in green roof are in both in the promotional policies and in construction as a tools in a broader plan to create green infrastructure for ecosystem services, although may not completely mitigate the ecological footprint in urban ecosystems.

The dominant constructions of territory, land and urban space in the contemporaneity are the complementarity of capitalism and the large-scale colonialism brought about by geospatial concentrations and the creation of great inequalities in cities. The spatial urban organization shows dysfunctionalities such as the abandonment of public spaces, organization in a way that hinders the agglomeration of people, the distancing of institutions from city centers in such a way that access is difficult. Democratizing democracy has a very broad meaning.

The territorial unitary vision of urban spaces is problematic in the sense that they are the reflection of the production of hegemonic imaginaries and fictions, from colonial fictions to nationalist fictions. Alongside authoritarian urban spaces, the spaces of the excluded coexist as a response, which gives rise to the struggle for public spaces that show many arists and many dimensions to accommodate urban social movements. The public space of the new social movements today is the space itself, the space itself is the value, it is the question of the political arena.

The extractivism of natural resources territorializes economic and political relations, giving rise to a contradiction in the processes of economic globalization under the assumption that it considered the deterritorialization of production, distribution and consumption processes. The processes of deterritorialization is just one of the sides of the condition of globalization as opposed to the processes of reterritorialization because there are certain elements inherent to the processes of production, distribution and consumption in certain places.

The struggle for land, territory and urban space is a struggle against the colonial and capitalist heritage of territorial space. Cities considered plurinational in geopolitical terms and may have territorial autonomy that is not merely administrative or political, so they are not independent territories. This type of autonomy is the result of the recognition of the existence of other ways of administering the territory, Cosmo visions, cultures, etc. The land and its natural resources today are within a geopolitics of the territory much more complex than the one that had been built before.

The struggles for land, territory and urban space prosecuted by the new social movements form a front that is common to territorial fascism with its forms of colonial domination and exploitation of the territory for the defense of territorial ecological conceptions in the face of capitalist pressures and colonialists. Territorial fascism refers to the logic of the territory that crosses the cities and ends up fracturing them, giving rise to spaces within cities that have an abysmal line between civilized areas, private urbanizations that go against public spaces and wild areas, where the popular classes live. These wild areas proliferate in cities that do not have the capacity to accommodate populations in an urbanistically reasonable, socially and politically decent way.

The different forms of territorial fascism exist in spite of political and legal homogeneity, but where institutions are able to act in a totally different way according to whether they consider the enemy territory or not in a civilized or savage conception of war. The internal territory can be a very poor neighborhood or groups of terrorists, etc. The internal territories are subject to forms of internal geopolitics that import the relations of international conflicts for the territory itself and that reproduces internal colonial relations.

A great innovation based on a new idea of territory that focuses on the neoliberal capitalist logic that validates the function of the territory as it is exploited is the consideration of the original groups that hold the logic that the territory has no commercial value. A great alteration occurs at the beginning of the 20th century in the conception of the land, because previously there was a conception, if you will, more human of the territory and of the earth.

The social struggle around territorial land in urban centers in Latin America is part of the logic of geopolitical concentration of territory and land through colonial history and colonial cultures. These situations that condition the current struggles over land and territory become relevant to the discourse of hegemonic and dominant practices. There are many international pressures for the exploitation of primary goods, foodstuffs and speculation about minerals, and consequently, the pressure on land and territory is causing all political conquests to be undermined by the governments that have instituted them.

The counter-hegemonic movements are movements that fight for territory, land and urban spaces. Movements that fight for a more equitable distribution of land are movements of indigenous peoples, populations that today are largely indigenous or aboriginal. The territory is the very root of the cultural identity that is expressed in urban spaces where they try to recover the memory destroyed by capitalism and colonialism. The emergent political protagonisms of colonialism consider that for certain social groups there is no dignity without territory. This is the case of indigenous peoples who try to claim respect for their culture and knowledge with respect for their lands and territories, in such a way that they seek to guarantee their dignity with the guarantee of territorial autonomy.

The nature, the territory, the use of the land and space have colonial, capitalist and ecological dimensions. The ecological dimension marks the ecological limits of the other two dimensions. What is at the bottom of the cause is a change of civilization that forces to modify the habits of production, distribution and consumption. The conceptual foundations of Southern epistemologies, the ecology of knowledge, the sociology of absences and emergencies, and of intercultural translation well established as reference frameworks, can help developed countries with a colonizing past, recognize more experiences and the knowledge to value the origins that come from the colonized territories.

In the traditional conception of urban territorial space, there is a conceptual attempt to create the idea of an urban territorial space that would be outside the hegemonic space of subaltern colonialism that was constructed as such, rather than settler's colonialism, colonialism of intense and direct occupation, within a very unequal colonial relationship. Colonialism created an arrogance that has incapacitated the colonizing countries to learn from experience and to teach the world because they despise all the innovations that may come from the colonized countries that have always been considered inferior.

The pressures of the international institutions of neo-liberalism, argue that the comparative advantage of less developed territories are mineral resources and that they should be exploited already. For this reason, extraordinary initiatives that had been designed to completely alter the development model based on extractivism, to protect biodiversity requires financing projects with a lot of political will. From a question of struggle for a distribution of land as an agricultural resource for a political construction of a territory with its own cultural identity, it has changed to become the reservoir of biodiversity precisely when the great orgy of natural resources occurs.

The concept of green bio economy is rationalized based on territorial decision making for smart city investments and capitalize on business models (Belissent, 2010 and McGeough and Newman 2004). Smart city solutions must start with the city solutions not the smart solutions (Belissent, 2010). The term smart city was coined in the 1990s to suggest that urban planning and development was incorporating innovation, information and communication technologies inserted in globalization processes (Gibson, Kozmetsky and Smilor 1992).

Smart city is an initiative that promotes innovation and efficiency of urban planning and design of public services, facilitates access to government information and communication. To create, develop and promote urban green innovation values are needed the relevant contribution of instruments for and innovative communication. Innovation is a novel way of doing useful things embodied and implemented through recursive communication and alignment in urban social networks. Urban social networks underpin green areas innovation.

The Smart City model aims to foster the creation and development of knowledge, innovation and creativity, increase the efficiency and provides information access and cohesiveness for all the parties involved in sustainable urban development. The policy formulation and implementation of urban green innovation ecosystems must be supported by a sustainable urban planning involving structures and resources.

From another territorial perspective of green urban sustainable planning, smart embedded technology devices are a characteristic of smart cities to distinguish it from intelligent cities and used to create territorial innovation ecosystems by sharing and supporting cooperation between knowledge-intensive activities, institutions for learning and knowledge development, and web-based devices and applications to generate collective intelligence (Komninos, 2008a, b, 2002). Living Labs (European Commission 2010) is a user-driven open research and innovation ecosystem to facilitate creative roles of users with the goal to involve communities of users in local urban contexts territories.

Open urban innovation and open business models are two concepts elaborated by Chesbrough (2003). The Living Labs concept is user-driven open urban innovation ecosystems which can be applied to smart cities embodying an open business model based on willingness and relationships of collaboration between the citizenry, local governments, social and non-governmental organizations and business enterprises to engage in innovation activities in a kind of deterritorialized space.

The creation and transformation of the urban territory according to industrial or commercial activities have allowed the systematic planning model to flourish since the 50s, continuing its predominance until today. However, the history of urban planning has evolved and continues to evolve in the direction of participatory planning in which the protagonists of the city, or everyday social actors, can express their influence in decision-making. Inevitably, urban planning represents a form of representation of dominant hegemonic thought. The new challenge consists in reproducing systems of participatory urban planning that are characterized by a local ontology and epistemology.

The existence of successful local development processes is not possible without a strong identity component that stimulates and spreads the potential of initiatives of a human group (Arocena 2002). The identity of a human group will be much stronger and capable of generating collective dynamics if the group has had to overcome difficulties, if it has been able to transform threats into trump cards, if it has won victories over adverse factors. On the contrary, history shows cases of collective decay when challenges disappear, when everything becomes too easy and too safe.

Finally, another important factor to consider is that territorial collaboration for urban green innovation systems is based on the concept of competitive advantage (Porter, 1990) and is driven by urban and regional development policies aiming to create the best conditions for sustainable development.

INNOVATING THE INSTITUTIONAL DESIGN

Innovative urban governments tend to be more democratic and accountable supported by institutional and cultural frameworks that allow development of the population in general while providing local funds for initiatives to benefit low-income groups and communities (Satterthwaite 2002).

Researchers have focused on distinctive theoretical approaches and practices of green area innovation by analyzing radical and incremental innovativeness from different perspectives such as energy-based, material driven, pollution-prevention, etc. Innovation is incremental and radical changes in ideas, practices, changing rules and institutions, ways of organizing society. Both radical and incremental innovativeness in green areas have a relevant impact on addressing the challenges of the urban environmental and sustainable development. Therefore, urban planning must provide green areas innovation to contribute to sustainable development and economic growth.

The social capital that allows participatory planning certainly depends on the local context. The most educated urban communities normally have a greater capacity to manage the territory through common initiatives and the aspect of population size and density can be a positive factor in the potential to create neighborhood or city networks.

The condition of uncertainty of urban development implies a constant process of monitoring, learning and adjustment in the objectives and intervention tools, the analysis methodology prioritizes the study of the interaction between variables of the urban system, proposing possible future scenarios and determining scenarios as objectives in the short and medium term. Concepts such as the common good are no longer taken for granted, but work is done by legitimizing and providing transparency to the processes that determine the intervention criteria, while promoting the governance of the actors involved.

It is prioritized to establish shared objectives and criteria with a flexible implementation before plans and projects imposed on the territory. Inclusion now also means integrating the multiplicity of interests, capacities and objectives of the actors involved in urban development.

The global, the totalizing, the statist and the centralizing bring criticism as they constitute elements that characterize the declining model.Alternative formulas emerge: "self-development", "endogenous development", "self-centered development", "integrated development", human scale development, grassroots development, ecodevelopment etc.It is in the local scene that the articulation between the singular and the universal, the place as a whole, is expressed as at no other level (Arocena 2002).

The delimitation by municipalities corresponds only to a territorial subdivision that does not necessarily correspond to a local society. The local must refer to a local society, local initiatives and local identity that stimulates and spreads the initiatives of groups, local actors. Local actors are organized neighbors who try to improve the quality of life of a neighborhood or a specific area. To refer to local society is to talk about a human group that inhabits the same territory and shares identity traits and shares common problems.

The innovation ecosystem is a strategic concentration and interrelations of intensive knowledge-based activities provided by different institutions such as business incubators, technology parks, technology transfer centers, efficient energy centers (Barcelona, 2011; Barcelona urban studies 2011; Duchesneau, Cohn, and Dutton, 1979) etc. Urban planning and designing are challenged by innovative abilities and an innovative culture to capitalize on the creation of urban green innovation ecosystems to attract individuals and business (McGeough, Newman 2004; Atkinson, Castro 2008; OECD 2003; The creative class 2011). The model of smart city can promote the public involvement framed under at improving and exploiting the urban culture heritage.

The urban natural and green resources and infrastructures are basic elements in the innovation ecosystems that can be capitalized and may develop into new business models. Innovation ecosystems start from the formulation and implementation of urban green innovation policies supported by urban planning, resources and structures. Urban and surrounding areas can evolve towards open, sustainable innovation ecosystems to boost research and experimentation of services driven by users in real-life environments.

Urban green area innovation is characterized as incremental versus redical, radical versus routine, revolutionary versus evolutionary, discontinuous versus incremental innovation, new versus extensions, pioneering versus modifying, original versus adapted and basic versus improvements, etc., by scholars and practitioners (Anderson and Tushman, 1990; Nord, and Tucker, 1987; Baker and Sweeney, 1978; Stahl and Steger, 1977; Van de Ven, 1988; Zaltman, Duncan, and Holbeck, 1973). The context of the last 40 years is a context that is not in any way revolutionary, but perhaps counter-revolutionary. In a counter-revolutionary context, expectations are frustrated and democratic institutions do not respond.

Urban green innovation projects can capture an old and shrinking area of the city and turns it into restructured and revitalized creative metropolis. Attractive and cost-effective projects of green innovation should take into account innovative planned building and green spaces outside. Redevelopment of vacant and abandoned urban spaces and buildings in shrinking cities for farming is a green innovation for revitalization. Adopting urban green innovation practices correlates with institutional design and policy changes that empower urban planning and development.

Some examples of urban green innovation projects are community gardens and farms, forestry projects, Etc., which support biological diversity and spatial heterogeneity (Tidball and Krasny 2009, 2007). All require investments, active participation and involvement in decision making process by local residents. Community gardens in the form green innovation exhibiting different types of management offer an opportunity for innovation in green space governance with innovative solutions to individuals, business, communities, etc. These different types of management are formed by local government, private organizations, health centers, schools, an organized group of gardeners, etc. (Lawson, 2005; Hou et al., 2009).

Urban green innovation can be steered toward an opportunity for sustainable knowledge, practices, institutions and solutions. Citizens and business demands for urban green innovation and green services quality are potential welfare of urban areas. An urban green innovation ecosystem use user-driven innovation methods and requires the support of an open platform for heterogeneous technologies intended to be used for designing and implementing innovative and creative green cases. However, the use of innovative technologies requires also an innovative institutional design.

Operational innovative institutional mechanisms such as differential land taxes and payments for environmental services to support sustainable urban greening activities that contribute to benefits such as carbon sequestration. Stressed urban green innovation systems require an institutional design shifting from the industrial economy and innovative bio economy towards a more ecological economy to effectively support the generation and use of urban ecosystem services. Urban innovation processes can use industrialization aimed to reach sustainable economy. Urban research, experimentation and innovation technology-oriented ecosystems may be aimed to contributing and developing potentially attractive environments to fulfill the needs of the citizenry.

For example, innovations in urban planning and policies on land use can integrate farming into multi-functional buildings. Urban farming in open rooftop generate several green-roof effects such as reducing the rooftop surface temperatures, reducing summer cooling load and heat losses, insulation against cold, etc. The spread of urban agriculture and gardens development and adaptation requires technological involvement, social organization techniques, diffusion and extension of production techniques. Comprehensive urban planning of cities and food policies can include farming and agriculture as an urban green innovation.

The creation of a collaborative approach to urban green innovation ecosystems is based on sustainable partnerships among the stakeholders from citizens, local government, leaders of the community, business firms, social organizations, etc. aimed to achieve resources and specific goals. The institutional design of the urban space is an object to attract considerable scientific–technological innovations interested in meeting the needs of people and supporting collaboration for the development of innovative solutions to sustainability issues. Smart Cities initiatives are more characterized by public interventions than by new technology deployment in policies of innovation and social inclusion aimed at creating societal and institutional design conditions.

The public space is used to carry out demands in which the public was not in itself a vindication: it was the new work code, the rights of women, and from then on. If the population goes through the non-institutional space it is because the institutions are not democratic or lack vitality and democratic force and therefore the understanding between institutions and institutional spaces is not achieved. Democratic institutional design does not fulfill their mission because they deviate from their functions. The people who have been expelled from the institutions are manifested in the streets depending on the capacity of democracy to respond. That is to say, the transition is manifested in a struggle for real democracy initiated by those who feel expelled and that is historically uncertain. What is claimed is an entry that implies a fundamental reform of the institutions.

Popular knowledge, rescued by the ecologies of knowledge, is knowledge that is often embedded in a practice that is born of struggle, is born in struggle knowledge, and only exists in the practical contexts in which it exists and does not exist. In the institutions of knowledge production. The theory and ecological knowledge as a practice opens spaces to multiplicity and diversity, insofar as it maintains that link to the social and moves away from privileging a certain type of knowledge, the knowledge that triumphed from the seventeenth century, scientific knowledge and the Eurocentric philosophical tradition.

The ecology of knowledge brings some hope in the post-institutional design times because it is carried out in other instances than the traditional ones because the institutions no longer manage to accommodate the echoes of the new generations, which in some way makes new and diverse forms of action are positioning themselves in the urban space, opening new political spaces.

The political struggle takes place in that space because the indignados believe that the institutional spaces were colonized by neoliberalism, neutralizing the right to political manifestation within the institutions, under the conceptualization of post-institutionalist. The post-institutional design moment is also translated into that occupation of spaces, and the logic is the same: it is a political response to a situation of frustration of expectations that were built in the last 40 years, obviously not accrediting institutions, nor in the rights that sustain them, because the right to private property is violated and the right to public property is violated.

Social movements are engaging in cultural innovation challenging conceptual frameworks an identity of the city and urban communities. The new forms of structural articulation between urban social movements and institutions, as well as lines of formalization between a micro and a macro policy, are essential components to improve urban green innovation processes. The acknowledgment of the role of social movements occurs in a neo-liberal pressure boom for natural resources that causes the re-primarization of the economy, that is, a return to that idea, which is the curse from colonialism, that Latin America it exports nature, exports commodities, exports natural resources, exports raw materials, and not industrial goods.

The occupation movement is more a dimension of the post-institutional design movement, which in this case is rape or private property or public property. Private property belongs to the owner, public property is subject to the rules of the State, so those who do not comply with the rules cannot occupy, these are the two dimensions of ownership. An opportunity for innovation for institutional design governance frameworks is a challenge that requires filling the knowledge gaps. Innovation in green urban systems at different scales and across sectors with the involvement of local society provide solutions to improve the quality of life of the urban communities.

A multidimensional measure of radical innovation is required to be applied across different institutional, community and organizational settings with acceptable reliability and validity. Radical innovation of R&D projects is a multidimensional factor which can be measured using a construct of innovation radicalness described by the amount of technological uncertainty, technical expertise, business practices and costs.

Local policies play an important role in creating the right institutional design setting to foster human capital for research and innovation capabilities to support the creation, establishment and development of incubators for hi-tech start-ups connected to global-scaled innovation systems. Cities exhibit some weaknesses and strengths on innovation capabilities. Cities located in less developed countries are more active in fostering innovation capabilities than in cities on well developed countries that are more active in hard domains. Governments are encouraged to increase investments in research and innovation to promote ICTs (Winden et al., 2007).

CONCLUSION

This paper has analyzed the interrelationships between the fundamental principles of urban green innovation. Urban green innovation projects have a relationship with other environmentally innovative activities such as green infrastructure, energy efficiency, water quality, drinking water infrastructure and waste water, etc. Urban green innovation projects are opportunities for producing goods, food, bioenergy, biomedicine, resource efficiency, farming technologies, new urban spaces, new forms of urban mobility and transportation, etc.

Local authorities of the city as the founding ground must have the potential to promote the vision of the urban green innovation ecosystem as assemblies of planning policies. Local authorities must provide support to enhance green innovation capacity and business-intelligence through discussion, debates and analysis of policies, research programs, and other forms to find solutions to meet the urban green spaces challenges.

The urban planning policies of local government have the potential to promote an urban green innovation ecosystem. Smart local government of a city has the capacity to generate service innovation and communication to deliver to local residents (Gonzáles and Rossi, 2011). Cities more active in improving their capacity to sense and act through ICT systems are also less likely to differentiate soft domains initiatives related to innovation, human capital and cultural heritage capabilities.

The innovation capacity on the use and development of technologies in ecosystems is incorporating parameters of sustainable and environmental urban green innovation planning projects. Urban green innovation planning projects is a strategy to stimulate organizational economic growth. Research and development programs embody urban green innovation planning to anticipate meeting the needs and aspirations of citizens to provide them green public services.

Innovative development in urban green planning is required to make use of some prospective studies and methodological tools focused on improving the urban green ecosystem in various elements such as water, waste treatment, energy, etc. Urban green planning and design might integrate risk management in transition periods to incorporate innovative projects such as from fighting against water to living with water (Rijke et al., 2008; Newman et al., 2011).

Fostering the city capacity for urban green innovation requires the implementation of human capital investment and improvement of quality of life initiatives supported by motivated local residents, innovative business, entrepreneurs and investors, talented persons, etc., able to start up new enterprises (Caragliu et al., 2009; Correia and Wünstel, 2011; Giffinger et al., 2007; Hollands, 2008; Rios, 2008; Toppeta, 2010).

Smart cities must instrument local urban green innovation ecosystems and the knowledge of innovation bio economy overall to face the challenge of securing high living standards. Future Internet technology arrangements in urban green environments involve large business and enterprises, micro, small, medium and enterprises (MSMEs), universities, research centers, etc. Future Internet facilities are used for developing and validating some service concepts and applications supported by the Living Labs approaches for smart cities.

Future Internet technologies engages users and citizens to enhance participation in the transformation process of individual and collective behaviors and social norms to discover and design sustainable scenarios to implement urban green innovation projects. To this, Learning Alliance can operate in the context of research action referring to the risk management in urban development projects. Learning action alliances are used for urban green innovation in different sectors.

The reference model of urban green innovation ecosystems can evaluate its innovative capacity to identify complementarities and inconsistencies in urban planning and designs. All the opportunities should be explored to build on the innovative urban green capacity of the cities to develop and transform a multifunctional green infrastructure into a more urban green innovation ecosystem. Location of source of experimentation and innovation in green urban areas help to build capacities to face uncertainties and enable changes and transitions in urban governance.

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KEY TERMS AND DEFINITIONS

Demorcatization: Democratization is a process of development of liberal social institutions that lead to the strengthening of civil society.

Instituciones: They are the set of the rules of the game of a society.

Institutional Design: The different institutional arrangements of those projects carried out for organizations that perform a function of social interest.

Public Interest: Set of claims related to the collective needs of the members of a community and protected by the direct and permanent intervention of the state.

Territory Democratization: Development of local institutions in relation to spaces that strengthen civil society and affirm themselves for political control.

Urban Green Innovation: It is an action of change that is a novelty of a green space, and therefore, is a terrain that is characterized by the presence of vegetation.

Chapter 7
Digitalization as a Key Issue of the Circular Economy to Promote Sustainability:
Prototyping Design for Homeless People

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ABSTRACT

Digitalization is a topic of circular economy in the context of the ReSolve framework. The use of information and communication technologies (ICT) in the context of social organizations can provide added value in order to foster integrative solutions. The aim of this chapter is aligned with the literature about ICT, circular economy, and sustainability to present the design of a prototype that fits homeless person integration strategies and addresses concerns in the various dimensions of sustainability supported by ICT. The authors use the design science research methodology in order to communicate the prototype results for the integration of homeless people. The prototype will be developed under the assumption of use in an organizational context by a multidisciplinary team, aiming to allow the cooperation of the various entities involved. This is a contribution to achieving the Sustainable Development Goals. The main results of this research suggest how to develop, in partnership with local organizations, solutions to solve social problems supported by a sustainable perspective.

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INTRODUCTION

The increasing dissemination of the use of information and communication technologies (ICT) and information systems (IS) as support for people management activities can be a competitive advantage and a contribution to the promotion of sustainable and inclusive development in the long term.

This chapter aims to constitute a contribution to knowing the practices instituted in organizations in the field of characterization of the situation of homeless persons (HP), creating an information management tool that helps and promotes the social inclusion of people in situations of social vulnerability.

It is intended, therefore, to keep information about the various aspects of HP, namely professional experiences they have had, family ties, regional framework in the current area and with regard to naturalness, personal tastes, personal interests, health situation, etc., allowing possibilities for social inclusion to be identified.

The chapter presents one of the components of the prototype design regarding data modelling and more specifically the analysis of requirements in order to define the information needed for the prototype as well as the actors involved in the system. It is considered that, based on this systematization of information, it will be possible to improve the provision of services.

LITERATURE REVIEW

The literature review is based on a set of topics that support the empirical study, such as the circular economy (CE), and their social dimension, sustainability in software design, good practices in information security and the Sustainable Development Goals (SDGs). The literature review has a comprehensive basis given the diversity of topics addressed in the chapter. Thus, the objective of the chapter is not a systematic review of the literature in the domain of the theme.

Social Dimension of Circular Economy

The circular economy and social innovations come together (Robinson, 2017) as "brothers in arms", with the concept of social innovation still understood, nevertheless (Carvalho and Viana, 2019). Firstly this section discusses the concept of social innovation, after which we will approach the concept of the circular economy and finally we will attempt to merge and connect these concepts.

Social Innovation

The concept of social innovation in fact occurs at the level of social practice (Lisetchi and Brancu, 2014). While some authors mention no clear boundaries between social innovation and other types of innovation (Howaldt and Schwarz, 2010; Murray, Caulier-Grice and Mulgan, 2010), they differ in their objectives and results (Hochgerner, 2010) because social innovation can occur in the public sector but also in other sectors (private or non-profit) or in a space between these sectors. Mulgan (2006) states that social innovation concerns activities and services motivated by objectives and responses to social needs mainly disseminated by organizations whose main purposes are social. We can state that social innovation includes new practices (concepts, policies, instruments, new forms of cooperation and organization). Methods, processes and regulation are developed and adopted by citizens, consumers and politicians in order to respond to certain social requirements and to solve societal challenges in a better way than previously done (European Commission, 2013). Bignetti (2011) defined social innovation as new or improved ideas or actions of knowledge to respond to social needs in various areas of society. The societal challenges that society currently faces is a mobilizing factor to solve a set of problems and needs through the creativity of civil society and public and private institutions, reinforcing the importance of having a more solidary, innovative and knowledge-based society.

BEPA (2010) argued that societal challenges fall within social and/or economic opportunities that are created and justified by the need for the promotion of public policies that encourage social innovation in order to achieve:

1. Provision of services for society and citizens, usable and reusable for everyday life;
2. Provision of services by the government making social innovation sustainable in the long term;
3. Creation of new business and entrepreneurship.

The Circular Economy

According to the Ellen MacArthur Foundation (2017), a circular economy is economic activity which builds and rebuilds overall system health. The concept attends the importance of the economy needing to work effectively at all scales – for large and small businesses, for organizations and individuals, globally and locally. The circular economy is the manifestation of a paradigm shift, and it will demand changes in the way that society legislates, produces and consumes innovations, while also using nature as inspiration for responding to societal and environmental needs (Cohen-Rosenthal, 2000, Hofstra and Huisingh, 2014). Several authors provide news insights and reviews to define the circular economy:

- Circular business models (Bocken et al., 2014, Lewandowski, 2016);
- Taxonomies, such as reduce, reuse and recycle (3Rs) (Sihvonen and Ritola, 2015);
- Create value throughout the supply chain (Schenkel et al., 2015);
- A paradigm that provide a relationship with sustainable development (Geissdoerfer et al., 2017).

According to Prieto-Sandoval et al. (2018), it is possible to highlight four relevant components to establish the concept of CE: 1) the recirculation of resources and energy, the minimization of resources demand, and the recovery of value from waste; 2) a multi-level approach; 3) its importance as a path to achieve sustainable development; and 4) its close relationship with the way society innovates. This chapter follows the 4th dimension proposed. Table 1 presents the circular economy concept, attending to its philosophical perspectives.

The circular economy is based on practical approaches and best practices. Table 2 presents four essential building blocks of a circular economy.

The European Union promoted the first Action Plan for Circular Economy in 2015 and since this date the EU has become more and more aligned with circularity in Europe. In 2020 it re-launched a new circular economy action plan (European Commission, 2020), and presented measures to:

- Make sustainable products the norm in the EU;
- Empower consumers and public buyers;

- Focus on the sectors that use most resources and where the potential for circularity is high such as: electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients;
- Ensure less waste;
- Make circularity work for people, regions and cities;
- Lead global efforts on the circular economy.

Table 1. Circular economy – philosophical perspectives

Schools of Thought	Contributions and Framework
Cradle to Cradle	The cradle to cradle framework focuses on design for effectiveness in terms of products with positive impact and reducing the negative impacts of commerce through efficiency.
Performance Economy	The vision of an economy in loops (or circular economy) and its impact on job creation, economic competitiveness, resource savings, and waste prevention. The circular economy should be considered a framework: as a generic notion, the circular economy draws on several more specific approaches that gravitate around a set of basic principles.
Biomimicry *"Innovation Inspired by Nature"*	CE as a new discipline that studies nature's best ideas and then imitates these designs and processes to solve human problems. Studying a leaf to invent a better solar cell is an example. It is thought of as 'innovation inspired by nature'
Industrial Ecology	This framework is sometimes referred to as the 'science of sustainability', given its interdisciplinary nature, and its principles can also be applied in the services sector. With an emphasis on natural capital restoration, industrial ecology also focuses on social wellbeing.
Natural Capitalism	"Natural capital" refers to the world's stocks of natural assets including soil, air, water and all living things.
Blue Economy	Blue economy insists on solutions being determined by their local environment and physical/ ecological characteristics, putting the emphasis on gravity as the primary source of energy.
Regenerative Design	Proposes ideas on regenerative design that could be applied to all systems, i.e., beyond agriculture, for which the concept of regeneration had already been formulated earlier.

Source: (adapted from Ellen MacArthur Foundation, 2017)

Table 2. Blocks for a circular economy

Blocks	Description
Circular economy design	Companies need to build core competencies in circular design to facilitate product reuse, recycling and cascading. Circular product (and process) design requires advanced skills, information sets, and working methods.
New business models	The shift to a circular economy requires innovative business models that either replace existing ones or seize new opportunities. Companies with significant market share and capabilities along several vertical steps of the linear value chain could play a major role in circular economy innovation and driving circularity into the mainstream by leveraging their scale and vertical integration.
Reverse cycles	New and additional skills are needed for cascades and the final return of materials to the soil or back into the industrial production system. This includes delivery chain logistics, sorting, warehousing, risk management, power generation, and even molecular biology and polymer chemistry. With cost-efficient, better-quality collection and treatment systems, and effective segmentation of end-of-life products, the leakage of materials out of the system will decrease, supporting the economics of circular design.
Enablers and favourable system conditions	For widespread reuse of materials and higher resource productivity to become commonplace, market mechanisms will need to play a dominant role, supported by policy makers, educational institutions and popular opinion leaders.

Source: (adapted from Ellen MacArthur Foundation, 2017)

This action plan enlarges the focus and includes a more global perspective including people, regions and cities in this new paradigm.

The Circular Economy and the Social Dimension: An Innovative Perspective for Sustainable Development

The circular economy could be understood as a way of promoting sustainable development. In this sense, the social, environmental and economic dimensions form a balanced triad. Thus, the circular economy respects a social dimension that calls for circular transformation followed by social transformation due to its possible impact on job creation and contributes to solving social problems. Additionally, the circular economy is also aligned with innovation, allowing longer-life products and other types of innovation beyond technical innovation: social innovation, regulatory innovation, etc. And in this context, it has impacts on health allowing, for example, the recycling of products containing hazardous chemicals and using them for creating other products, thereby generating a risk for consumers' health, Thus there are impacts on saving products and development of new business models that allow rental or leasing and are more focused on services than on products.

Nevertheless, studies that research circular economy in the context of the social or solidarity economy are still in their infancy. Around this phenomenon, Moureau et al. (2017, 497) highlight that "the social and solidarity economy, with its focus on equity with respect to labor and governance, provides an instructive and practical example that defies the constraints related to current institutional conditions and economic efficiency". And the same study argues that the social and solidarity economy can contribute to the development of a CE by further defining who bears the costs of economic activities.

The following section will address the millennium goals for sustainable development in the context of societal challenges.

Sustainable Development Goals

On September 25, 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development (UNDP, 2015), setting 17 objectives (see Figure 1) and 169 targets, covering social, economic and environmental dimensions around the world. The objectives focus on people, human rights and responding to growing social inequalities, as well as central concerns such as peace, security and climate change.

To monitor the degree of SDG achievement, 244 indicators were defined, with each country being responsible for selecting which are the most relevant in their national context, thus having the primary responsibility for gathering the necessary financial resources and capacity building.

In this context, the National Institute of Statistics (INE) has made a data platform available since April 2017 with SDG indicators for Portugal.

As part of the study on HP, we highlight the following SDGs:

1 – No Poverty: poverty is a condition that affects access to decent housing, adequate food, health care, quality education and access to work that allows personal development.

According to INE (2018), 18.3% of the population in Portugal were at risk of poverty in 2016. It should be noted that the percentage of people at risk of poverty in Portugal is higher than the value obtained in

Figure 1. Sustainable Development Goals
Source: (adapted from UNDP, 2015)

the European Union. Children are the population group most affected by the risk of poverty. The study also mentions that gender also affects people differently in terms of the risk of poverty.

9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation: developing quality, reliable, sustainable and resilient infrastructures, including regional and cross-border infrastructures, to support economic development and human well-being. Research and development comprises all creative work carried out in a systematic way, with the goal of broadening the range of knowledge, including societal knowledge, as well as the use of this pool of knowledge in new applications.

10 – Reduced inequalities: social inequalities result from multiple conditions, such as territorial inequalities, gender or age, social class, resources and education, among others.

In this sense, this SDG seeks to combat socio-economic inequalities and regional disparities by developing strategies to promote social justice, coupled with equal opportunities. It thus aims to combat poverty and social exclusion, covering areas such as health, education, a fairer and more inclusive labour market and more balanced income sharing, ensuring social minimums for the most vulnerable citizens (PR, 2017).

11 – Sustainable cities and communities: this objective aims to make cities and communities inclusive, being incubators of innovation and growth and drivers of sustainable development.

17 – Partnerships for the goals: to achieve sustainable development, the partnership between government, the private sector and civil society is fundamental, where the objectives are shared and centred on people and the planet.

Reducing homelessness globally is both goal of human rights and a focus for the 2030 Agenda. Actions include eradicating poverty, ensuring healthy living and fostering well-being, thus reducing inequality within and between countries (Omerov, et al., 2019). It also emphasizes the importance of understanding and acting upon interlinkages between policy areas articulated in the SDGs, and the importance of creating partnerships in view of their implementation, (Weitz et al., 2018).

Approaches to identifying, characterizing and systematically addressing interactions between all sustainable development policy issues still remain a challenge.

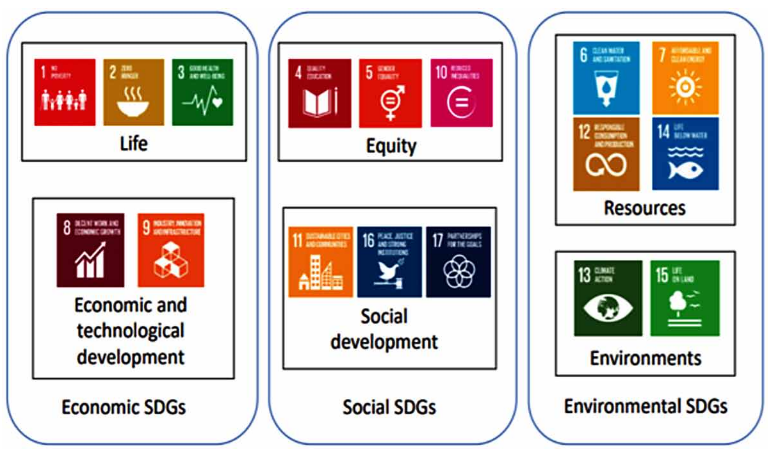
It is important to assess and analyse the interactions between distinct key contextual determinants and influencers, including governance and geographical contexts, implementation of technologies and policies and time-horizons.

Building a knowledge base and taking all interactions into consideration will be crucial in order to focus interventions more effectively.

It should be noted that SDGs cannot be separately analysed, as the improvement of one SDG will have positive and/or negative impact(s) on other SDGs. SDG implementation is concerned with synergies, complementarities, and potential trade-offs between each of the SDGs (OECD, 2015).

SDGs can be organized according to economic, social and environmental dimensions.

Figure 2. SDG classified into 3 dimensions and human needs
Source: (adapted from Wu et al., 2018)



Circular economy practices and principles are transversal, and the adoption of circular economy practices are important to achieve many targets outlined under several of the SDGs.

ICT in the Circular Economy

A circular economy (Minister of the Environment, 2017), is understood as an economy which actively promotes the efficient use and productivity of the resources it has harnessed, via products, processes and business models based on the digitization, reuse, recycling and recovery/regeneration of materials. In this way, it seeks to extract economic value and use from materials, equipment and goods for as long as possible in cycles powered by renewable sources.

Circular economy principles (Minister of the Environment, 2017) are:

- To design products, services and business models that avoid the production of waste and the pollution of the natural system;
- To keep products and materials in use, at their fullest economic value and utility, for as long as possible;
- To foster the regeneration of used material resources and underlying natural systems.

Technological innovation is of transversal importance to technologies and new business models (Ellen MacArthur Foundation, 2019), but the focus has been on strategies of low circularity. This theme needs (greater) inclusion in the innovations triggered by industry 4.0 and tools like blockchain, which are central to speeding up the digitization of processes, product-service systems and collaborative/sharing platforms.

The circular economy (Ellen MacArthur Foundation, 2019), is based on three principles:

- First, waste and pollution are designed out. This means that the products of today can become the resources of tomorrow and the negative impacts of economic activity that cause damage to human health and natural systems are eliminated. This includes factors such as the release of greenhouse gases, the use of toxic and hazardous substances, the pollution of air, land and water, and the landfilling and incineration of waste;
- Second, products and materials are kept in use. This includes favouring activities that increase product utilization, and reuse to preserve the embedded energy, labour and materials. Examples include designing for durability, repair, reuse, remanufacturing, and ultimately recycling. For biological materials, this could mean cascaded use of by-products before nutrients are returned to the biosphere;
- Third, natural systems are regenerated. This entails, for instance, deploying agricultural practices that not only avoid degrading soil, but actually rebuild soil health over time.

Technology is crucial to realize this vision at a scale of technological innovation (Ellen MacArthur Foundation, 2019), and plays a major role in bringing the circular economy vision to life. For instance, intelligent and connected assets can enable predictive maintenance to prolong asset life; blockchain can create traceability and transparency in supply chains to reduce waste; and repair is made easier by 3D printing of spare parts.

Artificial intelligence (Ellen MacArthur Foundation, 2019), as an emergent ‘Fourth Industrial Revolution’ technology, can support and accelerate the pace of human innovation to design products, bring together aspects of successful circular business models, and optimize the infrastructure needed to loop products and materials back into the economy. Utilizing AI capabilities could create a step change which goes beyond realizing incremental efficiency gains to help design an effective economic system that is regenerative by design.

According to the European Commission (2015), waste management in the EU should be improved, with a view to protecting, preserving and improving the quality of the environment, protecting human health, ensuring prudent and rational utilization of natural resources and promoting a more circular economy.

As already mentioned the European Commission (2020a), emphasizes actions in the circular economy, specifically: focusing on the sectors that use most resources and where the potential for circularity is high such as electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food; water and nutrients.

To address these challenges, the Commission, (European Commission, 2020b), will present a 'Circular Electronics Initiative' which mobilizes existing and new instruments. In line with the policy framework for new sustainable products, this initiative will promote longer product lifetimes and include, among others, the following actions:

- regulatory measures for electronics and ICT including mobile phones, tablets and laptops under the Ecodesign Directive so that devices are designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling. The upcoming Ecodesign Working Plan will set out further details on this. Printers and consumables such as cartridges will also be covered unless the sector reaches an ambitious voluntary agreement within the next six months;
- focus on electronics and ICT as a priority sector for implementing the 'right to repair', including a right to update obsolete software;
- regulatory measures on chargers for mobile phones and similar devices, including the introduction of a common charger, improving the durability of charging cables, and incentives to decouple the purchase of chargers from the purchase of new devices;
- improving the collection and treatment of waste electrical and electronic equipment including exploring options for an EU-wide take-back scheme to return or sell back old mobile phones, tablets and chargers;
- review of EU rules on restrictions of hazardous substances in electrical and electronic equipment and provide guidance to improve coherence with relevant legislation, including Ecodesign.

Becoming the world's first climate-neutral continent by 2050 is a once-in-a-lifetime opportunity to modernize the EU's economy and society and re-orient them towards a just and sustainable future (European Commission, 2020c).

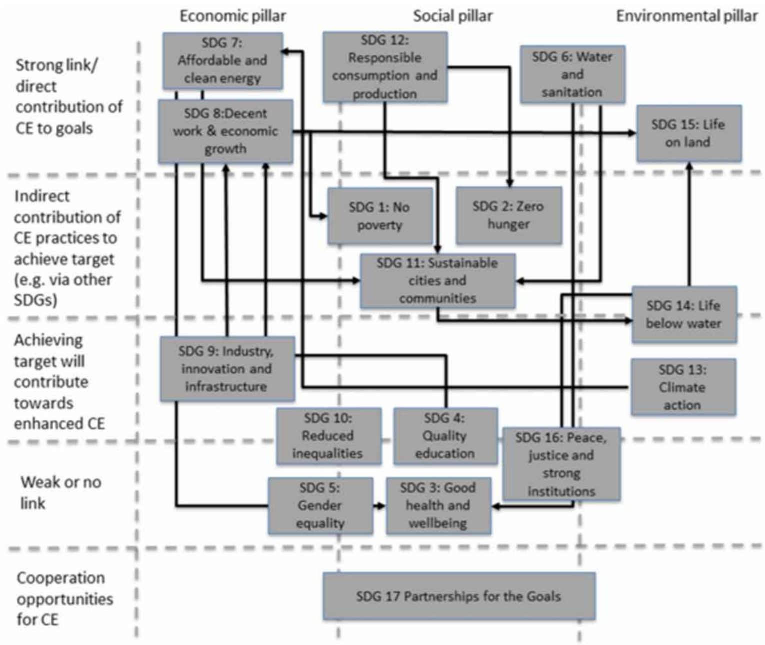
Research and innovation will play a central role in:

- accelerating and navigating the necessary transitions;
- deploying, demonstrating and de-risking solutions;
- engaging citizens in social innovation.

Schroeder et al. (2019) concluded that circular economy practices can contribute directly or indirectly to achieving a significant number of SDG targets. Figure 3 presents the goals according to economic, social, and environmental pillars, as well as their interconnection with circular economy practices.

Circular practices also potentiate synergies between several SDGs, for instance, promoting economic growth and jobs (SDG 8), eliminating poverty (SDG 1), ending hunger and sustainable food production (SDG 2), and those SDGs aiming for biodiversity protection (SDG14 and 15). It will also be crucial to establish synergies with quality education (SDG 4) to build the skills and capacity to make advanced CE practices and business models such as IS. Industry, innovation and infrastructure (SDG 9) together with sustainable cities and communities (SDG 11) can guarantee the provision of essential needs while maintaining stable economic growth, which is the foundation of social stability. Multi-stakeholder partnerships are also required (SDG 17).

Figure 3. The relationships between circular economy practices and SDGs
Source: (adapted from Schroeder et al., 2019)



ICT in a Social Context

Organizations are currently dependent on IS and ICT. It is considered that this dependence should be enhanced in order to provide integrated and optimized services to the population. ICT could provide added value in a social context in order to speed up the processing and sharing of information and contribute to the increase of sustainability factors.

The ICT sector should have concerns about implementing green IT policies, actively contributing to the sustainability of the sector (Reis & Silveira, 2020). Thus, it is important that, when starting a project, it is underpinned by replicable sustainability policies in the various departments, reinforcing its importance for the organization and relevance of the results achieved from sustainability.

Sustainability in the context of ICT, particularly in non-profit organizations, should be a strong concern. It is also considered that (Russo & Reis, 2019a), in the face of financial constraints and technological innovation, companies will still be resistant to the paradigm shift. However, social organizations, regardless of the factors listed, are also discussing a set of conditions of operation implicit to their condition.

Constant technological advances (Landum & Reis, 2012) have motivated some changes in ICT, providing society in general with relevance in recent years with regard to the concept of cloud computing, which is assumed as an emerging and disruptive paradigm. In this sense, non-profit organizations are faced with challenges in the sense of storing information to support their activities.

In general, organizations facing the volume of information they manipulate are potentially exposed to a set of threats and vulnerabilities. Thus, it is advocated (Russo & Reis, 2019b) that the risks should be analysed in order to understand how to continue the business in case of disaster and recover from this disaster, which are crucial activities in the context of organizations.

In view of the above-mentioned concerns, it is considered that the involvement of citizens in the SDGs and technology-related activities will enable the rapid dissemination of good sustainability practices and increase awareness of the technology that can be used for the good of society and to improve people's lives, especially of those most disadvantaged (Castro & Santos, 2019).

Good International Practices

The European Federation of National Organizations Working with the Homeless (FEANTSA) is a European NGO focused exclusively on the fight against homelessness. The Federation was founded in 1989 and brings together non-profit services that support homeless people in Europe.

The (FEANTSA, 2006), mentions that it has created a tool consisting of 10 main approaches to the development of an integrated strategy to deal with HP.

1. **Evidence-based approach:** a good understanding of the HP problem is essential for the development of effective policies. This can be done by: monitoring and documentation of street trends and the number of homeless people; development of indicators; research and analysis on the causes and solutions for HP in order to complement monitoring and documentation; the necessary regular policy review which is more effective with a good understanding of the lack of housing.
2. **In-depth (embracing) approach:** a comprehensive approach to combating HP includes policies on HP emergency services and a strong focus on prevention: emergency services are a crucial first step in preventing HP from living on the street for long periods; integration should be the goal of all HP and should be adapted to their needs and potential; prevention – both targeted prevention (eviction, exit from the institution) and systemic prevention (through housing in general, education, employment policies) are necessary.
3. **Multidimensional approach:** the lack of housing is recognized as a phenomenon that requires solutions based on multidimensional approaches, including: integrating housing, health, employment, education and training and other perspectives into a strategy for HP, as routes in and out of HP can be very diverse; interinstitutional work and general cooperation with other sectors as a vital component of the entire effective HP strategy since the lack of housing that cannot be sustainably addressed by the HP; cross-departmental work between relevant housing, employment, health and other ministries, which is crucial for developing strategies to combat housing shortages and avoid repercussions of policies developed in different areas.
4. **Rights-based approach:** a rights-based approach to tackling housing shortages and promoting access to decent and stable housing as an indispensable precondition for the exercise of most other fundamental rights through: use of international treaties on housing rights as a basis for developing a strategy for HP; the mandatory right to housing to ensure the effectiveness of housing is considered fundamental; recognition of the interdependence between housing and other rights such as the right to live with dignity and the right to health.
5. **Participatory approach:** the lack of housing is a field in which cooperation with service providers is crucial, given their experience in how to deal with the problem, and involves the participation of the following practices: involvement of all stakeholders (including service providers, services, users and public authorities) in policy development and evaluation, acknowledging that it is important to gather all available knowledge and capabilities to combat housing shortages; involvement of all stakeholders in policy implementation through a coordinated effort on how best to achieve the

objectives of any HP strategy; HPs' involvement in improving the quality of service and policymaking. Appropriate query structures should be set up to take into account HPs' actual experience.

6. **Statutory approach**: a statutory approach aims to support HP strategies with legislation through: a legal framework at national/regional level, enabling consistency and responsibility in the implementation of HP policies; statutory goals and objectives which serve to monitor and evaluate policy progress.
7. **Sustainable approach:** three elements create a genuinely sustainable approach to tackling housing shortages leading to sustainable solutions: adequate funding which is crucial for any long-term strategy to address and end homelessness; political commitment at all levels (national, regional and local); public support generated through information and awareness campaigns.
8. **Necessity based approach:** this approach is based on the principle that policies should be developed according to the existing needs of the individual and not the structural needs of organizations: individual needs are the starting point for the development of policies based on regular needs surveys and through individualized integration plans; an appropriate review of HP policies and structures is required on a regular basis.
9. **Pragmatic approach:** a pragmatic approach consists of the following two elements: that realistic and achievable objectives are necessary and possible when adequate research is carried out to fully understand the nature and specificity of HP, the needs of HP, the developments in the real estate and labour market and all other related areas; a clear and realistic timeline with long-term goals as well as intermediate targets.
10. **Bottom-up approach:** a bottom-up approach allows the development of policy responses to homelessness at the local level (within a clear national or regional plan), based on two elements: importance of local authorities for the implementation of HP policies; strategies through a shift towards greater involvement, more accountability and more binding duties at the local level; approach the provision of services to HP with local authorities in a strong position to coordinate partnerships between all relevant actors in the fight to end homelessness.

The ten approaches identified above aim to be an integral component in improving the situation of HP and promoting their autonomy.

METHODOLOGY

A project of this nature, in view of its complexity and specificity, implies the use of methodologies in order to include several aspects, thus contributing to the design of the prototype.

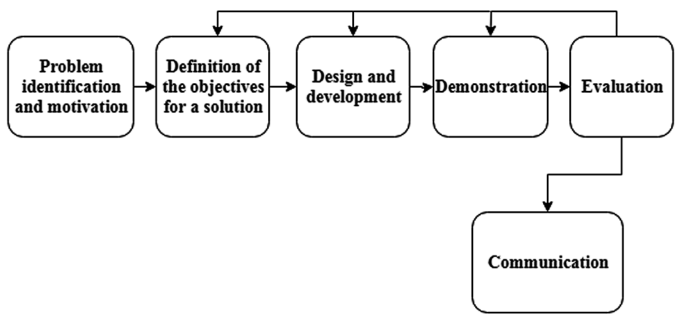
Methodology Adopted

The methodology adopted focuses on reviewing the literature in the field of theme based on the specificity of the organization under study. This methodology was selected to conduct the analysis of the characterization of the population.

The design science research (DSR) methodology was adopted as a theoretical basis to support scientific validity for the elaboration of this work (Peffers et al., 2007). Because it is a research methodology which is suitable for research projects in technologies, IS and systems architectures (Ferreira et al., 2012) inherent to the activity of art design, it thus ensures discipline, rigour and transparency (Pedro, 2015), cited by (Lacerda et al., 2013).

The DSR methodology (Roquete, 2018) is a research method that is adapted to the IS area with connections to issues originating in organizations, contributing to the resolution of specific and complex problems (Bianchi & Dinis de Sousa, 2015; Hevner et al., 2004). The scheme of this methodology is presented in Figure 4.

Figure 4. Design Science Research Methodology
Source: (adapted from Peffers et al., 2007)



In this sense, the methodology allows for the current characterization of the organization as well as developing and testing the prototype.

Characterization of the Current Situation of Homeless Persons

The characterization of the current situation, in the case under study, and in view of the specificity of the problem will characterize the organization as well as the various types of frameworks underlying the theme.

Cáritas Setúbal

The Mission of the Institution (Cáritas, 2019a), mentions that through the 20 Diocesan Cáritas, which cover the entire national territory, the institution has several projects in place in order to build a juster and more balanced society. One of the foundations of the Cáritas Act is "the Church's preferential choice for the poor". The poorest of the poor are all those who have social exclusion associated with their poverty. In this sense, responses are made available for individuals with disabilities, homeless people and vagrants, drug addicts, alcoholics, women at risk, HIV-positive people and AIDS patients.

In the city of Setúbal (Cáritas, 2019a), it ensures the provision of services to children, the elderly, homeless people, HIV-positive people and AIDS patients. The different activities are carried out by many employees, who are provided with the necessary training.

With regard to Identity (Cáritas, 2019b), Cáritas de Setúbal states that it is a service of the Diocesan Church for the promotion of its social action. Its primary activity is the implementation of social pastoral care aimed at the creation and functioning of parish services for better knowledge of problems. It is from this knowledge that it seeks to act directly in the prevention and solution of problems. Given the complexity of contemporary social phenomena resulting from their multidimensional characteristics, other key concerns are the possible contribution to social transformation, particularly in the fields of social relations and values in order to develop solidarity.

Legal Framework

The implementation of ENIPSSA 2017-2023 takes place through biennial action plans, which include the axes, strategic objectives and actions – adopted at the resolution of the Council of Ministers No. 107/2017 of July 25 (RCM, 2017) – implemented through activities, targets, indicators, a budget (direct and indirect), a calendar and entities (responsible and partners) (ENIPSSA, 2017). The Council of Ministers Resolution No 107/2017 (SPC, 2017) mentions that in 2009 the National Strategy for the Integration of Homeless People was created: Prevention, Intervention and Monitoring (ENIPSSA) 2009-2015, which aimed to create conditions that would guarantee the promotion of the autonomy of homeless people, through the mobilization of all available resources according to diagnosis and individual needs, with a view to the full exercise of citizenship.

According to this resolution (RCM, 2017), the assumption of competences in the implementation of ENIHP 2009-2015, its monitoring and evaluation of the whole process, was linked to an interministerial group, coordinated by the Institute of Social Security, I. P. (ISS, I. P.), consisting of a set of public and private entities, called the Implementation Group for Monitoring and Evaluation of the Strategy (GIMAE). The work of this group, with the inevitable consequences in the implementation and monitoring of ENIHP 2009-2015 was interrupted in 2013, and work resumed in 2016, following the Resolution of the Assembly of the Republic No. 45/2016 of March 11 and the dispatch of the member of government responsible for social security. In that order, the relevant guardianship is identified for the implementation, monitorization and evaluation of the strategy, with the collaboration of the various public entities included in it, for the preparation and presentation of an evaluation report of ENIHP 2009-2015 which covered the respective results, as well as recommendations and proposals for future strategy.

SPC (2017) also mentions that the ENIHP evaluation report 2009-2015 was presented in March 2017, and among its conclusions highlighted the fact that it has contributed positively to the reflection of this problem as a social laboratory, since it was the 1st national strategy integrated in the context of the issue of homeless people. It was also the 1st strategy in the countries of the so-called ‘Southern Europe’ to focus on the involvement of various public and private entities, both in design, having been discussed among the partners, as well as in implementation and monitoring. Its role was also important in terms of proximity services, as it boosted the creation of Homeless Planning and Intervention Centres (NPISA) which sought to remain active at the local level.

According to the ENIHP 2009-2015 assessment results in ENIPSSA 2017-2023 (SPC, 2017), although there was a deficit in operationalization, the assumptions that were at its base were nevertheless considered appropriate by all the entities that are part of GIMAE.

Thus, the recommendations were for the strategy to be defined for the ENIPSSA 2017-2023 cycle in order to enhance the work already undertaken, strengthen the measures to be implemented in each strategic objective and create the necessary conditions for its implementation.

Characterization of Homeless People

Within the European Federation of National Organizations working with HP (FEANTSA, 2010) is a network of non-governmental organizations (NGOs) which work to combat homelessness in Europe. The objective of FEANTSA is to prevent and/or alleviate the poverty and social exclusion of people who live homeless or who are at risk of falling into this situation, encouraging and facilitating the co-operation of all relevant European actors in this fight. FEANTSA currently comprises more than 100 organizations in almost all member states. The majority of FEANTSA members are national or regional organizations providing a wide range of homeless support services that include shelter, health, employment and social support.

In FEANTSA (2010), a set of objectives to combat homelessness are outlined:

- No one sleeping on the street – No one should be forced to sleep on the streets for lack of quality services tailored to their needs and aspirations. In Europe today, it is unacceptable that there are people who have to compromise their safety, health and dignity by sleeping on the street.
- No one sleeping in emergency accommodation other than "emergency" – No one shall remain in emergency accommodation beyond the time deemed "emergency". Shelters are designed as a temporary solution to a complex phenomenon. They are not created as long-term solutions for people in vulnerable situations and should not become substitutes for real "housing".
- No one living in transitional accommodation beyond what is required for a successful change – Homeless hostels, temporary accommodation and transitional supported accommodation all offer intermediate steps towards permanent housing and are designed for the short/medium term. Unfortunately, these forms of accommodation can become more permanent than they should, which leads to people staying for long periods and living in inappropriate situations.
- No one has to leave institutions without housing options – No one who is in an institution – be it a hospital, home or prison – should leave without sufficient support and adequate housing solutions. Young people leaving homes, sick people leaving hospitals and ex-prisoners are often vulnerable and can be helped, through support and good housing opportunities, to avoid the cycle that goes from institutional care to homelessness and from this, back to institutional care.
- No young person becomes homeless as a result of their transition to independent life – The transition to independent living is a time when people are vulnerable to becoming homeless. No young person should be at risk of becoming homeless for lack of first-home, service or benefit options during the transition to independent living. More can be done to help young people live independently and access appropriate housing options.

However, Freek Spinnewijn, Director of FEANTSA, said "We are probably witnessing the fastest growth of homelessness in the European Union of this generation. In this context, it is extremely difficult to be optimistic about the future. But there are a few reasons to hope" (FEANTSA, 2019).

National Plan for the Integration of Homeless People

Within Caritas – Setúbal and framed in the National Strategy for the Integration of HP is a set of actions which are transversal to the various units of intervention.

The National Strategy for the Integration of Homeless Persons (ENIPSSA) for the period 2017-2023 comprises three axes of intervention, aimed at promoting knowledge of the phenomenon of homeless people, information, awareness raising and education, strengthening an intervention which promotes the integration of homeless people, as well as coordination, monitoring and evaluation (ENIPSSA, 2017).

The defined intervention model (ENIPSSA, 2017) is based on a premise of monetization of human and financial resources, as well as the need to avoid duplication of responses and qualify the intervention in terms of prevention of homelessness and monitoring among users, focusing on the individual, the family and the community.

As such, ENIPSSA aims to implement the National Strategy at the local level, ensuring the mechanisms that allow continuity and sustainability to be given to the results and impacts, in close relationship with the Local Council of Social Action of the Social Network of Setúbal.

Caritas de Setúbal (Caritas, 2009), carries out its activity in its area of intervention in close collaboration with a set of partners:

- Grouping of Health Centres of Setúbal and Palmela;
- Association C.A.S.A. – Delegation of Setúbal;
- Setúbal City Council;
- Diocesan Caritas of Setúbal;
- Central Hospital Setúbal E.P.E;
- Portuguese Red Cross – Delegation of Setúbal;
- General Direction Social Reintegration – Setúbal Team;
- Institute of Employment and Vocational Training, I.P. – Employment Centre of Setúbal;
- Institute of Drugs and Drug Addiction, I.P. – CRI of the Setúbal Peninsula;
- Social Security Institute, I.P. – Setúbal District Centre;
- Public Security Police – Setúbal Police Division;
- European Anti-Poverty Network/Portugal.

The aforementioned partner network collaborates towards the integration of HP.

HP (Caritas, 2009) are considered the group that, regardless of nationality, age, gender, socio-economic condition and physical and mental health condition, are to be found:

- Homeless, living in a public space, housed in emergency shelter or with whereabouts in a precarious place;
- Homeless, in temporary accommodation intended for this purpose.

Thus, it is considered that, given the specificity of the organization under study, several aspects are included in the analysis HP.

RESULTS AND DISCUSSION

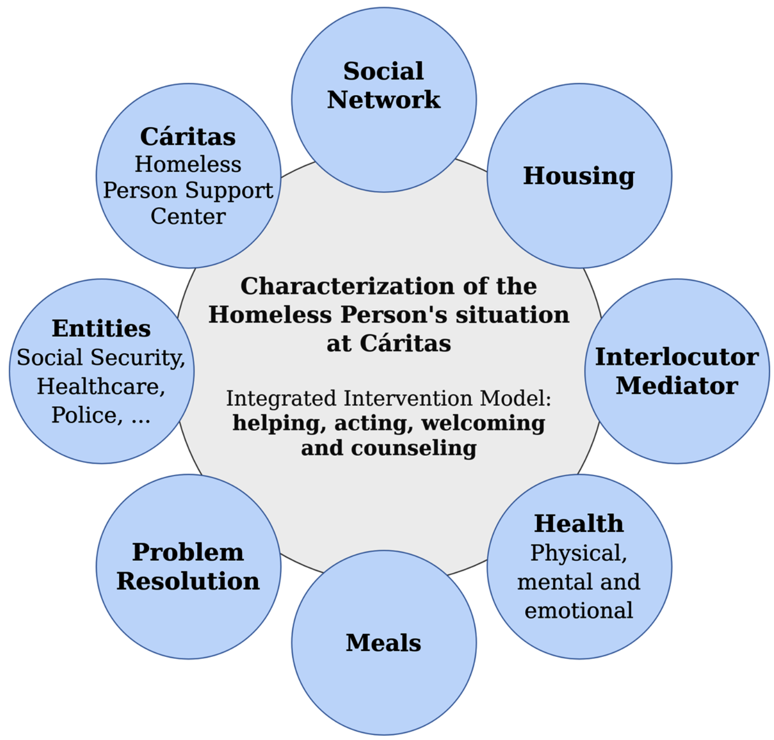
The prototype, with regard to HP, is being designed with reference to the characterization of the situation of HP in Caritas Setúbal (CS).

Partnership Integrator Model

In this section, we present the model that integrates Caritas as a basic institution to support HP, as well as the other partner entities that support the different aspects of the project, namely: Social Security, Health Centres, PSP and SEF.

Figure 5 systematizes the characterization of the situation of the HP of CS, giving prominence to the model of integrative intervention that includes care, performance and reception.

Figure 5. Characterization of Homeless Persons' Situation at Cáritas Setubal



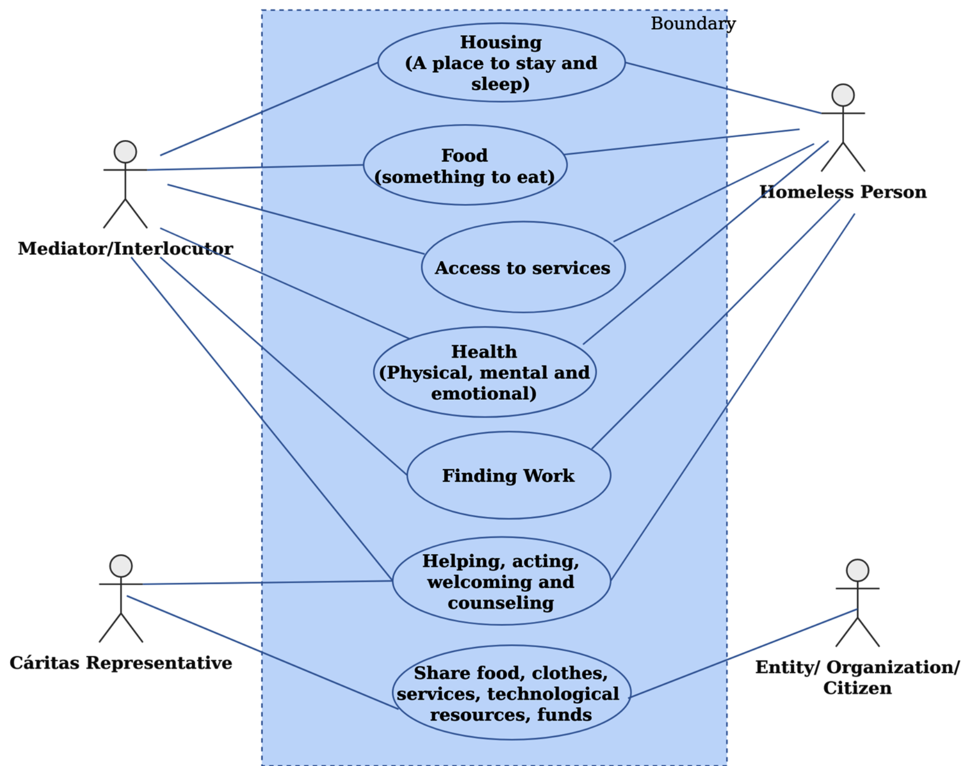
This model shows the establishment of partnerships under SDG 17, also with conditions to enhance SDG 1 – Eradicate Poverty, SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, SDG 10 – Reduce Inequalities and SDG 11 – Sustainable Cities and Communities (UNDP, 2015).

Analysis of Requirements

The requirements definition process allows you to identify which services (in the form of use cases) should be added to support the application. It also ensures the identification of the main requirements of the application that is to be made (Silveira, 2006). It is important to note that this is only a first representation. The requirements specification will be completed in later activities, that is, it requires an iterative process. Successive iterations will complete the representation of requirements as detailed information becomes available.

After the characterization of HP in the context of CS, in particular the entities involved and the role they play, the definition of the requirements of the users in which the actors involved and their objectives were identified, allowing the creation of the list of requirements, presented in the Use Cases Diagram in Figure 6.

Figure 6. Use Case Diagram for HP in CS



A use case is a special sequence of transactions carried out, in the form of a dialogue between a user and a system. The use-case diagram describes the system from an end-user perspective. The list of use cases presented corresponds to the actor's answer to the question "What do you intend to use the application for?".

Figure 6 shows all the features that the application will have, and who has access to those features. The actors "Mediator/Interlocutor" and "Homeless Person" use the application to find:

- A place to stay and sleep;
- Meals (something to eat);
- Services;
- Medical help;
- Occupation/work;

- Hosting help.

The actor "Caritas Representative" uses the application to serve and welcome the PSA, as well as make all donated goods available. The actor Entity/Organization/Citizen uses the application to provide/donate food, clothes, services, technological resources and funds.

The process of characterization of HP involves the analysis of several aspects, which are formalized upon the preparation of the flag form NPISA by the actors "Mediator/Interlocutor" and " Caritas Representative". For this purpose, the following items were identified: sequential number, date, name, name/service, address, contact, email, identification of the flag, contact, date of birth, gender, nationality, if foreign: regularized situation, with process in the flagging entity, identification documents (type and number); place of habitual stay (address or building returned to) where they have lunch, where they sleep, the street team with whom they has contact, contact of family/friend/acquaintance of theirs; where they were found; factual description (text to be substantiated), associated problems (health, additions, alcohol, ...), immediate referral, contact of the case manager, evolution of the situation.

The prototype will allow the various needs (meet, act and welcome) to be managed, namely in terms of housing, meals, access to services, health, counselling and work.

Building on concerns in the field of IS and ICT sustainability, it is considered that this research can contribute to the creation of integrative solutions in various fields to contribute to the resolution of problems and challenges in order to enhance the use of IS and ICT for people guided by the principles of the circular economy.

Solutions for Sustainability

During the project, the relevance of including sustainability concerns in the dimensions of the Karlskrona Manifesto (Becker et al., 2015) – human, economic, environmental, technical and social – also emerged. Thus, Figure 7 was designed to present the result of this reflection in the various dimensions of sustainability, given the specificity of the problem.

The establishment of partnerships under the Sustainable Development Goals (UNDP, 2015) thus becomes fundamental given the specificity of the theme.

Regarding the design of the solution, it includes the need to integrate housing, health, employment, education and other perspectives into a strategy to welcome HP. It also includes sustainability concerns in the economic (free cloud platform) and licensing dimensions, technical (green IT, code reuse and procedures); social (integration, care, performance and reception of HP); (improvement in health and well-being, accommodation, food, clothing and essential goods); (decent accommodation, reuse of perishable and non-perishable goods, reduction of waste).

ICT can enhance new business models. Technological innovation can be a cross-cutting factor in the context of implementing the SDGs and the strategies underlying the circular economy.

Mobile Application

As part of this project, the intention is to create an integrative solution with the various partners to support HP. It should be noted that an Australian non-profit has created Ask Izzy (https://askizzy.org.au/), a mobile app that helps HP connect to the institutions that can best help in each case. The application is designed to ask simple questions and, according to the answers, redirect HP to a rest centre or an

Figure 7. Diagram Key Terms about the Sustainability Dimensions for HP

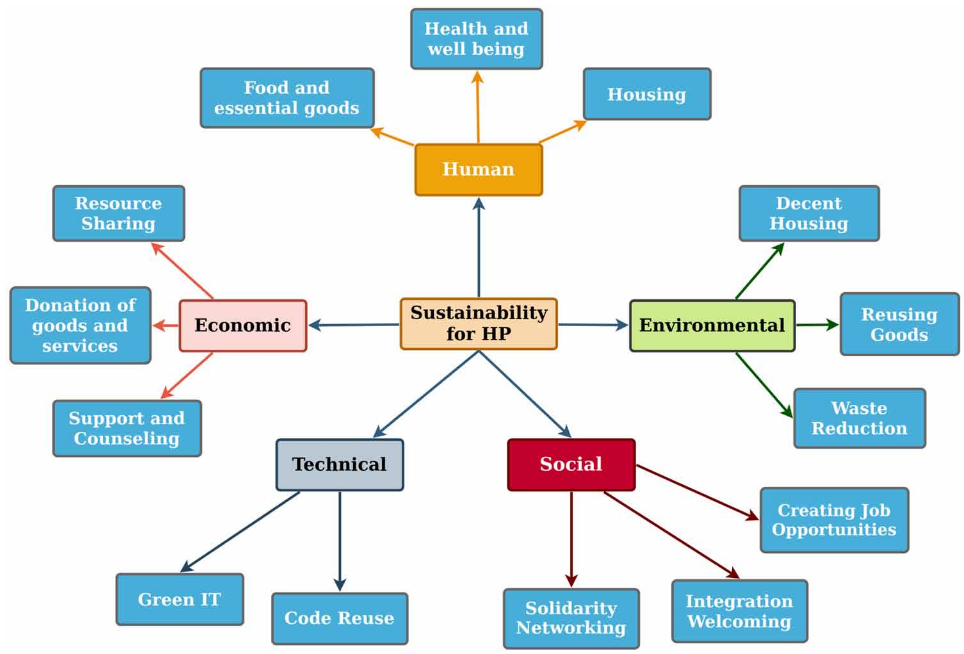
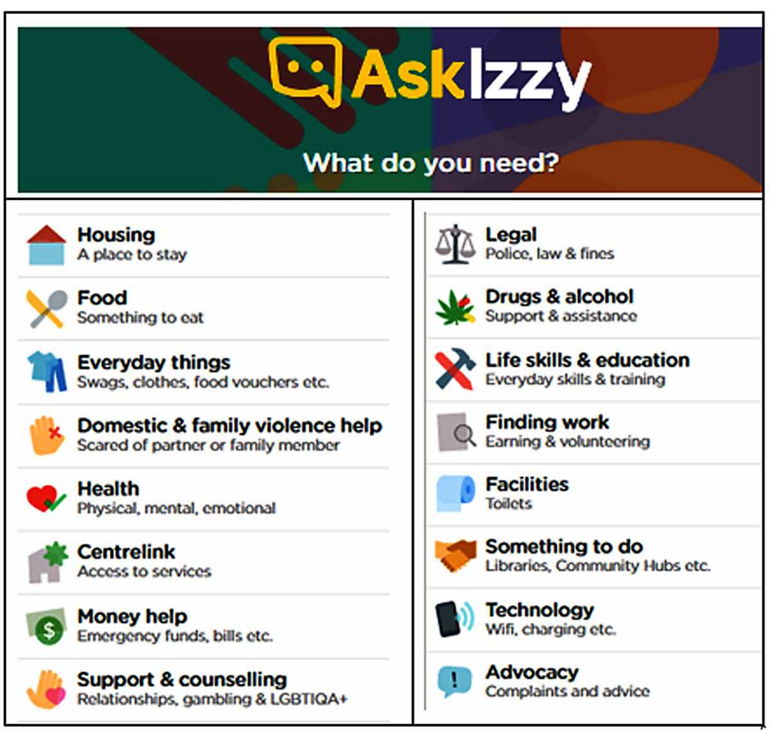


Figure 8. Mobile app – Ask Izzy – for HP
Source: (adapted from Infoxchange, 2019)



authority that protects them from mistreatment, for example. The app also connects to public transport services and Google Maps to guide users. This application is adapted in Figure 8.

As shown in Figure 8, the support provided covers in several areas, such as orientation to a place to stay (housing), food, daily life, aid in cases of domestic violence, health, access to education, relearning the basic tasks of everyday life, whether cooking or cleaning, and dealing with bureaucracy. This application illustrates a possible prototype to be developed (or adapted) within the scope of this project. This promotes the establishment of partnerships under SDG 17 (UNDP, 2015).

Some available reports (Hackett, 2019) show that the donation of a used smartphone to a HP has made it possible to contact:

- Resource centres and housing to know the services available;
- Potential employers;
- Transport and schedules;
- Medical care in free mobile clinics.

In fact, with the help of technology, it allows the user to find places to sleep, eat and socialize, as well as other forms of survival.

The mobile application to support the implementation of the problem underpins addressing concerns within the scope of the various aspects of sustainability and the circular economy, particularly with regard to housing, food, non-perishable goods (for example: textiles, furniture and clothing), health and education.

CONCLUSION

Social problems are multidisciplinary in nature, and therefore require integrated responses calling for cooperation between various institutions. However, there are still several constraints to cooperation between institutions, in particular operational ones. In this sense, ICT can create innovative solutions that facilitate the communication process between actors on the ground that facilitate the integration process, in this case of HP. ICT can enhance the creation of solutions that can be accessed by different actors in such a process.

The legal and institutional framework to support the activity made it possible to develop a reference framework. Given the specificity of the problem, it was possible to provide a non-functional prototype.

The motivation for the creation of the multidisciplinary prototype with sustainability concerns in order to aggregate the various aspects of the partners involved, allows an integrated service to be provided to HP.

This research is still at an early stage and aims to create a replicating methodology of this process of social innovation in several territories.

The development of the prototype to be implemented has implicit sustainability concerns in human, environmental, technical, economic and social dimensions.

Given the specificity of the theme, the development of the prototype is a pillar of aggregation and availability of HP information.

Thus, international standards (ISO/IEC 27002, 2013) will allow us to study good practice in the field of information security. The project has underlying sharing of information by different users. From this point of view, the definition of user profiles in access to information will be crucial, given the diversity of actors involved. There are also concerns in this context in performing backups in order to ensure the integrity and availability of information. Passwords will be another of the measures to be implemented given their importance in view of the specificity of the theme under study.

On the other hand, it is considered that organizations should look at the proper use of business intelligence platforms (Bernardino et al., 2019) to quickly acquire the information which is desirable in the face of the huge volume of data, reducing time and increasing the efficiency of decision-making processes.

The Y-Foundation study (2019) mentions the prospects for eradicating the issue of HP by 2030 in order to boost services, housing and employment based on good practice.

As future work perspectives, it is considered urgent to focus on the problem involving the sectors that use the most resources and where the potential for circularity is high, such as electronics and ICT in order to implement assertive strategies of the circular economy. As a future work perspective, continued study of the literature of the problem in its various domains is considered important.

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KEY TERMS AND DEFINITIONS

Circular Economy: This is the manifestation of a paradigm shift, and it will demand changes in the way that society legislates, produces and consumes innovations, while also using nature as inspiration for responding to societal and environmental needs.

Information and Communication Technologies: A technological resource set used to process information and ensure communication. When used in an integrated way, it enhances information transmission and communication processes.

Information Systems: The organized set of components such as people, processes of collection and transmission of data and material resources, automated or manual. The interaction of components enhances the processing and dissemination of information.

Karlsrona Manifesto: Establishes the principles and dimensions for the design of sustainable software systems.

Requirements Analysis: An iterative process to identify features and restrictions with a view to developing or adapting/customizing a software product.

Software Systems Development: Set of activities involved in the production of software. These activities are related to each other in an iterative and incremental process.

Sustainability: Ability to sustain life on the planet, considering the five dimensions: individual, social, economic, technical, and environmental.

Section 2

Applied Perspectives: Products, Contexts, Consumers, and Strategies

Chapter 8
The Circular Economy Solution to Ocean Sustainability:
Innovative Approaches for the Blue Economy

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ABSTRACT

This chapter gives a good grounding in view of the development of innovative technological solutions that enhance the valorisation and efficient use of marine resources through the integration of value chains, in a logic of circular economy, articulating food industry, biotechnology, and fisheries. Economy is a business model that extends the circular economy principles of sustainability and reuse to activities influencing the world's aquatic ecosystems, not only seas, oceans, and coastlines, but rivers and lakes, too. Both combine concepts of design out waste and pollution, keep products and materials in use, regenerate natural systems, sustainability, and share economy. However, the blue economy goes further to strengthen competitiveness by lowering costs and pursuing a more effective economy of scale. Consequently, the circular economy is becoming increasingly tinged with blue. The aim of this chapter was to present two case studies on sustainable business strategies for the circular blue economy.

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INTRODUCTION

The Blue and Circular Economy

The interest about circular economy evolved since 1990, when Pearce and Turner firstly used the term to describe an economic model based on the first two laws of thermodynamics (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). Since from that time, the circularity concept is very broad and has been thought in the context of ecology, clean production, zero-waste economy, close loop economy, environment, to name just a few. Sustainable development and circular economy are intrinsically connected and the relationship between concepts has been explored (Momete, 2020).

The population continues to grow and demand more resources, products and services. The transformative potential of a circular economy is huge, but the concept might be bent according to the different interests of the multiple stakeholders (Lim, Kim, Kim, Heo, Kim & Maglio, 2018).

The oceans are already significant generators of wealth. Recent reports estimated that the value of critical ocean assets is US$24 trillion, with an annual value of goods and services at US$2.5 trillion (about 5% of global GDP, the 7th largest economy (Kraemer, Rustomjee, Governance, & Cigi, 2017).

Although the term "Blue Economy" has been used in different ways, it is understood here as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable (Atman, Ramadass, Jalihal, Kirubagaran, Ramanamurthy, Vedachalam & Shenoi, 2018). The term was first coined at the 2012 United Nations Convention on Sustainable Development (UNCSD), or Rio+20 Conference, aiming to use innovative, integrated and cross-sectoral management to promote socially equitable and ecologically sustainable use of the natural (blue) capital provided by coasts and oceans (Pinto, Rita, & Combe, 2015). The United Nations sent here a very strong message to the international community that a healthy ocean ecosystem ensured by sustainable farming and fishing operations was a prerequisite for a Blue Growth (Eikeset, Mazzarella, Daviasdottir, Klinger, Levin, Rovenskaya & Stenseth,, 2018). The concept was promoted as the marine dimension of the broader 'green economy,' which was defined as an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (World Bank, 2017).

The Blue Economy reflects the fact that over 70% of the earth's surface is water, and that good ocean health is of central importance for global sustainability and climate adaptation. The oceans are a vital repository and supporter of global biological diversity, a critical source of food through fisheries and aquaculture, and a fundamental contributor to the global economy through sea-borne trade and other uses (Voyer, M. & van Leeuwen J., 2018).

Since the publication of the European Union's Blue Growth Agenda in 2012, the term Blue Growth has been used to describe a new era, where the Blue Economy is an essential feature of the European economy (Hadjimichael, 2018).

The Circular Economy is a win-win situation with several socio-economic benefits, such as savings of €600 billion for EU businesses (equivalent to 8% of their annual turnover), creation of 580,000 jobs and reduction of EU carbon emission by 450 million tonnes by 2030 (Europen Comission, 2019).

Many ocean and coastal nations around the world, most critically Small Island Developing States, but also including the European Union and larger coastal nations, are actively developing and promoting a blue economic growth agenda that includes the circular economy dimensions and principles (Global Environment Facility, 2018), and an essential challenge of the Blue Economy is thus to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to pollution (World Bank, 2017). Moreover a second significant issue is the realization that the sustainable management of ocean resources requires collaboration across nation-states and the public-private sectors, and on a scale that has not been previously achieved (World Bank, 2017), where a growing 'green' awareness in societies is leading to a change in habits of the population.

What we produce, consume and how we do this is of increasing interest to citizens and, as it usually occurs, economic sectors and politicians try to adapt themselves to new demands and requirements to maintain benefits (Ruiz-salmón, Margallo, Laso, Villanueva-rey, Quinteiro, Dias, … & Irabien, 2020). There will be no sustainable economy without recognizing the oceans as a vital repository and supporter of global biological diversity (Rosa, Sassanelli, Urbinati, & Chiaroni, 2019), a critical source of food through fisheries and aquaculture, and a fundamental contributor to the global economy through sea-borne trade and other uses (Voyer, M. & van Leeuwen J., 2018).

This reinvention implies an authentic approach of sustainable economic growth, but the path to a more sustainable future goes through a road with efficient use of resources (energy, water, land, minerals) optimization of waste management and value creation (Govindan & Hasanagic, 2018). Therefore, this sustainable future can be a reality only if the economies are rearranged on circular principles characterized by a balanced assessment of the economic, social and environmental needs (Geissdoerfer *et al*., 2017).

In this sense, the concept of "Blue Economy for Sustainable Coastal Development" is more restricted in scope and relates to the introduction of more innovative technologies in the market (Kathijotes, 2013). Based on this concept, innovative technologies are expected to generate new cash flows and, consequently, new jobs (Kraemer *et al.*, 2017). It is important to find investors who believe that these are excellent opportunities (Rosa, Sassanelli, Urbinati & Chiaroni, 2019).

"The Blue Economy" is a social system created through a step by step process. It is named after this beautiful Earth, whose sky and ocean are blue, as long as there is no pollution (Kathijotes, 2013). It is a concept that seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring the environmental sustainability of the oceans and coastal areas (OECD, 2019).

At its core, it refers to the decoupling of socioeconomic development through ocean-related sectors and activities from environmental and ecosystem degradation. It draws from scientific findings that ocean resources are limited, and that the health of the oceans has drastically declined due to anthropogenic activities (OECD, 2019). These changes are already being profoundly felt, affecting human well-being and societies, and the impacts are likely to be amplified in the future, mainly because of projected population growth (United Nations, 2018).

The Blue Economy has diverse components, including established traditional ocean industries such as fisheries, tourism, and maritime transport, but also new and emerging activities, such as offshore renewable energy, aquaculture, seabed extractive activities, and marine biotechnology and bioprospecting (Kockiskzy & Somosi, 2016). Several services provided by ocean ecosystems also contribute significantly to economic and other human activities such as carbon sequestration, coastal protection, waste disposal and the existence of biodiversity (World Bank, 2017).

An essential dimension of the Blue Economy involves how established ocean industries are transitioning to more environmentally responsible practices. An early example of this comes from the fisheries sector. The Blue Growth Initiative of the Food and Agriculture Organization of the United Nations (FAO) will assist countries in developing and implementing Blue Economy and growth agendas (World Bank, 2017).

A sustainable Blue Economy allows society to extract value from the oceans and coastal regions. However, this extraction needs to be in balance in a circular way to guarantee a long-term capacity of the oceans and to endure such activities through the implementation of sustainable practices (Europen Comission, 2019). This implies that human actions must be managed in a way that ensures the health of the oceans and where economic productivity is safeguarded so that the potential they offer can be realized and sustained over time (Europen Comission, 2018).

The European Union is supporting the transition to a Circular Economy with a broad set of measures to maintain the value of products, materials and resources for as long as possible while minimizing the generation of waste and turning waste into valuable resources (Rosa *et al.*, 2019).

Some good examples of the Circular Economy embedded in the Blue Economy are the mega-scale desalination plants that may become pivotal to the development of circular economic districts and spearhead the implementation of innovative business models (Europen Comission, 2019). The litter arises from various economic sectors and activities, either directly or indirectly, and inaction leads to rising economic, social and environmental costs. Counteracting and preventing marine litter can enable materials and their value to remain in a Circular Economy, and boost economic opportunities for enterprises that bet on sustainable development (Europen Comission, 2019).

INPUTS FOR BLUE ECONOMY STRATEGY: PORTUGUESE SEAFOOD INDUSTRY CASE STUDIES

Seafood Industry in Portugal and its Evolution Over Last Decades

Seafood is one of the most traded food commodities in the world. Portugal has a per capita seafood consumption of ca. 57 kg per year, the highest in Europe and one of the largest in the world (FAO, 2020). Fishery landings in Portugal are composed of near 40 categories of different taxonomic groups (e.g. fish, cephalopods, crustaceans and molluscs) comprising about 200 different species (Instituto Nacional de Estatística [INE], 2018). Sardine is the most important species in Portuguese fisheries, representing more than 40% of marine pelagic fish landings in Portugal by weight, followed by chub mackerel, tuna and horse mackerel. Molluscs have significant production in Portugal since 1986 and octopus is nowadays the most important seafood product in value. Aquaculture production corresponds only to 5% of the seafood produced in Portugal (mainly clam, gilthead seabream, sea bass and turbot) (INE, 2018). Canned fish industry strongly developed in the beginning of the 20th century as a result of both sardine fishery rewarding and an increase of canned products consumption during Second World War (Almeida, Karadzic, & Vaz, 2015).

Another important species in Portuguese seafood consumption is cod. The first records of Portuguese cod fishery in the Northwest Atlantic date back to the 15th century. Cod fishery in Portugal increased in the second part of the 19th century due to a tax reduction on fish but the production only covered about 10% of seafood consumption. Restrictions to fishing in international waters led to a decline in cod production since 1970 (Almeida *et al*., 2015). Nevertheless, cod is still the major imported species and an important tradition in Portuguese food. The Portuguese cod industry continues to produce salted and dried cod with imported fish, mostly from Norway, Iceland and Russia (Bjorndal, Brasão, Ramos, & Tusvik, 2016).

Despite the changes in the fishing industry over the past half century, the high per capita seafood consumption in Portugal has been kept (FAO, 2020). Nowadays, Portuguese seafood production only fulfils one third of demand and imports are four times higher than exports. Cod is the most consumed fish in Portugal accounting to about 38% of the seafood consumption. The second most consumed species in Portugal is canned tuna, because of its convenience. The third most consumed species is hake mainly due to its lower price as frozen product than fresh fish. Portuguese prefer the consumption of fresh fish, followed by salted and dried fish, which requires a constant supply of fresh seafood (Cardoso, Lourenço, Costa, Gonçalves, & Nunes, 2013).

The Portuguese fish processing industry in Portugal gained importance over the last few decades. The total production increased from 127,000 tonnes in 2000 to 212,000 tonnes in 2012, while turnover increased from €740 million in 2002 to €1078 million in 2012 (Bjorndal *et al.,* 2016). The expansion in frozen and salted & dried production has been particularly important, while canned production has been more stable. The fish processing industry in Portugal is protected by tariffs and supported by EU and Portuguese funds, which may explain the considerable expansion of the industry. These subsidies finance the acquisition/development of systems and equipment necessary for the processing, handling, storage, packaging, marketing and traceability of fish products and the development of new fish products, services, production methods or processes (Bjorndal *et al.,* 2016).

Blue Economy Application Cases: Innovative Strategies in the Seafood Sector

Fish is highly nutritious, rich in essential micronutrients, minerals, essential fatty acids and proteins, and represents an excellent supplement to nutritionally deficient cereal-based diets. According to Worldfish, 400 million of poor people depend critically on fish for their food. Additionally, the livelihoods of millions of people depend on the fishing sector. Nevertheless, the basis of this prosperity is fragile: the growing need for nutritious and healthy food will increase the demand for fisheries products from marine sources, whose productivity is already highly stressed by excessive fishing pressure, growing organic pollution, toxic contamination, coastal degradation and climate change. Furthermore, it is well known that fishing if unidirectional leads to the absence of natural regeneration of systems. Therefore, improvements are necessary to more effectively harness the power of trade within value chains and their related services.

New research from the High-Level Panel for a Sustainable Ocean Economy concludes that the ocean could provide six times more food than it does today by embracing innovation and adopting better management practices. Another challenge to the seafood industry is the better utilization of the whole seafood and to increase the number of consumed species, reducing co-products and by-catches, supporting initiatives on circular economy and developing innovative and healthy marine food. Thus, it is of major importance to find solutions to the problem of the high number of discards in the chain of production and sale of fish and to increase the fish production utilized for direct human consumption. These solutions will contribute to society in environmental and social terms and to itself in economic terms. Some industrial Portuguese companies are already applying some solutions, developing the circular (blue) economy in their production.

Soguima, a company from Guimarães dedicated to the processing and marketing of fish products has been developing new applications for fish skin in the past years. Previously a by-product used only for animal feed, fish skin has stood out as a by-product with several uses. It has the same characteristics as snakeskin and similar resistance to leather.

Nigel, a company from Peniche dedicated to processing of frozen products (fish, seafood, pre-cooked vegetables and ready meals), in collaboration with MARE (Marine and Environmental Sciences Centre) - Polytechnic of Leiria, developed a mackerel burger, adding value to a species that has low commercial value in Portugal. With this new product, the company expands the range of differentiating and innovative products associated with the marketing of fish. Nigel recognizes the need to present itself in the food market with new products of excellence, having as in their matrix the fish that allow the differentiation of the company in the national and international markets. This commitment is urgent, not only because of the constant need to stand out, but also because of the present economic situation, which is unfavourable to Portuguese food companies, mainly fish companies due to the progressive increase in the price of raw material and, therefore, it is urgent to develop new value-added products in order to revitalize the market.

Poveira, a Portuguese canning industry, therefore promoted the "Valor Peixe" project in collaboration with Portuguese universities to minimise the problems associated with the industry and exploit the added value of co-products. The project aims to valorise the co-and by-products and wastewater from the fish canning industry, taking into account that the waste corresponds to more than 50% of the processed fish.

Sonae MC, a company of the Sonae group leader in the food retail sector in Portugal, is leading the project ValorMar (Integral Valorization of Marine Resources: Potential, Technological Innovation and New Applications will develop innovative technological solutions) that will increase the valorisation and efficient use of marine resources through the integration of value chains, based on the circular economy concept. The main objective of ValorMar is the valorisation of marine resources through the research, development and demonstration of new products and the improvement of the productive processes, proposing innovative solutions that lead to the creation of new healthy food products using innovative, efficient and sustainable technologies.

Valorisation of Underexploited Fishery Resources

We live in a world of limited biological resources and ecosystems, which are essential to feed people and provide clean water and energy. The growing demand for food, feed, energy, materials and products due to a growing world population ask for new ways of producing and consuming in order to reduce the dependence on non-renewable resources. As refereed before, the development of a sustainable and circular bioeconomy is essential to deal with such challenge. There is a need to improve and innovate the way of food producing and consuming through the creation of new value chains and greener, cost-effective industrial processes.

As mentioned before, bioeconomy is an economic model that relies on the knowledge-based production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system. It also comprises full exploitation of by- and co-products resulting from biobased industrial processes, contributing for improved resource-efficient processes and for circular economy (FARNET, 2019). If we look for a global blue bioeconomy, policies should be focused in the research and development of new based seafood products, with new species, co-product, and under-valued products with sustainable wild and aquaculture species, while applying enhancing conservation processes based on/and for endogenous marine biological resources.

The EU is addressing several strategies towards a sustainable & circular blue bioeconomy in fisheries and aquaculture. Such strategies involve eco-designing, the use of co-products and recycling. Eco-designing is about producing equivalent or better-quality products with a low environmental impact in their manufacture and use (FARNET, 2019). In Portugal, Blue Bioeconomic activities have been traditionally related to fisheries for human consumption and coastal tourism, mainly accommodation and recreational activities, as well as shipping, shipbuilding and repair. The subsectors with the highest impact in Blue Economy between 2013 and 2016 were fisheries and aquaculture, ports and shipping, and shipbuilding, with an economic turnover of 5%, 13%, and 48%, respectively. Other Blue Bioeconomic subsectors, such as biotechnology and natural product research, have recorded a remarkable growth in volume of operations and projects, with numerous scientific projects being funded through European funding entities (Vasconcelos, Moreira-Silva & Moreira, 2019).

The Blue economy stakeholders in Portugal account for about 250 entities, namely small and medium-sized enterprises (SMEs), academic research entities, associations/incubators/non-governmental organizations (NGOs), and a small number of start-ups. The recent investment and entrepreneurial support to transfer scientific research into new economic activities is expected to increase considerably the involvement of start-ups in Blue Bioeconomic activities in the near future. A recent type of organisation, the collaborative laboratories (CoLabs) aim to foster the consolidation of collaborative practices between scientific, technological, higher education entities, and the social and economic sector, through the implementation of research and innovation programmes oriented to the creation of skilled and scientific jobs in Portugal. Many entities, mostly SMEs and academic research entities, are focused on innovation development and product differentiation. Most of the Blue economy stakeholders in Portugal are associated with biomass production, such as fisheries and aquaculture, while a relatively low number are associated with commercialisation and market entry (Lillebø, Pita, Garcia Rodrigues, Ramos & Villasante, 2017; Vasconcelos *et al.*, 2019).

Fish discards are a worldwide phenomenon resulting from fisheries and have been the subject of great concern on the part of all players in the sector, whether they are administrations, fishermen or scientists. According to FAO, 1996: "Discards are the portion of the total catch taken during fishing activity that is dumped or thrown overboard at sea. Discards can consist of both bycatch and target species. By-catch is generally dumped because it is undesirable and therefore uneconomic to keep on board". Among the different fishing gears, some are less selective than others are, such as gillnets and trawls compared to the line, capturing much more species than intended, resulting in high discards. About 40% of fish catch worldwide is unintentionally caught and is partly thrown back into the sea, either dead or dying. The fish that ends up on our plates often has a disturbing past.

It is well know that keeping non-marketable fish on board takes up valuable storage space and consequently, target species may be discarded due to poor quality, because the quota for that species has already been taken, low commercial value fish species, non-targeted species (by-catch) or undersized targeted species, being outside a particular regulation size range.

Managers, engineers, and scientists have attempted a variety of techniques to reduce bycatch/discard levels. These have included traditional net selectivity approaches, the development of fishing gear-taking advantage of differential species behaviour, and time/area fishing restrictions. These methodologies have worked with varying degrees of success depending on the species being managed and the willingness of industry to work together for positive solutions. Being difficult to change fishing gear, the strategy to minimize discards and boost the fishing economy may be related to the value increase of species with low or without commercial value. In addition, the most consumed fish species by Portuguese (cod and salmon) are imported, whereby the use of these unexploited resources is of major importance for the country, promoting a stability of trade balance. Furthermore, raw product availability has become a determining factor for many product development efforts, especially for national companies. Consequently, diversifying the target species is essential for fisheries sustainability and for market revitalization. The use of edible co-products of traditional operations of filleting or cutting and undervalued species assumes great importance because it minimizes the problems of production and unit cost of raw materials. These co-products or undervalued species are rich in proteins of high biological value, rich in polyunsaturated fatty acids of the omega-3 series, a source of vitamins (as vitamin D) and minerals (as Se, P and Ca), and essential amino acids (Tilami & Sampels, 2017). In this context, one of the most challenging aspects is therefore the progressive elimination of fish discards, developing alternatives for valorisation of those discarded species, aiming of maximizing the return on fishing captures and contributing to long-term environmental, economic and social sustainability. These strategies should include approaches to raise awareness and implement sustainable consumption habits in the population.

New Strategies to Increase Shelf Life of Seafood

Sharing, repairing and reusing are crucial steps to decrease the amount of virgin resources that are used. These strategies are also part of EU Plastics Strategy that aims to reduce plastic pollution whilst fostering growth and innovation (FARNET, 2019).

Fish and seafood products have high nutritional value but are highly susceptible to microbial growth at elevated temperatures and fresh and chilled fish have short shelf life. When long distance transportation is necessary, because the fish landing stations are a long distance from the processing plants or market locations, fish and fish products must be refrigerated or frozen immediately after harvesting to inhibit microbial growth and quality deterioration. The method of packaging and the type and quality of packaging materials are of great importance for preserving fish quality. The main functions of food packaging are protection (e.g. modified atmosphere and active packaging), communications (marketing and guidelines), convenience, and containment. Food packaging is also a concern for the environment due to the high production volumes, short usage time, and problems associated with waste management and littering.

Recent packaging applications aim to provide supplementary functionalities, apart from ensuring protection, integrity and safety of food products. Smart packaging, for example, may contribute to prolonging the shelf life and provide essential information regarding food safety and quality (e.g. package integrity, time and temperature history of the packed food, and freshness indicators). Another innovative packaging technology is the use of edible coatings or films, which are thin layers of material used for coating or wrapping food to extend shelf life. These packaging techniques provide a replacement and/or protection of the natural product surfaces to prevent moisture loss, gas aroma, and solute movement out of the food, while selectively allowing the controlled exchange of important gases. Edible films are prepared separately and then applied to the food, while coatings are formed directly onto the surface of the food. These methods can also retard oxidation and/or delay microbial spoilage, by the incorporation of antibacterial and antioxidant agents. The materials used to develop edible films and coatings for fish products must be capable of forming a film and be dissolved in an appropriate and safe solvent (Theofania & Taoukis, 2018).

Two cases studies have been selected to further illustrate, in the form of examples and best practices, certain innovative sustainable strategies in the seafood sector. These cases help depict the broadness and variety of the Blue Economy. The first case study is on sustainable solutions in the seafood sector using value chains that tap under-exploited sea species to jump-start an economic diversification strategy. A second case study looks at circular economy practices in the seafood sector using waste as a resource.

DATA COLLECTION

It is well known that the observed trend of more processing of fish products will increase the volumes of rest raw material and co-products, and the utilization of fish co-products has been gaining attention. In some countries, the utilization of by- and co-products has become an important industry, and improved processing technologies are leading to more efficient utilization.

Two case studies were selected showing the application of sustainable production principles and practices to blue economy sectors in Portugal, in a logic of circular economy articulating: food, blue biotechnology, technology and fisheries.

Case Study 1: Improving Circular Economy Practices in the Seafood Sector Using Value chains that Tap Under-Exploited Species

Co-products, by-catches and on-board discards from fisheries and aquaculture can be valuable resources for the development of new products. In this context, a full characterisation of the sensorial properties of fish species represents the first step towards a valorisation of those species.

VALOREJET project – "Use of discards and low commercial value species: valuation of new products using innovative techniques ", funded by MAR2020 (Portugal), employs a case-based action research to provide added-value to natural materials from renewable sources for an efficient and sustainable exploitation whilst safeguarding biodiversity and the marine environment.

The case study was divided into 3 interconnected tasks considering identification of target species, sensorial characterization and development of new food products.

The study was conducted in Portugal.

Task 1: Identification of Potential Species

In this study, a survey was conducted to inquire about the discards generated and processed in Portugal. These included three types of methods: interviews to fishers' associations, associations, fish processing industries and records consultation. An engagement of the fishing sector is essential for a successful valorisation of underexploited species. Results allow identifying potential new fisheries resources that can contribute to a sustainable fishing sector. Additionally, literature search in the subject area was conducted in order to secure qualitative and quantitative data on the character and magnitude of discards occurring in various fisheries. In conducting our literature search, the multiple meanings of the term "bycatch" at times made it difficult to acquire information regarding discards, especially total quantities and the biodiversity of discards from particular fishing activities.

Task 2: Nutritional and Sensorial Characterization of the Selected Species

The species were chemically and nutritionally characterized by determination of the following parameters: ash (Norma Portuguesa [NP] 2032:1988 method), humidity (NP 202:1991 method), chlorides (NP 2929:2009 method), carbohydrates, crude protein (NP 4488:2009method), total free fat and fatty acids profile using methodologies adapted from Fernandez, Grienke, & Soler-Vila (2015), and mineral elements by a method adapted from Pinto, Mourato, Sales, & Louro (2017). A sensory evaluation of the fish species was conducted, in relation to four attributes (appearance, colour, texture and flavour), using NP 8586-1:2001 methodology.

Task 3: Development of Marine Products With Added Value

New seafood products were developed according to six activities: product design, consumer testing, product optimization, process design, market testing, and cost analysis. Product characteristics were defined in the product design specifications. The raw materials and the processing conditions were investigated during product development. Important considerations during the product design/process development stage were the test procedures used, as they were adapted to the qualities required by the customer/consumer and not to arbitrarily chosen standards.

Case Study 2: Improving Circular Economy Practices in the Seafood Sector Using Co-Products as a Resource

Due to the initial high microbial load of raw fish and the increasing global supply of safe, convenient and environmentally sustainable seafood, research for new and efficient methods or technologies of preservation makes the application and development of novel packaging solutions essential (Augusto, Gil, & Silva, 2016). In addition, fish co-products result in a significant economic loss, as they are not used in a way that maximises their economic potential. There is opportunity to turn fish processing co-products into food, fish meals, fertilisers, pharmaceuticals and other marketable products. Furthermore, industry demands more sustainable solutions through the use of co-products from the food industry. Strategies to maximise the economic value of fish processing co-products are needed.

This case study reviews the development and application of biocoatings formulated exclusively with marine naturally occurring, sustainable and effective compounds that will provide an important competitive advantage for the seafood industry and retailers. With the implementation of this strategy, it is possible to achieve a "more circular" economy, as an operational concept on the way to a paradigm change. This will allow to face environmental and social problems arising from the globalization of markets and the current economic model based on a linear economy of "extraction, production and disposal". Thus, circular economy strategies emerge as a catalyst for competitiveness and innovation in the fisheries and food industry.

The core essence of this case study was to present a successful example of how Portuguese seafood industry co-products can be used as a resource.

The potential of the edible coatings based on marine co-products to increase seafood shelf life was assessed. The activities encompassed three different tasks to promote the extension of shelf life of raw tuna, because of its high commercial importance for the Portuguese Fish Processing Industry with short shelf life.

Task 1: Survey of the Company's Needs and Concerns

In this study, a survey was conducted in order to gather information about the co-products generated and processed in the fish industry. Additionally, a search was performed in the subject area literature to secure qualitative and quantitative data on the type of fish processing co-products generated and their use.

Task 2: Development of New Marine-Based Edible Coatings

In this task, edible coatings from marine resources (algae from sea-farms and co-products from the fishing industry) were developed and characterized, through the evaluation of their physical-mechanical properties.

Task 3: Validation and Applications of Selected Edible Coatings (According to Industrial Interest)

Based on results, selected edible coatings were applied to raw tuna (according to the industry interest) and extension of the shelf life of the food product was evaluated. The extension of food product shelf life was by direct method: raw tuna was stored for a period of time that is longer than the expected shelf life, in order to observe, test and record changes in the products characteristics. The type(s) of spoilage or loss of quality most commonly associated with the tuna was studied. One type of deterioration may dominate, or several may be equally important. From this information, a shelf life will be estimated. The shelf life will need to take into account possible variability between product batches and storage conditions, including whether the product is intended to be consumed over a period and so will be subjected to a number of temperature cycles.

DATA ANALYSIS AND RESULTS

Case Study 1: VALOREJET – Heading Value to Underexploited Portuguese Fish Species (How and Why?)

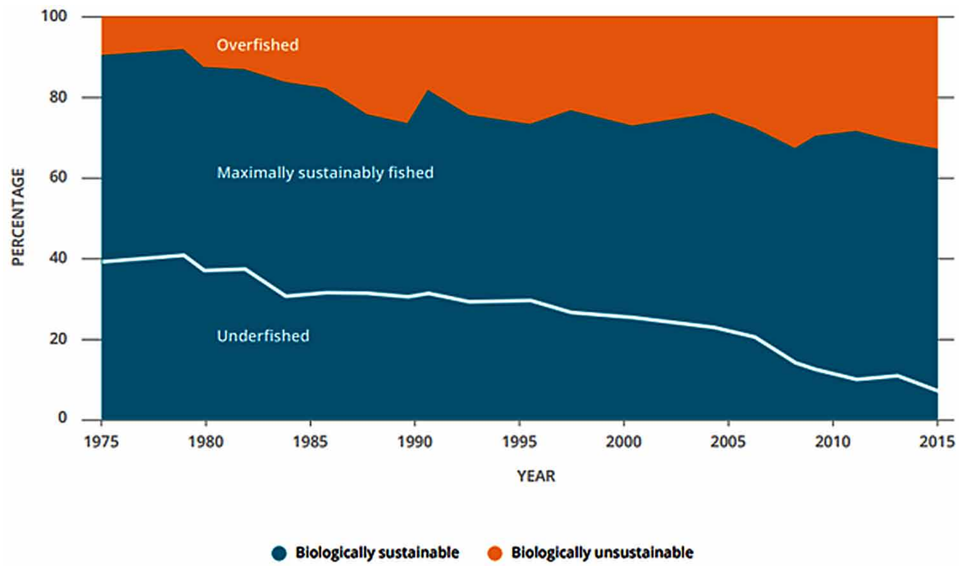
Task 1: Identification of Potential Species

Over the last years, consumer purchasing behaviour towards fish and seafood products has been capturing the interest of researchers internationally for political and economic reasons related to aspects of nutrition and diet, food safety, sustainability and business of the fish industry. Seafood is a valuable source of protein, important fatty acids, minerals and vitamins. According to FAO (2018), 17% of the global consumption of animal protein is provided by seafood consumption. The world marine capture fisheries have extremely grown over the last century, bringing the human per capita consumption of seafood to around 20 kg/year. However, for over 2000 harvested species, 30 species alone represent 54% of the total capture. In addition, large amounts of fish are discarded, and it is estimated that postharvest losses – losses between landing and consumption – and discards combined amounts to some 35% of global catches, corresponding to about 30 million tons annually (Figure 1) (FAO, 2018).

There is a socio-economic interest to increase the amount of marine fish available for human consumption by reducing on board discards and increase commercial value of underexploited species. Other important factors include better utilization of the whole seafood, reducing co-products, supporting initiatives on circular economy and developing innovative and healthy marine food products important for human nutrition and to food security.

In this study, a survey was conducted to inquire about the discards generated and processed in Portugal. Based on the results obtained six underexploited species were identified.

Figure 1. Global trends in the state of the world´s marine fish stocks
(From FAO, 2018).



The selected species present important landings (800 tonnes per year in the case of horse mackerel) or belong to families of high commercial interest (*Sparidae*, in the case of poplar) or to a group of species scarcely studied and that, together, have some expressiveness in the official statistics (the redheads sense, of which the red goat is the most landed species).

Among the species with low commercial value in Portugal, the blue scad (*Trachurus picturatus*), the black seabream (*Spondyliosoma cantharus*), and the redheads (generic name for a group of 6 to 8 species landed in Portuguese fishing dock) were named, as they proved to be particularly important in the quantities landed and in the commercial value they can reach. On the other hand, among the species with no commercial value, the learned rockfish (*Serranus cabrilla*) and the boarfish (*Capros aper*) are particularly abundant. Concerning boarfish, there is already a concern by the International Council for Exploration of the Sea (ICES) for its study in terms of resources, taking into account its high biomass values observed, for example, in the Celtic Sea.

Task 2: Nutritional and Sensorial Characterization of the Selected Species

The effect of seasonal variation on nutritional and sensory properties was assessed. Table 1 shows the annual nutritional value of proteins, carbohydrates and lipids, for each fish species under study. The high standard deviation shown reflects the high variations in nutritional composition through the year, highlighting the *Capros aper* species with a high fat content between May and October and high protein content between May and August.

The results of the physical-chemical analyses demonstrated the high nutritional potential of these species when compared with the most commonly consumed species in Portugal, which are mackerel, sardines and horse mackerel (INE, 2018; Bjorndal *et al.,* 2016). However, none of the species under study showed fat values as high as sardines.

Table 1. Nutritional Value per 100 g of product, annual average of 2019 for each species of fish under study

Fish Species	Energy (kcal)	Protein (g)	Carbohydrates (g)	Fats (g)
Trigla lyra	93.77 ± 13.38	18.11 ± 1.14	0.38 ± 0.93	1.10 ± 0.43
Trachurus picturatus	138.54 ± 20.32	18.12 ± 0.56	0.15 ± 0.38	3.75 ± 0.86
Spondyliosoma cantharus	106.52 ± 27.47	17.39 ± 1.49	0.00 ± 0.00	1.85 ± 0.65
Capros aper	109.71 ± 50.60	16.71 ± 4.50	0.64 ± 1.41	2.41 ± 1.55
Serranus cabrilla	63.737 ± 32.517	14.172 ± 7.010	0.000 ± 0.000	0.484 ± 0.242

Regarding sensorial analysis, four attributes were considered (appearance, colour, texture and flavour). The sensorial characterization of these species is an important issue in the process of appreciation and promotion for this underexploited resource. Thus, this case study was designed to evaluate sensorial profile of target species captured along the coast of Peniche in Portugal, hopefully adding value to this marine resource.

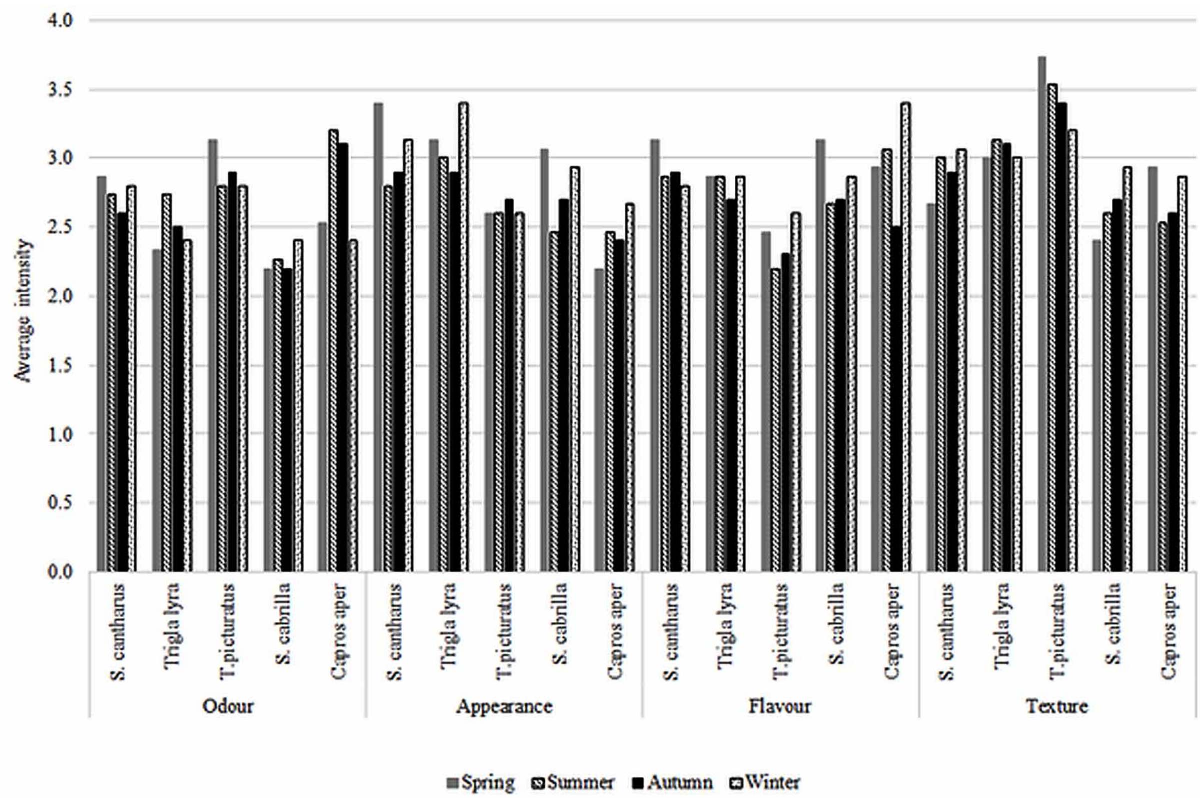
CATA (Check-All-That-Apply) is a popular approach for sensorial analysis for its simple format, small cognitive effort requirements and rapid elicitation of test products sensory characteristics from participants, allowing consumer-based sensory characterizations (Ares, Deliza, Barreiro, & Gámbaro, 2009; Ares, & Jaeger, 2015). In this methodology, panellists were presented with a sensory terms list to select those who are applicable to describe the focal sample in an easy and intuitive way for the consumer, providing valid and repeatable product information (Ares *et al.,* 2015). The descriptors most cited by the panellists for appearance (laminar structures), flavour (fat content), odour (sea odour) and texture (firmness) were the ones selected to trace the sensory profile of the fish throughout the year. It was found that sensorial properties are not constant along the year, varying greatly within species and depending on season (Figure 2). Figure 2 reflects the seasonal variation of appearance, flavour, odour and texture descriptors that are common between species. It appears that in its majority there is an increase in the sea odour between spring and summer. The laminar structures increase in intensity from autumn to winter for all species except in *Trachurus picturatus*, which occurs between the summer and autumn. Such seasonal increase is also seen for the fat content in all species, except *Spondyliosoma cantharus*, and for firmness, except for *Trigla* lyra and *Trachurus picturatus*. These results allowed to understand the time of year when the consumer prefers each species, as well as to compare their choices with the nutritional composition obtained.

Task 3: Development of Marine Products With Added Value

Nutritional and sensorial characterization was fundamental for assessing the nutritional potential of each species and for the development of new marine based food products. The species in this study exhibited a wide range of physicochemical and sensory characteristics that showed their potential for further exploitation when designing new products.

The development and launching of new products in the food market was another objective of this case study. To that effect, new production processes with increased sustainability were proposed. This overall objective was divided into a set of specific objectives in collaboration with a number of SMEs:

Figure 2. Seasonal variation of appearance, flavour, odour and texture descriptors intensity for each fish species. Odour descriptor: sea odour; appearance descriptor: laminar structures; flavour descriptor: fat content; Texture descriptor: firmness.



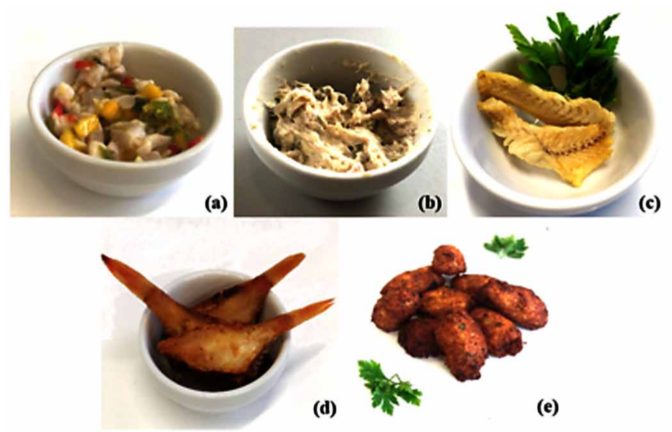
- develop a range of processed products to offer a greater diversity of fish species and new value-added products to consumers;
- consumer acceptance and market position.

New food products have a high chance of market failure. To increase the chances of success, a consumer-oriented methodology should be considered in product development.

The best formulation and the best process conditions were selected according to consumers acceptance of new products as well as to the objectives set by fish processing companies, *chefs* and internal sensorial panel. Thus, a different product was developed for each target species, namely black seabream *ceviche*, smoked blue scad *pate*, dehydrated lyre, fried boarfish and learned rockfish pastries (Figure 3). These new food products were processed using the fish species in free or combined form, adapting or developing new packages, evaluating their stability, functionality and sensory attributes over the storage time.

The self-life of the new food products was assessed by sensory analysis and microbiological tests. The sensory analysis was assessed by 2 trained panellists who evaluated the food product as "acceptable" and "not acceptable" aiming to detect any changes throughout the storage time. The microbiological analysis included the total microorganisms counts at 30 °C (according to NP 4405:2002) for all the products and psychotropic counts (according to NP 2307:1987) for fried boarfish and learned rockfish pastries.

Figure 3. Images from the new products developed using the studied species. (a) black seabream Céviche (Spondyliosoma cantharus); (b) smoked blue scad paté (Trachurus picturatus); (c) dehydrated lyre (Trigla lyra); (d) fried boarfish (Capros aper); (e) learned rockfish pastries (Serranus cabrilla).



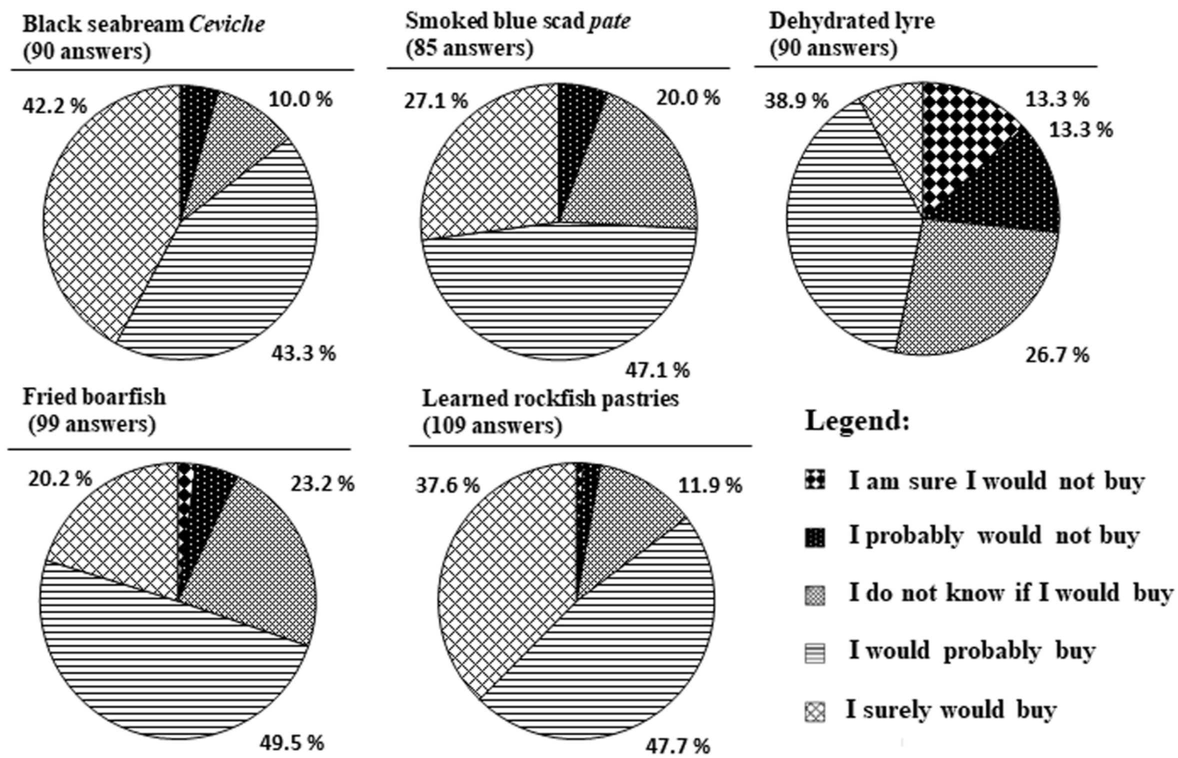
The *ceviche* and smoked blue scad *paté* were developed as products to be consumed within a short/medium period of time (15 days for ceviche and 2 months for *paté*), when stored in glass packaging and refrigerated (between 0 to 5 °C). Dehydrated lyre packed at room temperature in a laminated package has an estimated shelf life of 18 month. Fried boarfish and learned rockfish pastries are ready-to-fry frozen products to be stored in plastic packaging between -18 °C to -20 °C. Formulations were optimized for a crispy texture of crust after freezing and frying and selected based on sensory characteristics (results not showed). The sensory quality of the products developed, stored at -20 ± 1 ° C, is being evaluated by predicting a shelf life of approximately 18 months by comparison to equivalent products.

The success of the developed food products and, consequently, the viability of their introduction on the market was verified by sensorial consumer tests. Figure 4 shows the consumers responses related to the purchase acceptance for each developed product.

These results showed that black seabream *Ceviche* was the most accepted product followed by learned rockfish pastries. However, if both "I would probably buy" and "I would surely buy" answers are considered, the most accepted product is learned rockfish pastries (85.6%) without significant differences with *Ceviche* (85.5%). They are products with distinct sensorial characteristics and consequently with distinct target consumers. Pastries can be part of a meal while *Ceviche* is more suitable as an appetizer. The less accepted product was dehydrated lyre, yet with 38.9% probability of purchase, followed by fried boarfish, with 49.5% probably of purchase. The lower acceptance of dehydrated lyre may be related to the improper storage of this type of product (before the sensory test) which acquires moisture relatively quickly, losing desirable characteristics such as crispness. Nevertheless, this problem will be overcome with the appropriate packaging, and consumer acceptance will increase.

The objective of this study was not only to introduce the new fish-based products on the market, but also to valorise the fresh fish species themselves. This is one of the circular economy strategies that will make it possible to tackle an environmental problem, guarantee the sustainability of the oceans, increase the income from fisheries and revitalize the fish food industry. It will be possible because food industries and researcher work together, sharing and valuing the knowledge acquired in this project. New

Figure 4. Sensory appreciation of consumers through inquiries related to purchase intention of developed products



food products from low or no commercial fish value will also be an opportunity for the fish industries to control the progressive increase in the price of raw materials and to offer new products to the consumer.

In addition to the already referred strategies, other actions are being taken regarding marketing and awareness. These actions are based on teachers training (Figure 5) aiming at the knowledge transfer in the classroom, with consequent message spreading throughout students and family. The trained teachers showed high interest and creativity in projecting this subject in the classroom. The final objective will be the evaluation of the impact of training in the social behaviour and in the consumption of underexploited species.

In conclusion, the project is being successfully carried out, in the scope of innovation, operations in the field of fisheries and processing, through the development and introduction of new food products that help to improve the blue economy and preserve the oceans.

Figure 5. Training action for teachers of first, second and third cycles of basic education within the scope of the VALOREJET project.

Case Study 2: Improving Circular Economy Practices in the Seafood Industry Using Co-Products as Resource

Task 1: Survey of the Company's Needs and Concerns

Currently all the seafood industry co-products are sold as low-price animal feed, but they have the potential to be processed into high quality seafood. In addition to this missed opportunity, disposal of co-products often has a direct financial and environmental cost. Therefore, the study of eco-innovative solutions to increase the use of co-products and other marine resources, providing unique products to special market segments, are of major importance to the seafood industry.

A first step in assessing the potential to add more value to fish processing co-products is inquire about the co-products generated and processed in the industry.

Fish processing by-products, i.e. parts of fish that remain after fish parts for human consumption have been removed, are used to produce feed ingredients, fertilizers, pharmaceuticals and industrial products such as chitin and baits. Although most of the fish meals are made from fish species caught for that purpose, fishery co-products (fish processing by-products and fishery by-catches) are also used as raw material for fish-meal production. The co-products generated by fish processing industry are mostly heads, viscera, frames, skins, tails, fins, scales, mince, blood, among others, which may account to 60-70% of fish after processing. This valuable raw material remains a very underexploited source. Current research has been focusing on the possibilities of the utilization of fish processing co-products, aiming on the development of innovative, added value and attractive food products. For instance, fish processing co-products can be converted into commercially valuable products including protein meals and fish oils. Other applications include use of heads to produce pate and terrine (Silovs, 2018). Further separation of the components of seafood waste can be used to create protein powders and protein-enriched food products and oil-enriched food products (Ghaly, Ramakrishman, Brooks, Budge & Dave, 2013; Shaviklo, 2015).

Portuguese fish processing industry is mostly dedicated to traditional operations of fish slicing and filleting, and by- and co-products can be used as a nutrients resource. This study will impact the competitiveness of the Portuguese seafood sector by supporting selected SMEs in their innovation activities during demonstration market application of seafood co-products. This case study will improve valorisation of co-products from side streams of salmon and tuna. This case study will also improve the use of underutilised seafood such as seaweed. Through these eco-innovative solutions, the environmental and economic efficiency of seafood producers is impacted, with consequences in the overall competitive performance of the sector.

Task 2: Development of New Marine-Based Edible Coatings

The modern seafood industry is facing challenges and requires specific approaches to overcome them. One of these challenges is related to the packaging of food products with a short shelf-life period, especially those susceptible to oxidative and microbiological deterioration. Various deterioration mechanisms, such as the action of endogenous enzymes, microbiological contamination, mechanical damage and fat oxidation, decrease the quality of the fish and can be a risk to the health of the consumer and cause economic problems. Although the use of conventional packaging materials such as plastics is effective for food transportation and distribution, it compromises product shelf life and creates serious environmental problems. Thus, the search for new methods for more efficient preservation methods of food products is an emerging field of study that is gaining attention. Furthermore, industry demands more sustainable solutions through the use of co-products from the food industry. Therefore, alternative conservation techniques for raw fish and ready-to-cook fish products should be studied, as well as new packaging solutions.

Edible coatings (EC) containing natural compounds are a promising preservation technology for raw seafood without compromising fresh-like appeal and nutritional content. The production of marine-based biopolymers has received increased attention for their food applications and their barrier and mechanical properties have been studied. Additionally, the incorporation of marine natural antioxidants into films and edible coatings modifying their structure, improving their functionality and applicability in foods is gaining attention. In these films, the incorporated compounds are released in a slow controlled process to maintain an adequate concentration of these compounds for a certain period.

The development and application of edible biocoatings formulated exclusively with marine naturally occurring, sustainable and effective compounds that will provide an important competitive advantage for the seafood industry and retailers, is presented. For this business concept, the co-products will be used as a raw material for edible coating development.

The fish gelatin was extracted according to Vala, Augusto, Horta, Mendes, & Gil (2017), by an acid-swelling process in the presence of pepsin, followed by subsequent refrigeration, after a pre-treatment with NaOH. Tuna skins (*Thunnus obesus*), kindly provided by Portuguese company Omnifish (Peniche, Portugal) were used as the source of gelatin. Meat residue was removed manually and cleaned samples were washed in tap water and stored frozen at -13 °C until use. Before use, thawed tuna skins were cut into small pieces (0.5 cm x 0.5 cm).

In order to maximize the preservative effect of FG, seaweed extracts were added to coating formulations according to Vala, *et al.* (2017). The chosen seaweeds were *Fucus vesiculosus*, due to their high antioxidant and antimicrobial activities (Pinteus, Silva, Alves, Horta, Fino, & Rodrigues, 2017; Pinteus, Alves, Monteiro, Araujo, Horta, &Pedrosa, 2015), and *Codium* spp. due to preservative properties observed in previous studies (Augusto *et al.,* 2016b). The percentage of seaweed extracts was based in previous studies where 1% of chitosan was added, as an antimicrobial agent, to FG (Nowzari, 2013). Three distinct gelatin-based EC formulations were studied: 1) FG - gelatin (5%) + glycerol (25%); 2)

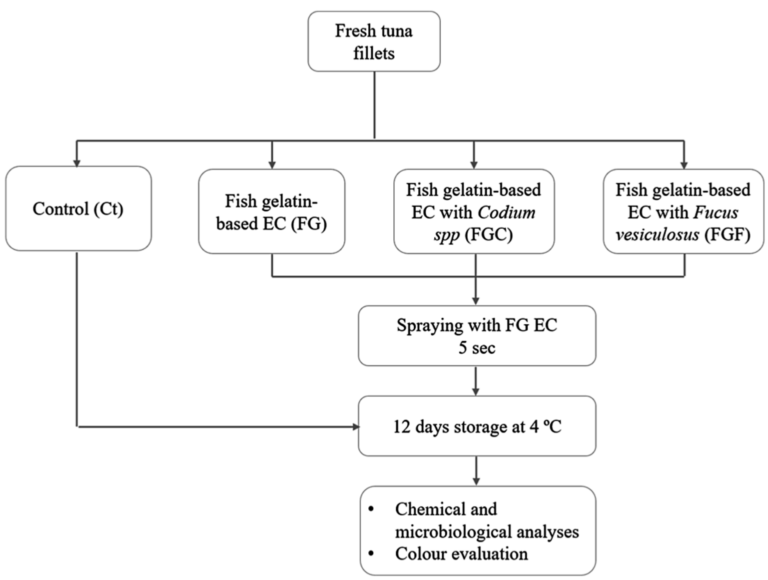
FGC - gelatin (5%) + *Codium* spp. (1%) + glycerol (25%); 3) FGF - gelatin (5%) + *Fucus vesiculosus* (1%) + glycerol (25%). Glycerol was only used as a plasticizer.

Task 3: Validation and Applications of Selected Edible Coatings (According to Industrial Interest)

In Portugal fish processing has expanded, and the country has become an important exporter of fish products (Bjornda *et al.*, 2016). Of these exported products, common ready-to-eat seafood products, including smoked and salted & dried products, are expanding, while canned products have been stable. Likewise, fresh tuna consumption has greatly increased, and tuna fillets packed as ready-to-cook product could respond to the growing market of minimally processed food by combining quality and convenience. According to FAO (2016), the yellowfin tuna (*Thunnus albacares*) predominates in tropical and subtropical waters and in 2014, 1.4 MT were caught worldwide, while *Thunnus obesus* catches predominate in ocean Pacific and about 0.41 MT were caught in 2014 (FAO, 2016).

The fish gelatin-based coatings developed (FG, FGF and FGC) were applied directly, by a spraying method, on the surface of fresh tuna fillets (Figure 6). Tuna quality was assessed over 12 days of storage at 4 ± 1 ºC in terms of chemical and microbial indices.

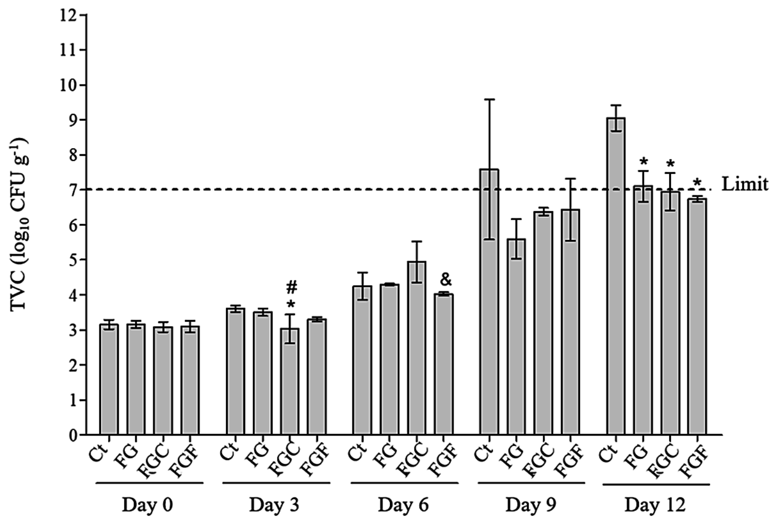
Figure 6. Flowchart of the application of fish gelatin-based coating solutions to fresh tuna fillets.



It was observed that, in general, coating inhibited microbial growth to a certain extent and the microbiological growth rate in control samples (Figure 7).

Samples coated with FG and seaweed extracts (FGC and FGF) did not reach the limit values of TVC until the end of the storage period and, as expected, FGF coating presented higher antimicrobial activity than FGC coating. Thiobarbituric acid reactive substances (TBARS) assay, a widely used index of lipid oxidation, determines the malondialdehyde (MDA) formed through hydroperoxides, which are the

*Figure 7. Total viable counts (log_{10} CFU g-1) for tuna samples of control (Ct) and coated with fish gelatin (FG), fish gelatin with Codium spp. (FGC) and F. vesiculosus (FGF) extract solutions, during 12 days of storage at 4 °C. Bars represent mean ± SD (n= 3). Statistically significant differences compared to samples with and without treatment in the same time ($p < 0.05$, ANOVA, LSD test) *Ct; #FG; &FGC (Vala, et al. 2017).*



initial reaction product of polyunsaturated fatty acids with oxygen. TBA values greatly increased during the 6-day storage in all samples revealing that the coatings were not enough as a barrier to reduce lipid oxidation (Figure 8). Nevertheless, the samples coated with FGF revealed a slightly smaller increase in TBA comparing to the other coatings used.

Total volatile basic nitrogen (TVB-N), an index that evaluated the activity of spoilage bacteria and endogenous enzymes in fish, was also determined during the storage period. As can be seen in Figure 9, all samples presented a progressive increase in TVB-N values. The highest increase of TVB-N values was observed at day 9 for all samples, with exception of FG with *Codium* spp. coating, indicating an effective reduction in microbial and enzymatic activities. At the end of the storage period, the recommended limits were reached only by the control samples.

Colour parameters of tuna fillets were also evaluated during the storage period (Figures 10 and 11), as fish colour is an important characteristic when it comes to the quality of fresh tuna. The use of EC increased the stability of red colour during storage. Additionally, a smaller variation in colour was observed for samples coated with FGF, probably related to the polyphenols present in *Fucus vesiculosus* that can prevent lipid oxidation.

In conclusion, the results showed that tuna skin gelatin-based EC avoid tuna deterioration and that the incorporation of seaweed extracts in FG EC could be a promising way to extend the shelf life of refrigerated tuna fillets. Incorporation of *F. vesiculosus* extract into FG EC was effective in decreasing microbial activity and, consequently, in the increase of shelf-life of tuna fillets. *F. vesiculosus* extract is thus a potential natural additive for EC formulations to be applied in raw seafood products.

In conclusion, management of fish co- and by-products represents an attracting topic, since this suggests a possible way to solve environmental impacts of fishery discards and, at the same time, it provides

*Figure 8. Thiobarbituric acid reactive substances (TBARS) values for tuna samples of control (Ct) and coated with fish gelatin (FG), fish gelatin with Codium spp. (FGC) and F. vesiculosus (FGF) extracts during 12 days of storage at 4 °C. HQL – High quality limit (Santos, 2008), MLC – Maximum limit for consumption (Santos, 2008). Bars represent mean ± SD (n = 3). Statistically significant differences compared to days in samples with and without treatment (p<0,05, ANOVA, teste de LSD): *Ct; # FG; & FGC*

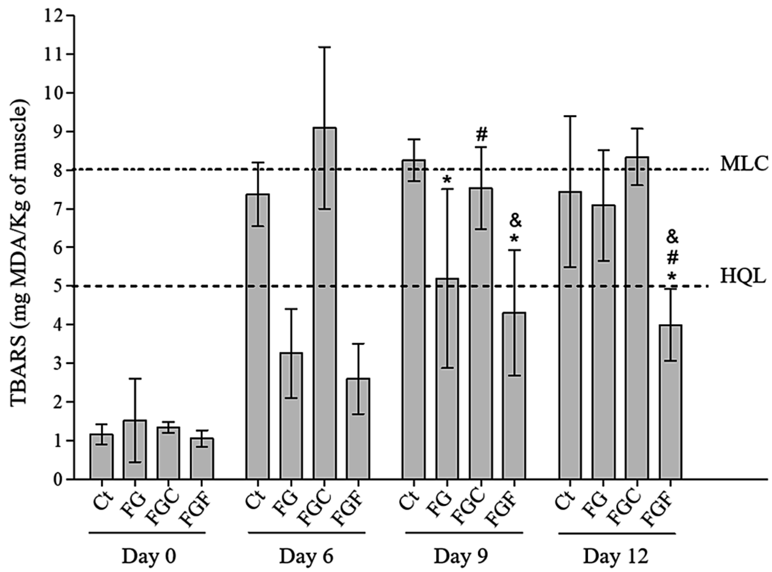


*Figure 9. Total volatile basic nitrogen (TVB-N) values for tuna samples of control (Ct) and coated with fish gelatin (FG), fish gelatin with Codium spp. (FGC) and F. vesiculosus (FGF) extracts during 12 days of storage at 4 °C. Bars represent mean ± SD. Statistically significant differences compared to days in samples with and without treatment: *day 0; #day 3; ʈday 6; and &day 9 (p < 0.05. ANOVA, LSD test) (Vala et al., 2017)*

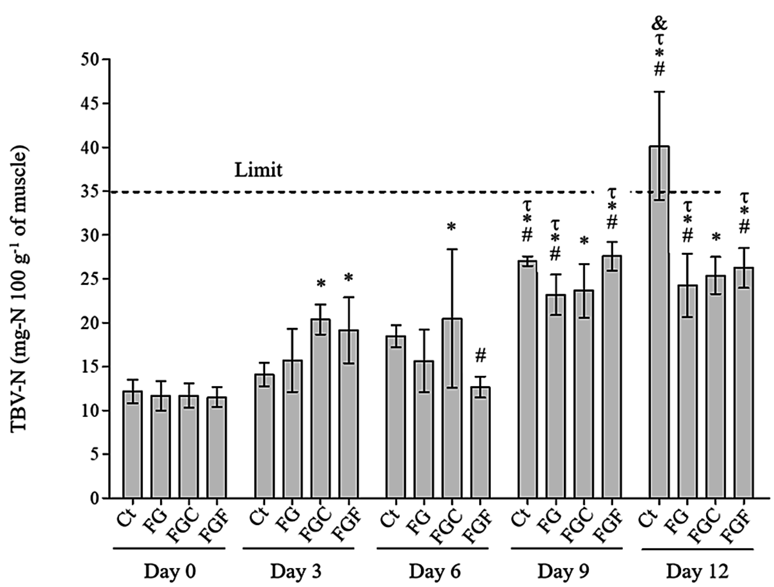


Figure 10. Colour parameters for tuna samples of control (Ct) and coated with fish gelatin (FG), fish gelatin with Codium spp. (FGC) and F. vesiculosus (FGF) extract solutions, in terms of a, b*, and L* of tuna fillets. Bars represent mean ± SD. Statistically significant differences compared to days in samples with and without treatment: *day 0; #day 3; &day 6 (p < 0.05. ANOVA, LSD test).*

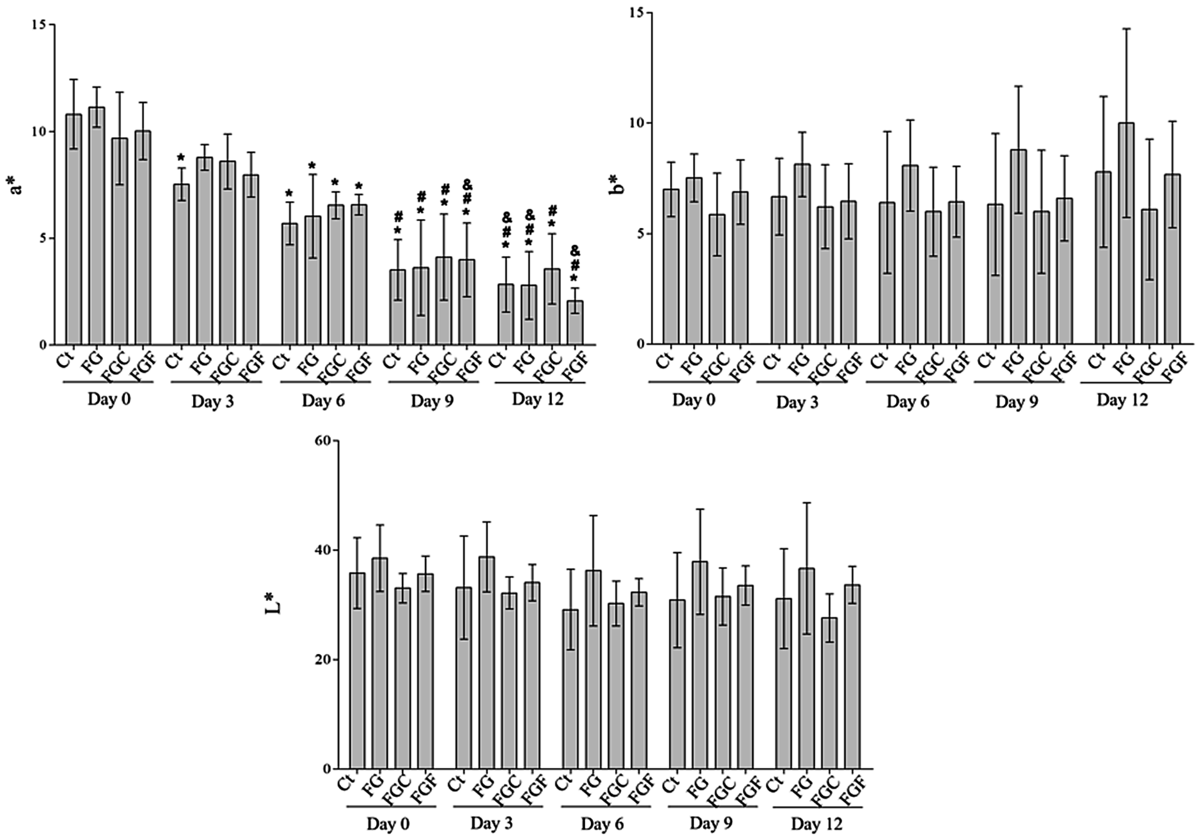
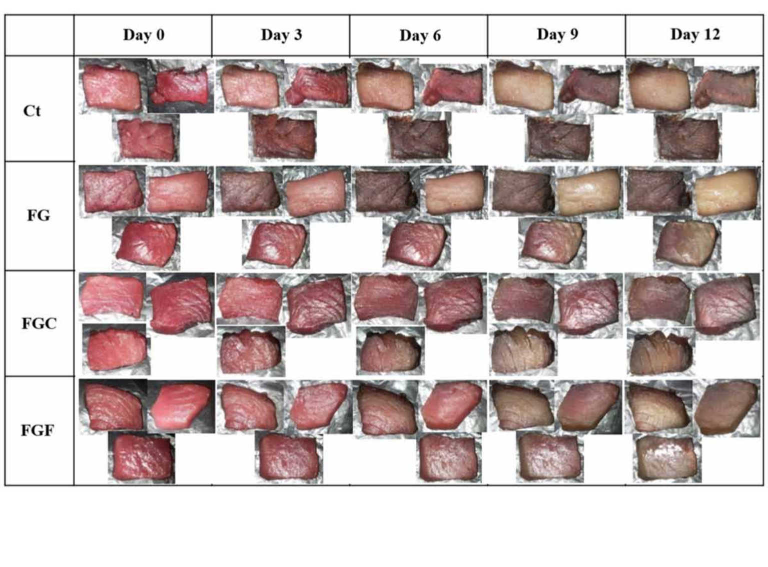


Figure 11. Visual evolution of tuna samples of control (Ct) and coated with fish gelatin (FG), fish gelatin with Codium spp. (FGC) and F. vesiculosus (FGF) extract solutions at days 0, 3, 6, 9 and 12.



a tool to exploit them as a source of feeds for farmed fish, so promoting future aquaculture growth in a sustainable way. The use of fishery by- and co-products allows the potential abatement of wastes that otherwise will be discarded, causing nutrient enrichment and water eutrophication. Fishery by- and co-products are an important source of high-added value compounds, however possible risks related to the presence of contaminants must be considered before their utilization.

CONCLUSION

Although the term "Blue Economy" has been used in different ways in this chapter, it has followed the World Bank, United Nations, and European Union understanding, as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable. An essential challenge of the Blue Economy is thus to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries to ecosystem health to pollution. Rethinking innovation for a sustainable ocean economy should encompass a sustainable use of ocean biological resources. The overall message is that: i) measures to reduce discards and postharvest losses should be established; ii) dialogue between the fishing industry and policy makers with the aim of reducing waste in fisheries to zero is of major importance; iii) efficiency of fish value chains to reduce losses and co- and by-products, in an effort to improve access and affordability to all, should be improved; iv) food products from underutilized marine species should be developed. With these action points, the blue economy will create new jobs, achieve a higher rate of growth, reduce poverty, and also secure international biodiversity and sustainability obligations. The creation of new marketable products, processes and services with high technological and innovation content, in addition to promoting intra and multisector cooperation, are central elements of blue growth.

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Chapter 9
Organic Food Production and Consumption Policies and Strategies

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ABSTRACT

This chapter aims to analyze the main factors of the production and consumption of organic products, as well as their policies and strategies. The analysis is based on the premise of the sustainable development of the production, distribution, and consumption systems of organic products that have the potential to improve the quality of life levels of producers, consumers, and society. It is concluded that the production and consumption of organic food is based on a more favorable agriculture of the ecological and the environment, as well as by providing more nutritious and healthy food for consumption.

INTRODUCTION

Current food systems have become highly dependent on oil. Food system emissions from production to consumption, contribute with more than 20% of global greenhouse gas emissions (Vermeulen et al, 2012). Dependence of the food system on fossil fuels has a high environmental impact on human diets. Organic food production is limited by environmental destruction due to the countryside crisis. Agricultural industrial practices degrade food systems with contaminated and poor quality products, with ecological services and ecosystems that worsen the quality of life conditions. In the consumer society in which one lives, consumers who are submissive to advertising and the influence of the media have developed a reduced capacity in making purchase and consumption decisions in such a way that the products acquired to meet the needs, are used and are thrown away.

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Consumerism is expressed in the acquisition of unnecessary and superfluous products, as well as exceeding in the purchase of basic goods, whether basic needs are met. The food called "junk" generates damage to people's health and the environment due to the overexploitation of natural resources and pollution.

Alternative, agro ecological and organic agriculture as ways of life, integrate the traditional knowledge of indigenous peasants with the knowledge derived from the advances and innovations of science and technology to conserve natural resources, improve biodiversity and ecosystems to produce food healthy ones of better nutritional quality, and in a fair working environment (Torres Serrano, 2002). Organic products do not use agrochemicals to generate a self-sustaining production system, which is based on natural inputs and good agro ecological practices. The aim of this sustainable production system is to care for and protect the environment, harvest fresh and process products free of toxic waste.

Agro ecological and organic food production is interconnected and interdependent human, nature and ecological processes more focused on conservation and food affordability. It is possible to feed the growing population taking into account the interactions, interdependencies and feedbacks of the technological, economic, social and environmental dimensions of a sustainable agro ecological systems (de Schutter 2014, The Economics of Ecosystems and Biodiversity TEEB 2015

Organic and agro ecological food are alternatives to those products of large-scale industrialized agricultural origin, they are free of fungicides, pesticides, agrochemicals, herbicides and antibiotics. The responsible consumption of organic food products takes into consideration the environmental impact of the production, distribution processes including logistics and transport, consumption and waste, the ecological footprint of lifestyles and human rights to consumption. The consumption of organic products is a worldwide trend as a result of a change of materialistic values to post-materialists based on a greater interest in improving the quality of life, biodiversity and sustainable environment, personal self-realization, democratic society, inclusion and social justice, etc.

The concept of food justice as an attribute of agro ecology and organic food systems is being used by government agencies, community and social organizations and some academics (Cadieux and Slocum 2015). Food justice movement calls warm about the disparities and dysfunctionalities perpetuated in the dominant and traditional food systems and the alternative agro ecological and organic food systems as well as the disparities that exist from production, distribution and consumption in any food system (Alkon & Agyeman, 2011).

Agro ecological and organic food justice advocates engage in urban agro ecology with the aim of expanding access to healthy food (Rajan & Duncan, 2013; Mares & Alkon, 2011; Reynolds & Cohen, 2016). The agro ecological and organic food justice movement brings awareness on the disparities embedded in any agro ecological and organic food systems, advocates policies, strategies and practices such as place-based projects in urban agro ecology and tries to change the food system through the use of politics to achieve more fair food system (Santo, Palmer, & Kim, 2016).

The sustainable development of the production, distribution and consumption systems of organic products improves the levels of quality of life of producers, consumers and society, by having more favorable agriculture of the ecological and the environment, as well as by providing food more nutritious and healthy for consumption. The sustainable production of organic food products is a function of the recovery, care and conservation of natural resources, biodiversity and the ecosystem.

The concern for sustainable, environmental and ecological development is related to the variables education, income, socio-economic level and occupational prestige, although these relationships are very ambiguous and do not confirm hypotheses of positive association. The relationship between the level of education and the tendency to carry out ecological and environmental actions is in favor of those who have more awareness and availability are those who have a higher level of schooling. The trend in organic food consumption has created a demand for green products that is more related to market segments that have high levels of income and spend less of their income to meet their needs (Gómez, Gómez & Schwentesius, 2002).

Organic food products are associated with natural foods that are produced by traditional and artisanal methods, so they taste better, are more expensive than those produced under industrial agriculture schemes because they are made without dyes, additives, pesticides, fungicides and other chemicals synthetic. However, agro ecology and organic place-based projects have limitations to overcome the structural inequities in the organic food system due to demographic, socioeconomic and political power asymmetries (Broad, 2016).

Organic products are promoted from large trading companies that offer investments and financing to private producers to increase the supply to consumers at the best price and in the required time (Gómez et al., 2000). Organic products go through verification, inspection, certification, and validation processes by international organizations. These actions are not only because they do not use synthetic inputs. The production and consumption of organic food generate trust and affinity towards the care and conservation of biodiversity and natural ecosystems.

ORGANIC PRODUCTION

Each organic product has its own production process which makes it unique (Florencia, 2013). The environmental and health impact of people in the production processes can be reduced with the sustainable consumption of organic products and ecological services taking into account that the critical factor is the natural resources, inputs and energy used. Organic, biological and ecological agricultural production systems use natural inputs and reject synthetic chemical inputs such as fertilizers and fertilizers, pesticides, fungicides, insecticides, seeds and other genetically modified organisms. Organic products are those that use biodegradable natural resources or that are recyclable and reject the use of synthetic chemical inputs.

The development of organic, ecological and biological production systems is based on ecological principles and agro ecological practices aimed at improving the well-being, health and economic and social living conditions of humans, as well as aimed at achieving environmental sustainability. The organic production system is based on the implementation of specific practices and standards applied that are economically efficient, socially inclusive and fair, and ecologically sustainable. Some of the special practices used by organic production systems are the use of compost and green manures, crop rotation, biological control, natural plant repellents, and so on.

The production costs of organic foods are lower than conventional products because their production requires fewer transformation processes. However, they are more expensive in the market due to their quality since their production is based on natural processes and do not require pesticides and fertilizers.

The agro ecological revolution in Latin America (Altieri & Toledo, 2011) is concerned with issues of agro ecology-based agricultural production, food sovereignty, agro exports and biofuels expansion. The development of production systems for organic agriculture in Mexico is driven by Mexican producers that serve the national market and with the support of foreign agents to meet the demand in the global markets for tropical and organic agro products and tropical and winter season. Green, agro ecological, organic, biological and ecological products that are destined for local consumption have the opportunity of the existing demand in the food market.

Foreign food producers in Mexico have taken advantage of the availability of abundant raw material at very low costs. Besides, they have received many benefits that have allowed them to enter the market with the production of altered foods. Mexican producers use their resources, with the support of State programs and with the experience of international agents and producers. Organic agriculture in Mexico is linked to the poorest rural sectors, one of them being indigenous groups. In Mexico, the organic food and product sectors are growing, with exports to the markets of the United States and the European Union. The potential for organic food production in Mexico is 169 thousand hectares (SAGARPA, 2015). SAGARPA has implemented the Organic Seal as a certification mechanism that gives certainty and added value to production.

CONSUMPTION OF ORGANIC PRODUCTS

Food-based on organic products is adopted as a healthy and nutritional lifestyle from childhood and later at any stage of people's lives when they need to improve their diet due to health problems. The food consumer chooses goods with import and transgenic origin, which result in an increase in obesity rates. This situation has compromised a social health problem and other food problems that affect people's health. Among the different consumption options available, there are those of organic products that reduce the damage and harm to the environment during its life cycle (Calomarde, 2000).

The needs, tastes and fears of consumers create demand for organic products and structure food production systems (Bueno Castellanos & Ayora Díaz, 2010). The demand for organic products and ecological services expands in the markets with the development of organic and agro-ecological agriculture.

The trend of sustainable consumption based on organic products is increasing because industrial production of food contain synthetic chemicals such as pesticides, herbicides, pesticides, fungicides and genetically modified organisms that cause harmful damage to health and result in consumer diseases and that pollute the environment. Organic products go through verification, inspection, certification, and validation processes by international organizations and not only because they do not use synthetic inputs.

Green food consumption is a marketing trend that focuses on actions of purchasing and consumption processes that are intended to take care of the environment. Organic foods are sustainable because they do not contaminate and care for the elements of nature with agrochemicals. The consumption of sustainable organic products is the result of a motivation based on the construction of emotional bonds of consumers towards the elements of nature. The amount of energy and resources used is the critical factor in the sustainable consumption of an organic product because it helps reduce the environmental impact.

Sustainable consumer behavior tends to reduce the use and consumption of natural resources, toxic and polluting materials and supplies. The emissions of organic and inorganic waste have implications on the satisfaction needs of future generations. The behavior of the buyer and sustainable consumer of organic products and ecological services to satisfy not only their basic needs, but also to avoid fears and fulfil the satisfaction by improving health and quality of life conditions.

Some of the factors and reasons that influence the behavior of the buyer and the consumer for the consumption of food products are considered on the desired to have a new lifestyle. This new lifestyle is defined by the satisfiers who acquire, consume and use, sustained by the biodiversity and ecosystems with the support of producers and consumers. The model of lifestyle dimensions tries to explain that consumers of organic products receive a higher income, have a profile with tendencies to be prone to behaviors related to exercising and caring for the environment.

The distrust of consumers to organic products increases the uncertainty and complexity of the processes of production, distribution and commercialization of the food system in the places of acquisition. However, many of the consumers do not know or they cannot distinguish the labels of products that are organic, do not find the advantages of organic products over conventional ones, or they do not trust them (MAPAMA, 2016, a, b). Therefore, organic food products are not the most consumed due to reasons such as ignorance, expensive prices, and difficulties in finding them.

Consumption of food made from organic products is not exposed to foods that are chemically altered as in the nutritional trends of vegetarianism and veganism. Veganism and vegetarianism are food trends based on habits of eating healthy foods free of pesticides, fungicides, synthetic chemicals and no animal-derived supplies. The purchase processes for the consumption of organic products take into account environmental and health factors as the basis of healthy and sustainable consumption.

The consumption of organic products is related to lifestyles with an ecological and sustainable orientation and awareness based on reflexive knowledge and environmental practices associated with attitudes and other psychological variables. Although the consumer adapts to their food needs, however, it is increasingly demanding because it has the potential to improve their satisfaction according to their demand levels. Therefore, producers and distributors need to focus on offering higher quality organic products, with better presentation, information and adaptation to the needs and requirements of the consumer (MAPAMA, 2016, a, b).

The consumption of organic products drives local and regional economies. In addition, they are being characterized by being responsible and supportive. Solidarity consumption takes into account labor conditions and the fair price of the processes of production, distribution and consumption of the product. Economic factors influence the decision to purchase organic food products from consumers by purchasing power considering that prices are higher than conventional products. Among the economic factors that influence consumer behavior are the economic environment, the price conditions, purchasing power, salaries, cost of capital, availability of money and credit, supply, demand and inventory levels of agro ecological and organic products that have an impact directly in purchasing decisions (Di Sante Villa, 2009).

The decision to buy these products depends on the purchasing capacity. In this sense, organic products are considered as aspirational and belonging, passing first the needs of health, care and protection of the environment, promotion of artisanal production, etc. Urban agro ecology contributes to develop skills and capacity building and education of participants who learn about the natural environment in cultivating organic food (Okvat & Zautra, 2011). Urban agro ecology for food production in urban spaces restrained by environmental conditions, represents a challenge for innovation, such as intensified technologies for plant growing, use of soilless for production such as idle and underutilized land, roofs, walls, vacant lots, brownfields, underground under artificial lighting (Solon, 2014; Osborne, 2015; Opitz et al., 2016; Mok et al., 2014).

The fair price for organic food producers seeks to obtain fair profits from the sale of their crops to market intermediaries (UNEP, 2011). Organic food goods tend to have a higher price than conventional products, which are not necessarily self-sustaining or supportive. Fairtrade is a movement that aims to promote responsible consumption by giving producers direct access to markets to reduce poverty. Fairtrade and solidarity consumption promote equality among all agents in the production-consumption chain.

The small producers of the South and South Coast of Jalisco have developed models of agricultural production and organic beekeeping and marketing for solidarity markets. These model have a strong focus on sustainable development that benefits local economies. Producers have full awareness of the care and conservation of natural resources under a holistic conception by using organic farming techniques (González & Nigh, 2005).

The care of the environment is a demanded norm that is socially accepted as necessary and explains the ecological behavior of people. Concerned about the increasing ecological degradation of the environment, some consumer segments show a buying and consuming behavior of organic products and foods that contribute to improving their health and reducing the negative impact on ecosystem degradation. The consumption of organic food products is currently concentrated only in some segments of the market that have the profile of being more demanding in quality, who know the origin, content and the benefits they provide. Market factors are price, product, logistics and distribution, and promotion and communication. These consumers are of the high level of education and with high income and are willing to pay a more expensive price than normal to acquire the satisfactory goods.

Consumer behavior is the process of selection, purchase, use and disposal of products and services, ideas and experiences that meet the needs and desires of consumers (Solomon, 2008). Consumer behavior is defined as the process and activities in which individuals participate to search, choose, select, buy, use, evaluate, acquire and dispose products and services meeting their needs and desires (Belch & Belch, 2008). Consumer behavior tries to investigate the reasons why consumers buy, use or give away what, how, where, when, how much, how often, for how long (Hoyer, 2010).

In consumer behavior, the consumer manifests itself as a set of multiple independent factors that interrelate with each other. The behavior of consumers or users results from stimuli, ideas, motivations, experiences, needs, desires and fears that are influenced by both internal and external factors. The consumer decision-making process occurs with the influence of the underlying economic, social, cultural, individual and psychological factors from the moment of the perception of previous stimuli to post-purchase behaviors (Lamb, Hair, & McDaniel, 2011).

The psychological factors that influence the behavior of the consumer of organic products when making purchasing decisions are based on tools that recognize the needs, perception, motivations, attitudes, desires, fears, beliefs, learning, feelings, habits, decisions, etc., to gather information required in the decision-making processes.

Motivation is an internal driving force of the person that occurs in a tension pushing the action to meet the needs (Schiffman & Kanuk, 2001). The motivation of people is the strength to obtain biological, economic and social survival objectives. Freud assumes that people are not aware of psychological forces and repress their impulses in their human development.

In the theory of learning, the behaviorist is based on the association of Aristotle and the empirical theory of Hume who argues that knowledge is constituted of impressions or data received through the senses and ideas that are copies in the mind of impressions (Rodríguez Garrido & Larios de Rodríguez, 2006). Behaviorism is interested in objective explanations based on observable behaviors and based on the stimulus-response association without taking into account the will of the subject.

Cognitive theory, as a response to behaviorism, explains higher mental processes such as cognition when the subject that interacts with the environment generates responses.

Human behavior is caused by cultural values, desires, etc., acquired through family and social institutions. Every culture has as defining elements its socially shared values and beliefs in an enduring way. It is difficult to change or modify cultural values and shared beliefs, considering that the person internalizes them since he learns them, and adopts them because he grows with them. This is the case of the cultural values of the Mexican inserted in its idiosyncrasy. The experiences that individuals have are reaffirming or modifying their personality characteristics.

The social factors that influence the purchasing and consumption decision-making processes are those with which individuals interact informally or formally such as family, school, religious groups, aspiration and reference groups, opinion leaders, etc.

Some of the variables of the buyer behavior and the ecological consumer that influence the decision-making processes of purchase and consumption of organic foods are the values, attitudes, beliefs, motivations, as well as socio-demographic and educational variables. Besides, among other factors that influence the behavior of the consumer of organic foods are the price, quality, flavor, health benefits, freshness, frequency of consumption, brand, purchasing power and purchasing power, gender, age, etc.

People's age correlates positively with ecological awareness, environmental concern and the consumption of organic products. In terms of gender, it is women who are most aware as consumers of the benefits of organic food, are consistent and participate intensively in ecological activities and environmental prevention. Therefore, the degree of schooling of buyers and consumers has a significant positive effect on the sustainable consumption of organic foods.

The behavior of consumers and buyers in their decision-making processes on organic products are influenced by internal factors that come from individual needs, tastes and fears, which are interpreted according to external stimuli and according to the psychological structure and Personal characteristics. Needs, desires and fears are personal factors that motivate the will of individuals to make purchasing decisions and consume satisfactory, mediated by personal characteristics such as personality traits, gender, age, educational level, profession, maturity level, people's lifestyle, etc. (Rodriguez Ardura, 2006).

The ecological concern and awareness of respect and care for the environment are motivated by the satisfaction of more universal individual and collective needs that go beyond basic and survival needs.

Variables that have influence, such as health, price, quality, available information on customer specifications, product presentation, socio-economic factors, etc., enter into consumer decision-making processes. The specifications of organic products and foods usually are very poor in terms of satisfaction of needs, the fulfillment of wishes, avoidance of fears, perception of health benefits and environmental impact, so more information is required.

Making simple or complex decisions to buy and consume ecological or organic satisfiers depends on their commitment to potential solutions, whether they are at the level of survival or at their most complex level of self-realization (Rivas & Grande, 2013). Depending on the level of complexity is the information necessary for the evaluation of alternatives. Buyers seek congruence with their perceptions, their information, their opinions and attitudes to justify their purchase decision decisions, as a result of complex interactions of psychological, social, cultural factors, etc.

Health and socio-demographic variables are two relevant factors in decision-making processes of organic food in the behavior buyers and consumers. The personal characteristics that influence and have direct effects on the ecological behavior of people and their decision-making processes for the purchase and consumption of organic products correspond to the sociodemographic variables. When consumers know what their specific need to feed with organic food is, they get involved in a decision that has a limited solution due to the different influential factors, such as health, support for local producers, commitment to care and protection of the environment, etc.

The purchase and consumption of organic food products show a consumer behavior that has a willingness to pay a higher price than the common products, some called scrap, which are of a more industrial agricultural production. The production of organic products and food for local consumption adjusts its price to offer an affordable price according to the conditions of the consumers.

When the consumer is involved in several purchase decisions simultaneously, the result of one decision can affect the others at the different stages of the process, whether is due to external influences in their entry phase, or to a process in decision making and behavior after the decision (Schiffman & Kanuk, 2001).

The processes of buyer and consumer behaviors in the decision making of organic products and ecological services, show discrepancies in factors such as awareness, ecological concerns and buying actions. Consumer behavior is guided by goals and purposes.

People's reality is based on differences in personality, motives, experiences, interests, level of influence, etc., factors that determine the purchase and consumption decisions of organic satisfiers. Some of these situational factors are the physical environment, the social environment and the definition of tasks in which the purchase and consumption activities are carried out. Among the physical aspects of the environment, the location and environment of the establishment, density of consumers, etc. In the social environment, aspects such as communication and social motivation of purchase are considered. In the definition of tasks, the reasons for purchase and consumption, purpose and purchase process, etc. are considered.

The purchase factors induce an individual to acquire a specific organic product in the purchase decision and make it essential in the cupboards by creating dependency with the fulfilment of the expectations. Satisfiers are accepted or rejected based on what consumers perceive as relevant to meet their needs, desires and lifestyles (Blackwell, Miniard, & Engel, 2002).

POLICIES AND STRATEGIES

Food may be a source of unsustainability due to how metabolism is satisfied and the impact it has on total energy consumption. This makes sustainable decline a priority as a strategy for the production, distribution of organic food and responsible consumption (Infante & González De Molina, 2010; González de Molina, & Simón Fernández, 2010; González de Molina, 2010, 2009). Organic production is a strategy to reduce the environmental impacts of industrial agriculture, such as the green revolution, dependent on synthetic inputs, to provide a healthy and nutritious diet that the population needs. Consumers of food products show different behaviors according to their motivations, age, income, gender, educational level, needs and tastes, etc., that influence their choices of goods and services.

The strategy of information, communication and promotion of organic food products must identify the corporate image of environmental and ecological responsibility, in addition to promoting ecological lifestyles with the emotional component that provides the benefits of taking care of good health and the quality of ecological services It provides the enjoyment and beauty of the environment.

The strategies of ecological communication and green marketing of products and sustainable organic foods also show discrepancies between producers, distributors and marketers to motivate and influence the decision processes of buyers and consumers. Ecological promotion strategies for organic green food products refer to well-being, health, nature and the environment because they contain no toxic substances.

The promotional activities strategy that considers advertising and public relations activities of organic food products must present the characteristics, and benefits provided by satisfiers, organic products or ecological services about the nature and the environment.

Local governments do not have or have deficiencies in regulations, policies and strategies for the development of organic agriculture and agro ecology that have increased due to the growing demand for organic products in international markets. State institutions must formulate and implement policies and regulatory regulations that support and encourage the efforts of producers and motivate consumers of organic products and ecological services. The agricultural sector of organic food products must be supported by public policies, regulations and strategies that enhance their sustainable development in terms of food safety, health, education, employment, foreign exchange, etc. Urban food strategies and policies are related to the new governance mechanisms that involves civil society (Blay-Palmer, 2017, FAO 2011; Viljoen and Wiskerke, 2012).

The implementation of public policies and environmental regulations to encourage the sustainable consumption of organic food products and ecological services that motivate and regulate the behavioral processes of decision-making is a priority of government institutions to improve health and food systems of people and care for and preserve nature, the environment and ecosystems. The lack of functional policies and strategies regarding the production, distribution and consumption of organic products for the attention and satisfaction of domestic demand will continue to be produced for international markets.

The increase and diversification of organic food products supply is a necessary strategy to strengthen production, distribution and consumption, as well as supply for the growing demand for vegetables, tropical fruits, cocoa, coffee, etc. Consumers of organic foods are more selective and demanding because they are better informed to choose about satisfiers and make purchasing decisions most efficiently, minimizing time and effort, so that the relation of quality-price variables is decisive. Producers and distributors formulate and implement their strategies according to the assumptions described (Buil Carrasco, Martinez Salinas, & Montaner Gutierrez, 2017).

The regulations and public policies on the production, distribution and consumption of organic products must be guided by growth and economic efficiency, social equality and inclusion, environmental sustainability, but above all to improve people's nutrition, health and well-being.

CONCLUSION

The dismantling of the industrial agro-food complex has been replaced by the restoration of local agro ecological alternatives that oppose corporate control over production and consumption and support for local producers to create local food systems. The sustainable production and consumption of organic food products is a function of the recovery, care and conservation of natural resources, biodiversity in the ecosystem. There is a growing consumer interest in local organic food grown agro ecologically by farmers with whom consumers can interact.

Urban agro ecology is interested in the production of healthy foods, taking care from the cultivation of the land to the supply and consumption of urban agro ecological foods. Converting land to urban agro ecology leads to community food security and self-sufficiency in any city (Colasanti, 2010) although urban agro ecology farming has limits to supply adequate organic food for the city (Thibert, 2012). Urban agro ecology may be a mean of food production within the city for greater environmental sustainability while the consumption of fresh vegetables and fruits reduces dependence on external resources and imports from rural areas, making them less vulnerable to the food crisis.

Interactions between producers and consumers participating in food networks with channels and learning contents, contribute to learn about agro ecological production and ecology. Agro ecological producers must establish minimum requirements to enter formal markets and be recognized through development and capacity building and the development of inclusive and participatory methods to create and guarantee organic products.

The emerging policy of the food system is disconnected from the ethical values of the sustainable environment, access to land, production, distribution and consumption, incorporating commercialized versions of urban agro ecological practices and avoiding socio-environmental exclusion.

A government's double policy design can encourage and stimulate agro ecological production by offering some fiscal incentives while increasing the price of agro ecological and organic products above the market average without excluding the poor people by providing special access. In this sense, the dual agro ecological policy approach can provide economic support for production while protecting access to food consumption for the most vulnerable people. The beneficiaries of organic food production can be entitling to incentives that may be the land private property owners who get lower taxes and not the disadvantaged communities who experience inequities in food security (Havens & Roman-Alcalá, 2016).

Urban agro ecology has the ability to contribute to food security for any household in any city depending on land available, climate and skills of farmers (Grewal & Grewal, 2012). Urban agro ecology cultivation increases food access and food security to all household of participants, practitioners, consumers and recipients (Algert, Baameur, & Renvall, 2014). Critics argue that urban agro ecology as strategy is limited to increase food security if the consumers lack access to land, physical capacities and skills needed in these activities (Ghose & Pettygrove, 2014). The export costs of agro-ecological products increase creating tensions in production prices for the domestic consumer market and to achieve self-sufficiency with the consequent worsening of living conditions.

Promoting agro ecological food systems requires the agreement and participation of agent´s ties to collaborate with the networks of all stakeholders, landowners, farmers, producers, consumers, market organizations, communities, civil society, non-governmental organizations, companies, institutions public, research institutions, universities. etc.

The establishment of localized resilient agro ecological food systems jointly with circular economy production and consumption models in local economies should be promoted by ecological units of local governments.

Urban agro ecology contributes to healthier and more sustainable living conditions of farmers and consumers involved in land-based activities. Urban agro ecology also contributes to better food sovereignty and sustainability based on economic, social, political and environmental dimensions. To implement an agro ecological food system, the state, social, private actors and academic and research institutions must be proactive.

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KEY TERMS AND DEFINITIONS

Agro Ecology: It is the discipline that is responsible for managing the ecological principles of the production of food, fuel, fiber and pharmaceutical products. This encompasses a wide range of approaches and they consider it a science and a way of looking at life, whether organic, conventional, intensive or extensive.

Consumption: It is the action of using and/or spending a product, a good or service to meet both primary and secondary human needs.

Organic Food: Are those that do not involve chemical substances in their production process such as pesticides, herbicides or fertilizers.

Policy: Is an activity oriented ideologically to the decision-making of a group to achieve certain objectives.

Production: The process of manufacturing, elaborating or obtaining products or services.

Strategy: It is a plan that specifies a series of steps or nuclear concepts that allow the use of available resources and that are aimed at achieving a certain objective.

Sustainable Consumption: Refers to the use of goods and services in a responsible way to minimize the use of natural resources.

Chapter 10
Sustainability Report Evolution:
The Nestlé Case Study Applicability

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ABSTRACT

This chapter is a unique case study that aims to present the evolution of non-financial reporting in Nestlé Portugal from 2007 to 2016 with the aim to study in-depth the Nestlé sustainability report practices. This study proposes to identify the key milestones in the evolution of this type of report, to compare with the disclosure strategy of Nestlé international, to understand if this company follow the IIRC guidelines, to identify the contribution of the audit by an independent entity, to conclude if Nestlé contributes to the achieving of United Nations Sustainable Development Goals, and to identify if the awards Nestlé received matter in its sustainability initiatives. Public institutional information was preferably used, particularly the sustainability report and integrated report, processed with various work tools using the technique of content analysis. The conclusions made it possible to understand that Nestlé emerges as a company that integrates these issues into its strategy and can be a model for companies that wish to follow this report path towards sustainability.

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INTRODUCTION

In recent years, the use of terms such as ‘sustainability’, ‘sustainable development’, ‘corporate sustainability’ and ‘shared value creation’ has become increasingly common, as they have become important concepts in political and economic agendas.

Sustainability Reports and Integrated Reports have become quite common and a widespread practice both in larger companies as well in medium and smaller firms. With the publication of the Brundtland Report in 1987, and subsequent United Nations-sponsored summits of Rio de Janeiro and Johannesburg, they have definitely contributed to fostering a shared awareness of the need to “reflect deeply on the ways in which society can contribute to social welfare without threatening the survival of the earth” (Moneva, et al., 2006, p. 123).

While “sustainability” and “sustainable development” are increasingly gaining attention from individuals, businesses, NGOs and governments, there has been and still is some misunderstandings, as well as a considerable controversy of what “sustainable development” truly means and how it is implemented (Russel and Thomson, 2009; Moneva et al., 2006).

Some authors consider sustainability as a condition and sustainable development as a process by which human activity moves towards sustainability (Bebbington and Gray, 2001). Others use the terms “sustainability” and “sustainable development” indifferently. (Moneva, et al., 2006).

Gray (1991) addresses sustainability and what it really is. In a simple way, he explains the depreciation process in accounting to the sustainable process in business and claims that sustainability means taking out an income which leaves the capital intact. He refers the importance of the Elkington and Bruke (1989) book: “The green capitalists: how industry can make money and protect the environment”. These authors show how major international companies match environmental concern and commercial performance improvement. The book outlines ten steps that all businesses can undertake to turn environmental problems into profits. These insights can help modern businessmen.

One of the important issues to be addressed is a definition of sustainability reporting and its interrelation with existing frameworks of financial reporting. The concept of sustainability accounting and reporting has been emerging over the last forty years. Therefore, it is a broad view of research on the topic. According to The United Nations Conference on Trade and Development (UNCTAD) (2015) a sustainability reporting should cover economic, environmental, social and governance performance and its impact on society. Furthermore, the UNCTAD claims that “despite an ongoing discussion about the specific details of sustainability reporting, there is a common understanding that this type of reporting refers to the procedure of quantifying and disclosing sustainability information in the annual report or in a separate document.” (p.5). Global Reporting Initiative (GRI) published standards to help companies to report a sustainability report. More recently, the International Integrated Reporting Council (IIRC) disclosed a framework with guidelines to disclosure an integrated report (that also refer the GRI guidelines). So, both organizations have contributed to the companies’ non-financial report.

According to the KPMG (2017) the majority of N100 (74 percent) and G250 companies (89 percent) are using guidance or frameworks for their reporting. The GRI framework is the most used, with 63 percent of N100 reports and 75 percent of G250 reports applying it. This report also refers that the vast majority (78 percent) of the world’s top companies now report non-financial information. The third-party assurance of their Corporate Responsibility reporting has grown steadily since 2005. Assurance to this kind of reports represents now more than two thirds (67 percent) of the top companies.

The turn of the century was interpreted by the United Nations (UN) as a unique and symbolic moment to articulate a new impetus for the Organization. In September 2000, Heads of State and Government, met at Summit level, and approved the Millennium Declaration. The Section III of this Declaration focuses on the "Development and Poverty Eradication" and was the main reference document of the Millennium Development Goals (MDGs). The goals constitute a partnership between developed and developing countries to create a climate at both national and global levels that will lead to development and poverty alleviation[1]. The goals set were: "Eradicate extreme poverty and hunger; Achieve universal primary education; Promote gender equality and empower women; Reduce child mortality; Improve maternal health; Combat HIV/AIDS, malaria and other diseases; Ensure environmental sustainability; and Develop a global partnership for development, according to United Nations Development Programme[2]". The UN launched the challenge to companies to integrate the Sustainable Development Goals (SDG) in their reports (UNCTAD, 2015).

Concurrent with the sustainability reporting topic, the current research analyses the Nestlé company and its non-financial report evolution. Food companies, such as Nestlé, has in its portfolio products that integrate several business areas, such as child nutrition, coffee and instantaneous drinks, chocolates, breakfast cereals, clinical nutrition, ice cream as well as pet food. So, they must deal with scrutiny and social pressure constantly, as they operate in a sensitive environmental and social industry.

Based on the analysis of Nestlé Sustainability Reports, i.e. which are referred to as the "Shared Value Creation Reports", this study aims to identify, the strategies used by Nestlé Portugal over time, and to present its sustainability performance through the non-financial report. As it matters to understand the reporting evolution, the period covered is from 2007 to 2016.

Nestlé Portugal was selected for the study because it is a company that benchmarks Sustainability as an integrating factor of its development strategy, presenting itself as a driving force for sustainable development and interested in fostering it in its business partners, competitors and in the market in general. In addition, as a leading company in the markets where it operates, it is submitted to pressures from the media and the general public for its large exposure.

So, this paper is a unique case study that aims to present the evolution of non-financial reporting in Nestlé Portugal, from 2007 to 2016, based on the Nestlé sustainability report practices. This study proposes to: a) identify the key milestones in the evolution of this type of report; b) to compare with the disclosure strategy of Nestlé international; c) to understand if this company follows the IIRC guidelines; d) to identify the contribution of the audit by an independent entity; e) to analyse whether Nestlé contributes to the achieving of the United Nations Sustainable Development Goals, and f) to recognise if the Nestlé awards received, contribute to the development of its sustainability initiatives.

This article is organized as follows. It starts with an introduction to the topic. Then previous research is explored and outlined to bring to light the gap in the literature and the contribution to the knowledge of this research. In section 3 the methodology is catered, explaining how the data were collected and analysed, and a presentation of the company under scrutiny is also provided. In section 4, the results obtained in the empirical study of Nestlé Portugal are presented and discussed. At last, the conclusions are provided as well as the limitations and opportunities for future research.

SUSTAINABILITY REPORT OVERVIEW IN COMPANIES

Several authors refer the need to continue exploring the non-financial dimension, allied to the company's sustainability. Eugénio et al. (2010), states that the social and environmental accounting report is still in its "infancy"/ early stages, when compared to the financial report. In this regard, some studies attempted to contribute to the knowledge by characterizing non-financial information disclosure practices in an industry based on their sustainability reports (Eugénio et al., 2013). The construction sector was analysed in Portugal and Spain (Caetano and Eugénio, 2015).

Branco et al., (2014) analysed rated companies. They concluded that rated companies showed more stability in sustainability reporting and auditing. Carreira and Palma (2012) analysed the non-financial report in preparation for its verification by an independent entity.

O'Dwyer and Unerman (2016) recommend a cumulative theorizing of "accounting in action" within the framework of representing social sustainability in a wider variety of contexts. They further state that organizations and societies can continually improve by creating the development of research projects in the area of social sustainability accounting.

Mata et al. (2018) bring a state of the art of the research in environmental reporting. This study presents a literature review of environmental reports based on papers published in 20 accounting journals between 2006 and 2015 and contributes to the reflection of the state of the art of research in social and environmental accounting. Dumay et al. (2016) presents a structured literature review about integrated report. This study reviews the field of integrated reporting to develop insights into how IR research is developing. It offers a critique of the research to date and outlines future research opportunities.

Other studies refer the importance of Sustainability Development Goals (SDG) in business arena. For example, Bebbington and Unerman, (2018), elucidate the roles that accounting can play in achievement of the SDGs. They explore "the leadership role that elements of the business world and accounting profession are playing with respect to the SDGs. Beyond business and the profession, it also examines how existing research in social, environmental and sustainable development accounting could inform accounting research relevant to SDGs, and the knowledge and skills of accountants in enabling areas of measurement, reporting and performance management." Bebbington and Unerman, (2018, p. 8).

Intergovernmental Working Group of Experts on International Standards of Accounting and Reporting (ISAR) has agreed that one agenda item of its thirty-second session will deal with good practices on enhancing the role of corporate reporting in attaining the SDGs. So, in 2015 they published the document: "Review of good practices on enhancing the role of corporate reporting in attaining sustainable development goals", which stood out as an important milestone to all countries in general and companies in particular, because it brings to the business arena the urgency of companies to work together to achieve the SDGs. It is also emphasised by the UNCTAD (2015, p. 1) that "Corporate reporting can play a key role in attaining the sustainable development goals (SDGs) as high quality and internationally comparable reporting contributes to financial stability, promotes good governance, as well as socially and environmentally responsible practices – which are key to sustainable development. Being a principal source of information on companies' performance, it can also serve as an important part of the SDGs monitoring and review mechanism."

As reported by Waal and Thijssens (2020), the Sustainable Development Goals (SDG) stresses the necessity of private businesses' active participation, appealing for their creativity and innovation to create value for the common good, such as reducing poverty, eradicating hunger, and protecting biodiversity. While currently some, especially recently formed private businesses, may consider the common good as their main business goal, most existing stock-listed businesses clearly do not. This study aims to map the undiscovered terrain of corporate SDG involvement as emanating from the sustainability reports of the 2000 largest stock listed businesses worldwide. It attempts to understand the Nestlé involvement with the SDGs.

As stated in Mata et al. (2018), several authors have examined sustainability disclosure and reporting practices and concluded that researchers had different aims. Some have analysed the extension and nature of practices of environmental reporting before and after the introduction of the legal standards (Frost, 2007). Others have used content analysis of sustainability reports (Cho et al., 2015). Others have compared reports (Bebbington et al., 2012). Some have analysed the certification of climate alterations (Aguiar and Bebbington, 2014); others have analysed the effect of environmental report certification (Edgley et al., 2010). Other authors have attempted to understand the environmental reporting practices of governmental departments (Lynch, 2010); some have examined report strategies of an industrial sector (Cuganesan et al., 2010); and some others have analysed the interaction between the Social Environmental Reporting of a company and external institutional pressures (Laine, 2009).

Table 1 summarises and presents the topics analysed in each study (classification proposed by the author) and the various authors who addressed them. Their analysis aims to contribute to the theoretical background and complement the written demonstration of the different concepts covered, such as reporting, sustainability, environmental accounting, sustainability reporting, integrated reporting, Global Reporting Initiative (GRI), and auditing. The concepts covered and selected to answer the current study research questions were: Reporting; Sustainability; Environmental and Social Accounting; Sustainability Report; Integrated Reporting; GRI; Audit.

Some researchers have analysed sustainability report at Nestlé. The following section describes it.

Table 1. Topics addressed by the various authors

Topic	References
Reporting	*Carreira e Palma (2012); O'Dwyer (2005);*
Sustainability	*Carreira e Palma (2012); O'Dwyer e Unerman (2016); Bebbington et al. (2017); Eugénio et al. (2013); Casca et al. (2017); Eugénio et al. (2015); Zaro et al. (2013); Prado et al. (2011); Larrinaga and Bebbington (2001); O'Dwyer (2005).*
Environmental and Social Accouting	*O'Dwyer e Unerman (2016); Bebbington et al. (2017); O'Dwyer (2005); Casca et al. (2017); Mata et al. (2018); Eugénio (2007); Eugénio et al. (2010); Gonzalez e Bebbington (2001).*
Sustainability Report	*Carreira e Palma (2012); Branco et al. (2014); Eugénio et al. (2013); Eugénio et al. (2015); Zaro et al. (2013); Campos et al. (2013); Caetano e Eugénio (2015); Mata et al. (2017); Barcellos et al. (2016); Nagano et al. (2013); Santos (2010).*
Integrated Reporting	*Mio et al. (2016); Dumay et al. (2016); Perego et al. (2016); Burke e Clark (2016); Zaro et al. (2013); Rodrigues et al. (2016); Evangelista et al. (2017); Barcellos et al. (2016); Fragalli et al. (2016); Nagano et al. (2013).*
GRI	*Dumay et al. (2016); Eugénio et al. (2013); Campos et al. (2013); Caetano e Eugénio (2015); Santos (2010).*
Audit	*Branco et al. (2014); Rodrigues et al. (2016); Figueiredo (2013); Gomes (2014); Nagano et al. (2013).*

Source: Authors' own research

Sustainability Report and Nestlé

In this research topic, Nestlé, as a big company with singular characteristics, was the target of different case studies during the last decade. Milne and Gray (2008) presented a report showing the International trends in corporate 'sustainability' reporting, in 2008. The different sectors (public, private and non-governmental organizations) try to be involved in the sustainability debate. Crespy and Miller (2011) refers that especially the NGO sector, increasingly demands a larger role in designing, developing, and implementing sustainability programs. This study compares two organizational types (Corporations and NGOs) regarding their commitment to sustainable development. One of the corporations chosen was Nestlé.

Gazzola et al. (2019) suggested that sustainability reporting offers a number of financial and social advantages, including social impact that builds trust towards the idea of civil society and its funders. Their aim was to analyse the growing social trends of sustainability reporting practices in non-governmental organisations (NGOs). Gazzola's study was about Nestlé case scandal and how Nestlé dealt with a social media campaign against it, regarding to Kit Kat brand (in Ionescu-Somers and Enders, 2012).

Some studies on sustainability report or strategies chose Nestle Company for their sample: for example, Jones et al. (2015) provided an exploratory review of the extent to which some of the leading companies in the food and drinks industry are publicly addressing water stewardship as part of their corporate sustainability strategies. In this study it is possible to understand the Nestlé Strategy for water stewarding. Narazaki et al. (2018), presented a case study on Nespresso, and investigated their strategy of developing an innovative recyclable aluminum coffee capsule, and a closed-loop recycling process, with the purpose of meeting the Triple Bottom Line. Nisa (2015) identified five important components: economic, social, environmental, holistic and business/commercial characteristics to analyse the Sustainability Business Model (SBM) of the selected companies. Nestlé was one of the sixty selected companies. Other researchers have also studied the Nestlé Company (Milne and Gray, 2013; Morros, 2016 and Corporate Citizen Magazine, 2014).

THE RESEARCH STRATEGY

There is a large amount of studies that used the case study as a research methodology (as Larrinaga and Bebbington, 2001; Eugénio et al., 2013; O'Dwyer, 2005). Qualitative case study research can be a valuable tool for answering complex, real-world questions, as they allow an in-depth explanation of a social behaviour. The present study adopts the qualitative methodology of a case study (Yin, 1984, 1994), using the technique of content analysis to secondary data. This case study is explanatory as it intends to analyse and explain the reporting practices of Nestlé Portugal. Best practices identified as successful practices in the company, were described. This is a longitudinal study. Data from Nestlé Portugal were collected and analysed from 2007 to 2016.

3.1. The Nestlé Company and the Data Collection Process

Nestlé is one of the world's largest food and beverage companies, with more than 2000 global and local brands, in 191 countries and which has been guiding its business with well-defined global ambitions for sustainability. Nestlé Portugal had 2100 employees in 2019 from 39 nationalities and a net income of 24.162.908 euros[3].

In 2010, Nestlé presents a set of values that are reflected in the way they do business, i.e. always acting legally and honestly with respect for their workers and their business partners. These values are transcribed in a public document entitled: Corporate Business Principles.

Creating Shared Value is the key approach to do business. It means that in order to create long-term value for shareholders, they must also create value for society. However, they cannot be environmentally sustainable, nor can they create shared value for shareholders and society if they do not comply with their Business Principles.

Nestlé fully believes that in order to be successful in the long term, it must generate value for its shareholders and, at the same time, for the communities within which it operates, as well as for society. This is what Nestlé calls Shared Value Creation. In analysing its complete value chain, we have identified three focus areas where Nestlé can optimize this Shared Value Creation: Water, Nutrition and Rural Development.

Given this statement of strategy and Nestlé's concern for sustainability, it is considered that the vital conditions are met to create a determined curiosity to enhance knowledge about Nestlé and its business, endeavouring towards a well-founded and grounded strategy for action that their Corporate Principles Businesses clearly identify.

As previously mentioned, Nestlé Portugal was selected for this study because it is a company that benchmarks Sustainability as an integrating factor of its development strategy, presenting itself as a driving force for sustainable development and interested in fostering it in its business partners, competitors and in the market in general.

Contacts with Nestlé Portugal were made, guiding the researchers to the documentary information on the company website - http://www.nestle.com. Nestlé's website is very rich in information on the topics under study, so the information screening and the analysis was made from reports, press releases, newsletters, testimonials, among others on the website.

The Research Objectives and the Research Questions

The purpose of this study is to analyse the evolution of non-financial reporting at Nestlé Portugal from 2007 to 2016. This is a 10-year timeframe in which non-financial reporting at Nestlé Portugal is expected to have evolved significantly, namely, the Sustainability Report and the Integrated Report.

This study proposes to answer to the following research questions, grounded in the literature review:

RQ1: What are the key milestones in the evolution of Nestlé's non-financial reporting since 2007?
RQ2: Does Nestlé Portugal have a disclosure strategy consistent with Nestlé International?
RQ3: Does Nestlé Portugal's reports follow the IIRC Framework?
RQ4: Are Nestlé Portugal's non-financial reports audited by an independent entity? If so, what is the contribution of this audit to the evolution of the report?
RQ5: As Nestlé is a company dedicated to sustainability disclosure, is there openness to align the Millennium Development Goals and the Sustainable Development Goals with its strategy?
RQ6: How do the awards Nestlé received matter in its sustainability initiatives?

Data Analysis

In a first phase evidence was gathered from Nestlé's texts and documents as annual reports, sustainability reports, integrated reports, press releases, newsletters, among others, to gain a thorough understanding of the company, including its integration in the political, social and economic context.

Thereafter, the collected evidence was systematically evaluated to identify patterns in the evolution of Nestlé's non-financial reporting. Careful and attentive reading of the various reports was performed of all the sustainability reports, from which key information was obtained for the discussion of the results. The company first published a sustainability report in 2007, which is why the review period starts this year. It was not possible to obtain Nestlé Portugal's Shared Value Creation Report of 2016. The report for this period was not published on the GRI website or on the Nestlé Portugal website, nor was it possible to obtain clarification from Nestlé Portugal, despite the exchanged emails, until the date of data study's conclusion (July 2018). Besides that, this study still analyses the period from 2007 to 2016 because many other documents from 2016 were analysed.

Other sources of evidence, as the Corporate Governance, Corporate Brochures, Occupational Health and Safety Policies, Environmental Sustainability Policies, HR Policies and Nestlé Portugal Corporate Principles, were taken into consideration, to guarantee the triangulation, which corroborated the information gathered for the analysis and support of the conclusions on the various issues.

Table 2 shows the sources of evidence, identified and analysed for each research questions.

RESULTS AND DISCUSSION

This study provides an explanatory single and longitudinal case study. Its main goal is to make an in-depth analysis of the evolution of non-financial reporting in the multinational company Nestlé Portugal, S.A.

Considering the proposed goals and the research questions, results and data analysis are presented and discussed. The analysis is carried out question by question, in the defined order.

RQ1: What are the key milestones in the evolution of Nestlé's non-financial reporting since 2007?

This information was collected from various reports (mainly the non-financial reports: sustainability and integrated reports) published during the period under study, and these milestones were selected as fundamental for the evolution of Nestlé Portugal's Non-Financial Report, through a comparative empirical analysis with the other events reported by the company.

Following a careful reading of Nestlé Portugal's Sustainability/ Integrated Reports from 2007 to 2015 (for this question was not possible to analyse 2016 because up to August 2018, the 2016 Report had not yet been published), it can be concluded that the main key milestones in the evolution of non-financial reporting are identified in Table 3.

RQ2: Does Nestlé Portugal have a Disclosure strategy consistent with Nestlé International?

For this analysis the Nestlé Portugal's characteristics that are consistent with the Nestlé International's disclosure strategy were identified. For each year, based on the sustainability reports, the following aspects were analysed and compared by constructing an analysis tool: report structure, disclosure date,

Table 2. Sources of Evidence

		Sources of Evidence									
	Questions/ Study Objectives	**Reports**	**Corporate Brochures**	**Health and Safety at Work Policies (2008)**	**Policies on Environmental Sustainability (2008)**	**HRs Policies (2012)**	**Corporate Business Principles (2004)**	**Corporate Governance (2016)**	**Nestlé Review (08/ 2010 - 09/2017)**	**Average**	**Period**
RQ1	Identify key milestones in the evolution of Nestlé's non-financial reporting since 2007.	X		X	X	X	X				2007-2016
RQ2	Determine if Nestlé Portugal has a harmonious disclosure strategy consistent with Nestlé International.	X	X				X				
RQ3	Identify if Nestlé Portugal's reports follow the IIRC Framework	X									
RQ4	Determine whether Nestlé Portugal's non-financial reports are audited by an independent entity. And what is the contribution of this audit to the evolution of the report.	X					X	X			
RQ5	As Nestlé is a company focused on sustainability disclosure, there is an opening for the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) (UN 2015).	X	X	X	X	X	X	X	X		
RQ6	Figure out how the awards received by Nestlé are important in sustainability initiatives.	X				X			X	X	

Source: Authors' own research

Table 3. Key milestones in Nestlé's non-financial reporting evolution of sustainability

Time -Frame	Non-Financial Reporting Milestones in Nestlé Portugal
2007	Publication of the 1st Nestlé Portugal Sustainability Report.
2008	Consulting stakeholders to understand Nestlé's practices and performance in Corporate Social Responsibility.
2009	Corporate social responsibility evolution line of thought for the creation of shared value; 1st Audit of the Sustainability Report.
2010	New version of the "Nestlé Corporate Business Principles" launching, reinforcing Nestlé's commitment to these principles, which are the basis of Nestlé's commitment to Environmental Sustainability and Shared Value Creation.
2011	New stakeholder consultation to understand Nestlé's practices and performance in Corporate Social Responsibility; Promotion of the 1st Shared Value Creation Forum integrated in *GreenFest*.
2012	Shared Value Creation Report renamed "Nestlé in Society".
2013	Reiterate the support of the UN Global Compact as a founding member of the UN Global LEAD *Compact* - Important platform for companies focused on leadership in sustainability.
2014	"Alliance for Youth" initiative launching – Objective- to reduce unemployment.
2015	Nestlé expressed concerted efforts to link its own Shared Value Creation agenda with the SDGs (2015).
2016	Up to August 2018, the 2016 Report had not yet been published.

Source: Authors' own research

number of pages, summary report publication, number of indicators, standards used in the audit, GRI version and classification, and title. As previously mentioned, the report for 2016, was not available.

The result of this analysis is presented in Table 4, where (X) means that similarities were found. It means that consistency was found in the strategies of disclosure of the Portuguese report and the International one.

Table 4. Summary of the Similarities in the Disclosure Strategy (Portuguese vs International)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Structure									
Disclosure date	X	X	X	X	X	X	X	X	X
Number of pages			X						
Report – Summary		X	X	X	X				
No of indicators	X								
Audit (regulation)									
GRI Version/ Classification	X	X	X	X	X	X	X		X
Title						X	X	X	X

Source: Authors' own research

From the present comparative information collection, although there are similar and different points in the reports throughout the years, it can be stated that overall there is no consistency in the disclosure strategy between Nestlé Portugal and Nestlé International. The structure, number of pages, number of indicators and the auditing standard are not similar. Only the disclosure date and the GRI version are consistent in both reports. The summary was similar for a few years, but recently it has been differing. On the contrary, there is an affinity in the title of the report.

Therefore, it is possible to conclude that there is some freedom in the non-financial reporting level and in the Nestlé Portugal publication in relation to the parent company, Nestlé International.

RQ3: Does Nestlé Portugal's reports follow the IIRC Framework?

This question aims to verify if there is evidence of the influence of the IIRC Framework on Nestlé Portugal's non-financial report. To this end, the strategy determined to answer this question was based on identifying firstly the IIRC Basic Principles and the Content Elements that the IIRC defines (listed in table 5 and table 6), in the reports published by Nestlé Portugal between 2007 and 2015.

To these reasons, a thorough empirical analysis of the various reports was made, developing a working tool for this content review. Based on the information gathered, Tables 5 and 6 were designed.

Table 5. Identification of IIRC Basic Principles

Basic Principles and Integrated Report Preparation	2007	2008	2009	2010	2011	2012	2013	2014	2015
A) Strategic Focus and Future Orientation	X	X	X	X	X	X	X	X	X
B) Information Connectivity	X	X	X	X	X	X	X	X	X
C) Stakeholder Relations	X	X	X	X	X	X	X	X	X
D) Materiality					X	X	X	X	X
E) Conciseness	X	X	X	X	X	X	X	X	X
F) Reliability and Completeness	X	X	X	X	X	X	X	X	X
G) Consistency and Comparability		X	X	X	X	X	X	X	X

Source: Authors' own research

Table 6. Content Element Identification

Integrated Report Content Elements	2007	2008	2009	2010	2011	2012	2013	2014	2015
A) Organizational Overview and External Environment	X	X	X	X	X	X	X	X	X
B) Governance	X	X	X	X	X	X	X	X	X
C) Business Model	X	X	X	X	X	X	X	X	X
D) Threats and Opportunities	X	X	X	X	X	X	X	X	X
E) Strategy and Resource Allocation	X	X	X	X	X	X	X	X	X
F) Performance	X	X	X	X	X	X	X	X	X
G) Prospects	X	X	X	X	X	X	X	X	X
H) Basis of Preparation and Presentation and by so doing consider General Reporting Guidelines	X	X	X	X	X	X	X	X	X

Source: Authors' own research

Taking into account the results provided by the tables 5 and 6 in identifying the Basic Principles for the Preparation of the Integrated Report and according to the Content Elements of the Integrated Report, it appears that there is evidence of the IIRCs influence over the period under review (2007 to 2016), in preparing Nestlé Portugal's Shared Value Creation Reports. This relationship is effective on the 2011 report (year of creation of IIRC conceptual framework). It was from 2011 that the reports began to highlight the concept of Materiality, for example.

However, through empirical analysis of reports throughout the implementation process, it is possible to identify similarities with the basic principles in preparing an integrated report, as well as to identify the content elements.

Therefore, although this structure was only disclosed in 2013, and the creation of the IIRC dates back to 2010, it is noted that Nestlé already had reports aligned with the IIRCs purpose in all its aspects, only excluding Materiality that was not analysed from 2007 to 2010.

RQ4: Are Nestlé Portugal non-financial reports audited by an independent entity? If so, what is the contribution of this audit to the evolution of the report?

The audit of the sustainability reports has been a commitment of various companies encouraged by various regulations, by the GRI framework, which gathers the guidelines for the sustainability reports formulation. The GRI is a widely used international regulation and its guidelines encourage companies to audit / verify their reports.

By analysing Nestlé's non-financial report, regarding its audit, and by examining its "verification statements" by an independent auditor, table 7 was designed. Information was collected to identify whether, or not, there was an audit, the company responsible for the audit, the standards used, the type of opinion, the scope of the sustainability report and the level of implementation (in the case of the GRI Guidelines use). Some contributions and observations were added.

From the information gathered, it is possible to confirm that since 2008, Nestlé Portugal has been concerned with auditing its Sustainability/Integrated Report. This conclusion is also supported by Corporate Citizen Magazine (2014) that states that Nestle's sustainability reports are routinely reviewed by a third-party assurance provider.

In order to continually improve its Non-financial Reporting, Nestlé Portugal intends to withdraw valuable contributions from its audits to achieve that improvement. Nestlé hired the company PricewaterhouseCoopers (PwC) to perform the audit. The ISAE 3000 standard has been used in recent years and Nestlé has obtained an unmodified opinion. From the analysis of the verification statements it can be concluded that PwC's audits of Nestlé Portugal's Sustainability reports are in line with the best practices used by the largest companies in Portugal. It was also possible to validate if the structure of these auditor reports is consistent with the others from different companies (as analysed by Gomes, 2012), giving the notion of some standardization of procedures at this level. However, it could not be accurately concluded that the audit had a direct impact on the evolution of the report of Nestlé over the years.

Q5: As Nestlé is a company dedicated to sustainability disclosure, is there openness to align the Millennium Development Goals and the Sustainable Development Goals with its strategy?

Table 7. Nestlé Sustainability Report Audit 2007 – 2015

Time-Frame	Audit	Company	Regulation Used	Opinion Type	Scope	GRI Level	Contributions / Observations
2007	None	-	-	-	GRI 3	B	GRI Application Level - Self Declarative.
2008	Stakeholders collaboration to understand Nestlé's practices and performance in Corporate Social Responsibility.	PwC	-	-	GRI 3	B	GRI application level - Self-declaration; ● Stakeholder audience through a questionnaire conducted by an independent entity (PricewaterhouseCoopers); ● Internal consultation of the different directions and operational areas of Nestlé; ● Comparative analysis of international and national reference companies operating in the same business areas as Nestlé;
2009	1st Audit	PwC	N/D	Unmodified opinion (clear), given in the negative.	GRI 3	B+	GRI application level - validated by the auditing company; This report was for the first time subject to confirmation by an independent entity;
2010	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 3.1	B+	GRI application level - validated by the auditing company;
2011	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 3.1	B+	GRI application level - validated by the auditing company. Nestlé has again discussed with its stakeholders to better focus its efforts on the areas in which they intend to concentrate on the new socio-economic context.
2012	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 3.1	B+	GRI application level - validated by the auditing company. Continuous improvement of report writing through experience in applying the GRI and following the audit guidelines.
2013	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 3.1	B+	GRI application level - validated by the auditing company. Continuous improvement of report writing through experience in applying the GRI and following the audit guidelines.
2014	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 3.1	B+	GRI application level - validated by the auditing company. Continuous improvement of report writing through experience in applying the GRI and following the audit guidelines.
2015	Yes	PwC	ISAE 3000	Unmodified opinion (clear), given in the negative.	GRI 4	According - Essential	GRI application level - validated by the auditing company. Continuous improvement of report writing through experience in applying the GRI and following the audit guidelines.

Source: Authors' own research

Considering the Sustainability Development Goals published by United Nations, Nestlé Portugal's reports between 2007 and 2015 were analysed, in order to ascertain if the company directs its action and disclosure strategy considering the MDGs. Table 8 summarizes some evidence that Nestlé Portugal sought to align its strategy with these values.

Table 8. Millennium Development Goals 2000 - Nestlé Portugal

SDG Principles		Sustainability Report							
		2007	2008	2009	2010	2011	2012	2013	2014
1	*Poverty Eradication*	Nestlé has incorporated in its Corporate Principles the United Nations Global Compact and its ten principles in the area of human rights, labour law, the environment and the fight against corruption.		In 2009, Nestlé's Environmental Sustainability Policy was updated and published, incorporating the United Nations Global Compact and through which the Company undertakes to implement.		Nestlé's Environmental Sustainability Policy incorporates the United Nations Global Compact, through which the Company undertakes to implement.		They continue to actively manage commitments to environmental and social sustainability required to operate factories and for the sustainable growth and development of the communities and countries in which they operate. They reiterate support for the UN Global Agreement as a founding member of the UN Global LEAD Compact.	
2	*Zero Hunger and Sustainable Agriculture*								
3	*Health and Wellness*								
4	*Quality Education*								
5	*Gender Equality*								
6	*Drinking Water and Sanitation*								
7	*Clean and Affordable Energy*								
8	*Partnerships and Means of Implementation*								

Source: Authors' own research

It was possible to find information in 2007, 2009, 2011 and 2013 reports. In these years, Nestlé Portugal reports highlight this concern and reiterate this position in the reports.

In September 2015, the 193 world leaders met at the UN headquarters in New York to formally adopt a new sustainable development agenda. This agenda consisted of 17 Sustainable Development Goals (SDGs), which should be implemented by all countries over the next 15 years, by 2030. The list of SDSs are: no poverty; zero hunger; good health and well-being; quality education; gender equity; 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 for the goals[4]. Thus, in a second phase, the 2015 sustainability report was analysed in order to verify whether Nestlé Portugal has directed its dissemination strategy in accordance with these goals.

From the results presented in Tables 8 and 9, we can validate that Nestlé has shown to be a sustainability-oriented company with an opening for the integration of the MDGs and SGDs in its strategy. Here are some excerpts from their reports that clearly identify the concern to incorporate the United Nations Global Compact in their Corporate Principles and Sustainability Policies.

Table 9. Sustainable Development Goals 2015 - Nestlé Portugal

SDG Principles		Report Verification
1	*Poverty Eradication*	In September 2015, 193 United Nations Member States adopted 17 Sustainable Development Goals, setting global priorities by 2030. Nestlé has committed to bringing its Shared Value Creation policy in line with those global goals.
2	*Zero Hunger and Sustainable Agriculture*	
3	*Health and Wellness*	
4	*Quality Education*	
5	*Gender Equality*	
6	*Drinking Water and Sanitation*	
7	*Clean and Affordable Energy*	
8	*Proper work and economic growth*	
9	*Industry, Innovation and Infrastructure*	
10	*Reduction of Inequalities*	
11	*City and Sustainable Communities*	
12	*Responsible Consumption and Production*	
13	*Actions Against Global Climate Change*	
14	*Water Life*	
15	*Earth Life*	
16	*Peace, Justice and Effective Institutions*	
17	*Partnerships and Means of Implementation*	

Source: Authors' own research

"Nestlé has incorporated in its Corporate Principles the United Nations Global Compact and its ten principles in the area of human rights, labour law, the environment and the fight against corruption." (Sustainability Report, 2007)

"Nestlé's Environmental Sustainability Policy, which incorporates the United Nations Global Compact and through which the Company commits to implement, has been updated and published." (Sustainability Report, 2009)

In 2011, a new statement that Nestlé's Environmental Sustainability Policy incorporates the United Nations Global Compact was found, through which the company undertakes to implement. And in 2013, they continue to actively manage environmental and social sustainability responsibilities necessary to operate factories and for the sustainable growth and development of the communities and countries where they function. With this report, they also emphasise their support for the UN Global Compact as a founding member of the UN Global LEAD Compact - an important platform for companies in the field of sustainability leadership.

In 2015, in the Shared Value Creation Report, Nestlé Portugal committed to align its policy with its goals set in September 2015, by the 193 United Nations Member States. With these statements, some of them textual, and given the sustainability strategy implemented and carried out by Nestlé Portugal, it is apparent that the company has been incorporating the global goals set by the United Nations in its strategy.

Q6: How do the awards Nestlé received matter in its sustainability initiatives?

In the period under study, Nestlé Portugal was awarded several prizes in various areas. For the present study and in order to determine how the awards received are important in the sustainability initiatives developed by Nestlé Portugal, the awards obtained in areas related to Sustainability were selected, bearing in mind *the triple bottom line* (Economic, Social and Environmental). Table 10 shows the different awards received and their contributions.

Table 10. Awards received by Nestlé Portugal and their contributions

Year	Awards Received	Contributions
2007	"Equality is Quality" Award - Awarded by the Commission for Equality at Work and Employment	It led to the consolidation of this equality policy. Winning the Prize in 2008.
2008	"Equality is Quality" Award - Awarded by the Commission for Equality at Work and Employment - APCE Award "Best Sustainability Report 2007"	Continuity of equality policy. The award for Best Sustainability Report is in line with Nestlé policies. Nestlé's goal is continually better in this policy.
2009	"*Safety at Work Awards 2009*" Award - ADC (Avanca Distribution Centre)	Safety at work is also a concern at Nestlé. It has established well-defined occupational safety policies and emphasizes compliance as an aspect that sets it apart as a leading company in the various sectors in which it operates.
2010	"Most Efficient Company" Award	Award received after participating in the Energy Efficiency Barometer in Portugal, promoted by the General Administration for Energy and Geology, in 2010, in partnership with ADENE - Energy Agency and PREMIVALOR Consulting. Energy efficiency is a relevant aspect of sustainability. Indicators such as Total Energy Consumption (GJI) and Total Energy Consumption per ton of product are displayed by the Sustainability Reports.
2011	- APCE Award "Best Sustainability Report 2011"; - *B-Green Action Award.*	With the award for best sustainability report won in 2011, it demonstrates a policy of consolidation of this objective already defined in 2007. Following its participation in the Green Festival, Nestlé Portugal won the B-GREEN Action Award that recognized the concept of Responsibility. Social Responsibility and the impact of the brands activation and actions developed during the festival.
2012	- APCE Award "Best Sustainability Report 2012".	Consolidation of policies to improve sustainability reporting.
2013	NA	
2014	Silver Award for Facebook Social Responsibility campaign against pet abandonment - Pet Sharing (Nestlé Purina).	Concern Actions for Social Responsibility are always present in the initiatives taken by Nestlé. This is an example of the social policies Nestlé has implemented.
2015	1st Place at the Healthy Workplace Awards 2015 in the Large Business Category.	This award is yet another prize within the scope of the occupational safety and conditions, policies defined by Nestlé.

Source: Authors' own research

It is possible to conclude that there is a strong dynamic of action towards doing more and better regarding sustainability initiatives at Nestlé Portugal. Whether at social, environmental or internal organizational initiatives promoting equality at work and employment and / or safety at work (for example). The various awards are proof of this, as they somehow certify Nestlé Portugal's efforts and strategy to promote sustainability.

Another concern of the company is to publish a good non-financial report that is consistent with the most advanced international standards, in order to remain at the forefront of the development of this type of report. This is demonstrated by the awards received in 2008, 2011 and 2012, which distinguished Nestlé Portugal's reports as "Best Sustainability Report".

CONCLUSION

Nestlé Portugal's non-financial report evolved not only following the technical development of this type of report, but was also strongly influenced by the different policies implemented in the monitoring of the various socioeconomic contexts that took place in Portugal.

In the period under review, from 2007 to 2016, several key milestones that contributed to this evolution were identified. These include the publication of the first Nestlé Portugal Sustainability Report in 2007, which marks the beginning of this research data collection process. In 2008 and 2011, inquiries to stakeholders, to perceive how they understand the performance of Nestlé Portugal in the Social and Corporate Responsibility thematic field were made, and at last, the Nestlé Portugal's commitment to coordinate efforts in order to develop its agenda along with the SDGs.

The research showed that although there are similar points in the reports when comparing Nestlé Portugal reports with Nestlé International ones, it is not possible to state that overall they are alike. Nestlé Portugal has a certain freedom in defining the structure of the reports, as well as in defining the information to be disclosed regarding Nestlé International.

In respect to the influence of the IIRC Framework, by means of the empirical analysis of the reports throughout the implementation process, it was possible to identify coherence with the basic principles in the preparation of an integrated/ sustainability report, as well as to identify the content elements.

From 2007 to 2015, Nestlé Portugal, sought to keep its sustainability reports evolving in line with the evolution of the issue, but also sought the support an independent entity to verify its reports. Additionally, it sought to gather information from its stakeholders not only to expand its reports according to the regulations, but also, to consider and incorporate in it, the stakeholders' main concerns and interests. Auditing reports is important to Nestlé Portugal so that its good practices are certified.

In the period considered, and on several other occasions, Nestlé Portugal, literally stated in its reports (2007, 2009, 2011; 2013 and 2015) that the global goals set by the United Nations (MIDs and SDGs) were incorporated in its strategy.

Concern actions for Social and Environmental Responsibility, without neglecting their economic concerns, are always present in the initiatives taken by Nestlé. In the context of the development of these initiatives, the fact that they are distinguished with awards means that their impact and added value for the intervention areas had a significant effect. These distinctions foster the continued implementation of the practice of developing social and environmental initiatives to consolidate Nestlé Portugal's sustainable development strategy and to make it more credible among its stakeholders.

Thus, it is possible to conclude that Sustainability and the dissemination of the actions taken in its promotion, are for Nestlé Portugal, more than a concern. These are themes that are an integral part of its strategy. With this study it was possible to conclude that the company is constantly seeking to evolve following the market trends in this area, as well as the most advanced non-financial reporting practices. Nevertheless, Nestlé must continue to work in this field as Jones et al. (2016, p. 83) stated: "The Chairman and the Chief Executive of Nestlé, reported 'We recognise that {….} we need to contribute more broadly to the societies where we operate".

Limitations and Future Research

This study was based on secondary data, i.e. public institutional information. In the future it would be important to corroborate the research conclusions with the company, by using for example, primary data collection, e.g. interviews with various decision makers, who have influence on the implementation and evolution of the sustainable development strategy, as well as its report during the period under study.

Nestlé is submitted to pressures from the media and the general public for its large exposure (as it is a leading company in the markets where it operates). There are many controversies surrounding the overuse of sugar in their products, or topics related to child labour or with the workers' exploitation. In the future it could be interesting to expand the case of Nestle, as Blanc et al. (2019) did to Siemens AG company. Additionally, it would also be of interest to apply the same research to other major companies in the same sector in the world, and compare the results obtained with those obtained by Nestlé.

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ENDNOTES

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Chapter 11
AgroForest Biomass and Circular Bioeconomy:
Case Studies

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ABSTRACT

The agroforest sector plays a leading role as a biomass supplier to obtain bio-based products that allowed an acceleration in the circular bioeconomy transition. This chapter applied a mixed-methods review to identify new attractive bio-based products and to evaluate its market potential in Portugal. Forest biomass was identified as an excellent raw material for (1) low-carbon building materials, (2) biotextiles, and (3) bioplastics. The potential of agro-food waste to obtain new bio-based materials was also emphasised. The new bioproducts identified have high potential and attractive markets. It was estimated that a 5% market share of these bioproducts in the global construction, textiles, and plastics markets in 2030 corresponds to an aggregate increase in revenues of 260-579 million € per year in Portugal. The environmental sustainability implications arising from the diffusion of these new biomaterials are also highlighted, focusing on the decarbonisation of the economy.

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INTRODUCTION

Developing the bioeconomy is relevant on the political agenda of the European Community as a collective whole (European Commission, 2018) and several of its states, including Portugal. Portugal published its Smart Specialization Strategy in 2015. Bioeconomy is not treated as a single topic but is rather scattered across different themes (Bio-based Industries Consortium (BIC), 2018). The circular economy is also considered as a promising approach to help reduce global sustainability pressure (Temmes & Peck, 2020). In Portugal, the circular economy concept is mostly applied in the area of waste management. There is a lack of circular economy awareness among Portuguese companies and high dependence on imported raw materials for production (Škrinjarí, 2020). In recent years, the bioeconomy and circular economy have been increasingly combined into a concept of circular bioeconomy (Hetemäki et al., 2017) with the intuit of mitigating some sustainability-related issues of the bioeconomy, particularly the inefficient use of natural resources (Temmes & Peck, 2020).

Portugal and Europe are currently experiencing a major development – the creation of a circular bioeconomy – with the capacity to transform the economy and society. This study analyzes the circular bioeconomy as a new economic paradigm with the potential of replacing materials and products based on fossil fuels by renewable materials in closed-loop cycles (Hetemäki et al., 2017).

Based on the principles of circular bioeconomy, the new bio-based products need to have high economic value-added, for as long as possible. For that, the reusability and recycling needs were taken into account in the design stage. The non-competition with food cultivation and avoid negative impacts on other ecosystem services should be privileged during bio-based products development (Hetemäki et al., 2017). In this scenario, the production of bio-based materials focused on the non-food use of bioresources as the forest biomass (Hurmekoski et al., 2018) and agro-food waste (Morone & Imbert, 2020) have been emerging.

Regarding new biomaterials and bioproducts, the potential of forest biomass for the implementation of circular bioeconomy and competitiveness in key sectors such as construction, textile and plastics have been emerging as the most promising bio-based markets (Hurmekoski et al., 2018).

Several studies have been developed to survey the opportunities and challenges of the European agroforest-based circular bioeconomy (Antikainen et al., 2017). However, few have identified the key growth markets and new products for bio-based industries in Europe (Hurmekoski et al., 2018), and especially in Portugal. According to the report of the Bio-based Industries Consortium (BIC) about the potential of Portugal for the bio-based industry (Bio-based Industries Consortium (BIC), 2018), Portugal has a significant potential for the implementation of circular bioeconomy. Agro-food and forest have been crucial sectors of the national economy. The substantial amount of by-products and waste from these sectors and the related processing industries are potential suppliers of biomass for the development of new bio-based products. Among these sectors, wood-based industries (sawn, pulp and paper), besides having great importance for Portuguese economy and employment, they use essentially raw material produced in the country. This is an advantage of the forest sector compared to other important economic activities that are based on imported raw materials (Rego et al., 2013). The establishment of the more promising bio-based products from forest biomass in Portuguese market could be an opportunity to accelerate the deployment of sustainable and circular bio-based solutions in Portugal.

Besides the lack of studies focused on the potential of circular bioeconomy to promote the sustainable economic growth in Portugal, other gaps in the research of the bio-based products need to be fulfilled. The more common question is “what can be made from lignocellulosic biomass”. At the same time, issues of "which (intermediate) products will be produced", "how much", "where", "for what reasons", and principally "with what environmental consequences" have gained less attention (Hetemäki & Hurmekoski, 2016; Hurmekoski et al., 2018). In this study, the environmental implications of the new biomaterials *versus* fossil-based materials focusing on the economy decarbonisation (Bell et al., 2018) were also assessed.

Another concern related to the circular bioeconomy to be widely accepted is to increase the use of residual bio-based raw materials and waste, hence reducing its dependency on crops which compete with agro-food markets (Morone & Imbert, 2020). Agro-food waste and by-products are excellent sources of biological compounds that can be exploited as raw materials to replace fossil fuels, complementing the use of forest biomass and being an asset in obtaining new, more versatile and sustainable bio-based materials (Fritsch et al., 2017). The agro-food industry represents more than half of the added value of the bioeconomy in Portugal in 2017, namely food, beverages and tobacco industries (31%) and agriculture (21.3%) (European Commission & Joint Research Centre, 2019; Eurostat, 2019). Some examples of bio-based products from the transformation of agro-food by-products/ waste, which can be applied in the Portuguese market were also highlighted.

Thus, this study intends to give an overview of the competitiveness and economic viability for the adaptation of a circular bioeconomy strategy in Portugal based on the development of new agroforest biomass-based materials. To this aim, the present study (i) identifies new agroforest biomass-based products with considerable potential and attractive markets (ii) estimates its market potential adapted to Portuguese economy (iii) assesses the 'environmental costs' of the fossil-based materials and the 'environmental gains" of adoption of the new bio-based materials.

BACKGROUND

The bioeconomy and the circular economy share the common goal of a more sustainable and resource-efficient world with a reduced carbon footprint. Both seek to avoid the use of fossil fuels to achieve climate goals and to decrease pressure on virgin raw materials. The concepts overlap to some extent, but neither concept is fully part of the other concept (Hetemäki et al., 2017).

The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value-added products. It replaces fossil carbon with renewable carbon from agriculture, food, forests and the marine environment biomass, including by-products and waste (Temmes & Peck, 2020).

The circular economy is a restorative and regenerative model by design where nothing is lost, and everything feeds a new cycle, and which aims to keep products, materials and resources in the economy with the highest utility and greatest value, for the longest possible period of time. At the same time, it allows the minimization of waste, and it postpones new production, therefore saving on natural raw material and additional energy (Campos et al., 2020). Extending the life cycle of products and materials, retaining their value and functionality for more extended periods of time, requires systemic approaches such as eco-design, sharing, reuse, maintenance, repair and recycling. Also, changing from non-renewable resources to biomaterials is an essential aspect of the circular economy's agenda (Meghan et al., 2014).

The principles of a circular economy must be applied to the bioeconomy. The use of biorefinery cascade processing to the biomass strongly overlaps with the concept of the circular economy and is an integral part of the concept (circular bioeconomy). It is a core strategy to maintain the value of biomass in material applications with high value added in the economy, for as long as possible, before sending it for energy recovery, while guaranteeing the preservation of natural capital (Jarre et al., 2020). In this line, the renewed EU Bioeconomy Strategy (European Commission, 2018) strongly focuses on circularity, thereby complementing the Circular Economy Action Plan (European Commission, 2019). Presently, the European economy is moving to a circular bioeconomy to boost Europe global competitiveness and promote sustainable economic growth (Arano et al., 2018). The “circularity” strategy benefits both the environment and the economy, being an opportunity to promote efficient use of bio-based resources through dissemination of best practices on the cascading use of biomass and support for innovation in the bioeconomy (European Commission, 2018b).

The most recent years have shown a growth trend in indicators such as value-added, turnover and productivity both in the bioeconomy and in the circular economy in Portugal. In 2017, the bioeconomy represented approximately 7% of the Portuguese value-added, corresponding to around 12 000 million euros, which reflects a positive trend since 2011. In the European Union, its share in the total economy is only 4.9%. It employs around 602 thousand workers, corresponding to 13.3% of the total employment in Portugal (European Commission, Joint Research Centre, 2019; Eurostat, 2019).

Regarding the circular economy in Portugal, the comparison with the European Union shows that the productivity of the Portuguese circular economy only represents about 46% of the productivity of the circular economy in the European Union (55,700 euros per worker) (European Commission, Joint Research Centre, 2019; Eurostat, 2019). Many of the companies follow a narrow view of circularity, motivated mostly by waste reduction and efficiency in the use of resources (Škrinjarí, 2020). There are a significant number of initiatives underway in the production cycle, with a strong emphasis on waste reduction and greater material and energy efficiency of the products and production processes, and a smaller number of initiatives to transform products, with value retention and creation, or to develop innovative proposals for customers that allow the use of products for more extended periods, which will allow a new type of relationship with the customer, both crucial for companies to maximize the benefits from the circular economy model (República Portuguesa, Ambiente, 2017).

The circular bioeconomy is explicitly linked to the forest sector (Hetemäki et al., 2017; Temmes & Peck, 2020). The forest always had high economic and environmental significance. Traditionally, forests have been mainly (and still are in many parts of the world) a source of renewable raw materials, like wood and other products, such as resin, cork, mushrooms and fruit. Further, its economic function as a supplier of private goods, offers recreational and environmental benefits to society (European Union Commission, 2003).

The European Union concentrates 5% of the world’s forests, with forests and other wooded areas occupying 42% of its territory, in a size of about 176 million hectares. In Portugal, the forest use of the soil represents 36.2%, and the agricultural areas correspond to 23% of the continental territory. Uncultured land and grassland make up 31% of the national territory, with uncultured land corresponding to 54% of this class, that is, 1,499 thousand ha (Instituto da Conservação da Natureza e das Florestas, 2019).

The forest has been among the leading export sector, one of the most important contributors to Portuguese economic sustainability, including the Portugal rural zones (Martinho, 2016). Besides that, the Portuguese forest sector has excellent potential to increase the forest output and competitiveness of forest activities and have been reiterated by the long term practices under the principals of circular economy and cascade use, covering resources efficiency and reuse of by-products and residues (Instituto da Conservação da Natureza e das Florestas (ICNF), 2019). On the other hand, the implementation of a forest-based circular bioeconomy could provide the necessary investments and incentives to ensure sustainable, integrated forest and fire management strategies and thereby reduce wildfires, while at the same time revealing that forests are a valuable resource to develop new bio-based competitive markets (Rego et al., 2013; Verkerk et al., 2018).

Regarding new biomaterials based in forest biomass, several authors have been highlighted as key sectors construction, textile and plastics to European markets (Antikainen et al., 2017; Dalia D'Amato et al., 2020; Hetemäki et al., 2017; Hurmekoski, 2017; Hurmekoski et al., 2018). In Portugal, wood products (for example, wood and cork industries, bio-based furniture, paper and pulp manufacture) and bio-based textiles stand out from other national economic sectors due to their wealth creation capacity (Mainar et al., 2017). On the other hand, Portuguese construction has been very active in the field of sustainable construction and energy efficiency (European Commission, 2018a). However, the identification of the key growth markets and new products for bio-based industries in Portugal have not been the subject of study so far.

The emergence of politically driven circular bioeconomy strategies worldwide calls for considering the ecological issues associated with bio-based products (D'Amato et al., 2020). The externalities associated with fossil fuel-based materials, such as additional health and environmental costs, are not taken into consideration. But environmental externalities may trigger change. The internalization of these externalities, such as through a carbon tax paid by those generating GHG emissions, would create a greater market incentive for sustainable innovation such that the sustainability benefits can become part of a company's core value-offering (Matthews et al., 2019). Few studies have been considering the environmental costs of conventional materials and its bio-based substitutes (Hurmekoski et al., 2018).

However, forests are not the only source of lignocellulosic biomass whose potential has not been appropriately valued. The amount of biomass waste generated by agricultural activities, food processing and other industry sectors has been increasing considerably as a result of population growth and the expansion of industrialization. The most relevant Portuguese sub-sectors in terms of by-product volumes are oil mills, wine, beer, rice, fruits & vegetables (Bio-based Industries Consortium (BIC), 2018; Duarte et al., 2007).

METHODOLOGY

Data Collection Based on the Mixed-Methods Review Process

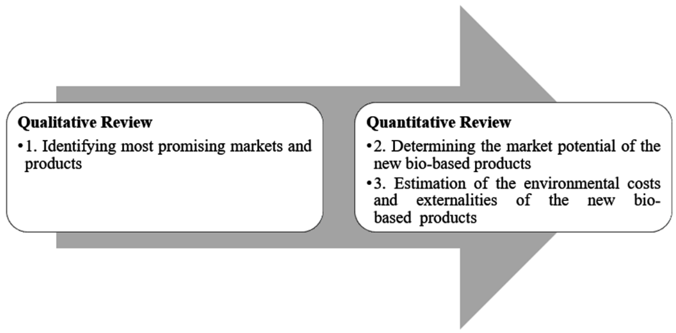
In this work, a mixed-methods review process was applied (Grant & Booth, 2009). This kind of process can refer to any combination of methods in which at least one of the components is a literature review and where the aim is to collect and analyse data, integrate the findings, and draw inferences using both qualitative and quantitative approaches in a single study (Grant & Booth, 2009; Hurmekoski et al., 2018).

Synthesising the insights of different types of data into a cohesive picture provides a broader understanding compared with using a single method or data source (Tashakkori & Creswell, 2007). The implementation of the mixed-methods review process in this study involves three interlinked steps (Figure 1).

Selection of Markets and Products

Based on the literature review, the most significant new bio-based products from forest biomass were identified. All the reports and works from this field reported that construction, textile, packaging and

Figure 1. Review process



plastic materials are the most promising markets regarding forest biomass-based products (Antikainen et al., 2017; Dalia D'Amato et al., 2020; Hetemäki et al., 2017; Hurmekoski, 2017; Hurmekoski et al., 2018). In Portugal, in 2015, forestry, manufacture of bio-based textiles, manufacture of wood products and furniture and production of paper contributed to bioeconomy value-added above the EU average (Ronzon & M'Barek, 2018). Moreover, the labour productivity of the Portuguese bioeconomy has significantly increased over the last years (+ € 6000 of value-added per person employed). The manufacture of the paper sector and the forestry sector recorded the progress of around € 30,000 per person employed from 2008 to 2015, and the production of bio-based chemicals, pharmaceuticals and plastics industry were € 10,000 more productive per person employed in 2015 than it was in 2008. As a result, in 2015, the labour productivity of the Portuguese bioeconomy was as high as half the EU-28 average (Ronzon & M'Barek, 2018). Even though Portugal is still far away from the EU-28 average, there has been a significant convergence of the Portuguese bioeconomy labour productivity towards the EU-28 average (about ten percentage points from 2011 until 2017) (European Commission, Joint Research Centre, 2019; Eurostat, 2019).

In Portugal, wood products (broadly speaking, including, for example, wood and cork industries, bio-based furniture, paper and pulp manufacture) and bio-based textiles stand out from other national economic sectors because to their wealth creation capacity, both upstream in the supply chain and the downstream user chain (Mainar et al., 2017). They are classified as 'key sectors'. The promotion of these sectors is, therefore, highly recommended from an economic perspective, given their high potential for creating value. Moreover, Mainar *et al.* (2017) reported about the Portuguese bioeconomy that bio-based activities generate more wealth in the supply chain of inputs than in the chain of applications of products and materials downstream. In addition, upstream, this potential for wealth creation is always higher than that for the average of the Portuguese economy. Also, the potential for wealth creation compared to the average of all economic activities, is more significant in Portugal than in the EU28, both upstream and downstream.

These results suggest the output of these activities is limited in terms of alternative uses and applications and with low value-added, which triggers more moderate spreading effects across the entire economy. In this sense, this work aims to highlight the economic potential, untapped, of advanced biomaterials coming from forest biomass. Alternative uses and applications of forest biomass with high value-added compared to traditional applications and which are still under-explored by the market are addressed.

Regarding construction, the Portuguese construction sector is foreseen to enjoy encouraging growth over the coming years, being very active in the field of sustainable construction and energy efficiency (European Commission, 2018a). Nowadays, sustainable construction is a strategical priority to the European Union. This concern is, even more, a priority in regions with significant wood-working industries like France, Italy, Spain, Portugal and Greece (Arano et al., 2018).

The most promising markets of construction, textile, packaging and plastic materials were included in the analysis. However, it was necessary to select specific products and technologies to allow quantitative evaluation of the diffusion of new products (production value) and to maintain a manageable range for the analysis (Hurmekoski et al., 2018).

Determination of the Market Potential of the New Bio-Based Products

The main objective of the present study was to understand the market potential of the bio-based materials obtained from forest biomass in Portugal; as a consequence, this study takes only the perspective of Portugal. The time horizon of 2030 was adopted for this study. The year 2030 is the threshold for the European bioeconomy agenda (European Commission, 2019). This allows along time for markets to adapt to changes in demand, yet restricts the analysis exclusively to new products that are already in the market or soon to be introduced to the market, which reduces the uncertainty of the study (Hurmekoski et al., 2018).

To estimate market demand, it is necessary to consider (i) the development in terms of market volume of products to be replaced; (ii) the competitiveness of the bioproducts; (iii) the international competitiveness of Portugal; (iv) the unit values.

The estimation of the production volume of the bioproducts in Portugal in 2030 was performed based on data and assumptions regarding the size and growth rate of the global market, the market share of the bioproduct in the worldwide market and the market share of Portugal in the world market. Thus, the production volume of a product in 2030 comes from the product between the global market volume in 2030, the market share of the bioproduct and the market share of the country.

To estimate the production value, other information required was unit values of bioproducts (prices).

The key variables in this calculation, as well as their sources, are summarized in Table 1.

Regarding international competitiveness, it was assumed that the market share of Portugal is consistent with the current share of the leading products from forest biomass (e.g. sawn wood for construction, dissolved pulp for textiles, packaging and paperboard for plastics) (Table 2).

Table 1. Key parameters and corresponding information source.

Parameter	Information Source
Global market volume in 2030	Hurmekoski et al. (2018)
Market share	Market share of bioproducts from forest biomass based on Hurmekoski et al. (2018); International market share based on FAOSTAT (2019)
Unit values	Hurmekoski et al. (2018)

Table 2. Market share assumptions for different product categories. Source: Hurmekoski et al. (2018); FAOSTAT (2019).

Market	Market Share of Bioproducts From Forest Biomass in the Global Market (a) (%)	Portugal's Market Share in the Global Market (b) (%)	Global Market Share (a x b) (%)
Textile	5%	1,30% (dissolving pulp)	0,065%
Construction	5%	0,22% (sawn wood)	0,011%
Packaging	5%	0,16% (packaging and paperboard)	0,008%
Wood-plastic composites (WPC)	100%	0,16% (packaging and paperboard)	0,160%

Estimation of the Environmental Costs and Externalities of the New Bio-Based Products

The environmental externalities associated with conventional fossil-based products and bio-based products from the selected emerging markets were estimated.

Environmental externalities refer to the economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise costs outside the market mechanism. Because of negative externalities, private costs of production tend to be lower than "social" costs. It is the aim of the "polluter/ user-pays" principle to prompt households and enterprises to internalize externalities in their plans and budgets (OECD, 2003). Following Morris & Bagby (2008), several different environmental impacts could be considered. In this study, Greenhouse gases (GHG) emissions were emphasized due to the political concern and the urgency of combating global warming. Based on the global warming potential of each GHG pollutant, emissions from all GHGs can be combined into a single reference substance. The reference substance for Global warming potential is carbon dioxide (CO_2). The aggregate quantity is called the carbon dioxide equivalent (eCO_2). This eCO_2 indicator is a measure for the global warming potential of the release of all GHGs. However, other environmental impacts are also assessed in this work, namely Human Health Respiratory Impacts, Eutrophication potential and Acidification potential. Following Morris & Bagby, (2008), the cost estimates for the reference pollutants for the four environmental impacts included in this analysis are as follows:

- Global warming potential: eCO_2 - $50 per ton for future damages caused by the emission of 1 ton of CO_2 equivalent.
- Human health respiratory impacts: ePM2.5 - $ 10,000 per ton.
- Eutrophication potential: eN (nitrogen) - $ 4 per ton.
- Acidification potential: eSO2 - $ 290 per ton.

The values of the costs estimated tend to be in a moderate interval of the range of available estimates on the environmental costs associated with the emissions of these pollutants for these specific environmental problems (Morris & Bagby, 2008). The conversion to euros was made at the average annual rate of EUR / USD for the year 2019.

Detailed data about environmental externalities are in Appendix 1.

DATA ANALYSIS AND DISCUSSION

Bio-Based Products From Forest Biomass with Market Potential Identified

Based on the literature review of the most emerging forest biomass-based products and the bio-based industries productivity in Portugal, the markets selected were the textile, construction, packaging and plastics. From each key market specific products as case studies were selected, which are listed in Table 3. In the following sections, the case studies were characterized.

Table 3. Selected new forest biomass-based products.

Market	Selected Products
Construction	Lignin as concrete admixture Cross-laminated timber (CLT)
Textile	Spinnova Lyocell IONCELL-F
Plastics and Packaging	Flexible plastic packaging (e.g., Paptic) Rigid plastic packaging (e.g., SULAPAC) Wood-plastic composites (WPC)

Construction With Wood Products

The civil construction sector has enormous economic and social significance. This sector represents 10% of the Gross Domestic Product (GDP) in Europe, employing 12 million people (Hurmekoski, 2017). However, the construction industry is one of the biggest environmental pollutant (Krasny et al., 2017). In the European Union, the construction sector represents 35% of all GHG emissions, 50% of extracted materials, 30% of all water use and generates about 40% of all waste (Hurmekoski, 2017). The 'greening' of this sector is a fundamental challenge for sustainable development.

Several studies have proved that environmental challenges faced by the construction industry could be partially resolved by the use of natural building materials (Krasny et al., 2017). To achieve a more sustainable construction sector is required to use natural materials like wood and cork. Wood has always been used for the construction of buildings. About 8 to 10% of family buildings in the European Union are made of wood, mainly in the Nordic countries (more than 80%). The application of wood in construction ceased, since the industrial revolution, due to the emergence of materials as concrete, brick or steel (Hetemäki et al., 2017).

Nowadays, the concept of "green building" has become more popular. Global environmental challenges and population's awareness concerning the harmful effects of GHG emissions in climate change have led to the reapplication of wood and wood-based products (Popescu, 2017).

The application of wood has intrinsic advantages as material in "green construction". Every tonne of wood used to replace other materials (concrete, steel, etc.) implies a reduction of 2.1 tonnes of dioxide carbon emissions (Sathre & O'Connor, 2010). Indeed, wood can reduce GHG emissions in several ways (Arano et al., 2018; Krasny et al., 2017):

- Wood stores dioxide carbon during the lifetime of the building and, if appropriately demolished, wood can be easily recycled.
- Wood contains low embodied energy (low total energy needed for production, transportation and disposal compared to conventional buildings materials).
- Wood as relatively light material reduces the need for foundation work, saving fuel and reducing emissions caused by the transport of materials.
- Wood buildings have, as a rule, excellent energy performance and good resistance in case of fire and earthquakes. In case of the fire, wood used for structural purposes does not collapse under higher temperatures and when used indoor can improve air quality (buffers humidity, softens acoustics, creates a stress-relieving atmosphere). The high seismic resilience of wood buildings is also an essential advantage in countries prone to earthquakes such as Italy, Greece or Turkey.

Nowadays, the use of wood has been rising, but the opening for the new markets as the large-scale construction like multi-storey residential and collective buildings (e.g. offices, schools, hospitals, industrial and sports halls, etc.) was only possible due to the emergence of new engineered wood products (EWP) (Arano et al., 2018).

Engineered Timber Products

Currently, wood building materials could be much higher and more durable and can be built out of wood from lower quality, more ubiquitous raw material due to the emergence of EWP (Arano et al., 2018; European Commission, 2018b). These new EWP materials were obtained following the subsequent production process: (1) Once harvested, wood is referred to as “roundwood”; (2) After roundwood is transported from the forest to a sawmill for further processing (removal of bark and surface defects) and approximately 50% is recovered as a viable board and plank products; (3) The remaining fibre by-products were applied in EWP products with market value. The remaining dust, shavings and fibre were typically used as biomass fuel (Ramage et al., 2017).

The benefits of these wood composites - made from laminated wood, adhesives and other materials, include more dimensional stability, more homogeneous mechanical properties and higher durability. Some examples of the most common EWP products in Europe are listed in Table 4.

Among the various EWP products, cross-laminated timber (CLT) panels take preponderant importance in modern wood construction (Popescu, 2017). The CLT panels are made of a minimum of three layers of sawn softwood (such as spruce or pine) stacked on the top of one another at right angles and glued to form a thickness in the range 50–500 mm suitable for floor, wall and roof elements of up to 13.5 m in length (Ramage et al., 2017). Its density (depending on the species used) varies between 430-470 kg/ m^3, being lower than that of concrete (2400 kg/ m^3) or steel (7850 kg/ m^3). The lower density of CLT is a significant handling and transportation advantage over conventional construction materials as well in term of foundation design (Popescu, 2017; Ramage et al., 2017). The CLT generally requires much lighter foundations than those needed by concrete and steel superstructures (Popescu, 2017). Besides, the cross-lamination gluing process gives the product dimensional stability and durability, allowing buildings to be constructed on up to 7 floors with a minimum of vertical retraction (Ramage et al., 2017).

Two other factors that have permitted high acceptance and increased application of CLT are its excellent performance in case of the fire and its ability to store large amounts of atmospheric CO_2 (Popescu, 2017). The excellent performance of CLT in terms of fire is because of the external surfaces once charred, ceased

Table 4. Conventional structural engineered wood products (EWP) in Europe (Source: Ramage et al. (2017)).

Engineered Wood Product	Application	Usage
Parallel Strand Lumber (PSL)	Beam Columns	Interior
Laminated Veneer Lumber (LVL)	Beam Columns Cord	Interior
I-joist	Joist Beam	Interior
Glulam	Beam (Long span) High loading	Interior/ Exterior
Structural Insulating Panel (SIPs)	Roof Wall Floor	Interior
Cross Laminated Timber (CLT)	Roof Wall Floor	Interior/ Exterior
Brettstappel	Roof Wall Floor	Interior/ Exterior

to continue burning, leaving the wood core structurally intact. Relatively to the CO_2 storage capacity, one cubic meter of wood, stores 0.8 tons of atmospheric CO_2, meaning that a typical wood-frame house structure containing ~ 14-20 m^3 of wood stores about 11-16 tons of CO_2 atmospheric. In comparison, an equivalent house built with CLT (Figure 2) stores around four times as much, that means that 56-80 m^3 of CLT will store 45-64 tons of atmospheric CO_2 (Popescu, 2017).

CLT has a range of other properties beneficial to both health and well-being, namely good airtightness, thermal performance and sound insulation. The hydrothermal ability of the CLT to absorb and reabsorb moisture allows improving the indoor air quality (Popescu, 2017). Another CLT advantageous feature is its resistance to collapse in the event of an earthquake. The CLT demonstrated outstanding performance in a wide variety of seismic tests in which its fundamental elasticity of the examined structures guaranteed its resistance to collapse (Popescu, 2017).

Figure 2. Construction with CLT panels
(Source: https://www.jular.pt/produtos/placas-e-paineis/paineis-clt).

Although CLT costs a little more than steel and concrete, it makes construction faster, safer, less environmentally harmful and have other health benefits to the population. Even though CLT does not completely eliminate the use of conventional materials, it is allowed to reduce them up to 80%, substantially reducing GHG emissions (Lawton, 2019). Another advantage of CLT is its suitability for buildings rehabilitation. This emerging reconstruction market brings the challenging opportunity of developing site-specific, high quality designed engineered structural and non-structural (e.g. windows, doors, etc.) building components (Arano et al., 2018).

In Portugal, there are some examples of CLT constructions, one of which is the rehabilitation of a building, namely a municipal swimming pool complex in Almada; a single-family housing in Alcanena and nursing home in Coimbra (rehabilitation) (Pontes da Costa, 2013).

In conclusion, the increased use of wood and EWP products allow to reduce the environmental impacts of construction, but could also leverage the development of other forest biomass-based market segments. Relatively low quantities of wood are required for construction, and new EWPs can be developed based on many different species and wood qualities. Supposing that reaching a 20% market share of wood construction in the European Union, it will only be demanded 10% of today's European wood production. So, new markets for EWPs can activate significant side-streams based on wood residues (e.g. chips, sawdust and bark, which can be used for the production of wood-based panels, composites, bioenergy and biochemicals) improving the forest economic viability (Arano et al., 2018).

Lignin as Concrete Admixture

Construction markets are strictly regulated, as well as influenced by tradition, culture, and the availability of local resources. So, a significant diffusion of prefabricated wood products in a short to medium run could be challenging (Hurmekoski et al., 2018). One suitable option for integrating forest-based and construction value chains is to use wood industry by-products such as lignin as an admixture for concrete, which reduces the need for cement and water in concrete (Bozell et al., 2004; Kalliola et al., 2015). Other potential applications of lignin in terms of materials are its incorporation into bioplastics, biocomposites, resins and carbon fibre (Tribot et al., 2019).

Lignin is a very abundant resource. It is a significant by-product of the pulp mills and consists up to 30% of the mass and 40% of the energy content of agricultural and forest biomass (Bozell et al., 2004). So, there is an excellent potential of availability of lignin from different Portuguese production industries, including by-products of the paper industry, wood products and furniture industry, and agri-food production. An added value solution for lignin is its use as a plasticizer additive for concrete. The annual demand for plasticizer additives for concrete can be estimated between 1.5 and 15 million tonnes worldwide if it is assumed that half of the annual cement production of 18 billion tonnes is prepared using a plasticizer dosage of 0.06 to 0.6% by weight of cement (Kalliola et al., 2015).

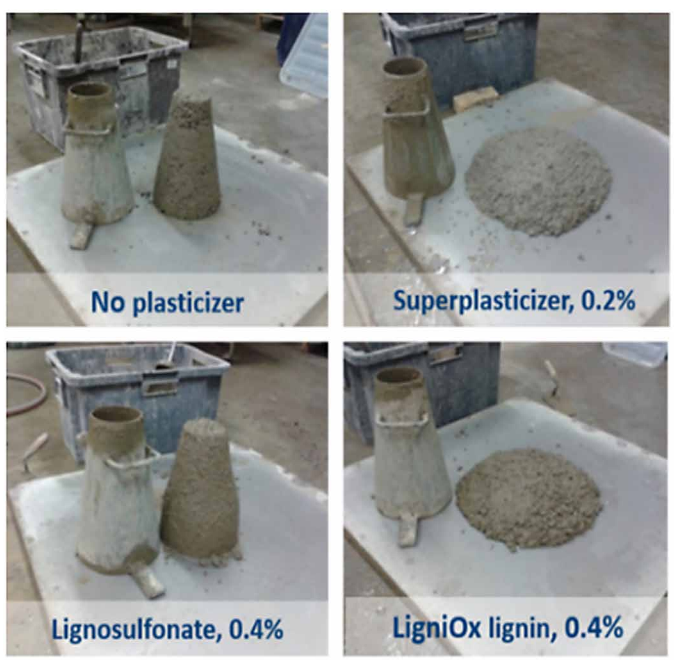
Structurally, lignin is a complex macromolecule chemically and physically very robust, but contrary to cellulose and hemicellulose, its structure varies considerably between different wood species (for example, softwood *versus* hardwood) and changes during fractionation (Bozell et al., 2004). Therefore, the lignin obtained by the pulp mills using the Kraft or sulphite process is a very different raw material.

Lignosulfonates (Bremner et al., 1995), derived from the traditional process of sulphite pulp production, is the source of lignin most used as an admixture of concrete. Its use was estimated in a world volume of 700,000 tons per year (Kalliola et al., 2015). Lignosulfonates are concrete additives highly useful as water-reducing agents and plasticizers. These lignin compounds can deflocculate the fine cement particles of the concrete mixture, forming a smooth and lubricated paste that involves the particles of sand and aggregates. However, lignosulfonates have some disadvantages as they are obtained from the less prominent pulping process, much more expensive than the other existing plasticizer options and exhibit some limitations compared to the existing superplasticizers (Bozell et al., 2004; Kalliola et al., 2015).

Currently, the primary source of lignin is the alkaline sulphate process (i.e. Kraft process). Nevertheless, only a fraction of the lignin produced is separated from the pulp liquors and used in special products. Typically, the mixture of lignin with pulp liquors is used as biofuel in paper production. Therefore, there is a clear need for other added value solutions to this source of lignin (Kalliola et al., 2015, 2017).

Lignin from the Kraft process could be an economical and environmental alternative to petroleum-based or lignosulfonate plasticizers in concrete mixtures. However, this lignin needs to be modified to reach the necessary efficiency for their use as plasticizers or dispersants. So, recently, a new lignin oxidation process - ligniOX was developed (Kalliola et al., 2017). LigniOX technology allowed to obtain a renewable plasticizer with high efficiency after an economic and ecological alkaline process of oxidation. These oxidation process converts lignin into versatile plasticizers, using safe and low-cost chemicals (O_2, NaOH). LigniOX as a concrete plasticizer provides: (1) higher performance compared to lignosulfonates and (2) performance comparable to synthetic superplasticizers at slightly higher doses (Figure 3).

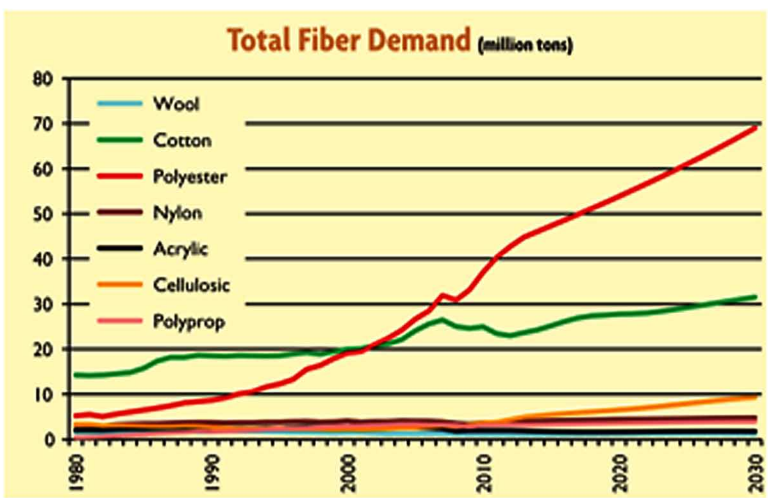
Figure 3. Performance of LigniOX compared to superplasticizers and lignosulfonates
(Source: https://ligniox.eu/ligniox-technology/).



Biotextiles

The textile sector is one of the most significant and growing industries in the world. The demand for textile fibres is increasing rapidly. In 2015, the global production of textile fibres was around 90 million tons, more than twice the production volume of 1990. Man-made synthetic fibres (mainly polyester) dominate the global textile fibre market (69%), followed by cotton (23%) and cellulosic fibres (known as man-made cellulosic fibres - MMCF) which represent only 7% of the global market. However, textiles demand will increase even more in proportion to the exponential growth of the global population. It is estimated that textile will experience a growth of more than 130 million tons by 2030 and more than 2050 million tons by 2050 (Hetemäki et al., 2017). In the specific case of cotton, it is expected stagnation of cotton production due to the limitations of availability of arable land, a large amount of irrigation required (about 3% of global water use) and the use of pesticides. At the same time, more food and textile fibres are being needed, but arable land is decreasing. So the agriculture use of land will be favoured to answer to the growing demand for food supply (Haemmerle, 2011). Thus, the ever-increasing fibre demand will mainly be covered by synthetic fibres (Polyester, Polyamide, Polypropylene, Polyacrylonitrile and others) for several decades (Figure 4).

Figure 4. Evolution and perspective of global textile fibre markets
(Source: https://www.textileworld.com/textile-world/fiber-world/2015/02/man-made-fibers-continue-to-grow/).



However, the environmental impact of the production of the different petroleum-based synthetic fibres has become highly significant. In addition, synthetic fibres being derived from not renewable sources (depletion of fossil resources), they are pollutants (emission of CO_2 during their product life cycle and their harm to aquatic and wild-life ecosystems), are not biodegradable and are not easy to recycle (Karthik & Rathinamoorthy, 2017). Therefore, there is an urgent need to reduce the use of synthetic textile fibres. MMCF are already well-positioned to replace textiles based on fossil resources, because of the quality of their fibres and due to their smaller environmental footprint. MMCF tend to be easier to use due to better moisture-absorbing properties than synthetic fibres (Haemmerle, 2011). One other hand, MMCF are also a close substitute for cotton (Chen et al., 2016). Companies which are mainly using cotton today will add MMCF to their productions to suppress their fibres needs (Haemmerle, 2011). MMCF are synthetic polymers made from natural sources like wood pulp and cotton linters (Shen et al., 2010). However, the wood pulp will be privileged due to the increase of the annual per capita consumption of cellulosic fibres from presently 3.7 kg (2010) to 5.4 kg in 2030 and limitations of cotton production, which only will permit the capacity to cover 3.1 kg of this demand (Haemmerle, 2011).

Viscose staple fibres are by far the most important MMCF (Shen et al., 2010). This textile can be produced from many lignocellulosic materials, including bamboo and agricultural residues. Currently, viscose is almost exclusively provided from the highly pure dissolved pulp (more than 90%). The pure dissolved pulp is bleached cellulose whose production has more than doubled over the last years, representing 3.5% of all global pulp production. Viscose can be produced in pulp factories with the sulphite process and factories with the Kraft process with acid pre-hydrolysis (Hui, 2015).

MMCF have attracted much attention in the last few years due to environmental concerns and the limited fossil fuels, land and water resources (Shen et al., 2010). MMCF-based textiles can be more sustainable than synthetic textiles or even cotton-based textiles. However, it is still necessary to make MMCF more environmentally friendly, removing the use of chemicals with potential toxicity. Traditional viscose uses carbon disulphide, a toxic compound. In the absence of implementing safety measures in terms of wastewater treatment, this chemical has severe effects on human health and the environment (Hui, 2015).

In a recent analysis of Life Cycle Assessment (LCA) carried out by SCS Global Services, it was concluded that the environmental performance of an MMCF-based textile would depend heavily on the biomass source and the production process. For example, viscose produced from recycled clothing performs much better than Asian production, based on the pulp of the European (eucalyptus) or Canadian boreal forest or the pulp of the Indonesian rain forest (Arano et al., 2018). In this sense, new technologies have emerged to improve the environmental performance of MMCF-based textiles, reducing water footprints, the need for toxic chemicals and increasing the recyclability. Some examples are Lenzing modified viscose processes - Modal® (high wet modulus fibres) and Tencel® (Lyocell process), Ioncell-F and Spinnova.

These new and more sustainable technologies for obtaining MMCF have the potential in reducing the environmental impacts over cotton and fossil-based synthetic fibres of the textile industry, and simultaneously allowed the transition to circular bioeconomy of the forest sector.

Lenzing Modified Viscose Processes

Currently, there are only two MMFC processes established on a commercially relevant scale, the viscose and Lyocell processes (Ma et al., 2018). Lenzing AG applied both methods. The company produces 1/5 of the world's man-made cellulose fibres by the application of three generations of technologies: the conventional viscose process (Lenzing Viscose®), the modified viscose process – for high wet modulus fibres (Modal®), and the Lyocell process (Tencel®), which is a solvent-based process (Shen et al., 2010).

As mentioned above, viscose has a leading position in the MMFC market; however, it is little attractive from an environmental standpoint (use of toxic CS_2, the formation of hazardous by-products and the high consumption of freshwater) (Ma et al., 2018).

Lyocell technology represents an environmental alternative to the viscose and to modal production, which is very complex. The underlying idea of the Lyocell process is to dissolve and process the pulp in a closed circuit without any chemical derivatization. Similar to Viscose® and Modal® fibres, the basic raw material of Tencel® is dissolved pulp from sustainable forests (Lenzing AG, 2020).

The Lyocell process represents a different spinning technology, in which the cellulose substrate is dissolved directly in Nmethylmorpholin N-oxide monohydrate (NMMO), without any chemical derivatization, to yield a spinning dope that is processed by dry-jet wet spinning (Ma et al., 2018). Lyocell technology allows recovering more than 99.5% of the solvent in a closed chemical circuit (Lenzing AG, 2020). Lyocell process is considered as greener technology than the viscose process.

Ioncell – F

Even though the Lyocell process to obtain Tencel® is considered a closed-loop, environmentally friendly process and a more ecologic alternative to the viscose process, some problems need to be solved. One of the biggest challenges is that the solvent used in the Lyocell process (NMMO) can undergo strongly exothermic reaction at high temperatures, which requires stabilizers adding to avoid spontaneous runaway reactions and extensive cellulose degradation. Besides that, viscose and Lyocell processes request highly purified dissolving pulp or paper-grade pulp for best spinning performance (Ma et al., 2018).

A recently developed alternative spinning technology termed Ioncell-F could be a more sustainable and ecological alternative to the production process of viscose and Tencel® (Michud et al., 2016). Ioncell-F produces cellulosic fibres from forest biomass using ionic liquids 1,5-diazabicyclo [4.3.0]non-5-enium acetate ([DBNH][OAc]) as a direct solvent for cellulosic substrates through a Lyocell-type dry jet-wet spinning process (Ma et al., 2018). The only chemicals applied are the non-toxic ionic liquid and water, and both are recirculated in the closed-loop process (Michud et al., 2016). Furthermore, the operation temperature o Ioncell-F is moderate (80 °C), an advantage to be tolerated by raw materials with varying amount of non-cellulosic components (Ma et al., 2018).

The tolerance of Ioncell-F process to low purity raw materials could be an opportunity to revolutionize the recycling of waste cellulosic materials. Recent studies using the Ioncell-F method showed that it is an up-and-coming technique for the conversion of waste cotton (Asaadi et al., 2016) and low refined waste cellulosic materials like waste newsprint (Ma et al., 2018) into high-quality MMCFs.

Ioncell-F fibre exhibit properties equal to or better than viscose and Tencel® fibres. Due to their high tenacity, Ioncell-F fibres are excellent to technical applications. Among the features of the Ioncell-F fibre, it is worth stating its moisture absorption capacity, biodegradability, shine and dye-capability like cotton and viscose (Michud et al., 2016).

Spinnova

Spinnova is the only textile fibre based on cellulose manufactured from certified wood pulp (from sustainable forest management), which does not use chemicals at any stage. This patented spinning technology (US20170016151) is based on the mechanical treatment of the pulp, as well as the flows and rheology of fibre suspension. In Spinnova process pulp is mechanically refined in a very thin material and similar to a paste called microfibrillated cellulose (MFC).

Spinnova is a much more sustainable solution than synthetic textiles and cotton because it does not use harmful chemicals, does not produce waste and the only secondary product is water, which is reused in the process. This textile fibre mitigates the effects of the textile industry on global warming and leaves a smaller carbon footprint in the process. Besides, the company is looking to use other biomass sources, like agriculture and organic waste, adding value to the problematic waste streams. Another advantage of textile fibre obtained by Spinnova process is to be suitable to functionalization. Depending on the application, Spinnova fibre can be repellent or water absorbent (Spinnova, 2020).

Companies like the Finnish brand Melli EcoDesign are experimenting the Spinnova fabrics. Melli EcoDesign specializes in clothing for babies and premature babies, is particularly interested in textiles with different textures (Figure 5).

Some news and data indicate that Spinnova technology could replace the entire global cotton production (25 million tons in 2014) with 60 million m^3 of wood. Others estimate that 10 million m^3 would be needed to replace 10% of the global cotton markets (Hetemäki et al., 2017).

Figure 5. Melli stores EcoDesign clothing made with Spinnova fibre
(Source: https://finland.fi/pt/negocios-amp-inovacao/inovacoes-finlandesas-em-fibra-podem-mudar-a-industria-textil/).

Bioplastics

Most plastics on the market are of synthetic origin, usually derived from fossil fuels, and are used in products such as packaging, PET bottles, trays, containers and clothing. According to the World Economic Forum, plastics production has increased over the past 50 years, from 15 million tons in 1964 to 311 million tons in 2014 and is expected to quadruple in 2050 to 1.1 billion tons. From all plastic sectors, the packaging is the most significant sub-sector, representing 26% of the total use of plastics (Hetemäki et al., 2017).

The production and use of petrochemical plastics are responsible for the main challenges of environmental sustainability: CO_2 emissions, increase of non-biodegradable plastic waste in ecosystems (for example, oceans) and waste problems in general. The triple-environmental problem of plastics (disturbance of ecosystems, creation of landfills, CO_2 emissions) grow the necessity to find alternatives for this material. The immediate action is to increase the recycling and reuse of plastics. However, it is also necessary to gradually replace plastics with new materials that are less harmful to the environment but that at same time do not constrain the recycling process.

A promising solution is to use bioplastics based on forest biomass, specifically plastics refined from cellulose (Hurmekoski, 2017). These undirect plastic-mimicking products have the advantage that could be produced using the existing industrial infrastructure of plastic sector (Hetemäki et al., 2017). Some examples of these plastic-mimicking products highlighted in the literature include wood-plastic composites, paper-like films for flexible packaging and other plastic resembling wood or fibre-mix materials for rigid packaging (Hurmekoski et al., 2018).

Therefore, the case studies of plastic market selected are new materials based on wood (cellulose) or fibre and wood-plastic composites, which are similar in terms of properties to plastics and thus can replace them in packaging.

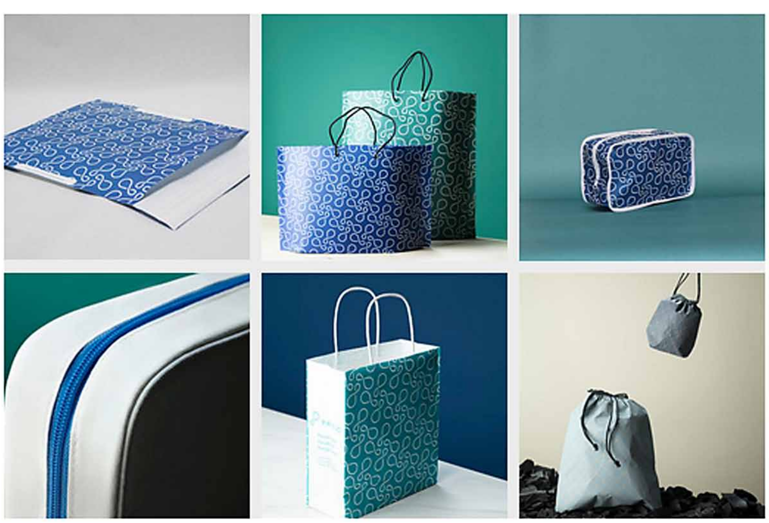
Flexible Plastic Packaging – Paptic®

Paptic is a next-generation packaging material, bio-based, recyclable and renewable, made from sustainable wood fibre. This material is developed by a Finnish company with the same name. Paptic is suitable for uses where plastic films were previously the only alternative (Metsafibre, 2018).

Paptic can be generated on production lines of special paper equipped with patented foaming technology. The material is manufactured with long-fibre wood pulp, offering pleasant haptic properties, in addition to the durability and resistance characteristics usually found in plastics (Metsafibre, 2018). Paptic's high durability is due to its high tear resistance, fracture toughness and stretching. The material extends up to 20%, compared to 5 to 7% in typical packaging papers. Their tear resistance is 300% higher than paper, and they weight even less than paper bags (30% lighter), also taking up less space. Another advantage of Paptic relates to its versatility, which can be converted into products with machines used for plastic and paper, but can also be stitched as a textile. In terms of sustainability, 80% of Paptic's raw materials biodegrade, having a lower environmental impact than current plastics (Metsafibre, 2018).

Paptic is suitable for a variety of uses, including bags, medical, cosmetic and e-commerce packaging, graphic applications and technical end uses (Figure 6).

Figure 6. Examples of Paptic application
(Source: https://paptic.com/)



Rigid Plastic Packaging – Sulapac®

Sulapac products are made from a combination of wood chips and biodegradable natural binders. The Sulapac can be recycled under industrial composting process, and it is free of microplastics (Sulapac, 2020b). Sulapac is industrially compostable following the European Standard EN 13432 (Sulapac, 2020a)

Sulapac possesses all the technological benefits of plastic without the disposal associated environmental problems. It is water and oil-resistant and is also oxygen-barrier (European Union Commission, 2018c).

Sulapac products combine ecology, luxury and unlimited design possibilities (Figure 7). It is suitable for the large-scale manufacture of rigid and flexible packaging, such as bottles and tubes. It can also be used for lightweight packaging. Sulapac is a real alternative to plastics used in cosmetics and food industries (European Union Commission, 2018c).

As forest biomass-based material, the sulapac products have a low carbon footprint, but they are similar to plastic in terms of price, formability and functionality. It can also be produced in large scale with the same types of equipment than plastic, for example, injection moulding machines, without the need to invest in new equipment (European Union Commission, 2018c).

Figure 7. Straws and packaging produced with Sulapac
(Source: https://www.sulapac.com/portfolio/#universal).

Another example of rigid bioplastic is Arboform® produced by TECNARO GmbH in Ilsfeld-Auenstein (Baden-Württemberg). This material is obtained by a combination of recovered lignin from the pulp and paper industry with natural fibres for reinforcement – such as flax, hemp or other plant fibres – to create a composite. This lignin based-material is processed based on standard technologies of polymer engineering. Like *sulapac*, the *arboform* can be injection moulded and pressed like thermoplastic raw material, without the need to invest in new equipment (Nägele et al., 2002).

According to Nägele *et al.*, (2002), *arboform* is forest biomass-based material combining the attributes of natural wood and the processability of a thermoplastics. Due to its wood-like appearance and malleability, it can be used in the automobile industry (e.g. carrier for wooden veneers or decoration of the front-end parts), housing industry (e.g. exclusive furniture, garden accessories and flooring), electronic industry (e.g. computer mouse, bass reflex tubes, covers for computers or TV sets and loudspeakers with special design) and consumer industry (e.g. musical instruments, toys, cases for watches and clocks, necklaces with wood aspects, button, ring, etc.) (Figure 8).

Figure 8. Soapbox produced with Arboform®
(Source: https://www.altramoda.net/en/prod/soap-box-from-liquid-wood).

Wood-Plastic Composites

The wood-plastic composite (WPC) is a hybrid material composed of natural wood flour filler and thermoplastic resins (typically synthetic). Currently, WPC production is one of the most dynamic and fastest-growing sectors in the wood industry. The trend in the production of WPC is increasing. About 220,000 tons were produced in Europe in 2010, and this capacity increased to 260,000 in 2012. United States of America demand for WPC is expected to grow at a rate of 6.9% per year, reaching US $ 5.9 billion in 2020 (Popescu, 2017). This exponential growth of WPC is linked to its applicability in several sectors including garden and yard products, packaging, consumer goods (Zhou et al., 2019); however, the significant growth sectors, worldwide, are automotive and construction products (Popescu, 2017).

The wood components in the WPC are generally used in the form of sawdust or small fibres and typically comprise between 30 and 70% of the final product (Zhou et al., 2019). Sawdust is mixed with new or reused plastic powder, from plastic materials such as polyethene (PE), polyvinyl chloride (PVC), polypropylene (PP) and acrylonitrile-butadiene-styrene (ABS). Subsequently, the materials are mixed to obtain a specific consistency (relatively thick) and, finally, they are extruded or moulded (Popescu, 2017).

The WPC compound, which consists of PE and wood sawdust, tends to be used mainly in construction and structural components. On the other hand, when PP is incorporated, the most common use of WPC is automotive and consumer products. In turn, wood and PVC sawdust create a WPC that is usually used in the manufacture of windows, as well as in decking applications. The combination of ABS and wood sawdust produces a WPC that can also be used in several forms (Thomasnet, 2019).

WPC contains a high content of cellulose, which allows to be subjected to the same processes than wood, like planning, drilling and sanding. Nails, screws and other fasteners generally achieve higher retention when applied in WPC than in sawn wood. Besides, WPC offers superior water resistance, superior resistance to microbiological deterioration and superior resistance to high-temperature environments in comparison to wood (Thomasnet, 2019; Popescu, 2017).

Another great advantage of WPC is the possibility of incorporating recycled plastic, which allowed to add value to the waste streams towards to circular bioeconomy concept (Keskisaari & Kärki, 2018).

The production of bioplastics from forest biomass presents itself as an opportunity to obtain new biomaterials at lower costs, which combine the properties of biodegradability and thermoplastics (Hurmekoski et al., 2018). Besides, they allow the side flows and by-products/residues of the wood industry to be valued, but also of other sectors such as agro-food and plastics, increasing the circularity of bioplastics production chain.

Market Potential of the Identified Forest Biobased Products

The new bioproducts from the forest biomass just identified in key sectors such as construction, textiles and plastics and packaging have high potential and attractive markets. After the qualitative review of the new biomaterials, we assess the market potential of these emerging bioproducts. In particular, we present quantitative estimates of the impacts of the diffusion of new products on the industry's revenues in Portugal.

Following Hurmekoski et al. (2018) closely, we estimate the impacts on revenues if products from forest biomass become 5% in the global construction, textiles and plastics and packaging markets in 2030, currently dominated by cement, synthetic fibres and petrochemicals, respectively. It is assumed that in 2030 the forest-based industry still depends to a large extent on traditional value chains given the long term of investment cycles, while the large-scale diffusion of new bioproducts is still unlikely.

Instead of deriving point estimates, a range of values was estimated, based on a minimum and maximum unit value (Hurmekoski et al., 2018). The intervals allow the understanding of the possible range of effects.

It is estimated that a 5% market share of these bioproducts in the global construction, textiles and plastics and packaging markets in 2030 corresponds to an aggregate increase in revenues of 260-579 million € per year in Portugal (Table 5).

Table 5. Implications for revenues in Portugal of a 5% market share of bioproducts from forest biomass (estimated values).

	Construction	Textiles	Plastics and Packaging	Total
Production value (10^6 €)	131 - 297	101-188	28 - 94	260 - 579
Unit value (€/ ton)	50 - 2 245	1 200 - 2 228	860 - 4 000	

Unit values are very different, depending on the stage of the product value chain. For example, biobased textiles can generate revenues between 101-188 million €, if biomass is used in MMCF, such as Ioncell-F or the production of Spinnova, respectively (Table 6). In contrast, valuing only the dissolved pulp, this would correspond to revenues of only 45 - 85 million €, clearly showing the potential for value creation in differentiated products with high value added.

For the same reason, the use of lignin as a concrete admixture can generate revenues between 0.616 - 4.5 million €, while wood products, which can range from processed wood products, such as CLT, to prefabricated building elements, including modular elements, can generate revenues between 130-293 million € (Table 6).

In the plastics and packaging sector, wood-plastic composites (WPC) have the greatest market potential, with a higher unit value than the other solutions, estimating that they can generate revenues between 19-78 million €.

Table 6. Implications for revenues in Portugal of a 5% market share of bioproducts from forest biomass – detail by sector (estimated values).

Market	Bioproduct	Production Value (10^6 €)
Construction	Lignin as concrete admixture	0,616–4,5
	Engineered wood products	130–293
Textiles	MMCF (eg., *Ioncell–F*)	101–149
	Spinnova	188
Plastics and Packaging	Flexible plastic packaging (e.g., Paptic)	2–4
	Rigid plastic packaging (e.g., SULAPAC)	6–12
	Wood-plastic composites (WPC)	19–78

Environmental Externalities of the New Bio-Based Products

Pollution generated by the production, use and disposal of materials results in numerous costs for society, namely, impacts resulting from climate change, impacts on human health, damages to property, reductions in the productivity of ecosystems, among many others. Producers or consumers do not typically pay these costs, but they negatively influence other members of society. Hence, they are designated external to the decision-making process of producers and consumers.

Not considering these "externalities" results in levels of production and consumption that are not economically efficient (optimal) when viewed from society perspective. Scarce resources are not efficiently allocated. The economy is not efficient, and the well-being of society as a whole decrease.

The internalization of environmental externalities is possible through environmental regulation, namely through taxes on products or on the pollution generated as a way to reduce the costs of externalized pollution. This way, private costs become closer to the social costs caused. The internalization of externalities results in allocations of resources that are more efficient for society. If they are entirely internalized, society will achieve the optimal solution.

The problem of pollution has definitely entered the international political agenda and at the top of the priorities is the concern with climate change and its unforeseeable consequences. The European Commission has just presented its European Green Deal with the ambition that Europe will become the first carbon-neutral continent in 2050. Significant developments are expected in terms of environmental regulation to achieve the set targets.

Thus, it is essential to point out the implications for environmental sustainability, in particular, for the decarbonisation of the economy, arising from the diffusion of new biomaterials.

In this section, we estimate the environmental externalities associated with conventional products used in the sectors of construction, textiles and plastics and packaging and compare them with the bio-products focused on this study.

Construction

The use of CLT, instead of concrete, allows to reduce GHG emissions by about half, only in the production phase. In addition, considering wood as a carbon sink, CLT retains 0.81 ton/ m^3 of material, which corresponds to about € 36/ m^3 of material (Table 7). From an economic efficiency standpoint, this means that the internalization of the positive externality is desirable. In other words, it is advisable a compensation to the producer corresponding to this positive externality, so that the optimum level of production is achieved.

If we add the construction phase, concrete has an externalized environmental cost of 207 €/ m^3 of material, only regarding GHG emissions. Thus, in a regulatory context of internalization of negative environmental externalities, caused only by GHG emissions, there is an increase in costs of 225 - 227 €/ m^3 of material (see Appendix 1 for more detailed information).

Table 7. eCO_2 emissions and the value of externalities (production phase).

	eCO_2 Emissions (ton/m^3 Material)	Externalities (€/m^3 Material)
Concrete	0,4 – 0,439	18 – 20
CLT	0,236	10,5
CLT (wood as a carbon sink)	-0,81	-36,2

Textiles

Traditional textiles are also major emitters of GHGs, in addition to the high impact in terms of water and soil use (Table 8), as opposed to MMCF (Table 9).

The internalization of environmental externalities caused by GHG emissions generates an increase in costs that can range from a minimum of 112€/ ton of fibre to a maximum of 357€/ ton of fibre, in the case of organic cotton and cotton, respectively, very distant from 5 - 6 €/ ton fibre in the case of MMCF. The difference is even more significant, as, in the case of MMCF, this figure includes, in addition to GHG emissions, the environmental costs of SO_2 emissions at the origin of the acidification problem.

Table 8. eCO_2 emissions and the value of externalities of traditional textiles (process stage: cradle to gate).

	eCO_2 Emissions (ton/ton fibre)	Externalities (€/ton fibre)	Water Use (ton/ton fibre)
Cotton	2 – 8	89 – 357	5 732 – 22 000
Organic cotton	2,5	112	24 000
Polyester	2,8	125	62

Table 9. eCO_2 and eSO_2 emissions and the MMFC value of externalities (process stage: cradle to gate).

	Pollutant	Emissions (ton/ton fibre)	Externalities (€/ton fibre)	Water Use (ton/ton fibre)
Tencel	eCO_2	0,05	2,2	263
	eSO_2	0,013	3,4	
	Total		5,6	
Modal	eCO_2	0,03	1,3	472
	eSO_2	0,015	3,9	
	Total		5,2	

Note: Viscose is also MMCF, although more traditional and with greater use of chemicals. Its polluting impact is closer to conventional textiles. For more information, see Appendix 1.

Water use is also incomparably lower in the case of MMCF, which also means much more moderate cost increases in a scenario of internalization of the externality (See Appendix 1 for more detailed information).

Plastics and Packaging

Bioplastics are exciting alternatives to conventional plastics from an environmental externalities perspective.

The polyethylene (PE) bag has an externalized environmental cost of 180 €/ ton plastic bags. In contrast, the Paptic bag emits only about 40% of the GHG emissions of the Polyethylene bag and has an external cost of 76 €/ ton plastic bags (Table 10 and Table 11).

Table 10. eCO_2 emissions and externalities of conventional plastics (process stage: cradle to end-of-cycle incineration)

	eCO_2 Emissions	Unit	Externalities	Unit
PE bag[1]	4,04	ton/ ton plastic bag	180	€/ ton plastic bag
Flexible/ rigid plastic – PET [2]	31,4	ton/ ton 1.5 L bottle	1402	€/ ton 1.5 L bottle
Flexible plastic – PP [3]	2		89	u.m/ ton material
Rigid plastic – HD-PE [4]	1,86	ton/ ton material	83	u.m/ ton material
Rigid plastic – PVC [5]	0,04586	ton/ m^2 deck	2,048	€/ m^2 deck

[1]Polyethylene including 10% recycled plastic;[2] Polyethylene terephthalates; [3] Polypropylene; [4] High density polyethylene; [5] Polyvinyl chloride.

Table 11. eCO_2 emissions of bioplastics (process stage: cradle to end-of-cycle incineration).

	eCO_2 Emissions	Unit	Externalities	Unit
Paptic bag	1,71	ton/ ton plastic bag	76	€/ ton plastic bag
Supalac	0,77	ton/ ton material	34	€/ ton material
WPC	0,02842	ton/ m^2 deck	1,269	€/ m^2 deck
WPC with recycled plastic	0,01550	ton/ m^2 deck	0,692	€/ m^2 deck

PET, a conventional plastic used in rigid and flexible plastic packaging and very common in plastic bottles, emits 31.4 ton of eCO_2 / ton 1.5 L bottles, which corresponds to a cost of 1402 €/ ton 1,5L bottles.

Sulapac offers solutions as an alternative to conventional plastics, such as Polypropylene (PP) (for example, the case of plastic straws) and HD-PE - High-density polyethene (HD-PE) (for example, boxes of cosmetic products), which are also very attractive from an environmental perspective. GHG emissions are around 40% when compared to traditional solutions. This means an environmental externality estimated at 34 €/ ton of material as opposed to 83 – 89 €/ ton in conventional cases.

WPC, which can be a PVC substitute, corresponds to a reduction of the externalities associated with GHG emissions by about 60%. This reduction is even more striking in the case of WPC with recycled plastic, making it possible to reduce to about a third of GHG emissions. Adding damages from emissions related to the remaining pollutants considered ($ePM_{2.5}$, eN, eSO_2), WPC has an externalized environmental cost of 1,703€/ m^2 deck while PVC has associated a total environmental cost of 2,445€/ m^2 deck. This value decreases to just 0,828 €/ m^2 deck in the case of WPC with recycled plastic (see Appendix 1 for more detailed information). These differences are very significant in the context of internalization of environmental externalities through environmental regulation.

Other Bio-Based Products and Biomaterials Based on Agroforest Biomass

Other bioproducts and biomaterials obtained from forest biomass can also be considered at the level of other sectors such as the food and cosmetics industry. We can highlight some cases, namely:

Food Ingredients

Polymers derived from wood (xylans, fibrillated cellulose and lignin) have been tested, and the results obtained indicate that they can be used to improve the texture and reduce the caloric content of food products. According to the VTT Technical Research Center of Finland, ingredients derived from wood can be used in the formulation of products such as yoghurt, bakery and meat products (FOOD manafacture, 2016).

Xylooligosaccharides (XOS), hemicellulose extracted from birch pulp, can be used as a texture enhancer in yoghurt at concentrations of 1.5% and 3%. VTT studies have shown that XOS improve the smoothness of yoghurt. Simultaneously, they improve texture stability; that means there is no separation of water from the gel in the tested yoghurts. Another benefit of the application of XOS instead of fructans is that XOS demonstrated to decompose more slowly *in vitro* model of the colon, so it is a most unlikely occurrence of flatulence, in contrast to fructan (FOOD Manufacture, 2016). XOS has a proven prebiotic effect, meaning they are non-digestible nutritional ingredients that beneficially affect intestinal health, selectively stimulating the growth and activity of one or more beneficial bacteria in the colon. XOS are growing ingredients on the world market. However, they are mostly obtained from sugarcane. There are already studies and projects at industrial scale-up phase, which explore lignocellulosic waste and by-products, particularly LIGNOFOOD and its precursor LIGNOXOS (https://lignoxos.eu/).

Another ingredient derived from wood with the ability to modify the food texture is fibrillated cellulose, produced by cellulose fibres using wet milling. Fibrillated cellulose can be used as a thickening and stabilizing agent, for example, in fermented dairy products, such as yoghurt. In the VTT *in vitro* digestion model, it was also observed that fibrillated cellulose binds to free bile acids, which is an indication of the potential cholesterol-lowering effect on the human body (FOOD manufacture, 2016).

Cellulose can also be used in the food industry in the nanocrystalline form (CNC). Several studies have shown that CNC can be applied as a low-calorie substitute for additives such as thickeners, flavour enhancers and stabilizers in a wide variety of food products, being useful in the production of fillings, snacks, crackers, soups, sauces, puddings, etc. (Mu et al., 2019).

Lignin is another candidate for a new food ingredient. The surfactant properties of lignin can be used to prepare emulsions (mixtures of water and oil) and foams with better texture. Lignin can also be used to reduce oxidation in food products. VTT tested lignin in muffin production, and in addition to provide the muffins with a softer texture, lignin proved to be an efficient substitute for whole eggs and yolks. Lignin can also function as an emulsifier in mayonnaise and allows more juiciness in meat products (FOOD Manufacture, 2016).

Another example of wood exploitation in the food sector is the wood extracts marketed and produced by Stoak Technologies (https://www.stoaktechnologies.com/). These extracts are obtained by liquefaction process and are sold as stabilizers and flavourings for beer, wine and spirits.

Food Coatings

Bio-based barrier materials consisting of natural xylans and water-soluble additives have been developed. An example is the Xylophane® material marketed by the company Seelution (Seelution, 2019). This material has an efficient oxygen-barrier capacity, as well as to the fats and flavours that allows to prolong the shelf-life of sensitive foods (including fatty and dry foods) or to be a sustainable alternative (renewable and biodegradable) to the barrier materials present in the market. Besides, given its water-soluble character, this barrier material can be coated, for example, on paper, cardboard or plastic without the use of other solvents (Biobased News, 2019).

CNC is another bio-based compound that has been shown to improve the mechanical properties of polymers, such as thermoset resins, starch-based matrices, soy protein, latex and polylactic acid (PLA). Thus the CNC can be applied in composites and later used as coating and/or food packaging films (Mu et al., 2019).

Cosmetic Ingredients

Between the different components of wood, lignin has a high potential in terms of application in the cosmetic sector. Lignin, after cellulose, is the most abundant component of wood; however, it has not been explored on a large scale like cellulose. The cosmetic and personal care products market could be a key sector to enhance the value of lignin. Lignin has desirable properties for the cosmetic industry, namely protection against UV rays, antioxidant and antimicrobial activity (Lee et al., 2019).

Lignin contains UV-absorbing functional groups, and because of this, it has been tested on a wide variety of materials for UV protection applications. Furthermore, it was found that lignin and lignin-based products are not cytotoxic. However, lignin has a dark colour that is rejected by consumers and constitutes a serious difficulty to its promotion in the sunscreen market. In this sense, new studies have been developed to obtain lighter coloured lignin (Lee et al., 2019).

Recently, Lee *et al.* (2019) developed a less aggressive lignin extraction process from *Miscanthus sacchariferous* and *Pinus densiflora*, obtaining lignin with a lighter colour than the lignin obtained by more conventional methods (high temperatures and acidic/ basic solutions). This lighter lignin also showed UV absorption capacity similar to conventional lignin and better performance as a sunscreen, in solution and when incorporated in a cream formulation. Additionally, it was also found that the lignin obtained by Lee *et al.* (2019) showed synergistic effects with commercial sunscreen that increased the sun protection factor.

The UV rays protection capacity of lignin has also been the aim of study for tissue functionalization. Bhushan *et al.* (2019) tested the functionalization of woollen fabrics in the presence of metal mordants using lignin extracted from peanut shells. These tissues showed UV protection, antioxidant and antibacterial activity (against *Staphylococcus aureus* spp. and *Escherichia coli* spp.).

In addition to lignin, bark extractives have been the fraction of wood most explored by the cosmetic sector. Extractives contain a large quantity of phenolic compounds (lignans, flavonoids, etc.) with potent antioxidant activity and other biological activities of interest to the cosmetic sector as anti-ageing. For example, in a study carried out with extracts of bark residues produced by the Canadian forestry industry, a high content and diverse phenolic compounds were identified. Among the twelve extracts studied, it was demonstrated that the ethanolic extract of the bark from the Indian pine had the broadest spectrum of skin anti-ageing activity, followed by the extracts of the red maple bark (Royer et al., 2013).

Soluble extracts of phenolic compounds from extractives also have potential application in the food industry as preservatives (Chana-Thaworn et al., 2011; Soriano et al., 2018) or bioactive ingredients with several health benefits (Bakasatae et al., 2018). Also, extracts contain a high oil content, namely plant sterols that can be explored in the cosmetic sector, but also as functional ingredients for human nutrition with beneficial effects in reducing cholesterol (Nisula, 2018).

There are already some wood extracts marketed. For example, BIO FOREXTRA (https://www.linkedin.com/company/bio-strat-ge/about/) produces wood extracts from bark by-products from the sawmill industry. Another example is the Nordic Beauty PiNe Bark extract from THE INNOVATION COMPANY (https://www.in-cosmetics.com/__novadocuments/604996?v=636991515600400000) obtained from Finnish pine bark (*Pinus sylvestris*). These extracts have a high content of flavonoids, known for their antioxidant action (much more effective in eliminating free radicals than vitamins C and E) and skin regeneration action.

Cellulose in the nanocrystalline form (CNC) is another derivative of lignocellulosic biomass that can be used as a thickener in the formulation of cosmetics (Phanthong et al., 2018).

Animal Feed

Another potential application of forest biomass derivative is in the animal nutrition area. XOS, for example, are ingredients that, can be incorporated into animal feed to provide nutritional benefits and different beneficial effects such as immunomodulatory activity, growth-regulating activity, antimicrobial activity, etc. For example, in chickens and fish, it was found that the addition of XOS to feed can increase growth and weight gain, improve endocrine metabolism and improve immune function (Aachary & Prapulla, 2011; Zhenping et al., 2013).

Agro-Food Waste as a Raw Material for Bio-Based Products

Waste could be an important feedstock and renewable resource to develop new bio-based materials. The population growth and the industrialization have led to a generation of the enormous amount of biomass waste, which are biodegradable and vastly underutilized (Cho et al., 2019). In a context of circular bioeconomy, the existence of waste is not consistent with its fundamental principles. Indeed, the main challenge in the transition from the linear to the circular economy is to use waste as a raw material for closing the energy loop (Venkata Mohan et al., 2019). Biomass waste is available in large amounts in Europe, and they are mainly derived from agricultural and forestry activities, sludge and food industry (Fava et al., 2015).

It is essential to distinguish between ‘food loss’ and ‘food waste’. Food loss should mean the decrease in edible food mass throughout the food chain. Food losses take place in production, postharvest and processing stages in the food supply chains. On the other hand, the term food waste is more comprehensive, and it includes all resources that are lost in the different sectors of the food supply chain and will also include those parts that were originally not intended for human consumption (Pap et al., 2014).

Regarding food waste, the European agro-food sector generates significant quantity of by-products and waste (about 250 mil MT/year) and simultaneous large volumes of highly polluted effluents (Fava et al., 2015). Currently, some food companies are paying for disposing of their waste and effluents. Thus, the food waste value chain presents great social and economic opportunities, as well as environmental benefits in transforming by-products and waste into a renewable and profitable raw material to obtain new bio-based products (Bell et al., 2018).

Several studies have shown that food waste and by-products are a valuable source of biomass that can be used to obtain various chemicals, materials and fuels (Garcia-Garcia et al., 2019).

The food by-products, residues and effluents of these industries consist of a mixture of proteins, sugars, fibres and lipids, together with vitamins and other bioactive compounds, and therefore can be cheap and abundant sources of chemicals, biomaterials and substrates for biotechnological production (Fava et al., 2015; Satari & Karimi, 2018). Energy recovery should be the last step of the cascade approach valorisation by itself, since is not the best, nor the most sustainable option (Fava et al., 2015).

Regarding the emergent market segments identified to forest biomass, food waste and by-products could also be exploited as raw materials to replace fossil fuels in the production of new biomaterials. In Portugal, the by-products/ residues with the highest valorisation potential taking into account the total national quantity produced and the moisture content are Brewers’ spent grain, grape pomace after distillation, locust bean pulp, rice husk, tomato pomace, olive pomace after oil extraction, hard fruit shells, wine stalks, grape seed and wine sludge (Duarte et al., 2007). Some case studies were highlighted in the sector of construction, plastics and textile also consider the leading sources of food waste and by-products in Portugal.

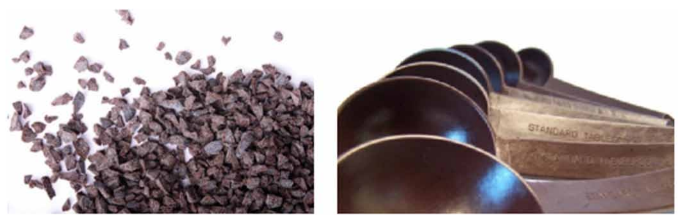
Agro-food residues have been tested as a source of lignocellulosic fibres, namely rice husks and banana by-products/ residues, showing that they are beneficial in strengthening the polymeric matrixes of the WPC (Habibi et al., 2008). On the market, rice husk, which is a significant agro-food by-product in Portugal, have been combined with wood fibre and thermoplastics to obtain recyclable, eco-friendly decking materials. Some examples are Duro and Duro Excellence from iDecKing revolution or WPC from Floorrich Global Pte Ltd (Figure 9).

Other bio-based plastics that mimic plastic behaviour have been developed based in agro-food waste and by-products, and some of them are already marketed. A relevant example is the Novatein® bio-based plastic produced by Aduro Biopolymers. Novatein is made from bloodmeal, a co-product from the red meat industry. Novatein, in the form of granules, could be applied in injection moulded or extruded products that are compostable (not yet tested against standards) (Figure 10).

In addition to their application in the bioplastics sector, food by-products and waste have been used to manufacture sustainable building materials. Agricultural waste as rice and wheat husk has been used to develop a composite insulation panel to be used in interior construction with thermal insulation properties

Figure 9. WPC made with rice husk from iDecKing revolution and Floorrich Global Pte Ltd
(Source: https://idecking-uk.com/products/materials/duro; https://floorrich.com/product_cat/wood-plastic-composites/).

Figure 10. Novatein ® granules and an example of its applicability
(Source: http://adurobiopolymers.com/Novatein; https://foodandcity.org/edible-materials/).



with promising results (Muthuraj et al., 2019). In the same study textile waste was also tested. Besides the scientific studies, there are also some bio-based materials derived from food waste used in building apparel already in the market. Some examples are:

1. Kokoboard panels boards or particle boards produced using a special glue (without formaldehyde) by pressing unwanted agro-waste from local farmers as post-harvest rice straw, rice husk, peanut shell and coconut dust. These boards are suitable for interior design including walling, ceiling, flooring and furniture making (Figure 11).

Figure 11. Eco-boards from Kokoboard
(Source: http://www.kokoboard.com/en/eco-board/).

2. MycoComposite™ (Mycelium-bound agricultural by-products) form Ecovative which are foams and wood substitutes manufactured from mushroom mycelium, which binds together agro-waste fibres such as flax, canola and hemp. The material is moulded or pressed into a variety of shapes and densities as packaging, acoustic and thermal insulation and board material. Krown Design is the partnership of Ecovative, which have been expanded this mycelium-bound agricultural by-products based-product to Europe creating and selling their products in the European market (Figure 12).

Figure 12. The Growing Pavilion. MycoComposite™ panels made by Krown.bio
(Source: https://www.grown.bio/).

3. Coco Tiles from Kirei made from coconut shells which are an agricultural by-product typically subjected to open burning. These tiles are rigid self-backed or mesh-backed that can be applied with construction adhesive in interior surfaces (Figure 13).

Figure 13. Coco Tiles from Kirei
(Source: https://kireiusa.com/products/coco-tiles#product-specs).

Another construction material in which different residues and by-products from the food industry have been increasingly integrated is concrete. Among the different agro-food residues and by-products we can emphasize bamboo, corn, banana, wheat and even the seashells of oysters, clams and cockles wasted by aquaculture (Luhar et al., 2019). An example of agro-food waste based-admixture for the concrete present in the market is Silpozz produced by N K Enterprises. This organic micro-silica/ amorphous silica was obtained from rice husk ash.

Researchers have been studying the production of bricks from waste materials. Olive stone, a component from the olive pomace, separated and mixed with clay showed to reduce water absorption and the thermal conductivity of fired clay bricks, and also act as an organic closed-pore forming agent in clay bricks, increasing their porosity, and so improving the thermal conductivity (Arezki et al., 2016). The olive stone also showed to be an appropriate material to make particleboards for interior design (Farag et al., 2020).

Another biomaterial type in which agro-food waste has been applied with great success are textiles. Currently, there are already textiles on the market obtained from by-products of fruit processing (pineapple and orange) such as Pinãtex ® and Orange Fiber ®.

The company Ananas Anam developed Piñatex; a pineapple leaves fibre-based fabric. The pineapple leaves fibres are glued together without knitting or weaving. Farmers extract the fibres from the leaves

Figure 14. Pinãtex manufacturing process: harvesting, dismantling, drying, washing, degreasing, fabric formation, finishing, final fabric
(Source: https://www.ananas-anam.com/about-us/).

on the plantation through a delicate disassembly process, and then fibres are combined to form a network and then converted into fabrics (Figure 14). The remaining biomass after fibre extraction can be used as a natural fertilizer.

The Pinãtex is distributed to designers directly by Ananas Anam, which uses it as a sustainable alternative to leather in footwear and fashion accessories, clothing, interior furniture and car upholstery (Figure 15).

Recently another alternative to leather obtained from animal-based by-products appeared on the market. *Atlantic leather* company introduced a line of Atlantic Leather that uses by-products of the fishing industry. This Icelandic tannery utilizes the skins of four species — salmon, cod, wolffish and perch — and recently introduced MIMOSA, a line of vegetable-tanned salmon leather processed with mimosa bark (Figure 16).

Orange Fiber ® is obtained using a patented process (WO2015018711A1). This process allows to obtain cellulose from citrus fruits (oranges and lemons) discarded by plantations and/ or by-products from citrus processing industries. Cellulose is extracted from the entire peel of citrus fruits, which includes albedo and flavedo, or just albedo. Cellulose is obtained by chemical extraction, preferably in the absence of chlorine, including a pre-treatment of agro-food waste raw materials with hydrogen peroxide

Figure 15. Products made with Pinãtex
(Source: https://www.dezeen.com/2016/06/09/pinatex-ananas-anam-vegan-leather-alternative-ethical-recycled-pineapple-leaves-sustainable-materials-design-camper/).

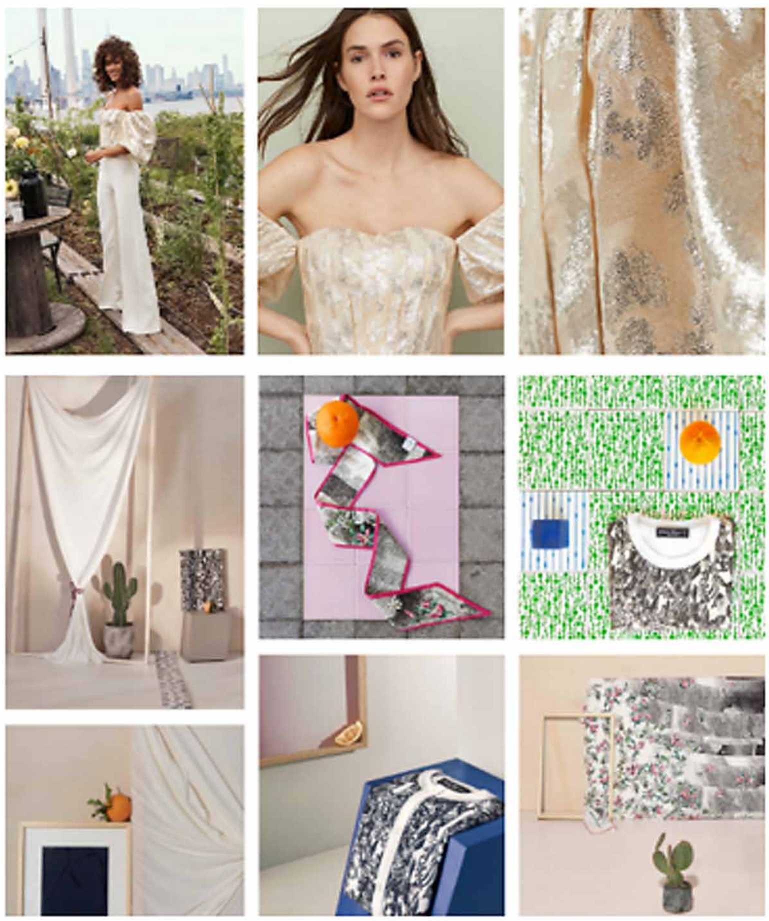
Figure 16. Atlantic leather bio-leather products
(Source: http://www.atlanticleather.is/; http://www.atlanticleather.is/vegetable-tanned-salmon-leather).

Figure 17. Summary of the production process of the Orange Fiber
(Source: http://orangefiber.it/en/how-to-turn-citrus-waste-into-a-sustainable-fabric/).

under basic conditions. Cellulose is optionally mixed with cellulose obtained by different processes, for example, cellulose extracted from wood. One significant advantage of Orange Fiber is that it can be converted into yarn by spinning process and then in fabrics (Figure 17). Well-known brands such as H&M and Salvatore Ferragamo (Figure 18) have already developed collections using Orange Fiber.

The use of vegetable fibres and other agro-food by-products as a raw material in plastics, construction and textile materials not only provides a renewable resource but also generates a non-food source of economic development for agricultural and rural areas. However, it is still necessary to develop a more significant number of studies in terms of durability, manufacturing techniques, cost-benefit and environmental impact (LCA).

Figure 18. H&M and Salvatore Ferragamo collections using Orange Fiber®
(Source: http://orangefiber.it/en/collections/).



SOLUTIONS AND RECOMMENDATIONS

The potential of forest biomass and agro-food waste as a sustainable raw material to produce bio-based materials for a border transition towards a circular bioeconomy was demonstrated in the of the present work. However, there are several challenges to guarantee the implementation of the new bio-based products in Portugal similar to other European markets. The creation of new markets, the large-scale production of bio-based products, their market penetration and the further development of credible sustainability certifications throughout the whole production process represent some of the main challenges of biomass-based products. Thus, it is essential to define some of the main challenges and opportunities for improvement for the forest and agro-food sector to move to a circular bioeconomy and leave the current linear economy.

The study concludes with several recommendations to promote and implement a circular bioeconomy efficiently:

- Ensure the availability of biomass from forest and agro-food sector by improving its mapping and assuring sustainable forest management (in case of forest biomass) to guarantee the competitive production of new biomaterials and bioproducts.
- Implement the principle of cascade use, ensuring the assessment of the environmental impacts of products throughout their life cycle, as well as the reduction of by-products.
- Develop industrial symbioses that will increase the security of raw material supply and generate the transition to a sustainable circular economy.
- Innovate in methods and technologies to optimize biomass flows and production processes and reduce gaps in the industrial production chain, so that the possible higher cost of bioproducts, due to the complexity of production processes, can be counterbalanced.
- Improve the standardization and certification of new products obtained from forest biomass to increase market confidence in products.
- Improve traceability throughout the value chain to obtain competitive advantages.
- Invest in consumer awareness to increase market penetration of new products.

The transition will not happen on its own and if this is left to the market alone. The Government has a crucial role to play in identifying areas where incentives can help unlock the necessary private sector investment.

New policies and legislation are required to create a regulatory and supportive framework in order to stimulate the forestry sector towards a circular bioeconomy, namely:

- Climate mitigation policies, which include policies to increase the use of forest territory, avoiding bushes and wasteland without agricultural or forestry functions;
- Sustainable forest management policies aimed at protecting and improving biodiversity through policy instruments such as standards and certifications, as well as policies aimed at increasing the availability of biomass;
- Bio-based content policies and the development of indicators and targets related to the bio-based content of products;
- Waste and recovery policies to promote the cascade use of forest biomass overcoming current barriers;

- R&D policies to increase investment, both public and private, in research and development in the area of forest and agro-food bioeconomy;
- Policies to support investment in the area;
- Market support policies aimed at driving a greater market need for sustainable agroforest-based products, including public purchasing and procurement policies;
- Awareness-raising policies designed to improve society's understanding of the social, economic and environmental benefits of bio-based products.

The combination of a regulatory and supportive framework, adequate environmental prices and public investment should guide the creation of a circular bioeconomy based on agroforest biomass.

CONCLUSION

Forest biomass and agro-food waste/ by-products showed to be an excellent source of biomass to develop new sustainable building materials, including prefabricated modular elements, but also particleboards, tiles and other materials to interior design. Lignin from forest biomass and agro-food waste showed potential application as admixtures to concretes. The agroforest biomass is also a leading supplier of cellulose for greener biotextiles and bioplastics.

The new bioproducts identified have high potential and attractive markets. It is estimated that a 5% market share of these bioproducts in the global construction, textiles and plastics markets in 2030 corresponds to an aggregate increase in revenues of € 260-579 million per year in Portugal. The analysis clearly shows the potential for creating value in high value-added and differentiated products.

Beyond the economic dimension, the externalized environmental costs of conventional products showed to be significantly higher than for the new bio-based materials. The differences are very relevant in the context of internalization of environmental externalities through environmental regulation and cannot be neglected by producers.

All the products identified have the potential to be implemented in the Portuguese market and can be the best strategy to move from a linear fossil economy to a circular bioeconomy. However, it is essential a behavioural change of forest owners and agro-food producers to add value to forest biomass and food by-products, respectively, implementing the principle of cascade use. An investment in new processes and technologies is also imperative to ensure the availability of agroforest biomass and reduce the possible higher cost of bioproducts due to the complexity of production processes. Besides that, the transition will not happen on its own, and if this is left to the market alone. The Government has a crucial role to play in identifying areas where incentives can help unlock the necessary private sector investment.

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APPENDIX: ENVIRONMENTAL EXTERNALITIES

Construction

Table 12. Environmental externalities of concrete: Atmospheric emissions

Process Stage	Pollutant	Emissions (ton/m³ material)	Externalities ($/m³ material)	Externalities (€/m³ material)	Ref.
Production	eCO_2	0,4 – 0,439	20 – 22	18 - 20	[2], [1]
Construction	eCO_2	4,646	232	207	[3]
	eSO_2	0,007	2,1	1,9	[3]
	Total		**254,1 – 256,1**	**226,9 – 228,9**	

Table 13. Environmental externalities of CLT: Atmospheric emissions

Process Stage	Pollutant	Emissions (ton/m³ material)	Externalities ($/m³ material)	Externalities (€/m³ material)	Ref.
Production	eCO_2	0,236	11,8	10,5	[4],[5]
	eSO_2	0,001674	0,5	0,4	[4],[5]
	Total		**12,3**	**10,9**	
Production	eCO_2*	-0,81	-40,5	-36,2	[4],[5]

* *Considering wood as a carbon sink.*

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Textile

Table 14. Environmental externalities of traditional textiles: Atmospheric emissions

Material	Process Stage	Pollutant	Emissions (ton/ton fibre)	Externalities ($/ton fibre)	Externalities (€/ton fibre)	Ref.
Cotton	*Cradle to gate*	eCO_2	2 - 8	100 – 400	89 – 357	[9],[7],[8]
		eSO_2	0,041	12	11	[7],[8]
		Total		**112 – 412**	**100 – 368**	
Organic Cotton	*Cradle to gate*	eCO_2	2,5	125	112	[6]
		Total		**125**	**112**	
Polyester	*Cradle to gate*	eCO_2	2,8	140	125	[6]
		Total		**140**	**125**	

Table 15. Other externalities of traditional textiles: Water use and occupation of arable land

Material	Process Stage	Externality	Impact	Unit	Ref.
Cotton	*Cradle to gate*	Water	5 732 – 22 000	ton/ton fibre	[6], [7], [8]
		Arable land	1	ha/ton fibre	[7], [8]
Organic Cotton	*Cradle to gate*	Water	24 000	ton/ton fibre	[6]
Organic Cotton	*Cradle to gate*	Water	62	ton/ton fibre	[6]

Table 16. Environmental externalities of NMCF: Atmospheric emissions

Material	Process Stage	Pollutant	Emissions (ton/ton fibre)	Externalities ($/ton fibre)	Externalities (€/ton fibre)	Ref.
Viscose	*Cradle to gate*	eCO_2	9	450	402	[6]
		eSO_2	0,014	4,1	3,6	[7], [8]
		Total		**454,1**	**405,6**	
Tencel®	*Cradle to gate*	eCO_2	0,05	2,5	2,2	[7], [8]
		eSO_2	0,013	3,8	3,4	[7], [8]
		Total		**6,3**	**5,6**	
Modal®	*Cradle to gate*	eCO_2	0,03	1,5	1,3	[7], [8]
		eSO_2	0,015	4,4	3,9	[7], [8]
		Total		**5,9**	**5,2**	

Table 17. Other externalities of MMCF: Water use

Material	Process Stage	Externality	Impact	Unit	Ref.
Viscose	*Cradle to gate*	Water	445 - 640	ton/ton fibre	[6], [7], [8]
Tencel®	*Cradle to gate*	Water	263	ton/ton fibre	[7], [8]
Modal®	*Cradle to gate*	water	472	ton/ton fibre	[7], [8]

Sources:

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Plastics

Table 18. Environmental externalities of conventional plastics (cradle to end-of-cycle incineration)

Material	Pollutant	Emissions	Unit	Externalities ($)	Externalities (€)	Unit	Ref.
PE bag [1]	eCO_2	4,04	ton/ton plastic bag	202	180	u.m/ton plastic bag	[12]
Flexible/ rigid plastic - PET [2]	eCO_2	31,4	ton/ton bottle 1.5 L	1 570	1 420	u.m/ton bottle 1.5 L	[10]
Flexible plastic - PP [3]	eCO_2	2	ton/ton material	100	89	u.m/ton material	[13]
Rigid plastic - HD-PE [4]	eCO_2	1,86	ton/ton material	93	83	u.m/ton material	[13]
PVC[5] *– Rigid plastic*	eCO_2	0,04586	ton/m^2 deck	2,293	2,048	u.m/m^2 deck	[11]
	$ePM_{2,5}$	0,00003	ton/m^2 deck	0,300	0,268	u.m/m^2 deck	[11]
	eN	0,00001	ton/m^2 deck	0,00004	0,00004	u.m/m^2 deck	[11]
	eSO_2	0,00050	ton/m^2 deck	0,144	0,129	u.m/m^2 deck	[11]
	Total			**2,737**	**2,445**	u.m/m^2 deck	

[1]Polyethylene including 10% recycled plastic;[2] Polyethylene terephthalate; [3] Polypropylene; [4] High density polyethylene; [5] Polyvinyl chloride.

Table 19. Environmental externalities of bioplastics (cradle to end-of-cycle incineration)

Material	Pollutant	Emissions	Unit	Externalities ($)	Externalities (€)	Unit	Ref.
Paptic bag	eCO_2	1,71	ton/ton plastic bag	86	76	u.m/ton plastic bag	[12]
Sulapac	eCO2	0,77	ton/ton material	39	34	u.m/ton material	[13]
WPC	eCO_2	0,02842	ton/m^2 deck	1,421	1,269	u.m/m^2 deck	[11]
	$ePM_{2,5}$	0,00003	ton/m^2 deck	0,300	0,268	u.m/m^2 deck	[11]
	eN	0,00002	ton/m^2 deck	0,00008	0,00007	u.m/m^2 deck	[11]
	eSO_2	0,00064	ton/m^2 deck	0,185	0,166	u.m/m^2 deck	[11]
	Total			**1,906**	**1,703**	u.m/m^2 deck	
WPC with recycled plastic	eCO_2	0,01550	ton/m^2 deck	0,775	0,692	u.m/m^2 deck	[11]
	$ePM_{2,5}$	0,00002	ton/m^2 deck	0,169	0,056	u.m/m^2 deck	[11]
	eN	0,00002	ton/m^2 deck	0,00009	0,00007807	u.m/m^2 deck	[11]
	eSO_2	0,00031	ton/m^2 deck	0,089	0,080	u.m/m^2 deck	[11]
	Total			**1,033**	**0,828**	u.m/m^2 deck	

Sources:

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Chapter 12

Circular Economy Principles and Their Influence on Attitudes to Consume Green Products in the Fashion Industry:

A Study About Perceptions of Portuguese Students

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ABSTRACT

Designing circular economy (CE) implies the adoption of a set of circular principles that support a society for the future. Understanding how CE principles influence attitudes to consume green products is a key factor aligned with consumer trends. This chapter aims to study how CE principles influence attitudes to consume green products in a particular case of fashion industry. Very few empirical studies on the perceptions of the fashion "users" exist. This chapter aims to bring some inputs to this topic. The methodology uses a path analysis study based on a sample of 110 respondents collected in a higher education institution in Portugal. The estimated model allows to test the relation between a set of variables, and the study reveals that: CE principles have a direct effect on the attitudes on the green products consumption in fashion industry in the sample considered.

INTRODUCTION

Circular economy has been evolving as a crucial approach comparatively to the linear economy. Nevertheless, studies that use empirical approaches to deeply research this phenomena are still in their infancy. Additionaly, according to Ellen MacArthur Foundation (2017:18) "clothing represents more than 60% of the total textiles used and in the last 15 years, clothing production has approximately doubled, driven by a growing middle-class population across the globe and increased per capita sales in mature economies. At the same time, clothing use has declined by almost 40%. Both developments are mainly due to the 'fast fashion' phenomenon, with quicker turnaround of new styles, increased number of collections offered per year, and often, lower prices". This fast fashion industry impacts negatively on environment due to the regular model of fast fashion consumption, the materials used and discarded in the manufacturies, and the production model based in large scale production in developing countries. The same report referred that if "fashion industry moved to a circular system the industry can unlock a USD 560 billion economic opportunity. Realising this opportunity requires new business models and collaboration across the value chain (e.g. production, marketing, and after-sales care), to keep safe materials in use". This scenario justifies the development of more empirical studies on circular economy in fashion industry.

This chapter aims to study how CE principles influence attitudes in the green products consumption in the particular case of the fashion industry, using a sample collected among a higher education students population in Portugal.

This chapter is divided into two main parts. The first part addresses the background, i.e., the literature review with the main theorethical concepts, such as circular economy, circular economy principles, green products, green products in fashion industry, attitudes and awareness, benefits and perceptions. The second part of the chapter accounts for the empirical study and its results, and finally the last chapter exposes the concluding remarks.

BACKGROUND

The Concept of Circular Economy

One of the world's greatest challenge is to support future generations without compromising their future (World Commission on Environment and Development (WCED), 1987). Biodiversity loss, global environmental metamorphosis, which include climate change, limits to growth, along with growing world population and all the externalities they imply, are key questions in modern times, with serious impacts demanding a global and cooperative address.

In this context, and taking into account the constrains of the existing economic model, the linear economy, in which products are used shortly and discarded, causing vast amounts of waste, the concept of circular economy materializes as a holistic approach to *reduce, reuse and recycle* the production and consumption procedures so as to minimise energy consumption and consequently waste production. Transition to a circular approach demands a paradigm change, considering sustainability and closed-loops processes essential regarding business models and industrial authorities.

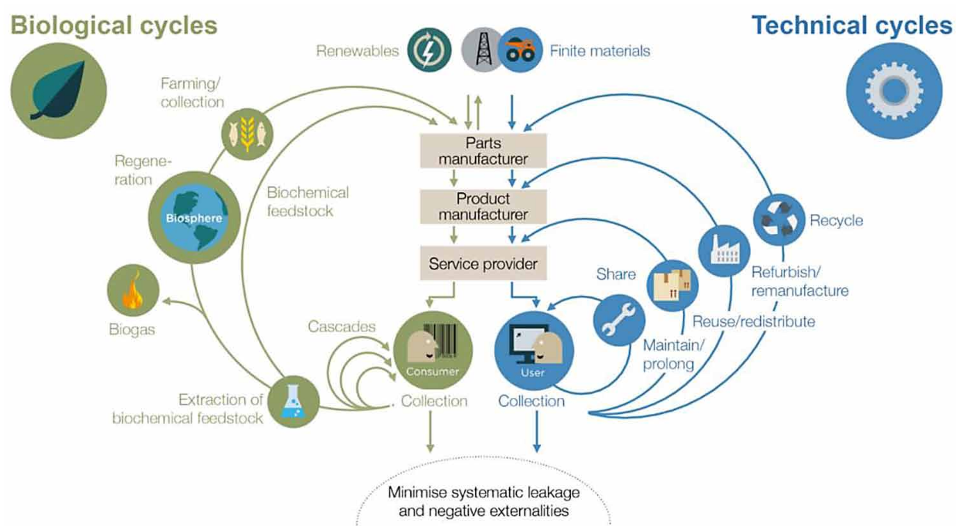
The concept of circular economy is an *umbrella construct* (Hirsch & Levin, 1999) based on a multitude of approaches like as 'circular flow of income' (Quesnay, 1758), 'industrial metabolism' (Simmonds, 1862), the 'spaceman economy' (Boulding, 1966), 'limits to growth' (Meadows et al., 1972), 'cradle-to-cradle' (Stahel & Ready-Mulvey, 1981; McDonough & Braungart, 2002), 'industrial ecology' (Frosch & Gallopoulos, 1989; Graedel & Allenby, 1995), 'regenerative design' (Lyle, 1996), 'remanufacturing' (Steinhilper, 1998), 'natural capitalism' (Hawken et al., 1999), 'biomimicry' (Benyus, 2002), 'eco-effectiveness' and 'eco-efficiency', (McDonough & Braungart, 2002; EMF, 2012), 'steady state economy' (Daly, 2005), and 'performance economy' (Stahel, 2010).

This construct was initially introduced to academia by Pearce and Turner (1990) (Su et al., 2013; Ghisellini et al., 2016; Geissdoerfer et al., 2017) as an approach to enhance circularity, minimising energy and natural resources consumption, key principles for sustainable resource preservation (Hislop & Hill, 2011).

Feng et al. (2007), Geng and Doberstein (2008), Yang and Feng (2008), Hu et al., (2011) introduce CE as an economic model that mimics ecological closed materials systems (Yang & Feng, 2008) and contemplates the efficient use of natural resources to pursue economic development, resource efficiency, machinery optimization or recovery, and management strengthening. It is also considered a preventive and regenerative eco-industrial performance, along with 'green' technologies, non-standard design approaches, and the combination of different production processes, which allows product and energy recovery.

In this light, CE materializes as a model based on closed loops design approaches in which value retention is maintained for as long as possible, or cascaded to a different loop so that value is kept. Economic systems ought to be structured mimicking a natural system, in which the output of an operation is the input of another (Braungart & McDonough, 2002; Ellen MacArthur Foundation (EMF), 2012; Pheifer, 2017). The Ellen MacArthur Foundation (2012) butterfly diagram, figure 1, demonstrates that a CE model aims to restore capital (financial, manufacture, human resources, societal or natural) guaranteeing closed loops of products and services, and outlines the sustained flow of biological and technical material cycles across the value chain.

Figure 1. The Ellen MacArthur Foundation & McKinsey butterfly diagram (2012)



Braungart and McDonough (2002) and the EMF (2012) also address the concept of 'eco-effectiveness', a design oriented approach, as a means to minimize and dematerialize products flow systems, enabling a continued exchange amidst environment and economy to the detriment of the 'eco-efficiency', approach considered in the predominant production and consumption model.

Stahel (2019) demonstrates that CE is an alternative economic model as it proposes an efficient exploitation of natural resources, maintaining their value and functionality over extended periods of time. It decelerates the use of raw materials through economy which will indirectly impact production outputs and waste emissions, distinctive features of the linear economy. By expanding products life span, it is possible to reduce by half the production inputs and waste production.

For all this reasons, it is imperative to enhance the implementation of the circular economy R-principles as an opportunity to transition to a more environmentally, socially and sustainable economy. There are several understandings of the Circular Economy's R Principles, and they vary according authors, their interpretation and time. The following section illustrates the Circular Economy's R Principles.

The Circular Economy's R Principles: Reducing, Reusing, Recycling, Rethink, Refurbishment, Repair, Redesign-Cradle-to-Cradle-Long-Lasting Product, Restorative, Recover

Circular economy encloses the overall activities within the scope of the reducing, reusing and recycling materials processes, as well as the distribution and consumption of these materials. It is recognised that raw materials have to be processed in cycles, by means of biogeochemical processes or by human interference (one of the premises of CE), otherwise environment will continue to deteriorate at a surprising pace (Robèrt, 1991). Nevertheless, CE practices cannot sustain recycling, as to some extent it turns out to be too difficult and demanding, because the amount of waste produced is not equivalent to the degree of resources depleted (Reh, 2013; Prendeville et al., 2014) characteristic of an economic open-ended system and to the entropy law (Daly, 1991; Andersen, 2007). The 'recycling' R-principle represents the less sustainable response to tackle with environment sustainability questions, if compared to the remaining R- principles when dealing with resource efficiency and profitability (Stahel, 2013, 2014, 2019). The focus should be placed on use and reuse of products rather than on discarding them before their value is fully exploited (Wijkman & Skanberg, 2015; Waste Resource Action Programme (WRAP), 2016).

It is important to design the product and its process as a closed system in which the waste produced is equivalent to the quantity of resources used, and the waste generated would be converted into raw material and re-enter the manufacturing line once more. As a result, economy becomes circular. Industrial products and materials can be reused repeatedly and redistributed in their original shape or with minor improvement or modifications to new customers. An economic industrial system based on the 'reuse' R-principle of products, enhancing remanufacturing, will improve the natural potential of the environmental to restore itself (Bastein, 2013; EMF, 2013).

CE is restorative and regenerative by design (Lacy & Rutqvist, 2015) and targets to maintain the highest utility and value of products as long as possible, differentiating the various technical and biological cycles, that is implement an economic system in wherein long-lasting design, reuse, refurbishment, remanufacturing, and recycling of goods is contemplated. The implementation of a CE approach should take into account system thinking, as decision making of the stakeholders (entrepreneurs, companies, and governments) engaged in the manufacturing processes, has a huge influence in the value chain (EMF, 2015a). The emphasis has to be put on value retention and on stock optimization and on product life extension (Stahel, 2013, 2019).

CE is also about 'refurbish' and 'repair'. 'Refurbish' corresponds to the process that products undergo when upgraded, i.e. parts and components of a bigger framework have to be replaced so that the life cycle of the product is extended (de Brito & Dekker, 2003; Fernández & Kekale, 2005), and 'repair', corresponds to the life extension of the products (King et al., 2006), by repairing parts and components (Stahel, 2010), or making modifications (Thierry et al., 1995). This life extension procedures can be executed by different parties (owners, technicians, and repair businesses) without experiencing ownership transfer (Hultman & Corvellec, 2012).

McDonough and Braungart, (2002) consider that a 'cradle-to-cradle' design concept, rather than a 'cradle-to grave' life cycle should be implemented, since the life cycle of products does not necessarily end in a 'grave', the equivalent to a landfill. Seeking a 'cradle-to-cradle' economic model products are designed and fabricated with a new purpose and with 'long-lasting' design (Geissdoerfer et al., 2017), through waste-free industrial processes. Pursuing efficiency through design and service supply presupposes a reduction in inputs, enhancing resource usage and economic development from natural resource utilization.

'Recover' or 're-mine' is another important R-principle. It refers to the retrieval of materials after the landfilling phase (Yan & Feng, 2014; Reike et al. 2018).

Highlighting the R-imperatives and their use is relevant strategy for CE implementation. Despite the individual prominence of the Circular Economy and Green Products in the academic literature, the relationship between the two concepts has neither been thoroughly defined nor explored. This chapter aims to explore how CE principles influence attitudes to consume green products. Thefore, the following section explores the 'Green Products' concept.

Green Products

The green product movement has been acknowledged as one of the drivers to enhance economic growth, environmental sustainability and well-being (Dangelico & Pujari, 2010). The term ‘green’ itself can be considered an *umbrella construct* (Hirsch & Levin, 1999) as it can have various meanings. In the last decades it has entered the research and scientific spheres acquiring the connotation of environmentally friendly qualities of a product, service, and technology. Moreover, different efforts have been carried out by researchers to delineate this construct, nevertheless, there is still some misunderstanding on what an environmentally friendly product is (Baumann et al., 2002), with concepts like ‘green’, ‘eco’, and/ or ‘sustainable’ (Albino et al., 2009).

Some decades ago, products with clear environmentally friendly information were difficult to identify, except for those which were natural and organic and that prospered. In the 1980s and 1990s, the consumption of ‘green’ products became a global trend emphasised by the marketing industry, intensifying customer awareness. Nevertheless, only in the first decades of the 21st century, with the outbreak of global challenges concerning climate change, resource depletion and waste, gained prominence, and it was at that moment that this construct started to be considered and incorporated in production processes (Air Quality Sciences, 2010).

Green products may be defined as the ones which contain recycled materials, reduce energy and water consumption when produced, reduce packaging, generate less waste, and consequently they reduce the amount of toxic waste (Nimse et al., 2007). Eventually, these goods are less disruptive to humanity and to environment when compared to products produced in a linear model. Albino et al. (2009) consider green products those which are designed to minimize their environmental impact throughout their life-cycle. The emphasis has to be put preferably on products and on production processes in preference of the use of clean technologies and pollution mitigation (Pujari et al., 2003; Chung & Tsai, 2007). As a result, natural resources and hazardous substances use is minimised, and renewable resources are widely employed. It is also highlighted that the efficient setting up and production of green products has a key role as it will allow to develop efficient and sustainable environmental approaches in the quest for sustainability (Pujari et al., 2003). Thus, concepts as ‘design for environment’, ‘eco-design’, ‘extended producer responsibility’ and ‘product management’ are becoming increasingly common in organizational culture.

Amatruda (2010) emphasises that a product is never 100% green as its development often involves impact on the environment. These products ought to have certain characteristics that will distinguish them from others produced according traditional techniques, used in a linear economy. Green products ought to be energy efficient, durable and have low maintenance demands; free of ozone depleting chemicals, hazardous substances or derivatives; they are commonly produced out of recycled goods or retrieved from renewable and sustainable resources; they are acquired from regional or local manufacturers or sources; they are biodegradable or have the possibility of being reused as a whole or in parts; the amount of energy used throughout their entire life cycle (resource extraction, manufacture, and transportation to the market point) is low; they have the option of being promptly recycled in closed loops which will grant that they are recycled into the same product or into a similar one without compromising their quality. In order to guarantee that a green product meets most of these requirements, and information on those characteristics, the Green Products Certification Labels, an authority responsible for evaluating the quality and guarantee their authenticity is available for consultation. The International Organisation for Standardization (ISO), an independent and non-governmental organisation, develops specifications for products, services and systems, on behalf of quality, safety and efficiency, to assist and promote international trade. For instance, the ISO 14000 for environmental management leads organizations to implement pollution prevention and to educate society towards green consumption. Examples of the latest ISO specifications are the ISO 20400 (2017), which promotes product value apart from procurement and acquisition, and ISO 26000 (2010) that provides guidelines on social sustainability along supply chains and throughout the entire economy.

Additionally, Albino et al. (2009) states that adopting extended manufacture responsibility regulations (Lindhqvist, 2000) would help to ensure that manufactures would be charged with the end of life environmental impacts of their products. This would represent an encouragement to manufacturers to enhance product design as a means to reduce waste production and raw material utilisation and strengthen recyclability and reusability. Companies and stakeholders are not only focused on obtaining profit but are also promptly exploring and investigating new possibilities, approaches and strategies to increase awareness concerning green products, while promoting competitiveness in the market, with the purpose of attaining sustainability.

MAIN FOCUS OF THE CHAPTER

Green Products in the Fashion Industry

The fashion industry is considered as a global scale industry that could impact negatively on the environment due to their production model, labour intensive and location in developing low labor countries that are not so aware about environmental impacts (Borghesi & Vercelli, 2003; Abecassis-Moedas, 2006). Fashion companies as global supply chains, use raw materials (e.g., fibres and leather) that are often sourced from distant locations and subcontract different production activities (e.g., milling, dyeing, weaving, finishing, cutting and sewing) to different companies scattered across the world (Jacobs, 2006). Some scandals in the fashion industry are related with the utilisation of non-environmental raw materials, such as the use of transgenic cotton (i.e., genetically engineered cotton obtained by imparting insecticidal and herbicidal proprieties to the plant) by C&A and H&M fashion as one of the industry's most exposed to the public (Caniato et al., 2012). Additionally, the intensive use of chemical products and natural resources can cause a high environmental impact (De Brito et al., 2008). Cotton and wool production demands large quantities of water and pesticides, whereas synthetic fibres are extracted from non-renewable resources and require substantial energy to produce (Myers & Stolton, 1999). Furthermore, companies are being considered responsible for environmental and social problems produced not only by themselves directly, but also by their suppliers (Koplin, 2005), and in addition, fashion brands respond to a competitive market offering several collections during a season, and frequently products have lower quality and limited durability. However, new trends and overall concern regarding environmental depletion are gaining momentum among brands, which are redirecting their market strategies offering more and more green products and brands.

In fact, market for green products is expanding worldwide in a variety of industries, such as food, fashion and cosmetics (Cervellon & Lindsey, 2011). Recent trends suggest that sustainability is a springboard to influence environmentally conscious consumers and to improve the overall brand image in developed countries (Faisal, 2010).

During the last few decades, the fashion industry adopted more suitable practices, regarding not only the companies themselves but also concerning the whole supply chain (De Brito et al., 2008). The methods reported are: the use of organic fibres (i.e., fibres that follow standards that nurture the soil or animal from which they were extracted without the use of toxic insecticides, herbicides or fungicides; examples of organic fibres are organic cotton, organic wool, kapok, and silk), (i) the reduction of the collateral effects of chemical products, the scarcity of natural resources, and CO_2 emissions (Chouinard & Brown, 1997); (ii) reuse and recycling of materials such as old clothes, manufacturing scraps, bottles, and tyres; (iii) vintage practices and second hand; (iv) clean technologies, both old and new, and even information technologies (Nieminen et al., 2007); (v) green certifications (e.g., Global Organic Textile Standards, Ecolabel, Global Reporting Initiative (GRI)-Apparel and Footwear Sector Supplement); and (vi) green product and process design, considering the production technologies, the product characteristics, and the materials used.

Caniato et al. (2012, p. 662) considered that drivers and practices can be divided into three sub-elements adapted from the straightforward Porter's view and the classification presented by De Brito et al. (2008):

- "Internal drivers can be related to efficiency objectives (i.e., cost reduction) (Handfield et al., 1997; Carter & Dresner, 2001) or to other company-specific factors (e.g., corporate values of the owner or the top management and corporate responsibility objectives) (Handfield et al., 1997; New et al., 2000).
- Market drivers are related to the requirements for environmental sustainability from the customers, who may be industrial clients or end consumers (Beamon, 1999; New et al., 2000; Hall, 2001; Zhu & Sarkis, 2006).
- Law drivers are related to the requirements of both current and future regulations (Beamon, 1999; Hall, 2001; Min & Galle, 2001)."

During the past years, eco-fashion has become chic and world fashion designers admit to distance from fast fashion. Table 1 shows some examples of waste-based design and eco-fashion around the world.

Circular Economy and Green Products: Attitudes and Awareness

The Circular Economy (CE) and the Green Products (GP) concepts have been receiving growing attention in the last decades as emerging approaches to attain sustainable development, economic growth and ultimately better living standards. These have undoubtedly moved from *niche conversations* (Hart et al., 2019) to highly discussed constructs, with papers, journal articles, reports, and explanatory documents being published expeditiously. In spite of all the mainstream attention received, reduced implementation has been accomplished so far, academia consider that this is due to the fact that literature on the concepts is mainly conceptual or theoretical, they are seldom empirically based (Linder & Williander, 2017; Ormazabal et al., 2018).

These two constructs propose to adapt or to transform the prevailing economic model into a more sustainable one. The concept of GP mainly focus on the environmental performance of the products whereas the economic approach is left in the background. Similarly, CE is promoted as a paradigm that promotes economic acceleration alongside with natural resource conservation and environmental alleviation (Geng et al., 2009). It is acknowledged as an economic approach that intends to be restorative and regenerative through design. It substitutes the end of life cycle conceptualization for recycling, reusing

Table 1. Eco-fashion examples around the world

Brand	Country	Eco-fashion
The Great Beyond	Australia	Uses hard, fast-growing bamboo to create soft, durable basics with impressive environmental benefits.
Matt & Nat	Canada	The handbag designer uses renewable materials like cork and rubber for their all-vegan products.
Adidas	Germany	This company teamed up with Parley for the Oceans to create shoes made entirely of reclaimed and recycled yarns and filaments from ocean waste and deep-sea gillnets.
H&M	Sweden	Created the *Conscious Exclusive collection*, which included the first-ever piece of eveningwear made with *Bionic Yarn*, a recycled polyester made from plastic shoreline waste.
Ananas Anam	Philipines	This company is turning pineapple leaf fibers into an environmentally friendly leather alternative called Piñatex. The process uses byproducts of pineapple harvest itself, so it takes no additional land, water, pesticides, or fertilizer beyond the ones already used to grow the pineapples in the first place. Compared to the energy-intensive leather industry, that's a big deal, and partner brands like Camper and Puma have already taken note.
Orange Fiber	Italy	This start up is transforming the 700,000 tons of annual waste created by Sicily's orange juice industry into silky, soft yarn.
Rosalie McMillan (designer)	UK	This designer is creating high-end jewellery with a clean aesthetic from materials derived from coffee grounds collected from London offices, which she dries, compresses, and contorts into bold, geometric shapes.
Amour Vert	USA	This company is using non-toxic dyes and zero-waste methods. Moreover, with each purchase of a tee, a new tree is planted, with over 220,000 trees planted to date.

or remanufacturing, thus eliminating the use of hazards substances and the massive waste production through the redesign of products, materials and services, relying on efficient technology to reduce environmental impact. Likewise, GP also consider the use of recycled substances and/or materials in production processes, and less packaging, which allows a reduction in the energy and water used, enabling, at the same time, a reduction in the waste generated. GP development and design consider products future environmental impact by relying on the use of clean production processes and promoting the use of renewable resources bearing in mind human prosperity in long term, preventing future generations of facing environmental hazards and shortage.

The implementation of these concepts face various challenges nowadays. They are still unknown among business stakeholders or there is a superficial understanding of the concepts. As there is the opportunity of embracing new economic approaches, small steps are taken considering the development of organisations (Ritzéna et al., 2017). According to de Jesus and Mendonça (2018) it is also obvious a lack of consumer and even stakeholder enthusiasm in pursuing these paradigms.

Dangelico and Pujari (2010), Vanner et al. (2014), Rizos et al. (2015), Pheifer (2017), and Hart et al. (2019) also highlight that generalised indifference concerning knowledge and participation of stakeholders (customers, suppliers and producers) in the transition to CE or the lack of understanding considering the holistic approach on CE or about GP, along with absence of cooperation among businesses, lack of vertical collaboration along the supply chain, and lack of cooperation between the different departments in a company, *silo mentality*, are enabling progress. Kirchherr et al. (2018) focus the analysis in the corporate sector, i.e., corporate culture is often addressed as one of the features that make business continue to be trapped to their old economic approaches even though efforts in these areas (CE and GP) had already been initiated.

CE and GP do not appear as established practices, the constructs are still unknown among business stakeholders or there is a superficial understanding of the concepts. As there is the opportunity of embracing new economic *approaches*, small steps are taken considering the development of organisations (Ritzéna et al., 2017). According to de Jesus and Mendonça (2018) it is also obvious a lack of consumer and even stakeholder enthusiasm in pursuing CE business models and regarding GP. Dangelico and Pujari (2010) refer that markets and businesses are not aware of eco-design additional benefits, namely waste reduction, and that the biggest constrain to GP market consolidation/expansion is to consider the environmental variable as a business advantage. The authors also highlight that this barrier could be overcome by introducing eco-labelling or third party certification, which would allow GP to be accurately identified enhancing, this way, credibility amongst consumers.

Academicians have recently assigned the reduced progress considering the implementation of CE initiatives and the utilisation of GP to a diversity of constrains, some of them presented above. There is an urgent need to change practices, regulations, initiatives, so that this cascade effect is broken and the transition to more sustainable models can be accomplished and allow these concepts to continue to gain prominence.

Circular Economy Enablers

Transitioning from the predominant linear economic model to a circular economy paradigm is one of the priorities outlined by the European Commission (2015) in its path to sustainability. The transition to modern and prolific production procedures will benefit both society as a whole and stands out also as an opportunity for companies on different levels. It will additionally influence economic growth, mitigate the negative externalities caused by the linear economic model on the environment, and consequently create more jobs as a result of innovation (Ellen MacArthur Foundation, 2013), and ultimately it will give rise to raw material cost savings for businesses (Houston et al., 2019). Even though corporations are already undertaking their paths towards circularity, a lot more needs to be accomplished concerning the implementation of circular economy business models. In order to do so, it is relevant to identify key facilitators/ enablers.

A review of the literature on Circular Economy was carried out so as to display the main enablers that will enhance business transformation and transition. According to Agyemang et al. (2019), some research lines have focused on identifying drivers in different sectors, manufacturing (Lieder & Rashid, 2016), construction (Smol et al., 2015), and service (Tukker, 2015), other authors have considered different categories, distinguishing between ‘basic drivers’, ‘public health’, ‘resource management’, and ‘economic financial capacity’ (Ilić & Nikolić, 2016), others considered group categorisation proposing comprehensive groups of drivers in certain areas, including ‘public health’, ‘environmental protection’, ‘climate change’, ‘waste resource value’, ’institutional and responsibility issues’, and ‘public awareness’ (Wilson, 2007).

Houston *et al*. (2019) identify enablers at two different levels: company and value chain. At the *company level* it is stressed out that it is fundamental to promote a high standard of engagement in structural changes within the companies, consequently a high level of management promptness is key to transition to a CE model. Staff engagement and motivation in is also highlighted as a key driver to improve productivity, and guarantee market competitiveness and revenues in a challenging market. Within the *value chain level* the following factors arise as key facilitators: cooperation among organisations can improve the transition to a circular economy, as collaboration can promote the development of innovative and circular design approaches, Non-Governmental Organisations, universities hubs and society in general can take circularity to debate and discussion into companies; the standard-setting of regulations throughout the value chain, i.e., to trace sustainability across the value chain and access the potential impact and environmental issues, product certification and Life Cycle Assessments (LCA) ought to be addressed. By means of a set of criteria there is indeed the possibility to accede information on production and disposal methods, which can contribute to the identification of socially conscious suppliers in pursue of circular models; international companies can uphold their subsidiaries promoting the transition to circular models by facilitating and accelerating this challenge.

Taking into consideration that companies are pushed towards CE paradigms bearing in mind the needs for profit, Mont et al. (2017) identified five relevant domestic drivers, which are economic, environmental protection, supply protection and adaptability, customer interactions, and businesses' policies and ambitions urged by the need of profit. Furthermore, these authors find 'coercive pressure' and market demand as the two main peripheral drivers, driven by regulations and market demand, considered crucial when pursuing circularity.

Govindan and Hasanagic (2018) also propose a CE categorisation in 'clusters' comprising *legislation and economy* which relates to all governmental policies related to product returning procedures and economic growth (Park et al., 2010; Li & Li, 2011; Ilić & Nikolić, 2016; Hazen et al., 2017; Quina et al., 2017); health, concerning public and animal health enhancement (Ilić & Nikolić, 2016; Pringle et al., 2016); environmental sustainability, which includes climate change (Clark et al., 2016; Ilić & Nikolić, 2016; Pringle et al., 2016; Hazen et al., 2017; Quina et al., 2017), agriculture standards and renewable raw materials (Yuan et al., 2006; Ilić & Nikolić, 2016; Pringle et al., 2016); society allying demographic growth, urban expansion, job opportunities, consumer consciousness, and product design (Su et al., 2013), which are crucial in material efficiency enhancing, energy expenditures and in promoting product value.

Pheifer (2017) classifies CE enablers into micro-, meso-, and macro-economic levels. Micro-economic facilitators refer to the atmosphere in a company and or consumer and their interactions; the macro-economic level considers the overall economy at international, national and regional scales; the meso-economic level considers all that addresses supply chains, company associates and industry level. With respect to the micro-level, Pheifer (2017) states that enterprises ought to incorporate CE approaches into their strategic plans, which have to be explicitly identified in form of measurable goals to allow to access the progress achieved; organise training programmes/ courses to enhance skills and competencies on the implementation of CE approaches; provide informational programmes to enhance the CE concept; consider circular design and focus on the product complete life cycle; develop a global approach as the means to determining the potential of value retaining throughout the entire chain; support close cooperation between all the company stakeholders (internal and external) as this allow business to grow successfully; implement assessment procedures and instruments to measure value retention (Circle Economy and EMF); investigate and scrutinize all the information and available data on CE implementation and case studies as it will allow to identify better customer approaches; customers are ready to pay more if they have the opportunity to get an item or service with greater value. At a meso-economic level, Pheifer (2017) accounts for the requirement to create a reverse supply chain, enabling repair, refurbishment, and harvesting for parts in order to transition to a circular model. Considering the macro-level, the author stresses out that it is compulsory to consider a *cradle-to-cradle* or eco-design approaches to recover value and to create the necessary conditions to put it into practice; stakeholders ought to engage in setting up regulations that consider ecological and societal expenditures into the definitive price of goods and services; stakeholders ought to take responsibility for the environmental footprint of products and services during their life cycle by setting up Extended Producer Responsibility (EPR); modernise the existing governmental programmes, though some are applicable to CE approaches; and governments have to seek and stimulate market demand of circular products and services.

Furthermore, some studies consider enablers in a broad spectrum of domains pointing out resource and environmental depletion, overall business potential, adaptation of regulations, consumer demand, awareness and cooperation and business performance enhancement (Geng & Doberstein, 2008; Zhu & Geng, 2013; Govindan & Hasanagic, 2018; Abubakar, 2018; Gaur & Mani, 2018).

It is common sense that the transition towards a circular economy will only take place on the account of companies' expenditures and with all the stakeholders, organisations and society, engagement. More and more companies have already profited from this competitive head start by adopting circular models, which means they are a step forward by embracing a proactive strategy concerning resource-efficiency and costumer value. The data gathered with this research provide an understanding of the catalyst factors relevant in the implementation of circular economic models, and which are the enablers to purse circularity considering the different researchers' proposals.

Green Products Benefits

Environmental concern has been an important topic as it is accepted that products have an environmental footprint throughout their whole life cycle, from production to consumption and finally disposal (Sdrolia & Zarotiadis, 2019). Following Royne et al. (2011) environmental concern is a multidimensional concept gathering concern for waste, concern for wildlife, concern for the biosphere, concern for popular issues such as erosion and climate change, concern for health, concern for energy, and concern for environmental technology. To overcome environmental problems an increasing number of companies are trying to be environmentally friendly and to offer environmentally friendly products, more commonly known as green products (Atikbay & Davut, 2019).

In general, green products take into consideration the environment as they encompass the following characteristics: not to be dangerous to human or animal health; not to damage the environment during production, usage or removing; not to consume excessive energy and other resources; not to cause unnecessary garbage with unnecessary packaging or short life span; not to consist of harmful materials to the environment (Moisander, 2007). Sdrolia and Zarotiadis (2019) define it as a product (tangible or intangible) that minimizes its environmental impact (direct and indirect) during the full length of its life cycle, subject to the present technological and scientific status.

Some authors identify the benefits of green products as features often associated with this type of products. Singh and Massey (2019), for instance, based on the knowledge about green products and their benefits over non-green products among consumers, ranked the benefits advanced by Chang and Fong (2010) as follows: the quality of green products is good and consume fewer amounts of resources; they are recyclable, decomposable and reusable; they can also reduce the environmental damage; they can create a company's solid environmental reputation; and they also fulfil customer satisfaction and bring faith and loyalty while purchasing these products. In addition, according to Mishra and Sharma (2011), green products do not harm or pollute the environment; these products are originally grown and use natural ingredients; they contain nontoxic chemicals; they are not tested on animals; and these products are recyclable and biodegradable (Singh & Massey, 2019). Lin and Lin's study (2015) goes further by identifying the values and benefits that consumers stand to gain when buying green products in their effort to adopt green lifestyles. Results of the study showed that consumers achieve multiple benefits including a reduction of expenses, promotion of eco-friendly awareness, promotion of physical and mental health, reduction in energy consumption, they protect the earth, time is saved, and environmental protection, and effective use of resources is accomplished.

Green products have a huge impact both on society and companies, and the social and environmental impact includes aspects such as cost effectiveness and efficiency of products (e.g. fuel efficiency), health and safety when using the product, performance by assuming that, in many cases, green products are designed to perform better than other products, and the recyclability when the product reaches the end of its life (Fonseca, 2015). Moreover, Baker and Sinkula (2003) highlighted another useful attribute of green products, their "post-use fate", that is, the existence of alternatives after the end of the product lifetime such as reuse, repair, recycle, remanufacture, re-condition.

The greatest appeal of turning green is not only because some of the consumers demand these products, but they also favor companies in achieving some benefits when adopting green practices (Fonseca, 2015). The literature shows the multi-dimensional impact of green marketing, namely its effects on environment, society, and business (Danciu, 2018). Kinoti (2011) considers improved organization performance (profitability, competitive advantage, increased market share, better products), personal rewards (healthier and more fulfilled lives), better physical environment (reduced air and water pollution, reduced energy use, conservation of natural resources), and sustainable development as benefits for companies when they rely on using green marketing

According to the report published by Ellen MacArthur Foundation and McKinsey Center for Business and Environment (EMF, 2015), the European economy is very resource intensive. The circular economy package published in 2015 seeks to boost European competitiveness through new business opportunities and innovative and 'circular' means of production and consumption (Barbieri et al., 2016). According to EMF (2015), there is a differential gain of the circular economy over the linear economy (take-make-dispose). The authors' proposals seek to enhance the value of the products beyond their recycling values, and six business actions are advanced in the ReSOLVE framework: Regeneration, which implies a shift to renewable energy and materials, and to regenerate ecosystems for instance through sustainable land management; Sharing of products, reusing of products in secondary markets, and prolonging their life through maintenance; Optimization, that is, increasing the performance/efficiency of a product through reducing waste, using big data, resorting to automation, and steering; Loop, keeping components and materials in closed loops by remanufacturing products or components and as last resort recycling of materials; Virtualization of products such as books or music and of procedures through fleets of autonomous vehicles, virtual offices, or online shopping; Exchange for better and smarter products or technologies such as 3D printing or multi-modal transport (EMAF, 2015). The ReSOLVE ideological framework provides an offer of tools for companies, institutions, countries or regions for closing the loop (Pondel & Bludnik, 2018).

Perceptions About Green Purchase Intention

The environmental consciousness worldwide increased in the last decades, and consumers became more concerned about it. According to Kim and Hall (2018) major fashion brands are engaging in greenbranding initiatives, environmental sustainability has been put on their management agenda. However, the research literature is mixed in assessing the potential of the green strategy. An empirical study related to green products in North America suggested that motivation of consumers for consuming eco-fashion and green beauty products, protection of the environment is not a priority. The main motives revealed by consumers appear associated to an egocentric behavior and related to health. The same study points out differences between North American consumers and European consumers: motivation for consuming eco-fashion is based on self-expression (mainly a North American motivation) and status display (mainly a continental European motivation). For several continental Europeans, purchasing green products appears to be a new form of conspicuous consumption (Cervellon & Lindsey, 2011). Other studies (Kogg, 2003; Forman & Jorgensen, 2004) have explored the potential of ‘‘green fashion’’ to provide a competitive advantage. A study on attitudes and expectations of Finnish consumers concerning sustainable textile and clothing products displayed that 62.7% of the respondents were very interested in ethical consumption and products’ environmental impact, whereas 28.3% were somewhat interested (total 91%). In reporting actual ethical consumer behaviour, 20.8% agreed that they behaved ethically as consumers and 57.1% agreed slightly with this (total 77.9%) (Niinimaki, 2009).

On the relationship between the selfish or altruistic intention of green consumption, further studies targeted on university students reinforced the research findings that showed that green consumption is related to an altruistic, and thus more collectivistic intention rather than a selfish consumer motivation, related to the personal context and gain that each may have. Research data collected through a closed questionnaire sent to a mailing list with online addresses of undergraduate and graduate students from the University of Amazonia (UNAMA) demonstrated that the consumer favors the app that stimulates altruistic behavior rather than the one encouraging selfish behavior (Arruda Filho et al., 2019). Thus, concluded the authors, “participants showed a preference for the responsible, solidary, and conscious consumption, to the detriment of a simply hedonic and selfish consumption, which was expected by the theoretical hypothesis” (Arruda Filho et al., 2019:429). Furthermore, Loureiro et al. (2008) collected data from participants at Universities in South Korea, the United States and Portugal with the aim of examining the roles of need for self-expression and arousal to explain commitment and whether commitment leads to preferential behavior, word of mouth and willingness to sacrifice for recycling and environmental preservation. The findings suggest that affective commitment to recycling and environmental preservation is positively associated with all three predicted outcomes and in all three cultures, namely propensity to spread word of mouth about environmental efforts, willingness to sacrifice on behalf of environmental efforts, and preferential behavior toward environmentally friendly products (Loureiro et al., 2008).

A study developed in Malasia about consumer’s perception towards green issues, examined factors that influence green purchasing intention and to examine factors related to usage of recycle bags. This study used a sample of 170 university students and suggested that young Malaysian customers revealed positive attitudes towards environmental protection issues and usage of recycling bags, the “Perceived environmental responsibility dimension”, accepted as the top predictor of green purchasing intention followed by “social influence”. The third most significant predictor is “concern for self-image” (Choshaly, 2017).

Concerning perception, some studies provide crucial remarks about individual’s perception of “self” and behaviour that they have about themselves (Choshaly, 2017). The questionnaires which access people’s behavior concerning consumer patterns ought to consider the “self concept” effect that includes self-image.

In general, individuals try to improve their self-image by purchasing products that are close to their self-image and avoid those which are not (Schiffman & Kanuk, 1997). “Self-image” is also described as the perceptions individuals have of what they are like (Goldsmith et al., 1999). Choshaly (2017) argued that self-image is a concept which can help to identify factors influencing green purchasing behaviour. Mannetti et al. (2004) suggested a direct relationship between intentions to use recycled products and the individual’s self-image of being an environmentally responsible person. Other study, argued that the concern for self-image in environmental protection was accepted as the third top predictor of green buying behaviour among Hong Kong adolescents, which came directly after social influence and environmental concern (Lee, 2008).

Additionnaly, the green purchase intention concept could be understood as the willingness of an individual to choose green products to other products (Abdul Rashid, 2009). Mostafa (2007) affirmed that "green purchasing behaviour denotes the consumption of products that are beneficial to the environment, recyclable, sensitive or responsive to ecological concerns" (quoted in Lee, 2009). Choshaly (2017) observed the relationships that exists between environmental knowledge, intention and behaviour to predict environmentally responsible purchase intention. Follows and Jobber (1999) similarly suggested that intention is formed as the end result of an evaluation or trade-off between the environmental and individual consequences.

Arruda Filho et al. (2019) revealed that for young university students, known as tech elite, the intention of use for green products with environmental characteristics is greater when the consumer has a high level of environmental awareness. Nevertheless, the greater difference between the predicted green consumption and the current use informed by the participants indicated a large gap between the prediction of use and the current use of green products for consumers (Arruda Filho et al., 2019). Moreover, Atikbay and Davut (2019) aim to investigate the relationship between consumers' environmental attitudes and consumer purchasing decisions on green products in the Turkish Republic of Northern Cyprus. The results showed that consumers who have high environmental and green products awareness are also at high level according to the purchase of green products but this relationship is not strong enough. Finally, Fonseca (2015) conducted a questionnaire to 250 costumers to analyze the impact that green products have on customers, and their intention to buy them. Out of 250 respondents, 63 and 118 "strongly agree" and "agree" respectively, that the post-use fate of a product (reuse, repair, recycle, re-manufacture, recondition) has a positive effect in the intention to purchase these products. Other findings of this study suggest that customers are more willing to acquire green products because they are environmentally conscious.

Methodology

This study applied a quantitative methodology, and to collect the data a questionnaire was applied, that aims to understand the perception of the respondents about green purchase intention in fashion industry. This questionnaire was based in a tested questionnaire applied to building industry in Panama (Moreno, 2019).

The questionnaire has questions on green products and Circular economy in the fashion industry, however this chapter just analyses the answers related to green products. Table 2 presents the questions analysed and the scales used in this research. All question used Likert scales between 1 to 5.

Empirical Model

To analyse the data this research applied a Path Analysis. Path analysis is a particular extension of the model of linear multiple regression proposed by Wright (1934). The focus of this type of analysis is to decompose the association between variables into different effects, direct and indirect, such as those that are observable in a set of causal relationships. This methodology is used in problems of causal modeling between variables, i.e., modeling of cause-and-effect relationships between two or more variables.

Table 2. Green products in fashion industry – Questions and Scales

Questions	Likert-Type Scale Response Anchors
Are you aware of the circular economy that refers to an industrial economy that is made to be restorative by intention and design. "Is it an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life?	Level of Awareness 1 – Not aware to 5 – Very aware
Are you aware of the basic circular economy principles? · Reduce resource use, by applying lean design principles and extending product life spans. · Repair components and parts so that products can be used longer by one and the same user. · Reuse products, by transferring them in their original (or modified) form to another user. · Refurbish products, by replacing malfunctioning components and parts by new ones. · Recycle materials or resources, by disassembling components and separating parts. · Recover embedded energy from non-recyclable waste material where feasible. · Rethink solutions at every system level by exploring alternatives and restating problems. · Restorative and regenerative by design to make the textiles system more sustainable by minimising its negative impacts. · Redesign the action or process of designing something again in a different appearance, function, or content.	Level of Awareness 1 – Not aware to 5 – Very aware
Do you understand the benefits of using green products available in the market for fashion purposes? · Recycling of plastics - reusing plastic materials to reduce waste and environmental pollution. · No animal killed - using synthetic leather and fur to made products not to kill animals. · Recycling food waste - reducing food waste and the disposal costs of the agri-food industry to produce fashion products. · Recycling other fabrics - reducing waste, the pollution, costs and other resources.	Level of Awareness 1 – Not aware to 5 – Very aware
What would be an important enabler for you (of the fashion industry) when you are buying products that are made with green products. · Reduce the pollution and waste · High quality · Low price · Don't use animals' leather or fur · Brand · Other? Identify	Level of Agreement 1 -Totally disagree 5 – totally agree
Are you actually using green products where you live? · Clothes and ties made with citrus waste · Sneakers and clothes made with recycled plastic · Sweaters made with recycled denim · Products made from liquid leather (product in the lab) · Bags made with the grapes waste · Clothes made with sustainable cotton · Other? Identify	Frequency of Use 1 - Using 5 – No using.
Are you interested in traditional fashion (make, use, dispose) or in Green fashion (reuse, repair, recycling)? · Traditional fashion · Green fashion	Level of Interest 1 - not interested 5 - very interested.

However, the term "causal" simply refers to an assumption of the model (that of a cause-and-effect relationship) and not to an inferential property of the technique, that is, the non-rejection of these hypotheses does not prove that the assumption cause-and-effect is true, simply because Path Analysis analyzes correlations and the existence of significant correlation does not necessarily imply causality (Everitt & Dunn, 1991).

Therefore, in a causal model, we assume that causality implies correlation, without the opposite being necessarily valid or necessary to test the hypothetical causal model. We can simply conclude in a study of trajectory analysis, which are the (hypothetically causal) trajectories supported by the data and what kind of effects (direct, indirect, unanalyzed and or spurious) clarify the synchronization between the variables.

Sample

Data was gathered from students enrolled in a Higher education institution in Portugal from December 2019 to January 2020. In total, 279 responses were retrieved, of which only 110 were taken into account for the present study, in order to access a sample of students aware of what circular economy means. With regard to the respondents' profile (see Table 3), the majority are women (65,5%) and men are 34,5%. Concerning the birth year of respondents, more than half (56,9%) are young adults, born in 1995 and above, with millennials capturing the majority of the sample (81,8%), also known as Generation Y (or simply Gen Y). Both undergraduate (39,1%) and graduate students (60,9%) from a range of courses in the business areas participated in the study.

Table 3. Demographic profile of the respondents

Sample Data Demographic Characteristics		Frequency	Percentage (%)
Gender	Male	38	34,5
	Female	72	65,5
Year of birth	1995-2010	62	56,9
	1980-1994	28	25,7
	1965-1979	18	16,5
	<1964	1	0,9
Course degree attending	Bachelor	30	27,3
	Master	67	60,9
	Other	13	11,8

Descriptive Statistics

Table 4 presents the descriptive statistics. The variables were calculated from an average of the items of the dimensions to which they correspond. Values can range from a theoretical minimum of 1 point to a maximum of 5 points. In this way, the Enablers dimension was the most valued by the respondents while the Attitudes dimension was the one that obtained the lowest average value.

Results and Discussion

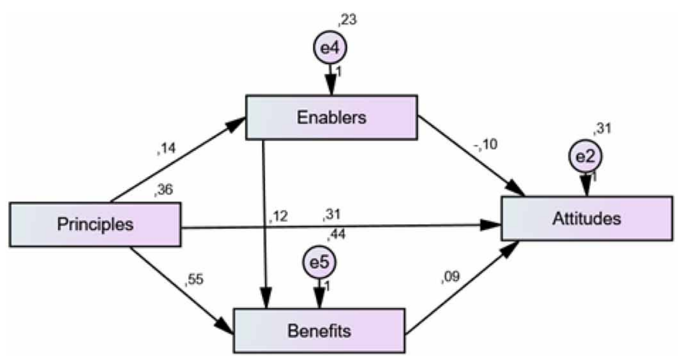
The Path Analysis considering the variables: Principles, Enablers, Benefits and Attitudes, allowed to design the following model (Figure 2).

Table 4. Descriptive statistics

	Minimum	Maximum	Mean	Std. Deviation
Principles	1.89	5.00	3.75	0.61
Benefits	2.00	5.00	4.10	0.74
Enablers	2.80	5.00	4.11	0.49
Attitudes	0.67	3.00	1.47	0.60

Notes: 1 – minimum 5 - maximum

Figure 2. Model for Green Purchase Intentions in Fashion Industry



According to this model, the Principles have a direct effect and two indirect effects. The direct effect on the Attitudes about Green Products in fashion industry (trajectory coefficient of the Principles for the Attitudes of Use) is 0.31 (i.e. for each standard deviation from the Principles, the Attitudes vary by 0.31 standard deviations in direct effect).

The two indirect effects are mediated by the Purchase Facilitators, from 0.14 (trajectory coefficient of the Principles to the Purchase Facilitators) to multiply by (-0.10) (trajectory coefficient of the Principles for satisfaction) resulting in a value of (-0.014). When measured through the Benefits (0.55 * 0.09 = 0.0495) it results in the value of 0.0495. The total effect (direct effect + indirect effect) of the Principles on Attitudes is 0.3455 (0.31 + (- 0.014 + 0.0495)).

Note that the Root Mean Square Residual (RMSR), which estimates the difference between the covariance estimated by the model and the covariance observed, presents values below 0.1, and it can be assumed empirically that the adjustment of the data model is good. Another adjustment quality index that corroborates the results is the GFI (unweighted least squares method), which presents values greater than 0.90, that is a reason to conclude there is a good adjustment of the model to the data.

These results are similar and not at all aligned with some part of the literature. The consumption of green products in the fashion industry is in its infancy, taking its first steps (Ritzéna et al., 2017). According to de Jesus and Mendonça (2018) it is also obvious a lack of consumer and even stakeholder enthusiasm in pursuing these paradigms. Our results reveal some higher sensibility of these consumers in this context. Nevertheless, the fact that only respondents who knew the CE concept were considered in the empirical study could influence these results.

Further research must be conducted to add on further discussion on the different profiles and compare the samples in order to evaluate possible similarities or differences.

The model revealed that enablers influence indirectly the attitudes. This achievement is aligned with some authors that highlight that companies are pushed towards CE paradigms bearing in mind the needs for profit moved by some drivers (Mont et al., 2017). Furthermore, these authors find ‘coercive pressure’ and market demand as the two main peripheral drivers, driven by regulations and market demand, considered crucial when pursuing circularity. In general literature is consensual about the influence of the enablers on the purchase attitude for green products (Govindan and Hasanagic, 2018, Park et al., 2010; Li & Li, 2011; Ilić & Nikolić, 2016; Hazen et al., 2017; Quina et al., 2017, Ilić & Nikolić, 2016; Pringle et al., 2016; Su et al., 2013). The benefits also influence indirectly the attitudes to purchase green products, and this result is also aligned with most of the studies found (Sdrolia & Zarotiadis, 2019) that argued the influence of environmental concern in the purchase of the products with a lower environmental footprint such as green products.

CONCLUSION

In the last decades global environmental awareness has been increasing mainly due to the depletion of natural resources, climate change, waste production, and pollution, and environmental constrains humanity can no longer cope with. Environmental sustainability has become a requirement in the agendas of developed and developing countries in order to promote the humanity well-being without compromising the future of generations to come (WCED, 1987).

Circular economy allows the adoption of a set of principles bringing a new paradigm to the economic reality. The patterns of consumption and production changed and concern with environment and resources have assumed great importance. In this context our chapter allows a better understanding about how CE principles influence attitudes in the consumption of green products, particularly in the case of the fashion industry, where fast fashion has a huge negative impact on the environment.

This study applied data collected in a Portuguese higher education institution, and using a path analysis model, propose some remarks, in part, not totally aligned with more theorethical literature: Circular Economy Principles have a direct effect on the Attitudes. The indirect effects (enablers and benefits) also reveal positive influence on the attitudes, nevertheless, these positive signal are more intuitive and remarked in other studies.

It is important to note some limitations on this study, the sample used in the model just includes the respondents that admitted to be acquainted with the CE concept, so perhaps the analysed consumers perceptions are more aligned with green economy and with more environmental concerns. Further research needs to confirm this exploratory study using different samples and enlarging the respondents.population.

Finally, we consider that this study allows some theorethcial and managerial implications. Firstly, in a theorethical perspective this study allows to confirm some previous research but also shows new paths by identifying a consumer segment that reveals some particular behavior in their purchase pattern. Secondly, the managerial implications are associated with the confirmation of green consumers that more often aim to have responsible purchase behaviors and reduce the impact of their choices in the environment. Entrepreneurs and manufactures, particularly in the fashion industry must be aware and provide products aligned with this green trend.

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KEY TERMS AND DEFINITIONS

Circular Economy: It is a holistic approach to reduce, reuse and recycle the production and consumption procedures so as to minimise energy consumption and consequently waste production.

Fashion Industry: It includes the production of clothing and accessories.

Green Products: Products that contain recycled materials, reduce energy and water consumption when produced, reduce packaging, generate less waste, and consequently they reduce the amount of toxic waste.

Chapter 13
The Circular Economy of Plastics:
Where We Are and Where We Can Go

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ABSTRACT

Plastic is an indispensable material for modern society. However, plastic waste is at the center of the current debate due to its presence and persistence in aquatic ecosystems. The literature recognizes that this problem is mainly due to the traditional linear economic model. The circular economy is a model based on the practices of reduction, reuse, recovery, and recycling of materials and energy. Circular economy solutions for plastic could hold the key to its present and future sustainability. Investigating the studies already done about plastic in the context of a circular economy is fundamental to understanding where we are and where we can go.

INTRODUCTION

Plastics are valuable materials that cover a wide range of applications in everyday life and can be found everywhere, from homes to industry. In the last 50 years, plastics production has increased 20 times. In 2014, the production was 311 million tons. It is estimated 600 million tons by 2035 and 1200 million tons by 2050 (Milios et al., 2018). Plastic recycling is relevant not only for the need to close material loops to maintain our natural resources. But also for the alarming observations of plastic scrap being scattered in oceans and lakes due to land and sea activities (Dahlbo et al., 2018).

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Circular economy models are emerging as a new paradigm for sustainable business. Growing demand and competition for limited resources are leading to price volatility, resulting in environmental degradation and threatening countries' competitiveness (Di Maio, Rem, 2015). Linear economy models, prevalent today, are driven by the "cradle-to-grave" philosophy. Linear orientation implies a "single-use" lifestyle, motivated by a "take-make-dispose" approach to resource consumption (Goyal et al., 2018; MacArthur, 2015). Circular economics emerges as a counterpoint to traditional linear models because it is an approach to economic growth aligned with sustainable development (Korhonen et al., 2018).

The alarming observations of plastic scrap scattered in oceans and lakes due to human activities, arouse societal reflection and, mobilize attention and resources for the development of solutions. Plastics recycling is still at a low level. In 2012, the annual volume of plastic waste traded globally was around 15 million tons, less than 5% of virgin plastic production (Velis, 2017). Globally, only 14% of plastic packaging was recycled, and even less was retained for subsequent use due to losses in sorting and reprocessing (MacArthur, 2015).

Global plastics production continuously increasing. In 50 years, plastics production increased from 15 million tons in 1964 to 311 million tons in 2014 (MacArthur, 2015). The sector that uses plastics most is the packaging industry, with a 39.9% share in Europe in 2015, followed by construction, with a 19.7% share in Europe in 2015. Most plastic packaging is discarded after a relatively short shelf life, while other products, such as those used in construction, have a longer shelf life. They account for 63% of the total of 25.2 million tonnes of European post-consumer plastic waste (Hestin et al., 2015). Plastic packaging has a variety of applications, from food and beverage packaging to toys and electronics. The primary function of a package is to protect the product. Thus, different types of products require different packaging properties, which results in a significant loss of resources.

Several questions arise: Is "plastic" the real problem? Or are the consumption practices of modern society wrong? Would it be possible to live in today's society without using anything plastic at all? Does it make sense to keep using plastic for all kinds of applications we use it today? Why don't we migrate to biodegradable materials? If plastic continues to exist, how can we best use it? Is the responsibility for the plastic which produces or uses? Or both? How can governments contribute to solving today's problems?

This chapter is not meant to answer all these questions, nor does it exhaust the subject. Given the current context, understanding what has already been built over time and contributing to the solution is crucial to know where we need to go. Thus, this chapter proposes as research questions: What we know about the circular economy of plastics? What opportunities for future studies emerge from this field? The main contribution of this paper is to present the current field of research, proposing a framework with main thematic clusters related to circular economy of plastics and identify these opportunities through a bibliometric search from the Web of Science database. Article summaries, book chapters, and proceeding papers have undergone content analysis to identify relevant topics. These topics were categorized into thematic groupings, where their level of relevance was determined by descriptive statistics. Finally, a framework summarizing the results was proposed. The next session provides a brief contextualization of circular economy.

The following section provides a brief contextualization of the circular economy concept. The session entitled "a preliminary study before discussion" presents the outline of bibliometric research conducted to support the discussion in this chapter. In the "discussion" session, contextual analysis of the data is developed. A framework with main thematic clusters in the field of study of circular economy of plastics is proposed. Future research directions and conclusions about the bibliometric research carried out closes this chapter.

BACKGROUND

Pearce and Turner (1990), two British environmental economists, raised the first concept of the circular economy. They point out that an open economy has reflected in the use of the environment as a waste reservoir. The first law of thermodynamics says that total energy and matter remain constant in a closed system. So, the open system can (and should) convert into a circular system by considering the relationship between resource use and waste (Geisendorf, Pietrulla, 2018). Facing existing environmental problems and resource scarcity, they exposed the need to look at the earth as a closed economic system. One in which the economy and the environment are not considered by linear interconnections but by a circular relationship (Boulding, 1966).

A linear economy is defined as the conversion of natural resources into waste via production. This waste production leads to environmental degradation in two ways: by removing natural capital from the environment and reducing the value of natural capital caused by waste pollution. Pollution can also occur at the resource acquisition stage. (Murray et al., 2017).

Linear economy models, prevalent today, are driven by the "cradle-to-grave" philosophy. Linear orientation implies a one-time lifestyle driven by a take-make-dispose approach to consumption (MacArthur, 2015) The circular economy is a counterpoint to traditional linear models, as it is an approach to economic growth aligned with sustainable environmental and economic development (Korhonen et al., 2018).

Although its concept coined almost 30 years ago, the academy effectively began more in-depth studies after 2010. Since then, the central theme of the academic debate has been exactly the search for conceptual oneness about the term circular economy (Ghisellini et al., 2016; Lieder, Rashid, 2016; Geisendorf, Pietrulla, 2018). As the theoretical field is still effervescent, the discussion of the empirical field is still settling down.

Much of the discussion, according to Korhonen et al. (2018), dues the idea is "a fragmented collection of ideas derived from some scientific fields, including emerging fields and semi-scientific concepts" (2018, p.39). These sources include, for example, industrial ecology (Frosch, Gallopoulos 1989; Graedel, 1996; Lifset, Graedel 2001), industrial ecosystems (Jelinski et al., 1992) and industrial symbioses (Chertow, Ehrenfeld, 2012), production (Stevenson, Evans, 2004), circular material flows (Lieder, Rashid, 2016), product-service systems (Tukker, 2015), eco-efficiency (Huppes, Ishikawa, 2009; Welford, 1998; Haas et al., 2015.), cradle-to-cradle design (McDonough, Braungart, 2003; McDonough and Braungart, 2010; Braungart et al., 2007), biomimetics (Benyus, 1997), performance economics (Stahel, 2006), natural capitalism (Hawken et al., 2008), Blue Economy (Pauli, 2010) and green supply chain (Srivastava, 2007).

The circular economy is treated as a solution to a number of challenges, such as waste generation, resource scarcity, and sustainable economic benefits (Lieder, Rashid, 2016).

Ellen MacArthur Foundation states that the circular economy model builds economic, natural, and social capital based on three fundamental principles: eliminating waste, keeping products and materials in use, and regenerating natural systems (MacArthur, 2015). Korhonen et al. (2018), proposes that the circular economy is an economy built from society's production and consumption systems that maximize the service produced from the energy flow between nature and society. For Geisendorf and Pietrulla (2018), "in a circular economy, the value of products and materials is maintained, waste is avoided, and resources are kept within the economy when a product has reached the end of its life" (p. 779).

Rosa et al. (2019) state that in circular business models, "value creation is based on maintaining the economic value embodied in products after use by exploiting them in new types of markets" (p.2). Murray et al. (2017) are more specific in proposing that circular business models are those whose "planning, resources, procurement, production and reprocessing are designed and managed, both process and product, to maximize ecosystem functioning and well-being" (p. 377). Ghisellini et al. (2016) confirm this idea, noting that while the implementation of the circular economy around the world is still at an early stage of development, it offers a reliable framework for radically improving the current business model for preventive and regenerative industrial eco-development, as well as increasing the welfare of society.

Despite the different conceptual propositions, some aspects are present in all of them. The pursuit of energy conservation in cycles as effective as possible, the use of renewable sources, and the disposal of waste are consensual. The academic discussion about the circular economy of plastics is explored in the following section.

A PRELIMINARY STUDY BEFORE DISCUSSION

A preliminary study was conducted to establish the discussion of this chapter. This study consisted of bibliometric research, divided into two essential phases: database search and abstract content analysis. A database search, a well-established form of meta-analytic literature search (Kim, McMillan, 2008), was firstly conducted.

Data were collected from the Web of Science database in October 2019, from boolean research under two conditions: only the term "circular economy"; and with the words "circular economy" AND "plastic *". For the returned data, no additional filters applied. Table 1 presents the results of the searches. The search considered only to topics and publications in English, published after 1945. For analytical purposes, the investigation in-depth through content analysis was done only the sample of documents resulting from the "circular economy" AND "plastic*". At this stage, a refinement was performed, removing from the sample publications that did not meet the minimum analytical criteria established.

Table 1. General search results

Description	Search Results
Search for "circular economy"	3937
Search for "circular economy" and "plastic*"	212
After Content Analysis	161

Source: (Authors, 2019)

All abstracts were examined in three key steps: pre-analysis, material exploration, and treatment of results.

In the pre-analysis, documents that did not meet at least one of the following requirements were excluded:

No summary associated with the publication;

Finding that the study was not directly related to plastic and circular economy.

A stage of material exploration allowed the identification of thematic clusters, where each study was allocated, as well as the most relevant topics associated with each of these researches.

Finally, proceed to the treatment of the results. Two simple descriptive statistics criteria were adopted to determine the association between topics and thematic clusters. Occurrence frequency analysis and classification by quartile. By definition, this classification determines how closely each topic relates to one of the categories, directly associated with the quartile in the ranked topic. Thus, as the options generated were:

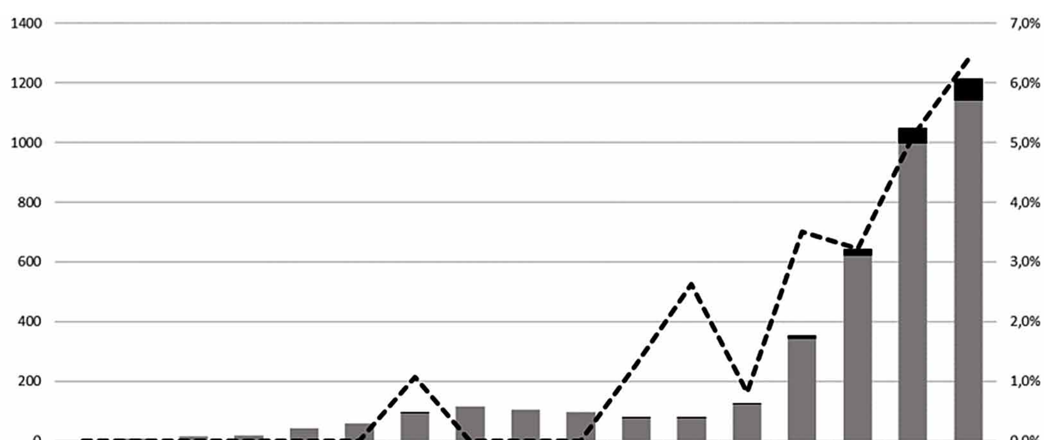
- 1st quartile topics: low relationship with thematic cluster;
- 2nd quartile topics: moderate relationship with thematic cluster;
- 3rd quartile topics: high relationship with thematic cluster;
- 4th quartile topics: very high relation with thematic cluster.

Results

Bibliometric Research

The results of the bibliometric survey are shown below in Figures 1 to 4. Figure 1 shows a marked increase in the number of publications from 2016. Both circular economy in its full range, as well as for the narrow field of study of the literature. Plastic in the context of the circular economy. However, the absolute number of publications combining "circular economy" and "plastic" is still small compared to the total number of circular economy publications (see Table 1). The proportion of studies with this emphasis, however, follows a growing trend. In 2019, 6.4% of circular economics studies focused on plastic waste.

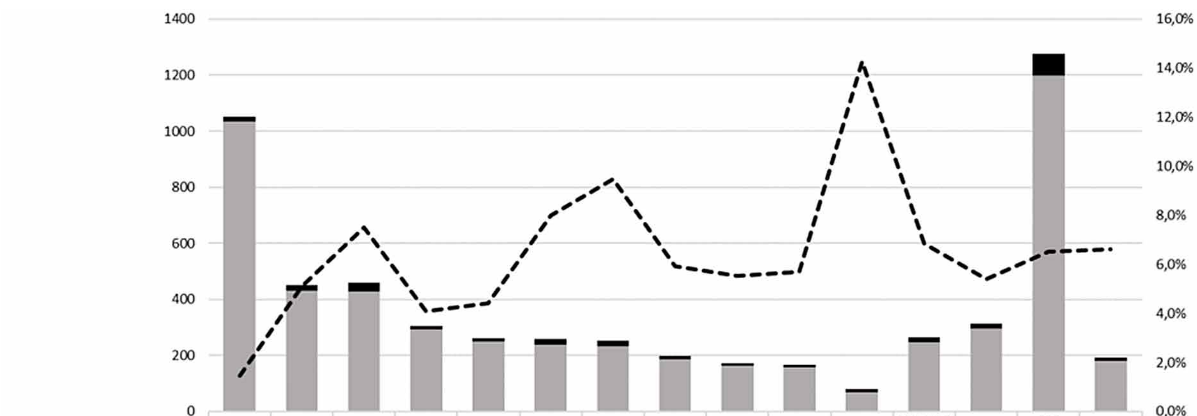
Figure 1. Research field profile: plastics in the circular economy
Source: Authors, 2019



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
"circular economy" and "plastic*" (refined)	0	0	0	0	0	0	1	0	0	0	1	2	1	12	20	51	73
"circular economy"	1	7	14	18	43	59	94	114	103	96	78	76	124	342	622	999	1140
% research about "plastics"	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,1%	0,0%	0,0%	0,0%	1,3%	2,6%	0,8%	3,5%	3,2%	5,1%	6,4%

Chinese researchers are the most published study on the circular economy in the world (1036 articles), as shown in the graph in figure 2. It is more than twice as many as Italy (430 articles) and England (427), which follows the ranking. China, as the top country, is not surprising. Since China enacted the Circular Economy Promotion Law in 2013 (Lieder, Rashid, 2016), scientific research has been stimulated. However, when the focus is on the context of plastic in the circular economy, this sovereignty Chinese is not evidenced. England, the USA, Italy, and Germany stand out against China in this context. European researchers have shown active engagement in this field, accounting for almost 70% of all researchers with this emphasis. Possibly a reflection of the efforts of the European Union, which adopted in 2015 an ambitious Circular Economy action plan, where initiatives for plastic waste highlights since 2018. Another highlight is the interest of African researchers in plastic solutions in the context of the circular economy. The proportion, in this case, is 14.3%, almost 2.5 times higher than the average researchers from other parts of the planet (6.5%). The main objects of study are African nations barriers and levers for waste management (Abiti et al., 2017; Jambeck et al., 2018; Joshi et al., 2019) and multi-material packaging recovery technologies (Yousef et al., 2018; Mumladze et al., 2018) and energy production (Sheldon, 2016).

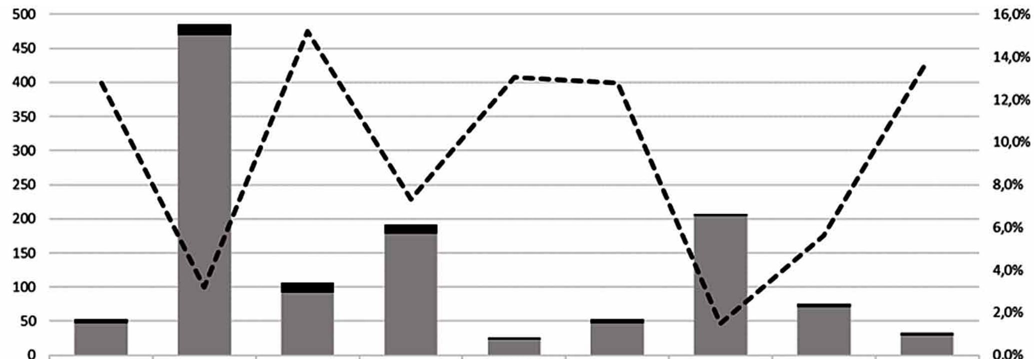
Figure 2. Research field profile: where the researchers are.
Source: Authors, 2019



	CHINA	ITALY	ENG	SPAIN	NETHRL	GERM	USA	SWED	FIN	FRANCE	AFRICA nations	AMERICA nations (others)	ASIA nations	EU nations (others)	OCEANIA nations
"circular economy" and "plastic*" (refined)	15	22	32	12	11	19	22	11	9	9	10	17	16	78	12
"circular economy"	1036	430	427	293	250	238	232	186	163	158	70	248	296	1199	181
% research about "plastics"	1,4%	5,1%	7,5%	4,1%	4,4%	8,0%	9,5%	5,9%	5,5%	5,7%	14,3%	6,9%	5,4%	6,5%	6,6%

The Journal of Cleaner Production is the most widely published publication on circular economy (470 articles). Sustainability (204 articles) follows, as shown in Figure 3. However, the proportion of studies focusing on plastics in these two publications is low (<3.2%). Still, in absolute numbers, the Journal of Cleaner Production publishes the most with this emphasis (15 articles). Waste Management stands out with the highest proportion of publications (15.2%), and the second in absolute numbers (14 articles). Resources Conservation and Recycling are also noteworthy (13 articles).

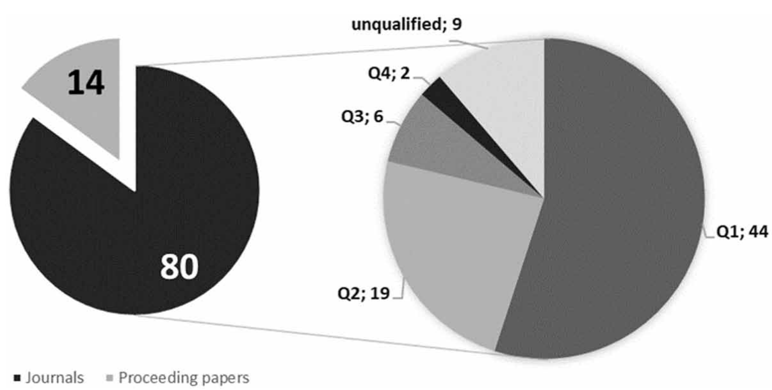
Figure 3. Research field profile: leading journals that publish articles about circular economy and plastic.
Source: Authors, 2019



	SCIENCE OF THE TOTAL ENVIRON.	JOURNAL OF CLEANER PRODUCT.	WASTE MANAG.	RESOURCES CONS. AND RECYCLING	ENVIRON. SCIENCE AND POLLUTION RESEARCH	WASTE MANAGEMENT RESEARCH	SUSTAINAB.	PROCEDIA CIRP	RESOURCES BASEL
H Index (source: scimagojr.com)	205	150	127	103	82	66	53	41	19
"circular economy" and "plastic*" (refined)	6	15	14	13	3	6	3	4	4
"circular economy"	47	470	92	178	23	47	204	71	29
% research about "plastics"	12,8%	3,2%	15,2%	7,3%	13,0%	12,8%	1,5%	5,6%	13,8%

The refined sample identified a total of 94 publications. Of these, 14 refer to proceedings of conferences, and 80 periodic journals. Figure 4 presents a proportional relationship from the Scimago Journal & Country Rank (SJR) classification of these 80 journals. The vast majority (79%) of the journals are of excellent quality (Q1 and Q2).

Figure 4. Publications profile (source: scimagojr.com)
Source: Authors, 2019



This pattern of results is not very different from those found by Geissdoerfer et al. (2017), who conducted a similar bibliometric study. At the time, with a January 2016 sample from the Web of Science database, the search for the term "circular economy" returned 295 results. Even with 13 times fewer documents returned than the present research, the effects on geographic distribution and most cited publications were quite similar. The difference in data volume obtained by Geissdoerfer et al. (2017) concerning this research is due to the publication boom that began in 2016. Its sample contained data before this period only.

Content Analysis

A total of 212 records returned from this research were read and pre-analyzed. After excluding irrelevant articles, 161 documents integrate the final sample. By the established criteria, 51 abstracts were excluded:

- 12 papers by the absence of abstract associated with the publication;
- 39 papers due to a study not directly related to the circular economy of plastics.

Regarding this last criterion, all studies addressed to the circular economy of wastes. However, the word "plastic" appeared in the text-only as an "example of waste". In general, these works dealt with other types of waste in the context of the circular economy, such as electro-electronic metal recovery, organic waste processing, and construction materials recovery.

A careful reading of the 161 abstracts allowed the coding of relevant topics in each research and, finally, categorized them by affinity. Five categories emerged from this analysis. In this study, we call these categories "thematic clusters". Are they:

- **Management:** Studies directed to the investigation and operationalization of strategies for reduction, reuse, and recycling of industrial and domestic post-consumer plastic waste. As well as studies to increase the efficiency of plastic management processes in its value chain;
- **Environmental Impact:** studies focused on the application of environmental impact analysis methodologies such as Life Cycle Analysis (LCA) and Material Flow Analysis (AFM);
- **Technology:** studies focusing on the determination of properties of recycled materials and composites, as well as the development of technological solutions for plastic waste;
- **Energy:** studies aimed at the development of energy production strategies, taking advantage of the calorific power of plastic waste;
- **Policy:** studies aimed at discussing legal and regulatory aspects associated with the production of plastics (virgin, recycled, and composites). As well as the management of industrial and domestic post-consumer plastic waste.

The relevant coded topics were associated with each of these thematic clusters. In total, 55 topics coded. Some topics were associated with more than one category. This condition only demonstrates that a particular topic has been studied from more than one research perspective. On the other hand, the absence of association of a specific topic with any of the thematic clusters may mean an opportunity for future studies of this topic.

The level of association between topics and thematic clusters was determined by frequency analysis and classification by quartiles. Table 2 summarizes this information.

Table 2. Summary of the main topics and its relationship level with the thematic clusters

Relationship Level	Very High	High	Medium	Low
Energy	· pyrolysis · waste to energy	· household waste	· fuel · waste mining	· chemical recycling
Environmental Impact	· contamination · life cycle assessments · material flow analysis	· bioplastics · end-of-life oceans	· circularity · household waste · nanoplastics · packaging · mechanical recycling · waste management	· composite · greenhouse gas · product stewardship · reusable packaging · sustainable production · microplastics
Management	· cities · closed-loop recycling · ecodesign · household waste · indicators · modeling · mechanical recycling · waste management	· 3D-printing · bioplastics · consumer behavior · distributed recycling packaging	· disassembly · upcycling WEEE plastics	· business model · circularity · end-of-life · green supply chain · industrial symbiosis · materials recovery facilities (MRF) · waste mining · oceans · reuse · sorting · sustainable goals · waste to energy microplastics
Policy	· oceans · packaging · sustainable goals · waste management	· importing solid waste · product stewardship · WEEE plastics	· circularity	· closed-loop recycling · contamination · ecodesign · greenhouse gas · mechanical recycling
Technology	· biodegradation · chemical recycling · composite · properties · mechanical recycling · waste to feedstock	· bio-catalyst · bioplastics · depolymerization · green chemistry · waste to energy	· 3D-printing feedstock · bio-based materials · carbon nanotubes · materials recovery facilities (MRF) · multilayer · sorting · WEEE plastics	· 3D-printing · biorefinery · blending recycled/ virgin material · cities · closed-loop recycling · distributed recycling · household waste · waste mining · pyrolysis · waste management

Source: Authors, 2019

DISCUSSION

Central Topics

The dialogues of today's society, whenever they associate the two terms proposed in this research, "circular economy" and "plastics", inevitably link to the discussion a third term: "waste". If common sense naturally relates these three terms, the scientific literature follows this same path. Of the 55 coded topics, 4 of these were highly central, and all are associated with the word "waste". They are waste management, mechanical recycling, household waste, and waste to energy. These topics have discussed from different perspectives in plastic and circular economics studies.

Waste management is a topic that has a strong relationship to management cluster, with several case studies of post-consumer plastic waste management (Kranzinger et al., 2017; Morlok et al., 2018; Cioca et al., 2018; Zacho et al., 2018; Hahladakis et al., 2018; Powell, Chertow, 2019; Hahladakis, Aljabri, 2019) and industrial waste management (Rutkowski, Rutkowski, 2017; Umer, Abid, 2017), modeling of selective collection systems (Brouwer et al., 2018; Gobbi et al., 2019; Mohammadi et al., 2019) and plastic value chain orientation (Milios et al., 2018). The association with the policy cluster is also strong, with emphasis on public policy case studies implemented for waste management (Wiesmeth et al., 2018; Van Eygen et al., 2018; Wichai-utcha, Chavalparit, 2019), the export of waste from developed countries to China (Brooks et al., 2018; Liu et al., 2018; Qu et al., 2019), discussions on international directives that set sustainability targets for countries (Penca, 2019; Foschi, Bonoli, 2019; Nielsen et al., 2019) and regulations for recycled content (Lee et al., 2014; Römph, Van Calster, 2017). The following links to another central topic: mechanical recycling.

This topic has a strong association with management and technology thematic clusters. In the first case, studies oriented to consumer behavior regarding the consumption of recycled products (Khan et al., 2019; Magnier et al., 2019). Additionally, case studies on recycled plastic valorization (Rutkowski, Rutkowski, 2017; Dahlbo, 2018; Paletta et al., 2019), and close the chain in closed-loop recycling (Eriksen et al., 2018; Eriksen et al., 2019), promotes circularity of the plastic materials.

The economic potential of the use of recycled resins in 3D printers has been carefully studied (Garmulewicz et al., 2018), both in management and technology perspectives. Not regarding the recycled physicochemical properties (Woern et al., 2018), but also the development of decentralized recycling strategies, which enable small-scale (including home) recycling, allowing the recovery of 3D-printing resins (Zhong, Pearce, 2018; Joshi et al., 2019).

In addition to the growing interest in 3D-printing resins, the study of physicochemical properties of recycled resins for higher value-added applications, whether 100% recyclable content (Reich et al., 2019), in blends with virgin material (Curtzwiler et al., 2019), or composites (Sommerhuber et al., 2016; Ayre, 2018), has also received much attention from researchers. The development of material recovery facilities (MRF) technologies, which increase the efficiency of plastic segregation (by chemical composition - PE, PP, PS, PET[1] - And by color), appear as potential solutions for household waste management. Two drivers guide these actions: operational efficiency (Rani et al., 2019; Lahtela et al., 2019) and reduction of occupational risks of workers at separation plants (Cioca et al., 2018).

The quality of household waste segregation is essential for adding value to recycled resins (Eriksen et al., 2018; Wohner et al., 2019). When mechanical recycling of household waste is not possible, waste to energy solutions presents as an option (Satchatippavarn et al., 2016; Klavins et al., 2018; Faraca et al., 2019). Not only for household waste derived from the selective collection but even for plastic materials recovered from landfill mining (Canopoli et al., 2018). The association of waste mining and waste to energy practices sets a new horizon, enabling the environmental recovery of degraded areas by the modern consumer society.

The following subsections provide an overview and contextualization of the other topics associated with each of the thematic clusters proposed in this study.

Management

The main challenges for plastic management in the circular economy context establishes household waste management and development strategies to make it viable. Mechanical recycling and waste to energy are some of the options. However, the problem is broader. Beyond the cities, industries (Ragaert et al., 2018; Domenech et al., 2019) and logistics chains (Rahman et al., 2019) are related to waste management topics. The development of circular economy performance indicators is fundamental in these cases (Huysman et al., 2017). Establishes ecodesign practices, such as disassembly and upcycling, contributes to the circularity of plastic. Also, the efficiency and applicability of each method can periodically be evaluated.

Ecodesign is a philosophy that guides the design of products and services that promote the least possible environmental impact as well as facilitate their reuse, mechanical recycling, or energy reuse (Guillard et al., 2018). The disassembly in ecodesign directs product designs to be easily repaired by the consumer when needed (Vanegas et al., 2018). The significant impact of this is the increase in product life, especially in electronics. Upcycling is the process of reconfiguring discarded products into new products, thus returning to the consumer chain. Upcycling has been particularly widely used in the fashion industry (Ragaert et al., 2018).

However, little has been studied about business models for valuing plastic in the circular economy. Only the study by Paletta et al. (2019), which addresses the barriers and challenges in this context, was identified in this bibliometrics. Given the impact of plastic waste on society, the diversity of possible solutions, whether in product or service, this particular topic needs further attention from the literature.

Technology

There are currently two opposing views in the discussion of technological solutions for plastic in the circular economy context. One focuses on the end of the use of plastics (or extreme reduction) in society, while another aims to value the plastic waste, reintroducing it in the value chain.

Research that focuses on the elimination of plastic drives the development of bioplastic solutions. Bioplastics are biobased materials produced from natural polymers derived from starch, cellulose, vegetable oil, and biomass. In addition to being from natural sources, they have high biodegradability (Prieto, 2016; Ruggero et al., 2019). Its application, however, is still restricted to some types of food packaging and disposable materials, such as plastic bags (Payne et al., 2019). The expansion of bioplastic applications depends on the evolution of mechanical properties, which give it strength and durability (Aliotta et al., 2019; Sangroniz et al., 2019). Improvement of these properties, however, impacts negatively on biodegradability (Paço et al., 2019). Therefore, the equation is difficult to balance. The higher the strength of the material, the lower its biodegradability.

Understanding the impacts of bioplastics on the circular economy context has been the subject of discussion in the literature. Some authors justify its circularity along the natural biological pathway of degradation. Bioplastics will give rise to nutrients and carbon sources for new plants, which will serve as the basis for the production of new bioplastics (Shogren et al., 2019). However, there are divergent opinions. The use of the biological degradation route and extraction from renewable sources may be less sustainable than recycling-oriented routes (Durkin et al., 2019). Conventional mechanical recycling processes are not suitable for bioplastics. The presence of bioplastics mixed with conventional plastics can cause serious quality problems in the recycled resin (Alaerts et al., 2018). High temperatures degrade the material, making its use unfeasible. Routes of chemical recycling, in this case, could be an alternative for the recovery of essential molecules. In this way, no renewable sources will be extracted to obtain these same molecules (Payne et al., 2019).

Conventional plastics, such as PE, PP, PS, and PET, are mostly made from petroleum derivatives, a non-renewable source. Technologies for the production of industrial-scale plastics from renewable raw materials, such as polyethylene from sugarcane, have already been developed (Júnior et al., 2019). However, renewable source plastics are still tricky to biodegrade. Changes the source of the raw material, not modify the physicochemical properties of the material. Traditional plastics can have high variability of mechanical properties, depending on their formulation, which explains a large number of applications of plastics in modern society.

Studies indicate that replacing 100% of plastics currently produced by bioplastics or other biobased materials does not seem to be a trend nor a solution (Kawashima et al., 2019). A dedicated market proportion for each type of material is suggested to be more consistent (Iles, Martin, 2013). Disposable single-use materials appear to be a promising market for bioplastics use (Payne et al., 2019). Durable goods and packaging requiring mechanical strength and extended chemical stability continue to be appropriate markets for conventional plastics.

Technological developments in mechanical recycling, both in processes and in product properties, have been previously discussed. Chemical recycling technologies are alternatives for promoting the circularity of both bioplastics and conventional plastics. These technologies are also referred to in the literature as depolymerization technologies. Chemical and biochemical routes have been explored (Payne et al., 2019). Many efforts have been made towards the use of enzymatic catalysts, also called biocatalysts (De Castro, Carniel, 2017; De Castro et al., 2018). Biocatalysts derive from green chemistry. Science focused on the invention, development, and application of chemical products and processes to reduce or eliminate the use and generation of environmentally hazardous substances.

Green chemistry is fundamental to the promotion of sustainable development. It applies in two stages of the circular economy cycle of plastics: the production and recovery of materials (Sheldon, 2016; Kaur et al., 2018). In industrial production, green chemistry anchored the concepts of sustainable production (Zapelloni et al., 2019). In the recovery of post-consumer plastic waste, this is where chemical recycling technologies (or depolymerization). It can drive in two ways: waste to energy and waste to feedstock.

Waste to energy technologies use waste as primary fuels or turn it into specialized fuels with broader applications and energy efficiency. Waste to feedstock technologies proposes breaking the polymer chains of post-consumer plastic waste by chemical reactions. To obtain fundamental molecules, making it possible to make it again the raw material for the production of new plastics (Hees et al., 2019). In the case of conventional plastics, this type of technology closes the technical cycle of these materials. In this way, it will no longer be necessary to extract oil to produce plastics in the traditional petrochemical model. Until now, only promising laboratory-scale studies [2]Bäckström et al., 2018), terephthalic acid[3](Pedersen, Conti, 2017) and carbon nanotubes[4](Moo et al., 2019). Production on industrial scales should be a reality in the coming years.

An important point: chemical and mechanical recycling solutions are not exclusive. Indeed, they are complementary proposals (Kranzinger et al., 2018; Hidalgo et al., 2019). Mechanical recycling recovers a reasonable share of domestic and industrial post-consumer plastics, giving rise to recycled resins with excellent physicochemical properties (De Almeida, Borsato, 2019). However, to another portion of the generated plastics that can not be recycled mechanically. As a rule, flexible plastics and multilayer materials cannot be recycled in this way (Mumladze et al., 2018). In these cases, chemical recycling is the best solution.

Energy

If waste to feedstock technologies are still under development, waste to energy technologies is already a reality. These technologies are widely used in countries with little territorial extension, such as Japan, South Korea, and some European countries. Locations where the installation of landfills (a standard environmentally friendly solution in linear economy models) is not feasible. Domestic post-consumer waste, which would be a problem, becomes a viable energy solution for these countries (Faraca et al., 2019). These technologies can be as simple as controlled waste incineration, where the fuel is the waste itself. Other technologies transform waste by pyrolysis processes, into biorefineries. Gases (Klavins et al., 2018) and combustible oils (Satchatippavarn et al., 2016; Marczak, 2019), much more efficient embracing in a diversity of applications, are produced there.

Environmental Impact

The environmental impact thematic cluster mainly groups studies that apply impact analysis methodologies of products, processes, and services to the environment. These include Life-Cycle Assessment (LCA) and Material Flow Analysis (MFA). Life-Cycle Assessment is a technique for assessing and quantifying possible environmental impacts associated with a product or process. This technique is widely used to compare the environmental impact of different products that perform the same function, and the effect related to varying possibilities of disposal of waste. Material Flow Analysis is an analytical method that quantifies flows and stocks of materials or substances in a well-defined system. It presents an essential tool for the understanding of biophysical aspects of human activity in different temporal and spatial scales.

LCA, in the context of the circular economy of plastics, has been widely applied. In this bibliometrics, we identified the LCA for disposable packaging (Wohner et al., 2019; Civancik-Uslu et al., 2019), reusable (Tua et al., 2019), wood-plastic composites (Sommerhuber et al., 2017), electro-electronic plastics (De Meester et al., 2019), mechanical recycling processes (Faraca et al., 2019), and bioplastics production (Spierling et al., 2018). In the case of MFA, the studies evaluated its applicability as a decision-making tool for the development of the circular economy at the regional level (Van Eygen et al., 2018; Virtanen et al., 2019) and in developing countries (Millette et al., 2019). Another relevant application of this methodology is to verify the persistence of pollutants derived from plastics in the environment due to the material's technical cycles (Lee et al., 2014; Groh et al., 2019).

The study of environmental contamination associated with plastics, in general, has been worrying about the scientific community. Micro and nanoparticles of plastics are known to be dispersed in the environment, and their effects on human health and other living organisms are still uncertain (Rhodes, 2018; Alexy et al., 2019). Potential health risks from the use of recycled materials, especially in food packaging, are a significant concern (Geueke et al., 2018). And arguably one of today's most recurring themes, the impacts of plastics on the oceans are at the center of the pleading, including mobilizing specific policies to this theme (Turner, 2018; Agamuthu et al., 2019; Forrest et al., 2019).

Policy

The growing social pressure against the consumption of plastics has promoted a broad discussion about regulations for the production, trade, and disposal of waste generated. In February 2017, the UN took a stand on the issue by launching the #cleanseas campaign[5], a global initiative to demand from the public and private sector concrete measures against water pollution. Since then, the scientific community has been mobilizing in the development of studies that support the development of local, national and global policies (Penca, 2018; Jambeck et al., 2018; Jiang, 2018; Turner, 2018; Agamuthu et al., 2019; Forrest et al., 2019).

Product stewardship regulations regarding the composition of virgin and recycled plastics, and the substances that may migrate to water or even the skin of users have been established around the world (Lee et al., 2014; De Römph, Van Calster, 2018; Groh et al., 2019). Regulations have also been established for greenhouse gas to influence governments to encourage the circular economy in plastic production (Liu et al., 2018).

The ban on Chinese imports of waste from developed countries has also received attention from the literature. It is in line with China's Circular Economy Promotion Act, enacted in 2013 (Lieder and Rashid, 2016). Some authors see this political decision by China as a catalyst for circular economy initiatives in European countries in recent years (Brooks et al., 2018; Liu et al., 2018; Qu et al., 2019).

Concerning European rules that charge for the reuse of plastics, the Waste Electrical and Electronic Equipment Directive (WEEE), enacted in 2003, already charged for the correct disposal of all constituent materials of these products. But it is in 2015 that the European Union launches a bold action plan for implementing the Circular Economy in Europe (European Commission, 2015). In 2018, a strategy dedicated to the packaging sector was set out in this action plan, demonstrating that at least in Europe, the circular economy is the way forward to ensure the plastic sustainability (European Commission, 2018).

FUTURE RESEARCH DIRECTIONS

Despite the growing interest of researchers, the field still needs further study and discussion in the five proposed thematic clusters. Some study opportunities would be:

- Studies with an emphasis on business models in the context of the circular economy. Generate knowledge about the potentialities and challenges for implementation and evolution of the circular economy model in the plastic chain;
- Deepen understanding of the impact of public policies and institutional pressures on the business strategies of firms operating in the plastic value chain;
- Development of mathematical models that help in the decision making of the best plan for plastic management in its value chain, considering the different institutional and sociodemographic aspects of developed and developing nations;
- Deepen engineering studies in chemical recycling, advancing scale solutions for waste to feedstock;
- Conduct studies that cross emerging technologies (such as blockchain and IoT), such as to promote the circular economy of plastics, within a value chain management context. Studying the impact of these technologies on industrial and urban settings can provide exciting insights for large-scale technical and financial analysis.

CONCLUSION

This chapter aims to present a picture of the field of study established so far, the circular economy of plastics. To this end, a bibliometric study was conducted, followed by a content analysis of abstracts returned from the Web of Science database. We identified 55 relevant topics, categorized into five thematic clusters that emerged from content analysis (management, technology, energy, environmental impact, policy). The designated topics contextualize different thematic perspectives.

Four topics were identified in how central topics. They were discussed from different perspectives of the circular economy of plastic studies. They are waste management, mechanical recycling, household waste, and waste to energy.

In the Management cluster, studies focused on increasing the efficiency of the use of plastic waste after domestic consumption. Solutions aimed at extending life, which are and favors recycling, are the main ones.

In the management cluster, studies focused on increasing the efficiency of the use of plastic waste after domestic consumption. Solutions aimed at extending life, which are and favors recycling, are the main ones. On the other hand, business models associated with the circular economy of plastics received very little attention. This is worrying, given that business models are likely to enable the circular economy of plastics. Whether by extending their useful life or by reverse logistics for reuse or recycling.

From the perspective of Technology cluster studies, two groups with different views are established. One that employs efforts in technological solutions to reintroduce plastic waste into the value chain, such as mechanical, chemical, and energy recycling. And another that seeks its extinction, focusing efforts on solutions that replace plastic with other materials, preferably biodegradable. Positives and negatives weigh on each side. Despite the diverging focus, a likely trend is that biodegradable solutions will make room for single-use products, while conventional plastics will not be extinguished, but will leverage on longer-life solution markets.

Energy cluster studies are focused on energy production from waste. Waste is not considered a renewable source of fuel, but it could be better than fossil sources, as it can eliminate materials that may not be recovered by mechanical and chemical recycling.

The environmental impact thematic cluster mainly groups studies that apply impact analysis methodologies of products, processes, and services to the environment, such as Life-Cycle Assessment (LCA) and Material Flow Analysis (MFA).

Finally, the Policy cluster brings together studies derived from discussions about the production and consumption of plastics by society. We highlight the debates about international directives, product regulations, reverse logistics, and disposal of plastic waste.

The field of research on the circular economy of plastics is emerging and fertile in opportunities for further study. It is hoped that the framework proposed from this bibliometric research can guide future studies that contribute to sustainable solutions for plastic in modern society.

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KEY TERMS AND DEFINITIONS

Bioplastic: Biobased materials produced from natural polymers derived from starch, cellulose, vegetable oil, and biomass.

Circular Economy: An economic system in which the materials are inserted in a cyclic flow, enabling their maximum utilization, reducing the extraction of raw materials from nature (mainly non-renewable), and other environmental impacts.

Chemical Recycling: Technologies that use physicochemical processes to transform waste into raw materials for the production of new materials.

Composites: Materials whose composition has plastics mixed with non-plastic materials.

Mechanical Recycling: Technologies that use physical processes to transform waste into raw materials for the production of new materials.

Plastic: Polymeric materials produced from mostly renewable and non-renewable raw materials, which have physicochemical properties that allow their use in a wide range of applications in modern society.

Waste Management: Acts associated with the correct disposal of waste generated in industrial and urban environments.

Waste to Energy Technologies: Use waste as primary fuels, or turn it into specialized fuels with broader applications and energy efficiency.

Waste to Feedstock Technologies: Break the polymer chains by chemical reactions, to obtain essential molecules that can be used of raw material for the production of new plastics.

ENDNOTES

1. PE: polyethylene; PP: polypropylene; PS: polystyrene; PET: polyethylene terephthalate.
2. Olefins are of low molecular weight hydrocarbons, which are the raw material for the production of various polymers (plastics) and elastomers (rubbers).
3. Terephthalic acid is a basic molecule for the production of PET (polyethylene terephthalate), widely used in food packaging, especially beverages.
4. Carbon nanotubes are materials that have excellent mechanical, electrical, and thermal conduction properties. They have very high value in the field of nanotechnology, electronics, optics, and other technological fields of materials science.
5. For more information: https://www.cleanseas.org/

Chapter 14
Repair Café Porto:
A Situational Analysis

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ABSTRACT

This chapter analyses Repair Café Porto (RCP) through the lens of a SWOT (strengths, weaknesses, opportunities, threats) method. It is based on the event-RCP held for three hours on a Saturday every two months from June 17, 2017 until April 28, 2018 and on a new economics approach of circular economy. It is intended to examine the potentialities and challenges of RCP. Repair Cafés are 'workshops' for people to bring consumer products in need of repair where they with volunteer fixers learn repair, maintain their broken or faulty products, or try product modification. It is an RCP-requirement that visitors who bring products participate in repairs undertaken. Regular repair stations include bike, electrical and electronic, clothing, and jewellery. The SWOT method is used to assess internal and external aspects of RCP. It is concluded that the success of RCP is dependent on financial support, the maturity of repair notion, and the alteration of consumers and producers' attitudes to see waste as a resource and to extend the life of a product.

INTRODUCTION

The EU's action plan for the circular economy underlines the importance of repair for resource security and sustainability (European Commission, 2016) and switches the focus towards waste reduction and reuse, the options at the top of the waste hierarchy. The Portuguese Government has signalled backing for practical actions that encourage circular economy recognising the value of repair as part of a waste reduction strategy and of circular economy (Presidência do Conselho de Ministros, 2017). Repair is an activity that improves resource security and brings economic benefits through more demand for skilled labour. The ability to repair goods is key to maintaining the functionality of products (Stahel, 2010) and avoiding their disposal. The loss of products and materials slows down the process of closing resource

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loops (Bocken et al., 2014), inhibiting the movement towards a circular economy. Moreover, short-lived products are an increased financial cost for the consumer. But product longevity, through design, repair and reuse, is central to circular economy thinking (Cooper, 2010).

Over the years different perspectives on waste have been seen around the world. Products were (are) designed – deliberately or not – not to be easy to disassemble, fix or repair, even though, at present, products can be designed to easier disassemble and repair (Charter, 2018). Moreover, for most consumers repair is now only an option for high cost items such as cars and personal computers, or for household fixtures such as heating systems (Cole & Gnanapragasam, 2017) when a few decades ago, a broken object like a toaster or a lamp usually led to a trip to the repairs shop. Now it often means a trip to these large parks, which receive used goods such as household appliances, furniture, and car batteries, amongst others. In Europe, repair services have been declining for a few decades, but the European Commission's package on the Circular Economy emphasises repair, recycling and reuse (European Commission, 2015). And there has been a rapid citizen-driven innovation for product repair solutions that challenge the perception of a society of waste. A huge amount of things are thrown into the trash, even when these things could still be fixed or reused. A wide majority of people performs poorly in how to repair their everyday objects, and also people have forgotten they can fix things. The problem is that knowing how to rework is nowadays a more and more obsolete aptitude, and society itself does not value these practical skills.

Nevertheless, over the last years, online information; increased sharing and collaboration of ideas and information; places that allow citizens to make and fix products; crowdfunding; the emergence of 3D printing tools; and thinking globally but acting locally have propelled numerous initiatives. Repair Cafés have emerged as citizen-driven initiatives to enable the repair of products at a community level and are part of broader movement where groups of individuals that are making and fixing products are coming together in Makerspaces and Fab Labs (Charter, 2018).

The growth of the Repair Café movement in Europe in recent years signals the interest that consumers have in repairing items. There is little data on these organised activities (Cole & Gnanapragasam, 2017). Findings from preliminary research carried out - from June 17, 2017 to April 28, 2018 – at Repair Café Porto (RCP) events and intended to examine the potentialities and challenges of RCP through the lens of a SWOT method are presented. These pop-up repair events are organised by RCP since 2017. And have counterparts in more than 1500 sites in about 30 countries (Repair Café Foundation, 2018).

Repair Cafés Background

The "Fixer Movement" is much diverse and is made up out of companies and community-based organisations such as the IFixit website (a website that provides free online repair guides and videos "How to" for various products), and the "Repair Cafés" (Ifixit, 2018; Charter & Keiller, 2014). The Repair Café concept has its origin in the Netherlands with the idea to think about ways to reduce the waste going to landfills. As an alternative way to reduce waste and to make products last longer, Repair Cafés can be understood as contextually embedded initiatives. Repair Cafés are 'workshops' for people to bring products in need of repair where they (together with volunteer fixers) learn how to repair, how to maintain their broken or faulty products, or even try product modification. Interested in raising local-level sustainability, the Dutch journalist Martine Postma launched the Repair Café Movement in Amsterdam, the Netherlands in 2009. Nowadays it is established as the Repair Café Foundation to allow people to gather and help repair, and thus prolong the life of products that would otherwise end up as waste. Repair Café Foundation has more than 1500 sites in about 30 countries, hundreds in Belgium, Germany and the Netherlands, and a dozen in Great-Britain. The number of Repair Cafés has grown rapidly as well as community-based repairing organisations that are outside this network. For example, in addition to this foundation of repairing, there are other repair cafés outside this network as repair initiatives in Germany including Café Fixes and Repairing Boutiques. They are community hubs where people can bring broken items and learn how to repair, socialize and help each other (Repair Café Foundation, 2018). Repair Cafés are conceptualized as purposely workshops that place emphasis on the 3Rs: reduce, repair and reuse. These are places where people can become resilient users, for instance, of tech and these users and consumers can take back control of what they own which can make people feel good and it can be quite fun.

Repair Cafés have become nodes in the circular economy, teaching its principles from bottom-up. Following the current alignment of European Union policies, there is the adoption the Circular Economy, this new guideline with a broad cross-cutting approach, ranging from people from different areas. Circular Economy is an economic model that maximises the sustainable use and value of resources, eliminating waste and benefiting both the economy and the environment. The idea is not new, and it is associated with a range of concepts such as “cradle to cradle” design and “industrial ecology”, which draws inspiration from biological cycles and emphasise the importance of optimising the use of resources in a system over time. Includes a range of processes or “cycles”, in which resources are repeatedly used and their value maintained wherever possible. What was regarded as ‘waste’ can be turned into a resource. And all resources need to be managed more efficiently throughout their life cycle. The whole model works as a living system where residue is a nutrient. In a circular economy you design out waste from biological and from technical materials. Things are designed for reuse that is to say every product or material has a second life (House of Commons London, 2014; Ellen McArthur Foundation, 2012). Although the concept has a broad history, today, rather than simply internalise the circular concepts, it is necessary to rethink the entire socioeconomic model, to reformulate processes, products, relationships and business (Stahel, 2010). The linear industrial process of ‘take, make, dispose’ that has driven economic growth and shaped lifestyles is not sustainable. As a consequence, although discarders of goods expect the products to be recycled properly, such devices contain toxic chemicals which, even if they are recyclable, make it expensive to do so, therefore, as a result, illegal dumping can also become a lucrative business. Moreover the easily obtained supply of cheap materials and energy are expected to become more expensive during the course of the 21st century. Radical change by business and civil society is needed to enable the transition to a more circular economy, which is restorative by nature, where waste is reduced or eliminated, and development of eco-design and product life extension is also a need (House of Commons London, 2014; Ellen McArthur Foundation, 2012). The shift to a more circular economy is on the European Commission’s political agenda since December 2015 to help companies and consumer’s transition to an economy where resources are used in a more sustainable way (European Commission, 2015). The industrial economy creates wealth through the optimisation of production processes and related material flows up to the sale. The shift to a sustainable economy, to create wealth with substantially reduced flows of materials and energy, needs new business models (Stahel, 2010). Stahel (2010) developed “closed loop” approaches to production that pursue goals such as product-life extension, long-life goods, reconditioning activities, waste prevention, and also the importance of selling services rather than products, an idea referred in the notion of ‘performance economy’ whereas circular economy is considered its framework. The idea of circular economy is to try to deal with issues like reduce the amount of resources we extract from earth, plus use those resources more efficiently by creating closer loops that maintain those resources in the productive cycles for longer rather than wasting them. There is an estimated £3.5 trillion of not in use resources mostly assets such as empty properties, but also consumer goods (Perella, 2015). Circular economy gives rise to cycles of products with value where many actors work together to create effective flows of materials and information using renewable energy. Circularity brings challenges, but it can represent the turning point for systems transformation and create many opportunities, and it is seen as strategic and fundamental to allow the development of theoretical and practical skills and to provide specific tools to act according to the premises of these economic model.

RCP means extending the lifespan of the product and seeing waste as resource. These are two of the circular economy principles, but Circular Economy draws on several more specific approaches that gravitate around a set of other basic principles, and is also Performance Economy. RCP as other Repair Cafés is an example of an initiative where people come together in "community workshops" to experiment with, modify, make and fix products (Charter & Keiller, 2014). RCP is a collection of sustainable actions for Portugal in terms of what Circular Economy is concerned, putting in practice its principles.

Increasing product longevity is one of the central considerations of Circular Economy thinking (Ellen McArthur Foundation, 2012) and a concept which the fixer movement embraces. Fixing our relationship as far as it regards the user's notion of repair is going to require change on a global scale, because the rate of speed of nowadays consumption has real social and environmental costs. Although recycling is important, there is a need to intervene before disposal – encouraging consumers to buy for longevity and diverting stuff from "end of life".

Repair is better than recycling. [because] Making our things last longer is both more efficient and more cost-effective than mining them of raw materials (Ifixit, 2018). In an organisation within this new paradigm shift that circular economy is, apart from recycling, there is a need to shift also the industrial production models: start to close the loop productions, not simply producing the goods, but also taking them back at end-of-life to extract valuable materials that can be used to produce new items to lower the waste of valuable materials as things get dumped into landfills or even thrown for recycling.

Repair saves money. [because] Fixing things is often free, and usually cheaper than replacing them. Doing the repair yourself saves you money. Repair teaches engineering. [because] The best way to find out how something works is to take/tear it apart. Repair saves the planet. Earth has limited resources. Eventually we will run out. The best way to be efficient is to reuse what we already have (Ifixit, 2018).

Repair Café Porto: Reasons Why, What It Is and Its People

The reason why – Repair Café Porto – was developed is mainly because for each new product there is a need for materials, energy and human labour and the increase of demand puts pressure on these. Repairing has the purpose of increasing the lifespan of the products and decrease the pressure on resources, energy and work. An easy way to reach this goal is by maintaining and repairing products.

The RCP is a partnership-initiative developed by Circular Economy Portugal (https://www.circulareconomy.pt/) and Opo'Lab (http://www.opolab.com/). The former is a non-profit association that aims to accelerate the transition to a circular economy in Portugal in different contexts (academic conferences, civil society, business events and social networks), promoting a society without waste, based on sustainable production and consumption, developing and implementing projects based on principles of circular economy. And the latter is a multidisciplinary centre dedicated to the exploration and thought of the creative use of new technologies in architecture, construction and design, among others, a house full of makers also known as a makerspace or fablab.

The RCP is an event-workshop with a fun spirit. It is about skill-sharing, encouraging consumers to buy for longevity, diverting stuff from "end-of-life" and getting creative with products that can no longer be used for their original purpose. It started in Porto in June 2017 and usually operates at Opo'Lab, a house full of makers, fixers and all sorts of tools and creativity. All kinds of items can be taken apart and repaired or repurposed by owners together with volunteer repairers. As 88% of the Repair Cafés, RCP has rules. There are no guaranties of repairs and RCP is not a replacement to a repair shop, it is an independent co-organised event, an event-workshop open to everyone, and with the objective to teach the general public how to repair things and aiming to create societies without waste in a spirit of fellowship. The focus is on sharing skills and learning. Participants are urged to have an active part in repairing and solving the problem, supported by experienced volunteer-fixers. It is a RCP requirement that visitors who bring products participate in the repairs undertaken. For instance one of the participants at one of the sessions of the RCP brought a mixer that was not working. This mixer was repaired with almost just a little bit glue, a bit of sandpaper and the participant's brushing to take the traces of a previous chocolate cake from the inner parts of the mixer. It gained new life with tips and advice from other volunteer-fixers, but mainly with the intervention of the participant who "got the hands dirty". She can now prepare a bunch of chocolate cakes again. Another participant brought a hair trimmer with blades that guarantee a precise cut of the hair of his beloved and cherished pets, a dog and a rabbit, but this hair trimmer was getting a bit "tired", so the years of wisdom plus the years of "hands-on" of a volunteer fixer showed this participant that the hair trimmer only needed a little lubricant, and so it was ready to take care of the hairs of the beloved animals. But this participant also brought a toaster that he learned with the help of a volunteer fixer to disassemble and assemble (Repair Café Porto, 2018). These are good examples of taking active part in repairing and solving the problem. Regular repair stations include: Bike, Electrical and Electronic, Clothing, Carpentry and Jewellery, among others. But why call it a "café"? The reason why it is named "café" is because a trip to the café is always the excuse for a well-spent moment. The team of RCP believes that repairing should be a fun activity, so they have always music and coffee, and sometimes also some snacks to share. An informal atmosphere is the key detail to make the repair less frightening and more accessible.

RCP sessions are held for three hours on a Saturday every two months (excluding August), usually at the multidisciplinary centre Opo'lab. Repair volunteers (or fixers) are from the local community and at each session volunteer fixers provide active participation repairs, maintenance and repair advice. Usually Repair Café volunteers hold the view that the concept of manufacturer planned obsolescence is a real issue, across a large number of products and that keeping a product at its highest value for as long as possible makes sense, both from an economic and an ecological perspective. Repair Café activities are not limited to just repair, modification to products such as clothing is also offered, and modifications to and upcycling of electrical and electronic equipment and components can also be undertaken if the user or the volunteer-fixer are able to do it or simple give it a try (Charter & Keiller, 2016). The focus is primarily on repairs, but there is also a margin for creativity where participants are encouraged to experiment and explore new ideas around reuse, product upcycling, re-assembling parts for a new purpose or for a better function (Charter & Keiller, 2014). Repair and mending doesn't mean people can't afford to buy something new, it means people don't want something being thrown away and what used to be some sort of an insignia of shame is now undergoing a change into something to be proud of. For instance, reusing our clothes is practical, symbolic, aesthetic, original, creative and trendsetting, and it can even mean an act of conveying a manifestation. If a product is repaired instead of being recycled, it means saving a huge amount of resources and energy. So to keep a product at its highest value for as long as possible makes sense, it means that it is worthwhile to put back the moment that a product is recycled, for as long as possible and to see recycling as the last to turn to option. There is really a need to find a better solution to the over-manufacturing of products, because recycling these products just isn't enough. Repair can be a big part of that solution. Maker and Fixer movements can be regarded as modern inventions, but there have always been fixers and repairers. So, the idea is to look at all broken items as less like an unexpected or undesirable event and more like an opportunity. There are basically two ways to extend the life of products: the first is to keep the products in use for longer, and the second is to give products a second life, a third life, fourth life, etcetera. So in order to keep products in use for longer periods, consumers can also use maintenance and upgrades to achieve this goal. The most frequent items that usually appear at RCP, in descending order, are bikes, household kitchenware (like mixers and toasters), jewels, clothes and lamps.

After 365 days of existence (in July 2018) the RCP in numbers reads as follows: 652 Facebook followers, 626 Facebook likes, 1260 minutes of repairs and a total pool of 13 volunteer-repairers/fixers. Figure 1 is illustrating the 365 days of RCP as a very short sum up of this year of RCP. During these 365 days of existence 75% of the items brought to RCP were successfully repaired by their owners or by the owners with the help of the volunteer-fixers.

The event-workshop RCP happens due to the effort of several people. Ana Coelho and Marisa Escaleira are both responsible for RCP. Ana Coelho's background and knowledge sparkled her interest for Repair Café and Marisa Escaleira's experience at the Repair Cafés in the city of Lisbon lead her to RCP. The former, besides being a member of Circular Economy Portugal, has deepened the study of Circular Economy tools as it is applied to the Portuguese industry and has over 10 years of experience in sustainable consumption in national and international projects. Moreover she believes that sharing knowledge and training through these tools, in a pragmatic and systematic way, is the guarantee of prosperity and sustainability for the economy that bears in mind community safeguarding the planet. The latter had already developed other projects and training in the field of sustainability and social innovation, and she believes in the design process as a problem solving tool that needs response. Both spend a percentage of their time coordinating RCP. They set up the dates for the ongoing stream of each two-months-Repair, they help with some Web – like 70% of the Repair Cafés, the RCP uses what is considered to be the most effective form of promotion that is the word of mouth, social networks and media such as newspapers' interviews and conferences to promote itself–, and they lead set-up and takedown at each event.

The Repair Café connects the challenges of consumption with people's relationships to their own stuff and provides a pathway for how community members can work together to learn the art of tinkering, restoring value to otherwise useless objects and providing a direct alternative to throwing things away and replacing these objects. Tackling waste and consumption as a community is at the heart of the Repair Café. Everything starts with people and what people can achieve. The volunteer-work and the volunteer-fixers are also the heart of the RCP. Each session around 6 experienced fixers (from a pool of a bit more than a dozen volunteer-fixers) provide active participation repairs, maintenance and repair advice, and these people are from several different backgrounds.

Like 75% of Repair Cafés (Charter & Keiller, 2016), the Repair Café Porto has a permanent venue - the Opo'Lab. Figure 2 illustrates what happens in RCP at Opo'lab. But RCP has also been a bit on the road as Figure 3 shows the event-workshop running at the Flea market Porto and at the sustainability event Cidade Mais in Porto.

Figure 1. A very short sum up of one year of Repair Café Porto where volunteer-fixers and participants can be seen in active participation repairs and receiving maintenance and repair advice. Regular repair stations include: Bike, Electrical and Electronic, Clothing, Carpentry and Jewellery, among others (Repair Café Porto, 2018).
Source: Repair Café Porto, 2018

Figure 2. Opo'lab in the city of Porto hosting Repair Café Porto. In the photo a volunteer fixer is explaining a participant why the iron is not working. The Repair Café Porto is an event-workshop for people to bring products in need of repair where they (together with volunteer fixers) learn how to repair, how to maintain their broken or faulty products, or even try product modification (Repair Café Porto, 2018).
Source: © João Afonso, Repair Café Porto, 2018

Figure 3. Repair Café Porto on the road at the Flea market Porto and at the sustainability event Cidade Mais in Porto. Repair Café Porto volunteer fixers showing the importance of real, hands-on, dirt-under-your-fingernails work (Repair Café Porto, 2018.
Source: Repair Café Porto, 2018

The Repair Café Porto initiative follows the National Environmental Education Strategy (Agência Portuguesa do Ambiente, 2017), namely the guiding principles and the thematic axis “making economy circular”: accelerate the transition from a linear economy to a regenerative resource economy to retain as much value as possible from products, parts and materials. Thus, it aims to contribute to an environmental education more cross-sectional, more open and participated. It is aligned with specific objectives such as to contribute for the critical and open-dialogue about waste by 2030, at least 70% of municipal waste should be recycled or prepared for reuse. For packaging materials, the target proposal is of 80% by 2030.

This event-workshop has the active participation of the public, raises environmental awareness and also inspires citizens by sharing knowledge in different formats and channels (e.g. Facebook) about the problem of waste and the efficient and sustainable solution that repair represents. RCP wants to educate for repair and for sustainability, and to have a bigger connection with other “repairs”.

Methodology

Repair Cafés operate within different surroundings. A situational analysis identifies how the RCP is positioned within these surroundings, and describes what happens within the RCP-events and outside. The process is often referred as a SWOT matrix or analysis meaning a strategic planning technique to help an organization identify strengths, weaknesses, opportunities and threats related to their planning. The research was planned according to the objective defined meaning intending to examine potentialities and challenges of RCP. There is no doubt that SWOT analysis is a valuable tool in terms of strategy because it invites the organisation involved to consider important and crucial aspects of their initiative’s environment and helps to organise thoughts. The idea that the ones responsible should be thinking about their initiative’s SWOT-based variables is of great importance in the process of decision making (Weihrich, 1982, Panagiotou, 2003, Yuan, 2013).

Repair Café Porto Through the Lens of a SWOT

Repair Café Porto is aligned with the general objectives that support the environmental culture that contributes to the Sustainable Development Goals Agenda 2030 in the environmental areas of sustainable cities and communities, and sustainable production and consumption; and contributes to the fulfilment of national and international commitments adopted by Portugal in the field of sustainability as it is aligned with European, national and local policies for the circular economy and waste management, such as the Circular Economy Package and the action plan for the circular economy in Portugal namely Action #1 (Reuse and communicate) and Action #3 (know, learn, communicate).

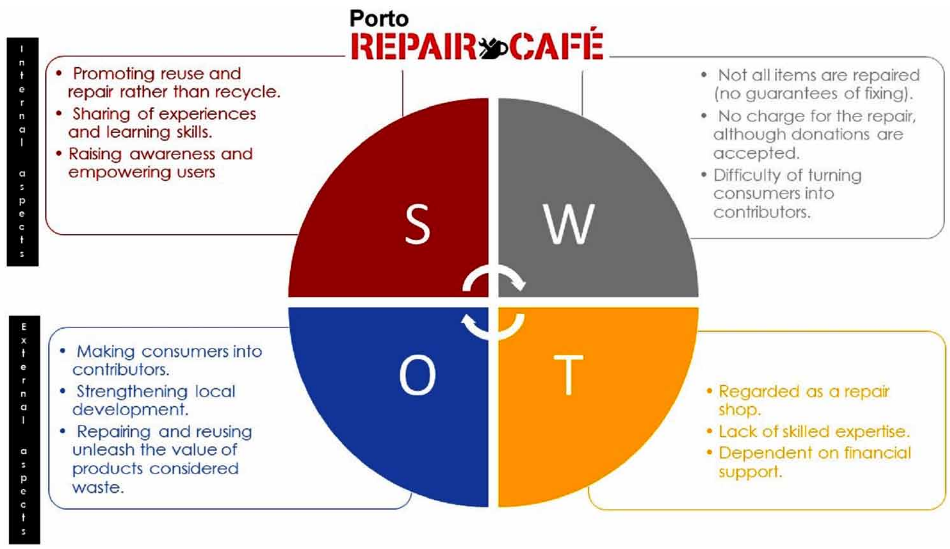
RCP promotes information and knowledge of citizens, raises awareness and empowers the citizens in repairing and reusing objects, promotes the change of individual behaviours, involving the citizens in the process of repairing their own objects, and inspires people for circular economy through Facebook and in presentations at conferences and events in an intelligible and accessible language to citizens.

RCP means sustainable actions because it means reduction and prevention of waste, it promotes reuse and repair rather than recycle, it helps users and consumers reduce waste, it raises awareness for the fact that most of the products are planned or designed with an artificially limited lifespan, so these products will become obsolete (unfashionable or no longer functional) after a certain period of time, it is about sharing economy practices, sharing of experiences and learning skills and getting creativity flowing, and it also engenders a good-spirit. The main goals of RCP are to decrease waste production (and thus reduce the use of new materials and energy) by increasing the lifetime of products through repairing and at the same time contribute to more durable product design, and to promote responsible behaviours by empowering users with repair skills while promoting sustainable local actions that generate a movement of conscious consumers and users in the city of Porto, and last but not least to promote a network of local repairers and repair services.

The analysis of the internal and external environment of the RCP with the aim of identifying internal strengths in order to take advantage of its external opportunities and avoid external (and possible internal) threats, while addressing the organisation's weaknesses is presented. The SWOT analysis is regarded as a useful technique that allows for the understanding of the strengths and of the weaknesses within this one-year-old-event-workshop, and also allows for identifying both the opportunities open to the initiative and also the threats RCP faces. So with a little thought, this tool-technique helped uncover opportunities that are well placed to exploit such as melding education and strengthen local development (as community building). And by the understanding of the weaknesses, it will be possible to better manage and eliminate threats that would otherwise be not made know or revealed. RCP recognises among its strengths the equipment and people available at the multidisciplinary centre Opo'lab, the ability to deliver information and the collaborative networks with whom it has already worked as Vintage for a Cause, Flea Market Porto and Cidade Mais. The use of a thinking tool such as SWOT provides insight into potential avenues, and it is also a good tool to gather input. As a result and to highlight the most important internal and external aspects of RCP Figure 4 is presented.

A SWOT is the analysis that is done as a first step within the strategy process, a first analysis that helps to begin with the strategic planning process (Weihrich, 1982, Panagiotou, 2003, Yuan, 2013) as it is shown with some brief proposed potential strategies in Figure 5.

Figure 4. Short version of the thinking tool that SWOT analysis is, in order to illustrate the most important aspects of the initiative Repair Café Porto. The Figure shows the strengths and weaknesses (internal aspect) within this one-year-old-event-workshop, and also allows for identifying both the opportunities open to the initiative and also threats Repair Café Porto faces (external aspects) (Repair Café Porto, 2018).
Source: own elaboration



In theory, the SWOT when regarded as a matrix is a mechanism to facilitate the connection between the strengths and weaknesses of the organisations, and the threats and opportunities of the market. It also provides a framework for identifying and formulating strategies through this analysis, which helps develop types of strategies: (SW) Strengths to Weaknesses Strategies, (SO) Strengths to Opportunities Strategies, Strengths to Threats Strategies. For instance, the strategies use the organisations' internal forces to take advantage of external opportunities (Weihrich, 1982). So by considering the existing strengths within the RCP event-workshop some strategies can be followed to cope with the threats and weaknesses and to grasp opportunities such as share lessons learned in language people understand and create a Repair toolkit to help plan and promote workshops, and also give access to repair services and find information on repair services, find sponsorship(s) either through direct contact with companies or crowdfunding and, last but not least, provide tools and payed training, just to suggest a few (See Figure 5).

Current Challenges

The Repair Café Porto faces some problems since it is an event-workshop that is dependent on volunteer-repairers or fixers. RCP is totally volunteer based so it risks having people busy and unavailable. And although donations are accepted, there is no charge for the repair which restricts its growth and doesn't allow the acceptance of further invitations to be happening in other spaces or places. There are no guarantees of fixing and not all items are repaired, since RCP is not a repair shop. Even so, in one year of existence 75% of the items brought to the RCP have been successfully repaired by their owners with the help of volunteers-fixers.

Figure 5. A brief on how SWOT analysis can help to focus through the development of potential strategies. For instance, to further develop Repair Café Porto in terms of future strategies the environmental threats and opportunities can be matched with the organisation's weaknesses and especially its strengths. The strength-threat strategy (ST) is based on the strengths of the organisation that can deal with threats. The objective is to maximise the former while minimising the latter. The strength-opportunity strategy means that any organisation would like to maximise both strengths and opportunities. For example, a potential strategy that can promote the reuse and repair is to find sponsorships for this event-workshop (Repair Café Porto, 2018). The idea is from strengths to take advantage of opportunities, from weaknesses strive to overcome them, making them strengths (Weihrich, 1982).
Source: own elaboration

The more frequent items that have been subject of repairs at this event-workshop in descending order are bikes, kitchen utensils, jewellery, clothing and lamps.

As Christopher Mele (2017) stated *Repair Cafés are not just about fixing things, they are about the community, also. These gatherings engender a spirit of friendly good-fellowship as volunteers learn the stories of the items they repair*. Nevertheless it may experience the difficulty of turning consumers into contributors and it can fail to incorporate requirements to increase reuse.

What can be regarded as threats to the RCP are the dependency on financial support and the lack of skilled expertise, but also the tendency to be regarded as a repair shop and the maturity of repair notion since many users or consumers regard repair as requiring too much effort and even money. No alteration of consumers and producers' attitude to see waste as a resource and therefore extend the product's life is also one of the aspects that sets back this type of initiative.

A Bunch of Opportunities

Underutilised products lie everywhere, but Repair Cafés can be a flourish of opportunities to maximise the use or reuse of products. RCP promotes information and knowledge of citizens, raising awareness and empowering these citizens in repairing and reusing objects, promotes the change of individual behaviours, involving them in the process of repairing their own objects – making consumers into contributors. There are a considerable number of opportunities within this project such as melding education and social inclusivity. Repair and reuse unleash the value of products considered waste. It strengthens local development, giving access to repair services and finding information on repair services. RCP aims to educate for repair, for sustainability and to have a greater connection with the fixer movement namely other repair cafés. One good reason why the volunteering in the RCP is important is that it promotes a healthy community and ensures a more active place and space. People who agree to take part in the repairing, upcycling and modification process, promote extension of the products life and less waste. These actions help the community to find motivation to act in order to stop pollution and waste.

In summary, the RCP would like to see the following actions in practice. Local authorities should help and even lead the communication by conveying the message of reuse before recycle and provide information to local repair services. Local authorities should not treat all broken or faulty products that they receive as waste, they should see it as an opportunity, and they should consider partnerships with repair organisations and only after this process, view these products as waste. Government should reduce VAT on repairs, since repairs mean resource efficiency. Although the circular economy literature emphasises the role of producer take-back schemes this is not the single solution, the circular shift must include independent repair companies and organisations (The Restart Project, 2018).

The Repair Cafe Porto (https://www.facebook.com/repaircafeporto/) is a sort of a catalyst for a more efficient and robust repairs' ecosystem in the city of Porto, providing a useful intervention in the waste stream of repair that is almost forgotten or almost does not exist or that people are not more aware of its existence.

CONCLUSION

With the current unsustainable economic model there is a need to move to a circular economy focussing on the efficient use of resources and extending product lifetimes. In order to do so, a far-reaching and reliable repair economy is needed.

The European Commission's (2016) Circular Economy Package recognises repair as to achieve resource efficiency. Community responses are emerging as opportunities for people to work together at a local level to facilitate repair, passing on repair skills and raising awareness of repair as an alternative to replacement.

RCP is focused in activities of a community-based group. Such groups are an important part of civil society and are recognised to provide innovative solutions to waste reduction and offer significant, small scale, opportunities for repairing products (Charter & Keiller, 2014, 2016).

The RCP has much to give to community repair, addressing waste by helping to facilitate repairs, and environmental education regarding reuse and recycling options for products. These events provide waste reduction, meeting places for people to share and learn repair skills and socialise, small scale opportunities for repairing items, prolonging the use and thus extending products' life.

While recognising limitations, it is possible to point relevant areas for further study and provide recommendations to remove barriers to repair activities such as: raise consumer awareness and confidence in existing repairers, of the importance of repairing and second-hand tackling climate change and resource security; make participants aware of recycling and waste collection; and campaign for policy reform to support design for repairability and disassembly.

Extending products' life by repair is an essential part of a movement towards a people-centred, resource efficient circular economy. And these groups facilitating repair, have a role to play in raising awareness and campaigning to promote policies that improve product repairability, promote design for repair and improve access to spare parts, tools and information. Product repair is important within the consumption process and disrupts the unsustainable linear economy (Cole & Gnanapragasam, 2017).

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Chapter 15

Circular Economy:
A Perspective of Builders, Architects, and Consumers in the Panama Construction Sector

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ABSTRACT

Humanity and planet Earth have no long-term future unless there is a commitment to respect and to live within its ecological boundaries, which demands a transition from the prevailing economic system, the linear economic system, to another that is circular. The construction sector is one that requires high resources in terms of energy, water, and raw materials, generating waste and harmful atmospheric emissions. This chapter aims to analyse consumers, architects, and construction companies' awareness, challenges, and enablers in the implementation of circular economy (CE). Secondary data as well as primary data in the form of interviews and questionnaires were applied in a building construction sector in Panama. Six hundred and fifty valid questionnaires were collected. The results show that respondents are aware of the circular economy concept, but not of all circular economy principles. Few would be willing to pay for its implementation. Several challenges were also highlighted, bringing to light the importance of policymakers' roles for CE implementation.

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INTRODUCTION

The Importance of Circular Economy

Economic growth, the depletion of natural resources and the predominant consumption trends based on the 'take, make, dispose' economic model (Ness, 2008) are draining planet Earth. This economic approach relies on a linear paradigm of manufacture and consumption, in which large quantities of natural resources are extracted to produce easily accessible materials and energy, which after a short span of time are discarded generating massive quantities of waste.

Economic and societal growth are remarkably desirable, yet the prevailing production and consumption levels cannot continue at this pace, and indefinitely at the expense of natural resources. The turning point and the time to find an alternative have come, and Circular Economy has been materialising as a new economic model and as part of the solution to tackle the global emergency society faces nowadays.

Circular Economy stands out as a new economic model which encourages stakeholders (business, organisations, governments and individuals) to reconsider and reassess manufacturing processes and practices to minimise consumption and consequently waste, as the demand for innovational business models that pursue sustainability on a larger scale is gaining prominence.

Circular Economy has been materializing as a new business model foreseen to lead to a more sustainable development and societal stability (Feng and Yan, 2007; Geng and Doberstein, 2008; Ness, 2008; Mathews and Tan, 2011). Taking this assumption into consideration, Ren et al. (2013) state that to attain sustainable development it is essential to find the perfect balance, harmony, and interaction between the economic, societal, environmental and technological areas of an economy, a specific sector, or even in a specific industrial operation.

A Circular Economy approach optimises the correlations among these elements (Ellen Macarthur Foundation, 2012), as it furthers a more beneficial and environmentally sustainable use of natural resources, key principles of the implementation of a greener economy, featured by promoting a new business model and by enhancing the opportunity to create new employment opportunities (Ellen Mac Arthur Foundation, 2012; Stahel, 2014).

Nevertheless, CE has frequently been addressed as an economic approach to dealing with waste management, which stands out as a very reductive perspective that ultimately may drive CE implementation to failure, in what recycling, reusing or recovery processes are concerned. The challenge is to move towards a preventive and regenerative design of products and services and seek for alternative approaches that can be implemented throughout their lifespan, as well as the engagement of manufacturing processes, the environment and the economy in which it is integrated, ensuring that the renovation concerns not only the material or energy recovery part but on the contrary it turns out to be an enhancement of the products' life cycle and consequently of the economic model when compared to the prevailing linear economic model (Geng et al. 2014).

Raising awareness among stakeholders concerning the implementation of a Circular Economy model and its principles is a crucial step to guide them towards the transition to new manufacturing and consumption patterns, which have the potential to help society achieve and increase sustainability and wellbeing at low or no natural resources expenditures.

The Importance of Circular Economy in the Building Construction Sector

According to Alizadeh (2016) the building construction sector stands out as an important industry and acts as a vital economic generator nowadays and is one of the biggest raw materials and energy consumers. Due to the type of machinery used throughout the different processes, the complex processes of raw material extraction, it is highly dependable of fossil fuels and energy, which means that it not only produces substantial CO2 emissions but it is also a sector that generates vast quantities of waste, dust, hazardous substances (toxins and chemicals) and along the process high sound and noise levels, which have already been recognised as a serious health danger (Alizadeh, 2016).

Taking these facts into consideration, it has been highlighted that the large amount of resources with high potential of reuse and recycle comprised in the materials used in this industry, has converted it into an essential sector considering Circular Economy (Alizadeh, 2016).

Implementing a CE approach in a building construction ought to provide more value to the project itself, to the environment and to humanity in general, as it would allow to reduce CO2 emissions, which affect ecosystems and human health considerably, and by doing so CO2 footprint would also be reduced, enhancing better air quality and consequently a reduction in respiratory diseases. Building has additionally been considered responsible for 35% of the energy use in the world and directly responsible for 35% of global CO2 emissions (Roodman and Lenssen, 1995). This energy consumption levels refer not only to the construction phase but to the whole process, starting with the production of materials that are going to be used throughout the construction process but also to the operations/ processes during the lifespan of a building.

Alizadeh (2016) also highlights that a CE paradigm would also reduce life cycle costs, i.e. reducing the operation and maintenance costs throughout a building life cycle can mean savings for the owners or tenants. The use of energy efficient products/materials reduces the amount of energy consumed by the building itself and the utilization of quality and low maintenance, and durable systems and products also represents savings in costs and resources. The usage of systems that reduce the quantities of energy necessary to function, also allow the reduction of energy consumption in the life cycle of a building. Currently there are products that use *inverter engines* that can be found in air conditioners, refrigerators, efficient bombs, led lights, and others, which enable excessive energy consumption. It is also emphasised that it is mandatory to reduce waste as an output, whether it is to use it for another purpose, as for producing energy, in incineration, or to be recycled to be used in the production processes of other products.

In order to fully implement a circular approach in the building construction sector it is imperative to respect a few resource efficient principles in the design processes (Waste Resource Action Plan (WRAP) (2012); Nakajima and Russell, 2014). The aforementioned procedures are: *design for deconstruction or design for disassembly*, this principle caters for significant changes considering the civil engineering projects throughout the buildings life cycles, i.e. designing for deconstruction or disassembly stands for design thinking in the long term. The traditional construction method which implies that buildings are demolished at the end of their life cycle create huge amounts of waste, as all materials and products are considered waste. The *design for deconstruction and disassembly* presupposes that at the end of life most of the buildings are disassembled instead of being demolished. Sometimes it is even possible to remodel them using the same products which were previously used in the construction. Modular building construction is an example that perfectly allows an easy disassembly and remodelling. Another process to consider is the *design for reuse and recycle*, i.e. choosing materials and products that can be reused and recycled at the end of their lifespan enhances reusability and recyclability of products in other activities or when considering the production of new materials. This is the perfect example of a circular processes with a closed loop production paradigm, one of the principles of the Circular Economy.

Another approach is to *design for adaptability or flexibility*, i.e. designing for adaptable and flexible use. Modular units and moveable interior walls are bringing greater flexibility and resource-efficiency into residential and commercial buildings. This product flexibility supports the efficient and effective use of a building during its lifetime. It is possible to adapt a commercial building into housing or housing into an office, or adjust the layout to any target need, using modularity and redirect its use (Ellen MacArthur Foundation, 2015). Flexible design also supports space sharing, and building expenses management, as people can only move forward with the essential parts of the building as they need or can afford. This will open better-quality housing access to people with less income, as it extends the building lifespan. It's a fact that during a building's lifetime construction trends and methods vary, mainly the architectonic style, so it is necessary to have the adaptability or the flexibility to operate changes and give buildings the chance to compete with newer constructions which have more modern styles. A different technique to consider is the *design for durability*, which means that matching materials to the planned purpose of the project/structure, considering fewer life cycle replacements and reduced maintenance cycles. This can be achieved if materials with long technical life cycles and less maintenance are considered.

Implementing these principles would allow to enhance Circular Economy in the construction industry. This will only be possible if stakeholders (designers, architects, construction contractors, consumers) are engaged in implementing and act in accordance to these principles. However, such a transition is not an easy task to accomplish as there are external factors to consider when implementing the previous processes, such as the country, the region, the society, the stock of products in the market, among various other factors.

The following chapter explores the awareness, benefits and attitudes when implementing a Circular Economy approach.

CIRCULAR ECONOMY: AWARENESS

The Circular Economy Concept

Recent studies demonstrate that efforts have been put on assessing sustainability in the construction and demolition sector as a result of its vast environmental impact and waste generation (Bowea and Powell, 2016; UNEP, 2016; Simion et al., 2013; Lu and Yuan, 2011; Blengini, 2009; Da Rocha and Sattler, 2009; Brown and Buranakarn, 2003; Klang et al., 2003), and thereby Huang et al. (2018), Esa et al. (2016), Lu and Yuan (2011) suggest the transition to CE and to its R-principles 'reduce, reuse and recycle' as a means to address waste generation and demolition, more effectively. Adams et al.(2017) state that the construction industry contributes significantly to the economies, contributing, on average, 5-13% of the gross added value (Eurostat, 2015). It stands out as a highly material and energy intensive sector, exhausting around 1,2 and 1,8 million tons of construction materials per annum in Europe (Ecorys, 2014). Construction and demolition are two activities that generate high quantities of waste, approximately 821 million tons across Europe in 2012, which represents a third of the total waste generated (Eurostat, 2016).

The European Commission (EC) (2011) believes that policies and strategies have been drafted in order to enhance the sustainability of the sector, nevertheless if it does not focus on the implementation of circular economy, it will not become a more resource and energy efficient sector (EC, 2014).

The implementation of the circular economy concept in the construction sector, still in its infancy, has been mostly assigned to construction waste reduction and recycling. In a circular approach, waste is part of a sequential loop that ought to be pursued (Altamura, 2013) and by doing so, the CE principles bring to light optimal strategies in dealing with waste at its final stage (Prendeville et al. 2014; EMF 2012; Braungart and McDonough 2009). Waste management allows a reduction in waste production at the source, maintaining the amount of waste produced to a minimum, through improved efficiency, recycling and long-lasting design (Esa et al., 2016), and consider the design for deconstruction. According to Adams et al. (2017) and following the EMF (2015) considerations on this sector, by applying CE principles to the built environment by 2030, £300 billion ought to be saved concerning primary resource benefits, as well as energy. Therefore, it is crucial to be aware of the benefits of circular economy as well as its principles. Bing Xue (2010) has analysed the circular economy perception and awareness in China, in different consumer sectors, and the results of this analysis reveal that most of the respondents (79%) were aware of the circular economy concept and its importance and have associated it with energy saving and environmental preservation (Adams et al., 2017). Although little research from the construction sector and more specifically from the construction sector in Panama, has been carried out.

THE IMPLEMENTATION OF CIRCULAR ECONOMY R-PRINCIPLES

Reducing, Reusing, Recycling, Rethink, Refurbishment, Repairing, Redesign-Cradle-To-Cradle-Long- Lasting Product; Recovering

The implementation of a Circular Economy approach allows to keep products, materials and their components at their highest utility and value in all circumstances and for longer periods of time. This assumption can be accomplished if stakeholders focus on the R-principles of the model (reduce, reuse, recycle, rethink, refurbish, repair, redesign-cradle-to-cradle-long-lasting product, and recover), and consider that it is restorative and regenerative by design and intention (EMF, 2013), which allows to differentiate the multiple technical and biological cycles.

Furthermore, the operationalization of a Circular Economy economic model ought to consider system thinking since decision making among stakeholders (business leaders, companies and governments) actively involved in production processes can directly impact in the value chain (EMF, 2015). The focus must be value retention, stock enhancement and on extending the lifespan of products and materials (Stahel, 2013, 2019).

Nevertheless, it is also essential to focus on product design considering the concept of closed system, in which the waste produced in production processes is equivalent to the resources depleted and ought to be used as raw material and reintegrate production lines once and again. Thereby, the economy transitions to a circular system, in which industrial products/materials can be used consistently and reallocated in their initial format or with minor adjustments to new users.

The ‘recycling’ R-principle comprises the recyclability of all the materials/products by disassembling components and parts and eventually categorize them. This principle stands out as less sustainable response to deal with environmental and sustainability issues, by comparison with the further R-principles, considering resource efficiency and profitability (Stahel, 2013, 2014, 2019).

Wijkman and Skânberg (2015) and the Waste Resource Action Programme (WRAP) (2014) consider that the ‘reuse’ R-principle is one of the most important principles, as the focus ought to be placed on reuse rather than on disposal after usage, exploiting, this way the products' value to the fullest. Thus, strengthening remanufacturing enables the natural capacity of the environment to rehabilitate itself (Bastein et al., 2013; EMF, 2013).

Circular Economy also considers 'refurbish' and 'repair'. In accordance with de Brito and Dekker (2003) and Fernández and KeKale (2005) 'refurbish' complies the process that materials experience when upgraded, i.e. components and sections of a larger structure must be exchanged in order to extend products' lifespan.

King et al. (2006) and Stahel (2010) highlight that 'repair' involves prolonging the life cycle of products by repairing components and parts or by modifying them (Thierry et al., 1995). This life-prolonging processes can be performed by third parties (owners, technicians, repairers) without necessarily implying ownership exchange (Hultman and Corvellec, 2012). The implementation of a 'cradle-to-cradle' design approach instead of a 'cradle-to-grave' paradigm shall be considered, once the lifespan of products must not inevitably end in a 'grave', corresponding to a landfill (McDonough and Braungart, 2002). Pursuing a 'cradle-to-cradle' economic pattern in which materials are designed and manufactured with a 'long-lasting' intention, through zero waste industrial processes remains an option to be considered (Geissdoerfer et al., 2017). Seeking efficiency by means of design and service supply suggests a reduction in inputs, improving resource consumption and economic development from natural resource usage.

'Recover' or 're-mine' stands out as an important R-principle, as it relates to the recuperation of materials after the landfilling phase (Reike et al. 2018; Yan & Feng, 2014). It is possible to recover embedded energy from non-recyclable waste products whenever practicable. This type of waste may, ultimately, be converted into forms of energy through waste-to energy procedures such as combustion and gasification.

The Benefits of the Circular Economy

It is common sense the need to preserve the environment and the use of the resources available wisely and controllable manner, as they existed in a limited number. Closing material loops, reusing and recycling industrial goods to extract their maximum value, reduce resource extraction, produce minimum waste, are important strategies not only to preserve the environment but also to guarantee wellbeing and economic growth (Ellen MacArthur Foundation, 2016; Allwood 2014; Frosch and Gallopoulos, 1989). There is a remarkable gain of the circular economy over the linear economy (take-make-dispose). It is notorious that the transition to a circular economy model offers possibilities to promote not only the reduction of natural resources utilization as well as their preservation, while reduces the carbon footprint (Pratt and Lenaghan, 2015; EMF and MCK, 2014). The implementation of a CE model will generate economic benefits, mainly an increase in the gross domestic product (GDP), employment growth and a reduction of the risk of supply and price volatility (EEA, 2016; Morgan and Mitchell, 2015; EMF, 2013). Lacy et al. (2014), Nasr, (2013) and Stahel, (2016) consider that the transition to a circular economic paradigm will give rise to higher competitiveness, natural resource availability, and the possibility and flexibility to enhance value creation. The implementation of CE would promote the optimization of the reuse/recycle R-principles of materials, products and components with the purpose of decreasing waste generation as far as possible. It would also revolutionize the entire production, consumption and supply chains, and also promote material and energy recovery in conformity with a cradle-to-cradle model.

The current research attempts to explore whether building construction companies, architects and consumers (construction buyers) in Panama, are aware of and understand the circular economy concept, its R's principles and benefits.

The Challenges

There are a number of challenges in the implementation of Circular Economy in the building construction sector. It is a singular and complex sector; buildings are unique pieces, made out of materials which have their own specifications and their own life cycles, and they all connect dynamically temporal and spatially. They are constructed out of manufactured components, that when assembled together those materials no longer figure in the philosophy of manufacturing, and consequently this is a neglected sector as CE models focus on manufactured products with shorter life spans, buildings and the construction sector is often neglected.

Ludwig and Matasci (2017) also consider the building construction sector a very complex one as it comprises a significant number of stakeholders across the entire value and supply chains. Therefore, these authors consider that to make it a more sustainable sector it is necessary to divide it into two different stages: the design and construction phase and the occupancy phase. In the first stage of a building structural elements of design, construction techniques and materials that create the building itself and determine its possible outcomes are defined, which requires a synergy between the different stakeholders (consumers, architects, designers, building construction companies and products suppliers) throughout the value chain. It is also during this stage that resource efficiency strategies ought to be identified in order to minimise waste generation in latter stages.

The construction stage is to a considerable degree established by the design stage, once large quantities of materials and products as minerals, metals, concrete products as well as energy are necessary. Enhancing resource efficiency during this stage demands new approaches to waste minimisation and management. Evidence-based demonstrates that policies to landfill variation, such as landfill taxes, may assist the increment of resource efficiency and the sustainability of reuse and recycle possibilities (Martin & Scott, 2003).

According to these authors and considering the occupancy stage, a gap exists between the potential of performance and the real performance of a building, the so called ‘performance gap’ (Bordass et al., 2001) i.e., there is a lack of efficient communication amidst occupants so that equipments and control mechanisms are properly used, and attitude regarding cooling and heating or technical questions associated with material testing and how these techniques are predetermined.

Nevertheless, there are several challenges in the process. Other major challenge in the construction industry, it comprises the lack of a holistic approach transversely to the supply chain, a lack of long-term thinking and the low value of many construction products at the end of life (Adams et al., 2017; IC, 2015; Schult et al., 2015). Nevertheless, there are a few examples emerging on the application of circular economy principles, mainly related to material choice and design considerations (Kiser, 2016; Adams and Thornback, 2016; Laubscher and Marinelli, 2014).

The current research explores which are the challenges that construction companies, architects and consumers (construction buyers) identify in applying the circular economy principles.

The Enablers

In order to implement the Circular economy principles, at a wide-scale adoption, the stakeholders would expect from society, some enablers, to name a few: taxes’ benefits from the government, financial support, or banking incentives (loans at very low interest rates for CE policies investments). The implementation of CE principles can be expensive, they require understanding, education, and concurrent attitude/

behaviour from each society contributor. It also requires legislation to be widely implemented. Wide awareness and attitude from society, changes in legal regulations, holistic system with collaborative value chains, new business models, and construction methods are necessary enablers for an effective CE implementation. The current research attempts to identify which enablers are identified in the consumers (clients), architects and building construction company's perspectives.

The Construction Sector in Panama

The building construction industry plays a key role in the economy of Panama considering that different areas (development, construction, promotion, finance and marketing) of the economic system are involved and contribute to the economy by generating a considerable number of jobs. Currently, this is a very competitive activity in the country as there are various construction enterprises and sellers who offer quality products or services at very attractive and competitive prices.

This sector has grown in last decades mainly due to the local growing demand concerning apartments, offices and family residencies. It has also been developing as an attractive activity for promotion and investment and represents a dynamic sector regarding employment and job creation.

According to the Panama Green Building Council, the construction industry ought to consider the resource efficient principles in the design processes, their economic, social and environmental impact along the construction phase, the buildings and residences lifespan, customers life style, the final disposal of materials and products, and the deconstruction process at the end of life. There are different types of construction in Panama of which stand out the residential ones, mainly composed by apartment buildings and single family houses. The commercial buildings are constituted by commercial premises, deposits, warehouses, offices, hotels and industry. According to the data disclosed by the Panamanian Chamber of Construction (2015), 64% of the investment on the construction sector were made on the residential type, whereas 36% were made on the commercial type. It is also stressed out that within the residential nature, 49.3% were made in building apartments, 38.1% in additions and remodelling, and 12.6% were made in residential houses.

Research Strategy and Data Collection

Data were collected using a hybrid research strategy. Different research strategies and data collection methods were used to achieve the research objectives and to respond to the research questions. Secondary data, as well as primary data in the form of interviews and questionnaires were applied in the building construction sector in Panama. Secondary data were used by analyzing reports and statistical information and to understand the circular economy aspects in general and worldwide. Face-to-face interviews were conducted to gain an in-depth understanding of the different perspectives of consumers (clients), architects and building construction companies on circular economy.

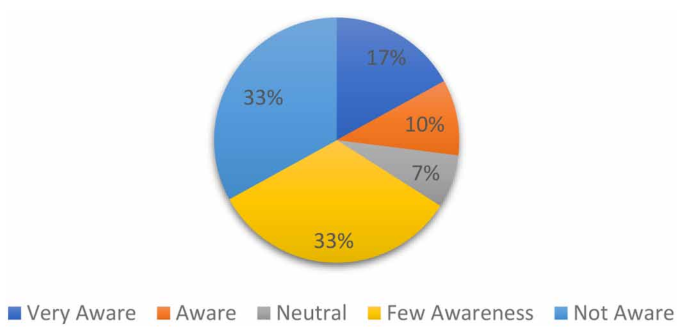
In-depth interviews and semi structured interviews were conducted from different position in the companies: architects, civil engineers, owners, CEOs, managers, brand managers, and independent architects and researchers were also interviewed. Interviews were carried out in April and June of 2018. Through a critical analysis of the literature, in-depth interviews and semi-structured interviews with architects, consumers, engineers, and managers of building construction companies, CE key factors were identified. Based on the interviews a survey instrument was designed and applied. The questionnaires were sent out using several databases: The Panamanian Chamber of Construction (CAPAC), the Technological University of Panama, The National University of Panama, The Panamanian Society of Architects and Engineers in Panama (SPIA). The questionnaire was applied online using the survey monkey tool. Data were collected between December 2018 and January of 2019. Six hundred and fifty valid questionnaires were collected. Three hundred were collected from consumers, two hundred from architects and one hundred and fifty from building construction companies. Data were analyzed through descriptive statistics.

RESULTS AND DISCUSSION

The Consumers' Perspective

When asked if consumers were aware of the circular economy, from the 300 responses, 33% (98) said to be unaware and 33% (97) have few awareness of the topic (Figure 1). The results suggest that there isn't a wide understanding in the society of the concept. This is an important insight for policymakers as education and wide communication is required for an extensive implementation of circular economy.

Figure 1. Awareness of the circular economy concept (consumers)
Source: Research data



Concerning the Circular Economy 7 R-Principles (Figure 2), only 40% of respondents were totally aware of two principles, i.e. "Reduce" and "Recycle", followed by "Repair" (38%). Most of the consumers have "neutral" knowledge about the other R principles of circular economy (Recover, Refurbish, Reuse and Rethink).

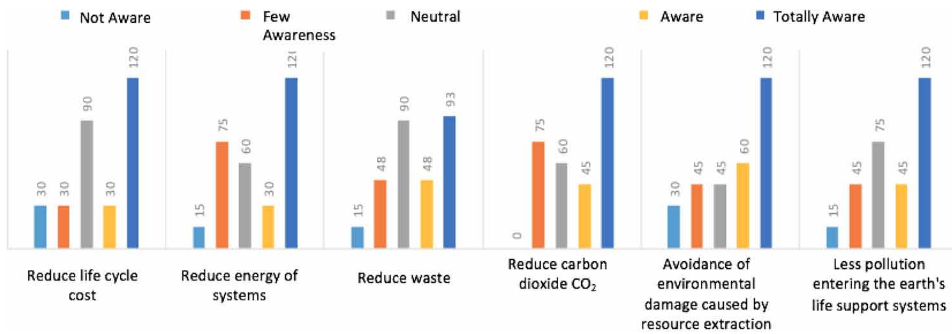
The results reveal a need to educate; to create awareness at large extend in the society about CE R's principles. It would be difficult to implement the CE principles if they are unknow for most consumers.

There is a general understanding of the benefits of implementing circular economy (Figure 3). Consumers recognise that the implementation of circular economy contributes mainly to the reduction of life cycle cost, pollution, avoidance of environmental damaged caused by resource extraction and reduction of CO2 emissions. The waste reduction is the least recognised contributor of CE.

Figure 2. Awareness of the basic principles of the circular economy: Reduce, Repair, Reuse, Restore, Recycle, Recover, Rethink (consumers)
Source: Research data

N=200	NOT AWARE	FEW AWARENESS	NEUTRAL	AWARE	VERY AWARE
Reduce	0,00%	0,00%	11,11%	11,11%	77,78%
Repair	0,00%	0,00%	0,00%	22,22%	77,78%
Reuse	0,00%	0,00%	12,50%	12,50%	75,00%
Refurbish	0,00%	0,00%	44,44%	0,00%	55,56%
Recycle	0,00%	0,00%	0,00%	0,00%	100,00%
Recover	0,00%	11,11%	44,44%	0,00%	44,44%
Rethink	11,11%	22,22%	22,22%	0,00%	44,44%

Figure 3. Awareness of the benefits of the circular economy (consumers)
Source: Research data



When asked consumers to identify the challenges of applying CE, from 1 – totally disagree to 5 – totally agree, they clearly identified them; on average they score 4 (Figure 4). Respondents agree that all the challenges are of major importance. The results suggest that policy makers will have to overcome these challenges to implement CE.

Almost half of consumers identified Taxes benefits from the government, Financial support amd Bank incentives for loans as an important enabler when buying or renting an apartment / villa / business for economic purposes (Figure 5). Consumers consider that fiscal and finance support are important to be aligned with the implementation of CE.

The Architect's Perspective

From the 200 architects, 80% (160) acknowledge the concept of the circular economy, while 10% (20) said they have few awareness and other 10% (20) are aware (Figure 6). The results show that most of the architects are informed of the circular economy movement and they could act as an excellent influencer to help builders and consumers to be aware and implement CE.

Figure 4. Challenges to implement the circular economy (consumers)
Source: Research data

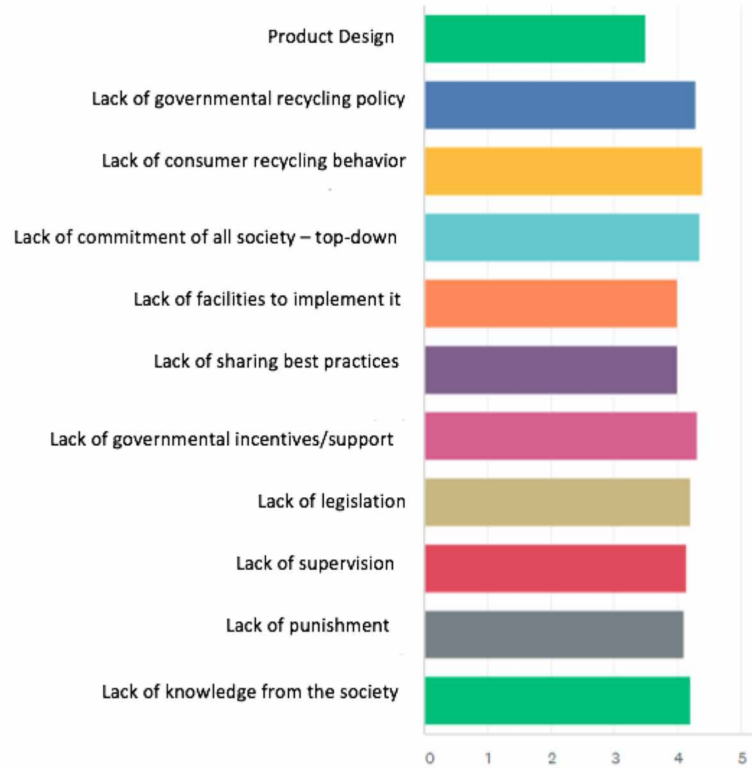


Figure 5. Important enabler when buying or renting an apartment / villa / business with circular economy (consumers)
Source: Research data

	TOTALLY DISAGREE	DISAGREE	NEUTRAL	AGREE	TOTALLY AGREE
Taxes benefits from the government	5,00%	10,00%	25,00%	10,00%	50,00%
Financial support	10,00%	5,00%	20,00%	25,00%	40,00%
Bank incentives for loans	5,00%	10,00%	20,00%	25,00%	40,00%

Architects have greater awareness than consumers regarding the R's principles of circular economy. All of them (Figure 7) acknowledge recycle (100%). Recycle is followed by reduce and repair (78%), and them reuse (75%). The less known principles were rethink and recover (44%). Architects may share environments in which the topic is commonly spoken (universities, international conferences, international suppliers) and therefore are more aware of the concept.

Figure 6. Awareness of Circular Economy (Architects)
Source: Research data

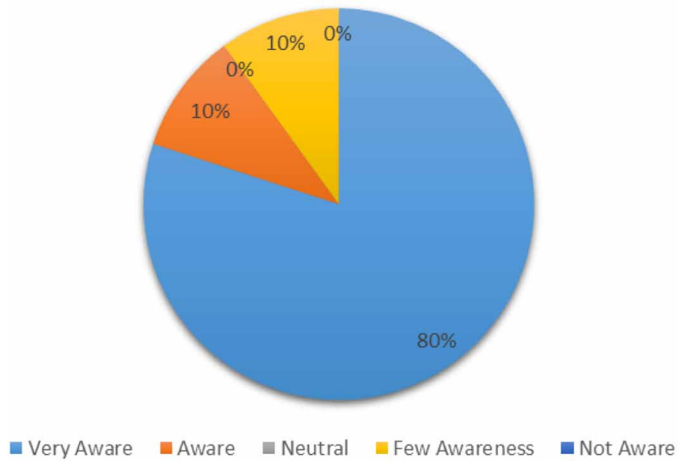


Figure 7. Awareness of the basic principles of the circular economy: Reduce, Repair, Reuse, Restore, Recycle, Recover, Rethink (architects)
Source: Research data

N=150	NOT AWARE	UNAWARE	NEUTRAL	AWARE	VERY AWARE
Reduce	0,00%	0,00%	0,00%	80,00%	20,00%
Repair	0,00%	0,00%	0,00%	80,00%	20,00%
Reuse	0,00%	0,00%	20,00%	40,00%	40,00%
Refurbish	0,00%	0,00%	60,00%	40,00%	0,00%
Recycle	0,00%	0,00%	0,00%	60,00%	40,00%
Recover	0,00%	20,00%	20,00%	60,00%	0,00%
Rethink	20,00%	0,00%	60,00%	20,00%	0,00%

It is also interesting to note that architects are very aware of the benefits of the circular economy (Figure 8) with an average score of approximately 5 (very aware). The scale ranges from 1- not aware to 5 - very aware. As an architect they need to be informed of the new trends in buildings and materials, and the concept is part of the expected knowledge.

Most of the challenges identified by architects for the implementation of the circular economy, obtained an average score higher than 4, being the element of less challenging the one that is related to their profession, i.e. the product design (Figure 9). Applying circularity in projects in the city of Panama is still very complicated, due to the lack of a system to support it.

Figure 8. Awareness of the benefits of the circular economy (Architects).
Source: Research data

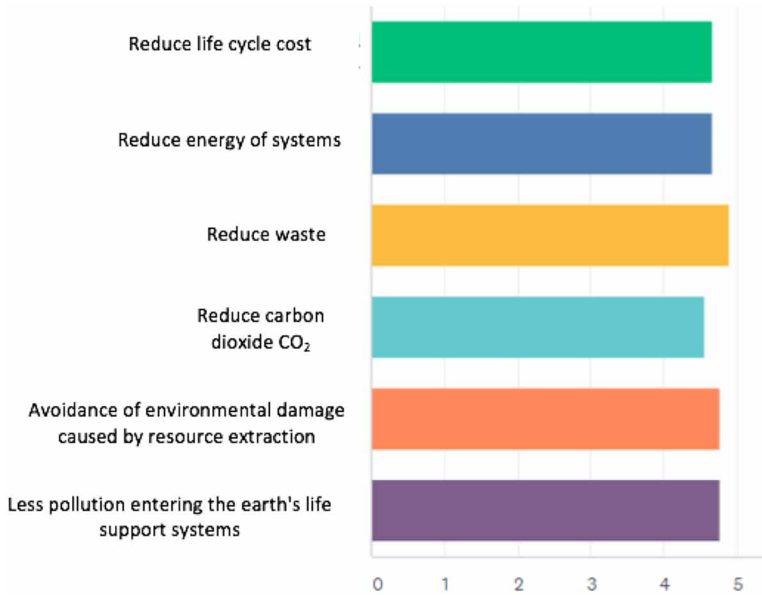
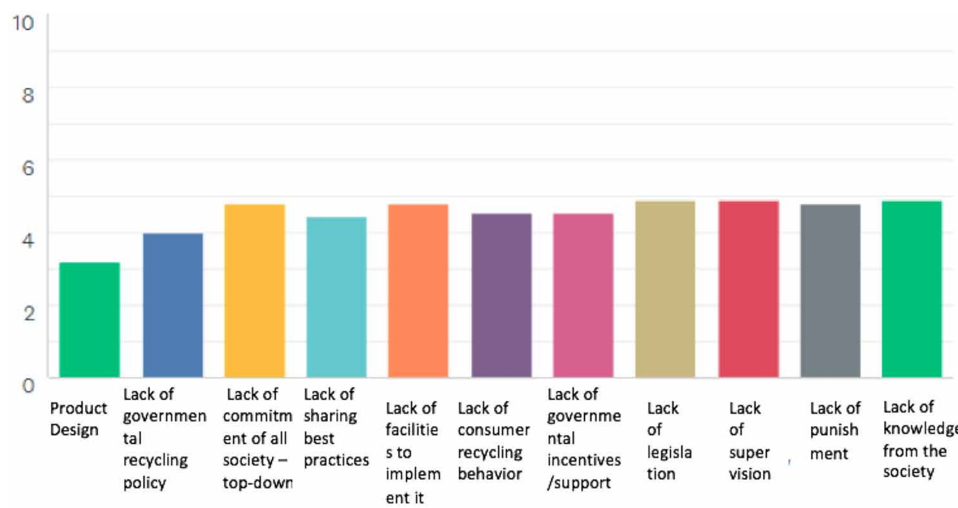
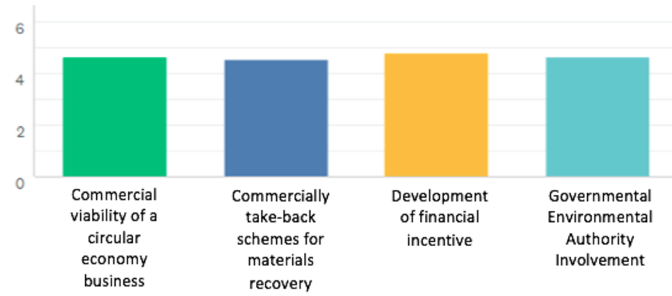


Figure 9. Challenges in implementing the circular economy (architects)
Source: Research data



When asked architects their opinion from 1 to 5, of their level of agreement regarding the enablers for the implementation of Circular Economy, they identified all of them as very important, scoring above 4 (Figure 10), being the most important the development of financial incentives. It seems that if architects would not have the necessary incentives to implement CE, even being the most knowledge group of respondents, they may not pursuit it.

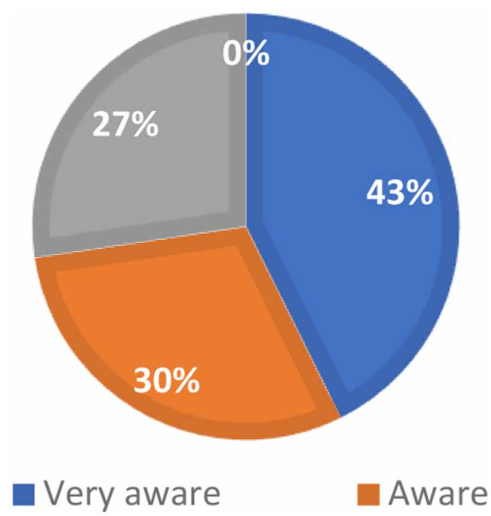
Figure 10. Important enablers when designing an apartment / villa / building for commercial use to apply a circular economy (architects).
Source: Research data



The Building Construction Companies' Perspective

From 150 responses from the building construction companies, 43% (64) are very aware and 30% (45) are aware of the circular economy concept (Figure 11). It would be expected that they would be an interested part of the business to acknowledge the business trends.

Figure 11. Awareness of the circular economy (building construction companies 2019).
Source: Research data



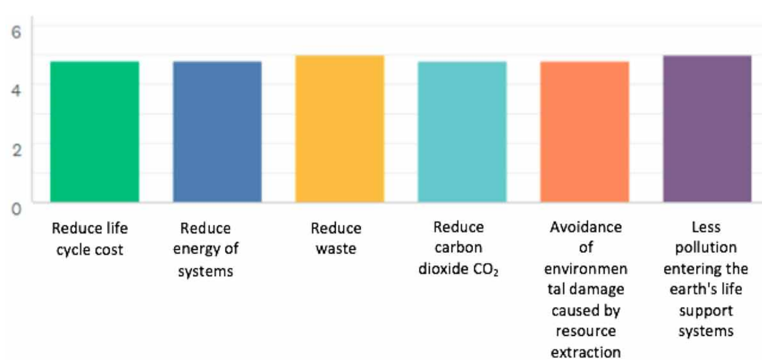
Overall building construction companies have a higher degree of awareness regarding the Circular Economy R-principles (Figure 12). 80% percent of the construction companies identified reduce and repair, and 60%, recycle and recover. Only 40% of the companies are very aware of the reuse principle. This can be explained as in terms of business management, reduce, repair, recycle and recover are commonly used principles to contain costs.

Figure 12. Awareness of the basic principles of the circular economy (building construction companies).
Source: Research data

N=150	NOT AWARE	UNAWARE	NEUTRAL	AWARE	VERY AWARE
Reduce	0,00%	0,00%	0,00%	80,00%	20,00%
Repair	0,00%	0,00%	0,00%	80,00%	20,00%
Reuse	0,00%	0,00%	20,00%	40,00%	40,00%
Refurbish	0,00%	0,00%	60,00%	40,00%	0,00%
Recycle	0,00%	0,00%	0,00%	60,00%	40,00%
Recover	0,00%	20,00%	20,00%	60,00%	0,00%
Rethink	20,00%	0,00%	60,00%	20,00%	0,00%

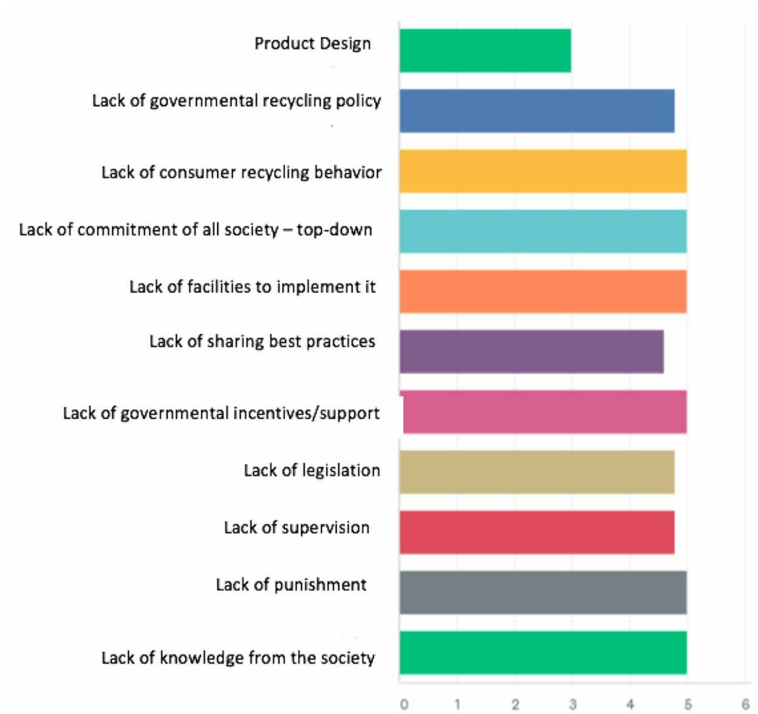
Overall, building constructions companies are the group of respondents with a greater degree of awareness of the benefits of the Circular Economy implementation. They are very aware that CE can bring reduction of pollution and waste, with 100% of firms (150) asserting that (Figure 13). Other interesting result is the perception that companies have that Circular Economy reduces life cycle costs and energy systems, contracting some viewpoints that associate CE implementation to a costly process.

Figure 13. Awareness of the benefits of the circular economy (building construction companies)
Source: Research data



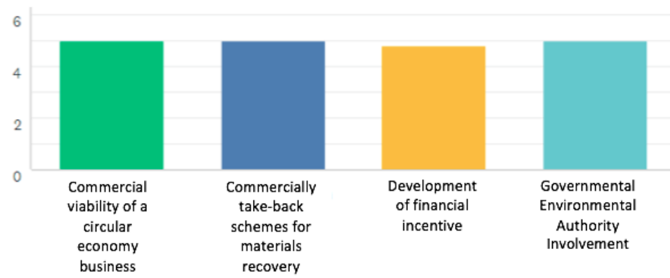
Regarding challenges, the building construction companies identified several constraints, giving the highest score, i.e. 5, from a scale from 1 - totally disagree to 5 - totally agree, they are: lack of consumer recycling behavior, lack of commitment of the whole society from top to bottom, lack of facilities to implement it, lack of government incentives/support, lack of punishment, lack of knowledge of society (Figure 14). For the building construction companies there are still a lot of challenges to overcome in order to implement circular economy. For this approach to be applied all the ecosystem of the construction section needs to cooperate; the entire system must be aligned, and due to the complexity and unique features of the sector, companies may perceive difficulties in achieving it.

Figure 14. Challenges in implementing the circular economy construction companies.
Source: Research data



Four enablers were identified as crucial to applying CE principles to the building construction sector, they are: commercial viability of a circular economy business; commercially take-back schemes for materials recovery; governmental environment authority involvement, and development of financial incentives. Building construction companies need enablers for leading most of their projects in CE implementation.

Figure 15. Important enablers to build an apartment / villa / building for commercial use, applying a circular economy (construction companies 2019).
Source: Research data



MAIN REMARKS

The current research attempted to understand three different perspectives from consumers, architects and building construction companies, of the awareness of the concept of Circular Economy, its R-principles, benefits, the challenges in its implementation and the necessary stimulus to pursue it in the building construction sector in Panama.

The results showed that respondents understand well the circular economy concept, and thus it can be inferred that circular economy is not an unidentified concept. Developing and implementing Circular Economy projects is often associated with energy saving and environmental preservation, which indicates that there is some concern over environment and its preservation.

The results revealed that architects are the most aware of the circular economy concept group of respondents, accounting for 80%, followed by building construction companies with 43% and at last consumers with 16%. The findings have important managerial implications for policy makers. Architects could be a good influencer in the promotion, dissemination and CE implementation. Architects are also the group of respondents that are overall most aware of the circular economy principles, followed by the consumers and the building construction companies. Building construction companies are the most aware respondents of the benefits of the circular economy. The results may reveal the business nature of the companies, that always seek for efficiency (resources saving), and cost effectiveness. Consumers were the group with less understanding on the topic. On a first analysis, the results emphasize that architects and building construction companies are aware of the circular economy construct and principles. However, at an individual level, among consumers, the lack of awareness was identified. The results showed that there is a need to educate the society about Circular Economy. This is an important insight for entities such as the Panamanian Chamber of Construction that have the task to inform the society of projects, laws, and novelties in the sector. The absence of a broader general agreement on the CE concept amidst the public in general regarding the construction sector could be a determinant factor to this situation. This recognized information gap, supported by the findings presented, demonstrates that an essential part of the supply chain, the consumers as well as the building construction companies, have an inferior level of understanding on how to adopt or how to pursue circular economy principles, which is potentially hampering the transition to a circular model at an early date. The major challenges spotted are the lack of incentives to invest or promote long-lasting design strategies. Further motivation and stimulus are imperative to facilitate the transition to a circular economy paradigm. There is a need to develop laws and policies to enable companies to implement circular economy principles. This laws and policies can include, reduction of taxes, loan benefits and financial support.

This research is unique in its nature as it attempts to gain and in-depth insight of Circular Economy, and its principles from three different perspectives of stakeholders in the building construction sector in Panama. The results obtained are important in the managerial point as well as in its contribution to the knowledge for previous research (Adams et al. 2017; Xue, 2010).

The current research was limited by time-constrains, and a border time-line would allow a greater data collection. Further research may include the replication of the survey instrument in other countries to compare perceptions of the building construction stakeholders' views.

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