TÉCNICO
LISBOA

Natural Sustainable Packaging:

Connecting Circular Economy with Sustainable Development Goals

Filipa Paulino Alves

Thesis to obtain the Master of Science Degree in

Industrial Engineering and Management

Supervisor: Prof. Ana Isabel Cerqueira de Gouveia Carvalho

Examination Committee

Chairperson: Prof. José Rui de Matos Figueira

Supervisor: Prof. Ana Isabel Cerqueira de Sousa Gouveia Carvalho

Member of the committee: Prof. Henrique Aníbal Santos de Matos

November 2019

Abstract

The current world crisis is a direct consequence of years of prosperity in developed countries. Mass production, technology development and higher economic power led to resources' depletion, waste production, global warming and major inequalities across the economic and social dimensions. Nevertheless, Earth has limited resources and, accordingly, the current production and consumption rates are not sustainable, leading to a growing urgency to act upon reversing the currently settled destruction path.

The global throwaway culture has led to a drastic packaging waste issue which demands urgent improvements within circular economy, as packaging itself must not add to the environmental footprint of a product and should be safe, cost-efficient and user-friendly. Consequently, the increasing demand for products leads to increased packaging demand which, in an era of resource scarcity, requires creative alternative solutions without compromising society's sustainable development.

The Sustainable Development Goals (SDG) were presented in the 2030 Sustainable Development Agenda to provide a conceivable future for society by working towards decreasing the inequalities in the social and economic dimensions while making efforts towards saving the environment.

Achieving such ambitious goals in a short period of time is, however, not an effortless task. Accordingly, fully transitioning to a circular economy devises a crucial pre-requisite to attain these sustainable goals and to tackle the dangerous world crisis. This is only possible due to the restorative nature of circular economy aiming to maximize efficiency in all dimensions.

This dissertation aims to find the best natural sustainable packaging materials to introduce in Portugal, which are strictly integrated in a circular economy process.

Upon extensive literature review, the theoretical knowledge of the best circular economy practices leading to the achievement of sustainable development goals was systematized. Then, upon case-study analysis followed by a multi-variable analysis method and semi-structured interviews with relevant sustainable packaging companies, a hands-on information overview of the sustainable packaging alternatives was achieved. Lastly, the final solution was assessed in regards of its accordance with the methods to track the sustainable development goals' achievement, leading to the understanding that there is not one best option for each company, but rather a portfolio of products made from distinct materials is what gives companies advantage in this packaging industry in constant transformation.

Key words: Packaging, Sustainability, Circular Economy, Sustainable Development Goals

Resumo

A atual crise mundial é uma consequência direta de anos de prosperidade nos países desenvolvidos. Produção em massa, desenvolvimento tecnológico e maior poder económico levaram ao esgotamento de recursos, produção de resíduos, aquecimento global e grandes desigualdades nas dimensões económica e social. No entanto, o planeta possui recursos limitados e, consequentemente, as atuais taxas de produção e consumo não são sustentáveis, levando a uma crescente urgência de tomar medidas para reverter o caminho de destruição atualmente estabelecido.

A cultura global descartável levou a um problema drástico de desperdício de embalagens, que exige melhorias urgentes na economia circular, pois a própria embalagem não deve aumentar a pegada ambiental de um produto e deve ser segura, económica e fácil de usar. Consequentemente, a crescente demanda de produtos leva ao aumento da demanda de embalagens que, numa era de escassez de recursos, requer soluções alternativas criativas sem comprometer o desenvolvimento sustentável da sociedade.

Os objetivos de Desenvolvimento Sustentável (SDG) foram apresentados na *2030 Sustainable Development Agenda* para prover um futuro concebível para a sociedade, trabalhando para diminuir as desigualdades nas dimensões social e económica, tentando assim salvar o ambiente.

Alcançar objetivos tão ambiciosos num curto período de tempo não é, contudo, uma tarefa fácil. Por conseguinte, alcançar uma transição completa para a economia circular cria um pré-requisito crucial para atingir esses objetivos sustentáveis e enfrentar a perigosa crise mundial. Isso só é possível devido à natureza restaurativa da economia circular, com o objetivo de maximizar a eficiência em todas as dimensões.

Esta dissertação tem como objetivo encontrar as melhores embalagens sustentáveis criadas a partir de materiais naturais, para serem introduzidas em Portugal, estando estritamente integradas num processo de economia circular.

Após extensa revisão da literatura, sistematizou-se o conhecimento teórico das melhores práticas de economia circular que levavam à conquista de objetivos para o desenvolvimento sustentável. Após a análise de casos de estudo seguida de um método de análise multivariável e entrevistas semi-estruturadas com empresas relevantes de embalagens sustentáveis, foi obtida uma visão geral das informações práticas sobre alternativas de embalagens sustentáveis. Por fim, a solução final foi avaliada em conformidade com os métodos para monitorizar o progresso no desenvolvimento sustentável, levando ao entendimento de que não há uma melhor opção para cada empresa, mas sim um portfólio de produtos feitos de materiais distintos que concede vantagens às empresas numa indústria de embalagens em constante transformação.

Palavras-chave: Embalagens, Sustentabilidade, Economia Circular, Objetivos do Desenvolvimento Sustentável

Acknowledgments

This thesis is dedicated to everyone who has shaped the person I am today. I may have only a few words, but my feeling are better shown than written.

First, I would like to thank my family for the endless hours of love, care and making sure I always had what I need in live and for pushing me in my studies when everything felt lost.

Secondly, to all my friends for the happiness and friendship. You all showed me that there is more to life than study and that university is only a platform to aid the decision of choosing what to with our talent.

Lastly, thank professor Ana Carvalho, for the opportunity to write this thesis and for the time dedicated to the endless mistakes and frustration.

A deep thank you to all the persons interviewed that contributed to this dissertation .

Table of Contents

List of Figures

List of Tables

Glossary

3D	Three-Dimensional
CE	Circular Economy
CERE	Coalition for Environmentally Responsible Economics
CSA	Case-study Analysis
CSR	Corporate Social Responsibility
D2C	Direct-to-consumer
DM	Decision-Maker
EPA	Environmental Protection Agency
EU	European Union
GDP	Gross Domestic Product
GI	Global Index
GRI	Global Reporting Initiative
KPI	Key Performance Indicators
LCA	Life-Cycle Assessment
MDG	Millennial Development Goals
NGO	Non-Governmental Organization
SDG	Sustainable Development Goals
SPC	Sustainable packaging coalition
SPI	Social Progress Index
UN	United Nations
UNEP	United Nations Environment Program
US	United States

1. Introduction

1.1. Background and Context

The world is currently facing a global crisis due to climate change, inequalities and the still fast-growing worldwide population, putting our planet and its resources under unprecedented stress (Sachs, 2012). This stress mainly derives from the current take-make-dispose model which is blind to products' after-life, in addition to the excessive extraction of virgin materials (Ghisellini, Cialani and Ulgiati, 2016).

Therefore, the current 1.7 Earths pace of resources utilization (Global Footprint Network, 2019) is unsustainable, as "Deserts are expanding, the sea level is rising, the population is growing, per capita consumption is increasing, the volume of livestock and cattle is growing, and biodiversity is depleting at ever faster rates" (Korhonen, Honkasalo and Seppälä, 2018), threatening future generations.

Furthermore, "progress on social issues does not automatically accompany economic development" (Social Progress Imperative, 2017) and too many people live, nowadays, without its full human rights. In addition, "Inequality has been on the rise across the globe for several decades" (Inequality, 2019) and currently, global inequalities and economic gaps are astonishing, with the richest 1% owning 45% of the world's wealth (Inequality, 2019), whilst millions of people die every day due to starvation.

The urgency to attain a sustainable development has driven international attention to the means to achieve it. Accordingly, in 2015, the 2030 Agenda for Sustainable Development was presented, emphasizing the recognition that "ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests" (Sustainable Development, 2019). In particular, goal number twelve stresses the need to ensure a sustainable production and consumption and goal thirteen addresses fighting climate change.

Revolutionizing the way current business is made, reduce hazardous emissions or eliminate waste is, however, a heavy task that, according to Ritzén and Sandström (2017), requires "disruptive changes and radical innovations". One particular way to attain all the seventeen goals by 2030 is to implement a circular economy as it "incorporates aspects of sustainable development, such as social or economic sustainability" (Geisendorf and Pietrulla, 2018).

By 2030, in the European Union (EU), 70% of all packaging waste must, at least, be recycled, in packaging involving industries (Packaging Europe, 2019). Accordingly, emphasis on product packaging must be provided, and this dissertation aims, therefore, to evaluate natural packaging material options in order to overcome this goal, by eliminating unnecessary waste and simplifying waste management while reducing resources' usage.

1.2. Problem Definition

"Packaging – much of it single-use food wrapping – has created a rubbish problem that now pollutes every corner of the world" (The Guardian, 2017). Accordingly, an alternative to cheap and disposable plastic must be found, since only 9% of all plastic ever produced has been recycled (Forbes, 2019).

To overcome the pressing plastic packaging issue, an evaluation of feasible natural packaging materials must be performed, to recognize alternative solutions which are less hazardous to the environment.

A particular way to attain the aforehand goal is by implementing a circular economy. Accordingly, Packaging Europe (2017) stresses that "packaging will play a fundamental role in supporting a circular economy. If less material is used in product creation, there is less to dispose later".

Furthermore, the natural packaging alternatives must foment the 2030 Sustainable Development Agenda by achieving pre-selected individual sustainable development goals (SDG), as fully transitioning to a circular economy devises a crucial prerequisite to achieve most of the SDGs (Ellen Macarthur Foundation, 2017) since "CE practices also offer potential to create synergies between several SDG" (Schroeder *et al.*, 2018).

The main focus is, consequently, identifying the main packaging products responsible for the majority of the waste created, in particular in the single-use products' market, as these must be replaced by sustainable options.

Accordingly, in the end of this dissertation, natural packaging alternatives which incorporate a circular economy design must be presented and evaluated by the identified methods of SDG measurement, in order to leverage the achievement of the proposed SDGs within the scope of this dissertation.

1.3. Objectives

The execution of this dissertation aims at discovering the best natural packaging materials to introduce in Portugal, in particular, to substitute plastic packaging by the former ,which is associated with the implementation of a circular economy model deeply connected with the progressive work towards achieving some sustainable development goals defined by the United Nations through the 2030 Sustainable Development Agenda.

To do so, three main objectives must be accomplished:

1) Problem definition: analysis of global crisis key causes, with consequent understanding of main plastic issues and packaging consumption

2) State of the Art: comprehensive literature review on Sustainable Development Goals and Circular Economy, with focus on sustainable packaging and best practices in the industry, as a baseline for the work carried out

3) Materials analysis: investigation of raw materials and its implication on packaging issues, followed by the execution of a study leading to the understanding of which are the best sustainable packaging alternatives to be introduced in Portugal.

1.4. Structure

The present project is composed of five main chapters, each one to be further clarified.

Chapter one presents the background and context of the present work, in addition to the explanation of the problem found. The objectives and structure of the project are also stated.

Chapter two provides a literature review with consequent deepening of knowledge regarding the major topic to be addressed, the Sustainable Development Goals. In addition, current practical examples on implementation and reporting tools are discussed. The main goal of the chapter is to deeply understand each individual goal and its implications, to be used as the foundation for further development and implementation work.

In chapter three, an analysis of circular economy and a literature review on the subject is provided, with the goal of understanding how the goals from the previous chapter can be achieved. In addition, focus will be on natural sustainable packaging options as a way to complement the implementation of a circular economy, supported by a demand characterization for such products.

Chapter four regards the methodology to be followed through the development of the present project, as it is a vital part to achieve the proposed goals of chapter one.

In chapter five the focus will be on the raw materials analyzed throughout the dissertation. A qualitative and quantitative analysis is provided in order to select the best materials according to its characteristics, usability, cost and manufacture location.

Chapter six demonstrates the comprehensive linking amongst natural sustainable packaging, circular economy and sustainable development goals.

Lastly, chapter seven provides overall conclusions regarding the literature review and summarizes the findings of the research. Moreover, further research work is suggested to complement what was achieved with this dissertation.

2. Sustainable Development Goals

This chapter presents the literature review regarding the Sustainable Development Goals with the background and context in section 2.1 and a brief explanation of each Sustainable Development Goal in section 2.2. Following, the current practical implementation of these SDGs in the industry is provided, in section 2.3.

Section 2.4, focus on SDG progress assessment and presents three distinct tools to aid such tracking, followed by summing up the evidences found and conclusions in section 2.5.

2.1. Background and Context

The United Nations (from here on referred to as UN) was founded in 1945 with the main goal of preventing future wars, due the vast devastation World War II carried out (United Nations, 2015).

Currently it is composed by one-hundred and ninety-three (193) member-states and aims to encourage international cooperation though acting upon the succeeding topics (United Nations, 2019):

1. Maintain international peace and security
2. Protect human rights
3. Deliver humanitarian aid
4. Promote sustainable development
5. Uphold international law

In the year 2000, a landmark was achieved when world leaders and policy makers agreed on the Millennium Development Goals, presented in table 1 (from here on referred as MDGs), being the "most successful anti-poverty movement in history" (United Nations, 2015). This was an eight-goal framework created to enable the attainment of global action, for the next fifteen years (2000-2015), within a set of crucial social priorities (Sachs, 2012). However, it was mostly focused on the poorest countries, as their development was high priority (Gupta and Vegelin, 2016).

Table 1 – Millennial development goals (United Nations, 2019)

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

Throughout the fifteen years the MDGs were being developed, significant improvements were achieved. These were, however, greatly varied across goals and countries (Sachs, 2012). As a consequence, a shortfall on achieving all the eight goals was almost inevitable and with the environmental and poverty related goals needing deeper action, an extension of the MDGs was required.

In 2015, during the UN Sustainable Development Summit, over 150 world leaders decided upon the seventeen sustainable development goals presented in figure 1 (from here on referred to as SDGs) which are a call for action upon crucial issues for the sustainable improvement of humanity (United Nations, 2019). “The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. ” (United Nations, 2019).

Figure 1 – Seventeen sustainable development goals (International monetary fund, 2019)

These SDGs reflect the growing urgency in addressing an international sustainable development and thus, acting through the triple bottom line approach of economic development, environmental sustainability and social inclusion (Sachs, 2012). According to Stafford-Smith *et al.* (2017), for a successful implementation of the SDGs, innovation in the sources of financing used and inclusive growth are vital to perpetuate progress.

Since the adoption of the 2030 Sustainable Development Agenda, the wealthiest and most powerful countries have been the ones with the least significant progress, which is reasonable, as the more developed a country is, more effort is needed for significant changes to be made (Deloitte, 2018). In addition, according to Muff, Kapalka and Dyllick (2017), the more developed a country is, the higher is its ability to act regarding sustainability.

All the goals are to be achieved by 2030 and to accomplish a real change and immense impact, every goal must be approached individually, nonetheless, exploited by as many synergies amongst other goals as possible. In addition, the focus should be on the interconnections (across all sectors, social actors and countries) and dependencies amongst goals (Stafford-Smith *et al.*, 2017).

Successfully implementing and accelerating the achievement of the SDG will be based on how well countries are able to provide knowledge sharing platforms to increase diffusion, capacity building, specially related to technology and technical capabilities and, lastly, innovation as a way of adaptability to each country's needs (Jha *et al.*, 2016). Therefore, on one hand it imposes a great demand on the scientific community to come up with alternatives and solutions, on the other hand, it requests the global coordination of monitoring and modeling efforts in social, economic and environmental dimensions. Consequently, it implicates close partnerships and efforts with the most varied stakeholders (Lu *et al.*, 2015).

The first organizations being able to implement most of the SDGs by 2030 will be the ones collecting the most benefits regarding profit, customers and future generations, hence being a significant incentive towards embracing the challenging agenda for 2030 (UNGSII, 2017).

According to the Social Progress Imperative (2017), there are four main challenges for the implementation of the SDGs, which must be carefully considered:

1. **Elimination of silos**, as "cross-sectoral stakeholder engagement" is vital
2. **Localization of implementation**, as each SDG must be adapted to the country or region it is addressed to, as different levels of development and local constraints require different means of implementation
3. **Measurement**, due to the lack of rigorous manners to measure each indicator created
4. **Aggregation**. Each region has a different context, hence different indicators are used to address the progress of implementation of the SDGs, and all the gathered data must be aggregated to provide a manner to measure each country's overall progress

Since the SDGs were presented, much is yet to be understood, such as what standards of monitoring and controlling exist or what connection between the goals' targets exist. To answer some of these questions and address the challenges of SDG implementation, Lu *et al.* (2015), proposed five priorities:

1. **Devise metrics to track the progress** done so far and include parameters such as carbon emissions and lifespan, using existing methodologies as a starting point for innovation. In addition, the ambiguous terms must be defined quantitatively, in order to be compared.
2. **Establish monitoring mechanisms** to acquire quantitative data, using social scientists to decide on how to analyze them and by whom. Furthermore, the analysis and interpretation of the data should be done at the same time to prevent even more variability.

3. **Evaluate progress** upon chosen goals and decide on how to incorporate the different contributions of regions.

4. **Enhance infrastructure** with developed countries helping out developing countries building capacity for data collection and own evaluation mechanisms. Furthermore, it would allow the need of capabilities' expansion and global coverage to allow direct comparisons of collected data.

5. **Standardize and verify data for robustness and quality-control**. All collected data must be open access and released as soon as possible, using shared online platforms. In addition, sanctions for those who do not comply must also be applied, after all this is a global effort and, as a community, the humanity can't afford to have entities not complying.

One particular way to accelerate the achievement of all the seventeen goals by 2030 is to implement a circular economy system worldwide, working as the foundation for a disruptive change (Ritzén and Sandström, 2017). The main reason is that circular economy "incorporates aspects of sustainable development, such as social or economic sustainability" (Geisendorf and Pietrulla, 2018), which underpins the reason of the development of the 2030 Sustainable Development Agenda and each of the seventeen individual Sustainability Development Goals.

2.2. Individual Sustainable Development Goals

As aforehand mentioned, there are currently seventeen distinct sustainable development goals to be achieved by 2030. In this section, a brief description of each goal will be provided.

The first goal of the SDGs is set to **eradicate extreme poverty**, in all forms, worldwide. As in 2015, still ten percent of the world's population was living with under $1.25 per day (Sustainable Development, 2016). Making sure every person has equal rights to economic resources and access to basic services is crucial to achieve economic growth, as it can provide sustainable jobs, promote equality and increase the resilience of the vulnerable to climate related events, in addition to other economic, social and environmental shocks and disasters.

Achieving **zero hunger** (2nd goal) means ensuring access to food security and safe nutrition all year round for everyone. In addition, promoting and increasing agricultural sustainability is crucial, as it offers key solutions for local development with properly functioning food commodity markets (using traditional knowledge passed on by older generations) and eradication of poverty and hunger.

Good health and well-being (3rd goal) can only be achieved by ensuring healthy lives and promoting the population's well-being. In order to do so, improvements in the hazardous pollution in water, soil contamination, epidemics of AIDS tuberculosis, malaria and neglected tropical diseases must be accomplished, which are the main causes of premature deaths, apart from hunger (Sustainable Development, 2016). In addition, special attention to research and development and access to affordable vaccines and medicines, while strengthening the prevention of treatment of diseases is of crucial matter.

The 4th goal, **quality education** isn't easily achieved. However, lifelong learning opportunities for all and, inclusive and equitable education must be the basis to address this problem. Having access to quality education to acquire relevant skills is a necessary building block to improve the population's quality of life and society's sustainable development.

Despite of what has been thought in the past, achieving **gender equality** (5th goal) is a positive development in a society and it can, inclusively, promote economic growth. Gender equality is a fundamental human right and also, a vital foundation for peace and a prosperous and sustainable society. To achieve it, women and girls must be empowered, and they must have an effective participation in leadership levels and decision-making in political, economic and public life.

Water is essential for survival and one can't live healthily without the 6th goal, **clean water and sanitization**. Accordingly, having universal and equitable access to safe and affordable drinking water, sanitation and hygiene is vital. Moreover, the implementation of integrated water resources management at all levels, improvement of water quality, significant increase of water-use efficiency, safeguard of sustainable withdrawals, supply of freshwater and protection and restoration of water-related ecosystems are required to ensure life expectancy.

The 7th goal seven addresses the problem of reliably supplying **affordable and clean energy** worldwide and using modern energy services. In addition, since energy is central to every activity, to be able to spare scarce resources, substantially increasing the share of renewable energy in the global energy mix, improving the energy efficiency and enhancing international cooperation to facilitate access to clean energy research and technology are a main priority.

Achieving **decent work and economic growth** (8th goal) is not an easy task, as today's society allows for too many discrepancies. Efforts must be made to promote sustained, inclusive and economic growth. It will only happen if the conditions to do so are set up and the whole population has access to full, productive and quality employment.

The 9th goal stresses addressing **industry, innovation and infrastructure** problems. To develop the global society and make it more industrialized, a set of actions must be taken, such as building and investing in resilient infrastructures, promoting inclusive and sustainable industrialization and foster innovation. Furthermore, sustain per capita economic growth, achieve higher levels of economic productivity, promote development-oriented policies and progressively improve global resource efficiency in consumption and production are the building block to make it happen.

As the current differentiation among developing and developed countries exists, depending on how industrialized each country is and their economy, it is simple to understand that reducing such a **gap in inequalities** (10th goal) is something to strive for and that is not easily accomplished. To make it happen, international policies must be implemented, while special attention is paid to the needs of marginalized and disadvantaged populations worldwide.

All SDG goals, in a way, strive together for achieving the 11th goal, **sustainable cities and communities**, and in particular, a sustainable development. As a consequence, cities and human settlements must be safe, resilient, sustainable and inclusive, where cities provide opportunities for all, particularly the access to safe and basic services, water, energy, housing and transportation.

The 12th goal addresses **responsible consumption and production**, meaning all stakeholders involved must work together to ensure a reduction of the consumerism, which is the current paradigm, and also to set up the infrastructure and ideas for a sustainable production. Such might be achieved by recycling, repurposing and using circular economy.

Climate action, the 13th goal, is one of the reasons for the creation of the SDGs. Therefore, it is urgent to act towards the needed changes to combat climate change and its hazardous impacts on the planet. This is a global challenge, and to be effective in the long run, young people must be educated from a young age, to put them on a path to start addressing the issue as early as possible. Education and communication of information are the key.

As has been noticed, oceans are one of the most polluted ecosystems, mostly with plastic. To ensure there is a healthy environment for **life bellow water** (14th goal), conservation and thoughtful use of oceans, seas, rivers and marine resources must be stressed, for sustainable development.

Life on land, the 15th goal, on the other hand, is also extremely endangered. Therefore, protection, restoration and promotion of sustainable use of the ecosystems, management of forests, combat of desertification and reversion of land degradation and biodiversity loss are urgent. It is so extreme that in the past 40 years, over 60% of wildlife has been extinct (The Guardian, 2018).

Peace, justice and strong institutions is the 16th goal of the SDG's. It is extremely important to promote peace and inclusive societies, to provide access to justice and build effective, accountable and inclusive institutions worldwide, at all levels. This can be achieved by using our right to vote and elect leaders that believe in sustainable development and acting to better our society.

Lastly, the 17th goal, **partnerships for the goals** intends to strengthen the means of implementation of the SDGs and to revitalize the global partnerships to create the foundation for a sustainable development worldwide, using the strengths of wealthier countries and institutions to improve the conditions and efforts of the most disadvantaged ones.

Currently, the progress of each target per goal is tracked using the SDG Tracker, created by Our World in Data. Up to date data on each indicator can be found, to better understand the still needed efforts to fully achieve SDGs of the 2030 Agenda (SDG Tracker, 2018).

2.3. Practical Examples of SDG Implementation

To be able to propose solutions regarding feasible natural packaging alternatives, it is necessary to understand what is already being done in the industry, how it is being done and, ultimately, its impact on SDG achievement.

By analyzing the packaging process and the companies who report their efforts to attain SDGs, it became clear that the most direct and closely related SDGs to this dissertation goals are goal nine “Industry, innovation and infrastructure”, goal eleven “Sustainable cities and communities”, goal twelve “Responsible production and consumption” and goal thirteen “Climate action”. Therefore, these are the goals to be further explored.

It is visible, across distinct activity sectors, the efforts several companies have already undertaken into implementing the SDGs. Table 2 presents examples of what is currently being done in the industry to address the aforehand mentioned SDGs. However, most companies are yet to report their efforts of integrating sustainable packaging options with the achievement of the 2030 Sustainable Development Agenda. Therefore, the examples provided will be regarded to both sustainable packaging solutions and other relevant solutions in the industry, for SDG achievement, in order to provide insights on what can actually be accomplished and pose as example and inspiration to future related innovations and best practices.

To be noticed that the most visible efforts in regard to sustainable packaging occur mostly across goal number twelve – Responsible production and consumption – in particular, due to the process of packaging creation itself, hence innovations are easier to generate. Therefore, the conclusions drawn upon the analysis of table 2 will provide a wide and holistic vision of the impact of the solutions to be proposed by the work at hand.

Table 2 – Implementation of SDG in companies

	Current practice	Innovation	Impact
Goal 9: Industry, Innovation and Infrastructure by **Hewlett-Packard** (UN Global Compact, 2015)	Current manufacturing practices focus mainly on mass production of parts which create an immense amount of waste. It allows the usage of a vast choice of materials being, however, resistant to change as producing new products mostly demands different machines.	New commercial 3D printer technology, with potential to accelerate the adoption of 3D design and hardware innovation, which makes it possible to produce individual replacement parts locally, rapidly and inexpensively, can extend lifespan of some products.	Potential to improve materials efficiency with savings in the sort-run and avoiding waste associated with mass production. In addition, enables superior designs and increases the recyclability and value of product material.

Goal 11: Sustainable Cities and Communities - **PETr PAN** (UNLEASH, 2019)	During most events, single-use plastic cups are usually provided. Therefore, each person uses more than one cup per event, which then must be recycled, not avoiding the creation of a major plastic waste, nevertheless	Supply of a plastic cup rental service for events, which eliminates the use of disposable cups through providing a reusable alternative. Incentives to users are provided to encourage them to reuse the cups they have.	Effective reduction of the amount of plastic waste being produced in both the short-run and long-run as single use plastic cups are being transitioned to reusable plastic cups
Goal 12: **R**esponsible Production and Consumption) - **PackLess** (UNLEASH, 2019)	Take-away food is sold in single-use plastic containers which have demand high resource consumption and induces irreversible environmental impacts.	Circular model for food containers to provide a supply chain that is cost-effective to retailers and convenient to consumers by providing reusable and durable containers to food vendors. Consumers will be incentivized to return the containers that once collected will be washed and return to food vendors for reuse.	Reduction of the amount of food containers disposed into landfills, with consequential savings through avoiding the ongoing consumption of resources and energy to manufacture single-use take-away containers.
Goal 13: Climate Action - **Sachet sorting and collection** (UNLEASH, 2019)	Since thin-film plastic is difficult to collect and segregate once in the waste stream, developing countries, in particular, with simple collection infrastructures do not prioritize this type of waste.	Creation of a sachet collection system through incentivizing consumers to deposit sachets (low value but high-volume waste product) at the traditional street shops.	Potential to divert 285 000 tons of thin-film plastic from entering the ocean, with additional awareness of waste issues and behavioral nudges towards recycling.

2.4. SDG Assessment

Having aforehand explained what the sustainable development goals are, described each one in particular and presented some industry examples, it is now relevant to explain the metrics to measure its implementation and to further assess the improvement attained.

The following section will present different methods to measure and assess SDG implementation and reporting: section 2.4.1 addresses the global reporting initiative, 2.4.2 explains the social progress index, section 2.4.3 describes the GapFrame and lastly, section 2.4.4 clarifies the linkage among methods and how its usage altogether improves the attainment of the SDGs.

2.4.1. Global Reporting Initiative

In 1997, the Coalition for Environmentally Responsible Economics (CERE) and Tellus Institute, upon support from the United Nations Environment Program (UNEP), created the global reporting initiative (from here on referred to as GRI), since they believed organizations have a critical role in addressing sustainability issues.

GRI is an international and independent organization that focus on empowering businesses and organizations worldwide acknowledging and reporting their impacts on sustainability, carrying social, environmental and economic benefits to all stakeholders (GRI, 2019).

An organization can only understand what it needs to improve by understanding what the output of its efforts is and how far the achievement of its goals is. To do so, it needs to report its results.

Currently, and according to KPMG's survey regarding Corporate Responsibility Standards, in 2017, 93% of the world's largest two-hundred and fifty companies publish, yearly, a sustainability report on their performance (known as corporate social responsibility - CSR) regarding their environmental, economic and social impacts, with the intention of informing all stakeholders, even though this practice has become standard out of social pressure. Particularly, 75% of these use the GRI Standards.

Whether a company chooses to report its sustainability actions out of pressure or due to the company's vision, a significant amount of benefits stems from it, such as increased transparency, better decision making (better understanding and mitigation of risks, seizing of opportunities), built trust around the sharing of information across all levels, improved efficiency and accountability, with all of the above leading to improved financial results (GRI, 2019). Consequently, GRI is the facilitator for companies and governance levels to better understand how to implement the SDGs on their businesses and legislations, and therefore, deeply contribute to the sustainable growth of society, as they need guidance in how to do so. Moreover, SDGs "explicitly call on business to use creativity and innovation to address development challenges and recognize the need for governments to encourage sustainability reporting" (GRI, 2019).

The sustainability reporting standards, GRI's framework, is currently a global best practice on how to articulate reports on sustainability, as it is the most credible and flexible reporting tool which ensures compliance to all the requirements imposed by international organizations on sustainability. The GRI standards provide topic-specific reporting standards in economic, environmental and social modules, in addition to universal standards such as foundation, general disclosures and management approach (GRI, 2019).

The economic standards focus on, for example, economic performance, market presence or procurement practices, while the environmental standards focus on materials, energy, emissions, biodiversity, among many more. Lastly, the social standards focus on employment, occupational health and safety, non-discrimination and local communities, as an example.

However, the negative side of such a helpful framework is that it actually focus on having more companies worldwide performing the reports, rather than improving how to report and transmit the data and results obtained, better reporting or better use of the information obtained.

"GRI's Sustainable Development Goal is to foster inclusive development and sustainable, green, economic growth by empowering decision makers through our sustainability standards and multi-stakeholder network" (GRI, 2019). Consequently, it is focused on four key objectives:

1. Sustainable development policy
2. Increasing and improving reporting in developing countries
3. Transformative capacity building
4. Innovation in emerging issues

By addressing these four key principles and, in particular, having topic-specific standards related to the main pressing topics which the SDGs are based upon, it is deeply related to the overall goal to be achieved by the implementation of the SDGs, a sustainable growth.

2.4.2. Social Progress Index

"In an increasingly performance-oriented society, having the right metrics is very important. What we measure affects what we decide and do. If we use incorrect measurements, we will drive the wrong priorities" (Social Progress Imperative, 2017).

The human economy operates under three major points, all interdependent of each other: natural resources, ecosystem services and natural capital (Costanza *et al*., 2009). However, politics often disregard social and environmental issues upon economic matters (Gupta and Vegelin, 2016).

In the past, a country's economic progress would be measured by its gross domestic product (GDP), a specialized tool measuring the flow of all final goods and services produced within the market, in exchange of labor and capital. However, GDP is not a broad enough measurement, as a variety of important activities are not considered, such as social capital formation, health, quality of education and depletion of natural resources, therefore being an inaccurate measure of well-being, which is vital for measuring the implementation of the SDGs (Costanza *et al.*, 2009).

Being GDP a measure of economic quantity, it fails to measure the quality of life and of the environment and, in addition, it also encourages activities that in the long term will harm the community well-being. To move forward, our well-being must be measured using a variety of tools, and not just one that we blindly follow.

Social progress is defined as "capacity of a society to meet the basic and human needs of its citizens, establishing the building block that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential" (Institute for Strategy & Competitiveness, 2019). Therefore, there is not anything more important than fulfilling social progress worldwide and, consequently, it is of extreme importance tracking this fulfillment. For this, a measurement tool is needed.

According to Michael Green (2019) "Countries need a new measure that assesses and quantifies the things that really matter to real people" such as if they have enough to feed themselves, shelter, access to education, clean water and many more (Social Progress Imperative, 2019).

In order to successfully measure the social progress, the Social Progress Index (from here on referred to as SPI) was created by the non-governmental organization (NGO) Social Progress Imperative. It is, therefore, a global view of people's quality of life, discarding measurements of wealth and economic indicators. As such, ultimately, it is used to measure the success of each country in implementing the SDGs, compare the success and accelerating progress.

Since economic indicators are often used to measure growth and process, SPI is, hence, used systematically as a complementing measure to other economic indicators, in a wide-ranging and inclusive way, benchmarking success and also, improving human wellbeing. Its score is a simple average of all three dimensions, which will later be addressed (Social Progress Imperative, 2019).

The methodology of the SPI is simple, yet complete and incredibly useful. The proposed framework comprises three very distinct elements that are the analysis's basis: dimensions, components and indicators, all set to measure different aspects of social progress (Social Progress Imperative, 2019).

There are four key design principles of the framework:

1. **Exclusively social and environmental indicators** to measure social progress without using any economic indicators or proxies and thus, measure rigorously and directly the connection between economic development and social development.

2. **Holistic and relevant measurements**, by knowing exactly what constitutes a healthy society, for any country, not just the poorest.

3. **Measuring outcomes** instead of inputs, as results are relevant and not the effort to achieve them.

4. **Actionable**, so leaders and governments can actually implement the policies needed to drive faster social progress.

SPI comprises three distinct dimensions, meaning three crucial areas within social progress: basic human needs, foundations of wellbeing and opportunity. The score for each dimension is, similar to the overall SPI score, a simple average of the four included components, which are different for each dimension.

In basic human needs, it is measured how well a country is able to provide access to nutrition, clean water, housing with basic utilities and a safe and secure society.

Foundations of wellbeing, on the other hand, measures whether a country's citizens have access to basic education, information and knowledge and if it has the basis for living a healthy life. Moreover, the protection of natural environment is also assessed.

Lastly, opportunity, which is usually one of the most overlooked aspects of human wellbeing, measures individual's personal rights and the ability to make their own decisions, freedom and the potential for wide-ranging personal opportunities, as a human being within a society. Furthermore, it also considers the availability of advanced forms of education and if hostilities prevent individual from reaching their full potential.

The components part of the framework is where specific actionable subsets of dimensions are evaluated with the help of the predefined indicators. All of the aforementioned areas are shown in figure 2.

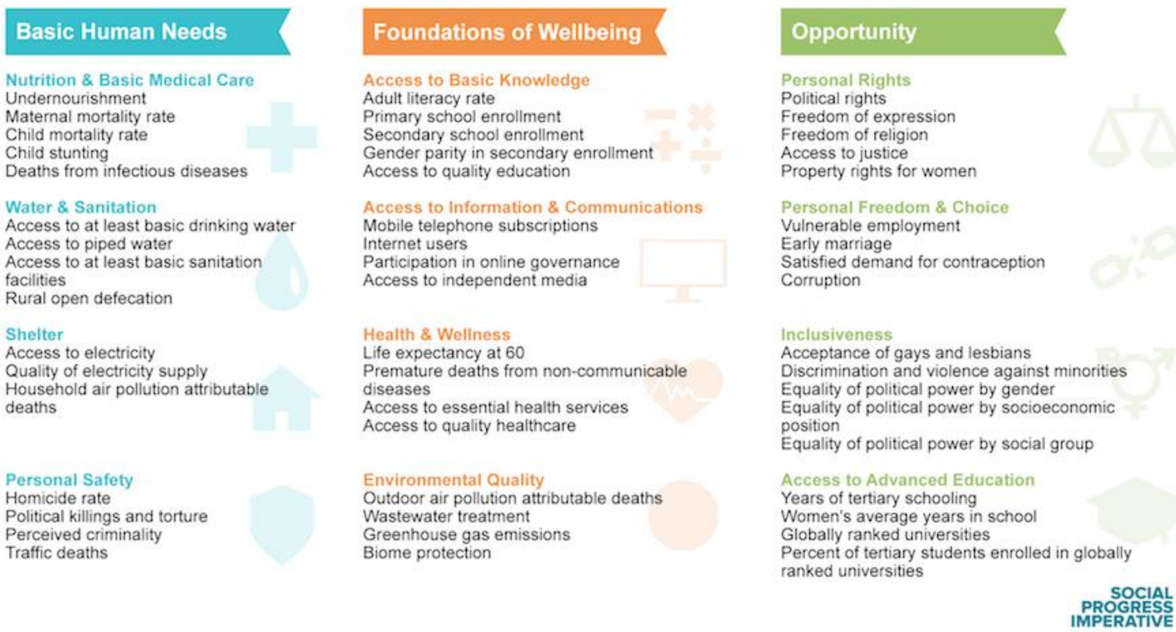


Figure 2 - SPI framework (Social Progress Imperative, 2019)

Each year, each country should guide themselves using the results obtained and comparing it to previous years and countries in the same tier. In the SPI there are six different tiers in which countries are grouped in according to clusters with common breaks, being six different breaks, or tiers, the best option for the Index.

Despite the similarities across some countries in the same tier, there's also significant variation in performance across components of each tier. All countries with sufficient data to be ranked, which in 2018 were 146, are ranked from “very high social progress” to “very low social progress” and then assigned to a specific tier (Social Progress Imperative, 2019).

In conclusion, SPI measures the success of each country in implementing the SDGs and, allows for comparisons and acceleration of progress.

However, despite the framework being directly towards countries, it can be adapted to companies as a useful way to follow guiding criteria on which aspects must be further developed and, therefore, driving innovation and progress.

2.4.3. GapFrame

GapFrame is a framework which “translates the Sustainable Development Goals into nationally relevant issues and indicators for business” (GapFrame, 2019). It is represented in figure 3 and builds on a “safe operating place” which considers Earth’s limitations and social requirements and includes twenty-four issues (each one directly related to one or more sustainable development goals) and sixty-eight indicators. The furthest an issue is from its safe place, the higher the gap is and, therefore, the higher its priority is (Muff, Kapalka and Dyllick, 2017).

The framework is used to compare the current position of a country with its ideal position, to understand the priority in addressing each goal and the current state of their sustainability development. Moreover, it can be calculated by country, region or event issue and provides the lowest score value of 4 distinct dimensions: governance, planet, economy and society. In addition, five criteria were defined to evaluate a country’s position and the gap to be closed:

1. Threat
2. Critical, thus requiring urgent action
3. Watchlist
4. Safe place, using an 80/20 rule, with an 80% range being good enough
5. Towards ideal

An average result measure is used to show a global image of the country’s position, against its own ideal, being the global score (from 0 to 10, being 10 the ideal) an average of the four previously stated dimensions.

Concluding, GapFrame provides countries with an understanding of their priorities in addressing the issues stated by the framework, in their region, or nationally, therefore clarifying the national and business relevance of the SDGs. Furthermore, it supports organizations in translating the issues to be addressed into sustainable business opportunities being, therefore, a strategic business tool incredibly useful for decision-making (Muff, Kapalka and Dyllick, 2017).

Figure 3 – GapFrame framework (GapFrame, 2019)

2.4.4. Integration of Methods

Despite the three tools being extremely important to track progress, GRI is more focused on how individual organizations present their results and improvements, SPI is the outline for each country to guide itself on the progress being made and lastly, GapFrame supports enterprises in finding business opportunities within the priority issues to address in a country.

For all the four stages of reporting, GRI provides guidelines and assistance for organizations which will result in positive outcomes such as sustainability reporting standards, transparency of information, better decision-making and finally, progress making. Therefore, by using these guidelines, implementation and tracking of SDGs becomes much easier, efficient and accurate.

Regarding the sustainability reporting standards, GRI helps the identification of the link between GRI standards and each SDG, facilitates the understanding on how to communicate performance and progress of the SDGs and supports the identification of actions related on how to report performance.

Transparency of information regards communication across all levels and stakeholders, thus helping to accelerate the implementation of the SDGs and its reporting. In addition, GRI supports the understanding of how to report contributions and evaluate if SDGs are correctly mapped against GRI disclosures.

As from communication and more information comes better decision-making, understanding how each SDG is being implemented and what are its impacts, influencing multi-stakeholder movements and staying updated on sustainable development advances are crucial to make sure the organization is moving towards the right path.

Lastly, making progress derives from good information management and all the above. Therefore, it is vital to properly store and manage all the previously collected information and use it to benchmark and improve.

The main difference among the Gap Frame framework and the Social Progress Index framework is that the first one regards countries finding what are the main issues to address, hence prioritizing the issues, in regards to the implementation of the SDGs, while the latter is focused on presenting the aggregation of progression towards the main pillars of social progress and, therefore, presenting how well a country is doing regarding the implementation.

The GapFrame is extremely important for prioritizing the tackling of each SDG in a specific country and to use it as a business opportunity. However, for this to happen, one must understand what is being done so far and that's where the GRI comes in, reporting all the efforts and the output achieved regarding environmental, economic and social impacts, while SPI reports the progress of each country in aggregating all the three dimensions of social progress, which cannot be fully measured using any other tool currently available. *Business Reporting on the SDGs* is then, the bridge among all the reporting tools, bringing together the benefits of reporting with acceleration of implementation of the SDGs.

For every SDG and, in particular, every business topic, a set of GRI indicators is attributed. Moreover, GRI, in collaboration with the United Nations Global Compact, has started an initiative set to be an action platform for companies to accelerate the reporting of SDG implementation, named *Business Reporting on the SDGs* (GRI, 2017). It will complement, educate and enable organizations on reporting their progress, since proper reporting, by individual organizations, is yet to be defined. The following tools are the basis of the action platform:

1. Report Analysis of the goals and targets
2. Integration of the SDGs in corporate reporting
3. Addressing investor's needs regarding business reporting on the SDGs

To conclude, every day efforts are being made to make sure the implementation of every SDG is achieved by 2030, being it by the implementation of measures addressing each SDG or by reporting the progress and benchmarking.

Table 3 presents the advantages and disadvantages of each reporting tool. To be emphasized that all tools must be used together, for greater improvement, as they serve distinct purposes.

Table 3 – Advantages and disadvantages of SDG assessment methods

	Advantages	Disadvantages
GRI	• Social, environmental and economic benefits • Performance tracking • Increased transparency and efficiency • Better decision-making • Accountability and trust within company • Improved reputation	• Focus on quantity of companies reporting • Lack of guidelines on how to use the gathered information
SPI	• Context specific • Holistic measure of policies' effects on social progress • Objective measures • Measures outputs, not effort • Actionable	• No economic indicators • Difficulties in measuring countries with less available data (indefinable) • Lack of rigorous measurements for all indicators
GapFrame	• Translates SDGs into relevant measures • Strategic business tool for long-term opportunities • Educational tool • Prioritizes action	• Requires experts and further research • Countries too self-focused

2.5. Chapter Conclusions

SDGs have become increasingly indispensable due the growing urgency of sustainable development.

Succeeding a thorough research on SDGs and best procedures to achieve them through businesses, minimal relevant literature was found concerning the topic. However, and despite the significant progress that has already been achieved, reversing the damage that has been done in the last decades and achieving these sustainable development goals by 2030, is yet a remote accomplishment.

Several companies, particularly the ones with most market presence, have already put in significant efforts towards implementing the SDGs. However, as expected, there is still a significant uncertainty on how to do it and how to measure the implementation's progress, as rigorous measurements are yet to be established for all the indicators.

Nonetheless, currently, the achievement of the sustainable development goals is evaluated upon the methods aforehand described in section 2.4.

Therefore, firstly SPI is used to measure the output attained through actionable and objective measures in the social and environmental areas, for a holistic understanding of the improvements and indicators' analysis. Then, GapFrame is used to provide the prioritization in the matters to address while providing strategic tools for opportunities in the long-term. Lastly, the GRI is used to track the business' performance and support the decision making, while making sure all international sustainability requirements are met.

3. Circular Economy

This chapter presents the literature review regarding the Circular Economy with the background and context in section 3.1 and an explanation of the building blocks of such model in section 3.2.

Section 3.3 introduces sustainable packaging and its implications within circular economy followed by a demand characterization for sustainable packaging in section 3.4., in particular, natural sustainable packaging. In section 3.5 the drawbacks of using sustainable packaging are shown and the operationalization of circular economy is presented with industry examples in section 3.6. Section 3.7. presents the key performance indicators of a circular economy implementation and, lastly, a summarization of the evidences found, and conclusions are presented in section 3.8.

3.1. Background and Context

Currently, society's consumption stems a "linear take-make-dispose model" leading to scarcity of resources due to inefficient usage, hence being unsustainable (Ellen Macarthur Foundation, 2017). The depletion of non-renewable resources has caused severe ecological damages and social impacts (Ritzén and Sandström, 2017). Furthermore, several companies have realized the current "throwaway culture" is harming their businesses, as they are facing increased exposure to risk, higher resource prices, supply disruptions and price volatility (Ellen Macarthur Foundation, 2012). According to Korhonen *et al.* (2018), the solution for a sustainable development encompasses implementing a circular economy (from here on referred to as CE), through its four main building blocks (to be further described in section 3.2), as a paradigm shift grounded by nature's behavior, directly contributing to achieving the SDGs thoroughly explained in the aforehand chapter.

CE aims to "decouple growth from finite resource consumption" (Ellen Macarthur Foundation, 2017) and devises the three following main drivers (Costa, 2019):

1. Regulation (SDGs and the Paris Agreement, for example)
2. Eco trends for products' footprint reduction
3. Business opportunities, since the world economy is only 9% circular and there is the need to fill in that circularity gap using innovation as a tool

Despite several circular economy practices have started with the industrial evolution and, in 1976 Walter Stahel and Genevieve Reday outlining a vision for an economy in loops (Environmental Journal, 2018), the research regarding the concept itself is yet to be extensive (Korhonen, Honkasalo and Seppälä, 2018). Consequently, thus far, there is not a formal definition of circular economy being, however, the most accepted one posed by the Ellen Macarthur Foundation (2015), stating "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles".

Therefore, it comprises the three main principles that follow (Ellen Macarthur Foundation, 2015):

1. “Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows”

2. “Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles”

3. “Foster system effectiveness by reveling and designing out negative externalities”

To offset the current linear model and move to a “reduce-reuse-recycle” model, Ritzén and Sandström (2017) emphasize the importance of using the **four R-strategy** which refers to repair, reuse, recondition and recycle.

In addition, Beta-i, a main European player in entrepreneurship and innovation, further includes, in one of its articles written by Costa (2019), the rethink, reduce and recover steps. However, the main step is still missing, refuse, as most of the waste produced derives from consumption of useless products one does not need but still acquires, in particular, if it is uncharged.

Rethink refers to exploring alternatives and finding solutions at every level, such as new business models, whether it is by redesigning products to facilitate its recovery and recycling or by sharing products beyond singular ownership. AirBnB is a clear example of the latter.

Reduce is related to resources usage and buying of new products by, for example, “applying lean design principles” (Costa, 2019) to extend products’ lifespan. A good example is product manufacturing through 3D printing.

Repair already existing products is also vital, to extend it usage and thus reduce the need for new products. This can be done, for example, by only changing the product parts that can no longer be used, comparable to a bicycle with a flat tire.

Reuse products by giving them to a different user who can make more use of it, thus valuing the product we own. A good example can be second-hand markets which are gaining more presence worldwide, by the day.

Refurbish, or a similar word, recondition, refers to replacing the malfunctioning components of a product by new ones. In this way, the product can still be used for a long time.

Recycling is the most know concept within the circular economy model, where product components are discarded depending on which type of material they are made of, so they can be transformed again into new products.

Recover is an intrinsic concept, where the main goal is to make use the embedded energy of waste material instead of non-renewable energy. Therefore, money, energy and resources that otherwise would be wasted, can be used.

Despite these measures, implementing a circular economy worldwide requires a major paradigm shift and poses the foremost challenges of resources scarcity, environmental impact of actions and being able to grow economically while changing the current paradigm (Ritzén and Sandström, 2017).

Additionally, production, consumption, legislation and management changes, combined with innovation are intricate to achieve, yet crucial (Prieto-Sandoval, Jaca and Ormazabal, 2018). Such challenges lead to high complexity of implementation, hence carrying some barriers which are described in table 4.

Table 4 – Barriers for moving towards circular economy (Ritzén and Sandström, 2017)

Financial	• Measuring financial benefits of circular economy • Financial profitability
Structural	• Missing exchange of information • Unclear responsibility distribution
Operational	• Infrastructure/Supply chain management
Attitudinal	• Perception of sustainability • Risk aversion
Technological	• Product design • Integration into production processes

On the financial side, one of the main barriers to fully implement CE is the lack of investment (Ellen Macarthur Foundation, 2017) due to the fear of whether this paradigm shift will still be profitable, especially when changing from a product to a service-oriented economy (Ritzén and Sandström, 2017)). Moreover, it is further intricate to understand the extension of profitability when there are barely any measures for the abstract benefits circular economy can provide. However, according to Mckinsey & Company (2016), "a circular economy could generate a net economic gain of €1.8 trillion per year by 2030".

Regarding structural levels within organizations and business, the main issue is the amount of change a single department can handle, and due to CE complexity, it would require interdepartmental work, meaning there would be the need for more integration of functions. In addition, to move to a closed loop system, there is also the need to completely restructure the interaction within supply chain and the product and energy flows.

Despite the former, one of the biggest barriers is people behavior. When one is not fully aware of a concept and does not want to further develop its knowledge, it is clearly impossible to change a mindset and evolve, thus only showing inertia related to topics. In addition, if risk aversion is added, no progress is made as innovation is only achievable with risk taking, as they provide a creative climate (Ritzén and Sandström, 2017).

Lastly, in the technological area , there is a lot of concern on how new technologies work, how much they cost, how easy to use they are, and what the quality of the products will be.

When analyzing all five of the previous stated barriers, one can easily understand how the organizational changes required by circular economy are not yet explored enough and that sustainability needs to be further integrated in all levels of an organization, globally, locally and individually, in a partnership system, in order to be able to fully take use of its benefits (Ritzén and Sandström, 2017).

3.2. Building Blocks

The aforehand section 3.1. depicted the problem at hand and the urge of a circular economy implementation in order to ensure a sustainable development.

According to the Ellen Macarthur Foundation (2015), this implementation entails four key building blocks to foster the transition from the current linear economy to a circular:

1. Circular design of products
2. New business models
3. Reverse cycles
4. Enabling conditions

Circular design of products regards changing the way products are designed from single-use to being able to be re-used, recycled and transformed (cascading process). This also includes thoroughly choosing which materials are to be used, using standardization and modularization and finding applications for by-products and process waste (Arcadis, 2016). However, in order for this change to happen, companies need to acquire core competencies in circular design and advanced skills in material science and working methods to create a circular flow of production (Ellen Macarthur Foundation, 2015).

Being circular economy such a disruptive change, the implementation of new business models is needed to guide business through the transformation and seek innovation. The key change is moving from "property to performance driven earning models" (Arcadis, 2016), meaning consumers will no longer be property owner but users will, instead, therefore shifting the trend to reutilization, sharing and less need of products. Innovation, in particular in business models, will mostly be created by entrepreneurs seeking the circular economy benefits. However, major players in the market with significant capabilities will also take a leadership role in making a change, which is followed by other small businesses in distinct geographies, as the risks towards change will be fewer (Ellen Macarthur Foundation, 2015).

When addressing reverse cycles, material preservation is a key concept, where materials are collected and insert back into the production, thus reducing the input of virgin materials and waste during the process itself and creating the potential for better-quality downstream applications (Ellen Macarthur Foundation, 2015). The focus is on manufacturers, production structures, collection and treatment systems and end-of-life assortment, therefore, more efficient supply chains. It entails having third parties performing shared services for cost-efficiency, therefore, a global network cooperation is essential.

The last building block is enabling conditions for a widespread implementation of a circular economy. Therefore, the focus is shifted to education, collaborative platforms, financing, and a new economic framework that aligns with the aforehand mentioned changes (Ellen Macarthur Foundation, 2015).

3.3. Sustainable Packaging

Nordin and Selke (2010), interpreted sustainable development in packaging as "integrating the broad objectives of sustainable development to business considerations and implementing strategies that address social aspect as well as environmental concerns related to product/packaged systems, its entire life cycle throughout each stage of the supply chain".

As aforehand mentioned, the majority of products bought are packaged and, according to Costa (2019), 41% of all plastic production is used for packaging, being often considered as waste and, at the same time, a key player to achieve sustainable development (Sonneveld et al., 2005).

Product packaging devises, therefore, a crucial role when it comes to achieving a fully circular economy, demanding sustainable decisions from the sourcing of raw materials to its disposal (PWC, 2012). Consequently, new alternatives are needed (PAC NEXT, 2017), as the major challenge is being able to "protect and distribute the right product to the right end-user in a safe, cost-efficient and user-friendly way", in addition to preventing waste and providing safe use, with good balance among packaging and product itself (Grönman et al., 2013).

Driven by non-renewable resources shortage, increasing costs and lack of landfill space, efficiency of packaging to be able to compete for resources (Nordin and Selke, 2010) led to the best starting point for improving product waste, packaging, its carbon footprint and environmental damage - fully making use of eco-design - one of the main principles of circular economy (Svanes et al., 2010).

According to Svanes et al. (2010), four phases are needed to fully employ eco-design:

1. Establish sustainability context
2. Define sustainability issues
3. Assess
4. Act and receive feedback

In this way, designers can involve other stakeholders in the process and not just rely on a computer program or tool to tell them the most efficient way to design a product.

Following the first of eco-friendly design inspired by nature and its relations with the surroundings, the next step is to provide a sustainable packaging (Grönman et al., 2013). The Sustainable

Packaging Coalition (SPC) outlined the eight criteria below, for defining what sustainable packaging is (Sustainable Packaging Coalition, 2011):

1. Beneficial, safe, and healthy for individuals and communities throughout its life cycle
2. Meets market criteria for both performance and cost
3. Sourced, manufactured, transported, and recycled using renewable energy
4. Optimizes the use of renewable or recycled source materials
5. Manufactured using clean production technologies and best practices
6. Made from materials that are healthy throughout the life cycle
7. Physically designed to optimize materials and energy
8. Effectively recovered and utilized in biological and/or industrial closed loop cycles

Designing and manufacturing sustainable packaging might not be as simple as expected, as a trade-off between resources, cost and proper conditioning of the product/fulfillment of main requirements set by legislation often needs to be addressed (Grönman et al., 2013). Therefore, improvements of product/packaging life cycle throughout its entire supply chain are vital, embodying a cradle-to-cradle concept, while still ensuring the economic advantage (Nordin and Selke, 2010).

Implementing a cradle-to-cradle concept, expressing a circular economy, should include a proper Life Cycle Assessment (LCA), in particular, as increasing volumes of manufactured goods are produced and it is “imperative to establish that packaging does not add to the environmental burden in its own life cycle as well as that of the product it protects” (Lee and Xu, 2005).

Other drivers play key roles in achieving packaging sustainability, “such as consumer behavior, consumption trends, market segmentation and development in distribution” (Nordin and Selke, 2010). As an example, Lee and Xu (2005) express the results of a study carried out which reveals consumers are more concerned about product toxicity rather than packaging, emphasizing their lack of knowledge on sustainability, being the latter one of the major issues to achieve better sustainability packaging benefits for all stakeholders.

Accordingly, consumer demand, involvement and education regarding sustainable packaging innovation is key, as “consumers should be able to see sustainable packaging as a tool to assist their purchasing decision, to encourage minimization of packaging waste and ultimately to help promote sustainable consumption (Nordin and Selke, 2010).

Lee and Xu (2005), stress the existence of several types of packaging materials to be considered, such as biodegradable materials, bioplastics and intelligent packaging, supported by industry initiatives to implement the 3-R rule to packaging: reduce, re-use and recycle. However, these are not enough to prevent the increasing amount of packaging waste. Therefore, consumers are demanding “highly functional and personalized packaging” leading to packaging innovations in order to address this growing demand (PAC NEXT, 2017).

Consequently, the key to fully transition to a circular economy is being able to balance the consumer demand and perception with new technology and materials to provide more ecological packaging and reduce its waste (PAC NEXT, 2017).

According to PAC Next (2017), the success of packaging innovation is deeply related to long-term investment aligned with the collaboration of the entire value chain of the product (including the end-user), well-communicated objectives, willingness to address other stakeholder's needs, shift of policy landscape, stricter rules on material imports and increasing awareness regarding effects of climate change. Only with the aforehand aspects mentioned will it be possible to fully implement sustainable packaging within a circular economy and achieve zero packaging waste.

3.4. Demand Characterization

In order to understand the extension of what sustainable packaging can change within the implementation of a circular economy solution and its viability in the market, a characterization of the demand for such products was performed.

Therefore, understanding the full lifecycle of plastic use, from its production to its disposal is vital to optimize packaging environmental performance. Moreover, a market acceptance study was carried out in order to understand the demand for such type of packaging products and potential market value.

3.4.1. Plastic

Plastic production has been increasing since the start of mass production in the 1940s, having revolutionized how the 21st century challenges are met (Plastics Europe, 2016).

The European plastics industry has a yearly turnover of **350 billion EUR** (Polymer Properties Database, 2015), with over two-thirds of its plastic demand being centered in Germany, Italy, France, England and Spain, as these countries are five out of the seven most populated and largest countries in Europe (Plastics Europe, 2016).

In 2017, Europe, the 2nd largest producer of plastic materials, was responsible for almost 20% of the global production of plastic (**65 million tons**), as seen in figure 4, which had reached a volume of **348 million metric tons** worldwide (EEA, 2019; Plastics Europe, 2019). Moreover, this number is expected to triple by 2050, reaching over a billion metric tons (Statista, 2019).

Despite the vast amount of plastic being produced every year, it is extremely important to understand which industry segment is the main responsible. As shown in figure 5, packaging is the primary responsible in Europe, with almost 40% of the demand. Therefore, and as aforehand mentioned, it is critical to act within this segment, as it presents a bottleneck to the reduction of Europe's plastic production.

However, there is one important point to mention. Despite a continent being the major plastic manufacturer, it does not mean that it is also the biggest plastic consumer, as often factories are located in Asia for cost-saving purposes.

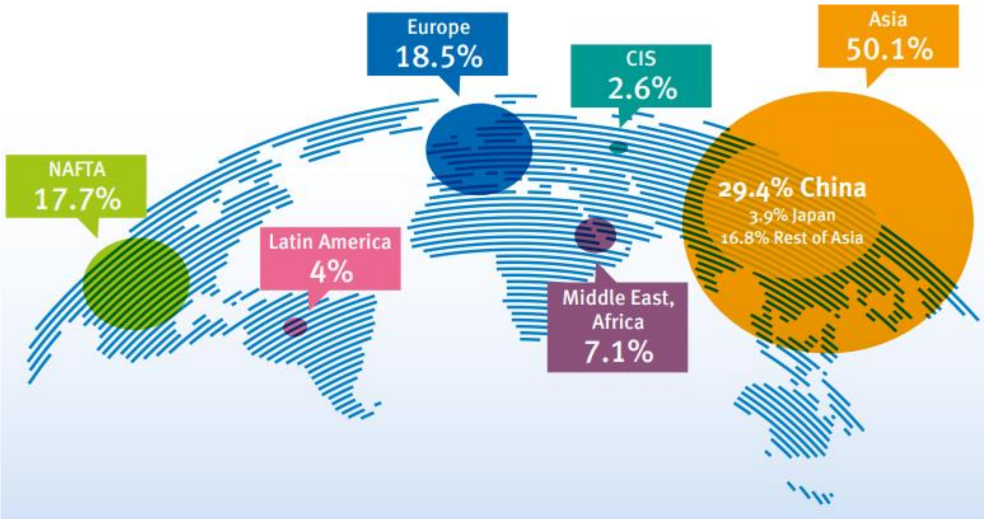


Figure 4 – Distribution of global plastics production (Plastics Europe, 2018)

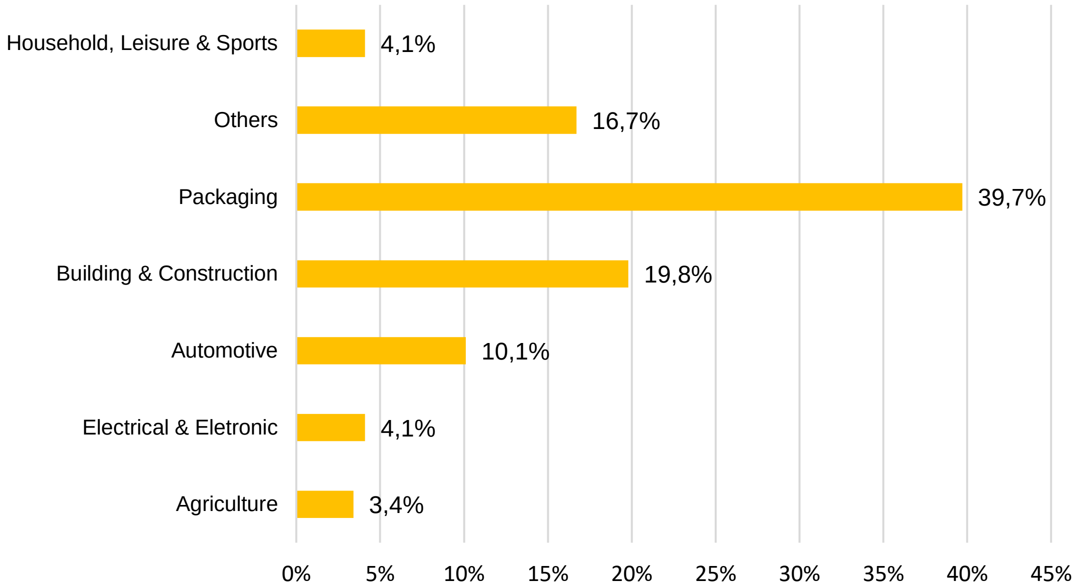


Figure 5 – Distribution of European plastics demand by segment in 2017 (Adapted from Plastics Europe, 2018)

3.4.2. Plastic Waste

The top twenty countries ranked in plastic waste mismanagement produce, per year, **26.5 million metric tons**, being most of them located in Asia (Earth Day Network, 2018).

Moreover, Asian nations contribute with the majority of plastic pollution, clogging water ways that lead to major rivers, with eight out of ten of the most plastic polluted rivers in the world located in this continent (WEF, 2018).

In 2018, the European Commission stated that Europeans generate **25 million tons of plastic waste**, per year. As Europeans produce just about 10% of the world plastic waste, and the top twenty most polluting countries in this sector are mainly located in Asia and Africa, worldwide plastic waste is well over **250 million tons**. It means that over 70% of all produced plastic is considered waste.

The World Economic Forum (2019) states that every year, **78 million tons** of plastic packaging are produced, which is in alignment with the information retrieved from figure 4. Moreover, as Europe is responsible for about 20% of plastic demand, it is considered that in Europe, yearly, **15 million tons** of plastic packaging are produced.

Through this alarming amounts of plastic production, and to understand the magnitude and supply chain of this production, it is necessary to quantitively track the plastic packaging flow, starting with its sourcing, moving towards the production and, lastly, its disposal options.

Therefore, figure 6 portraits the plastic packaging flow in 2013. Moreover, natural sustainable packaging intends to reduce at its maximum, the amount of plastic packaging production, which will also eliminate the need for end-of-life options such as landfills, incineration and prevent leakages of hazardous products to the soil and sea.

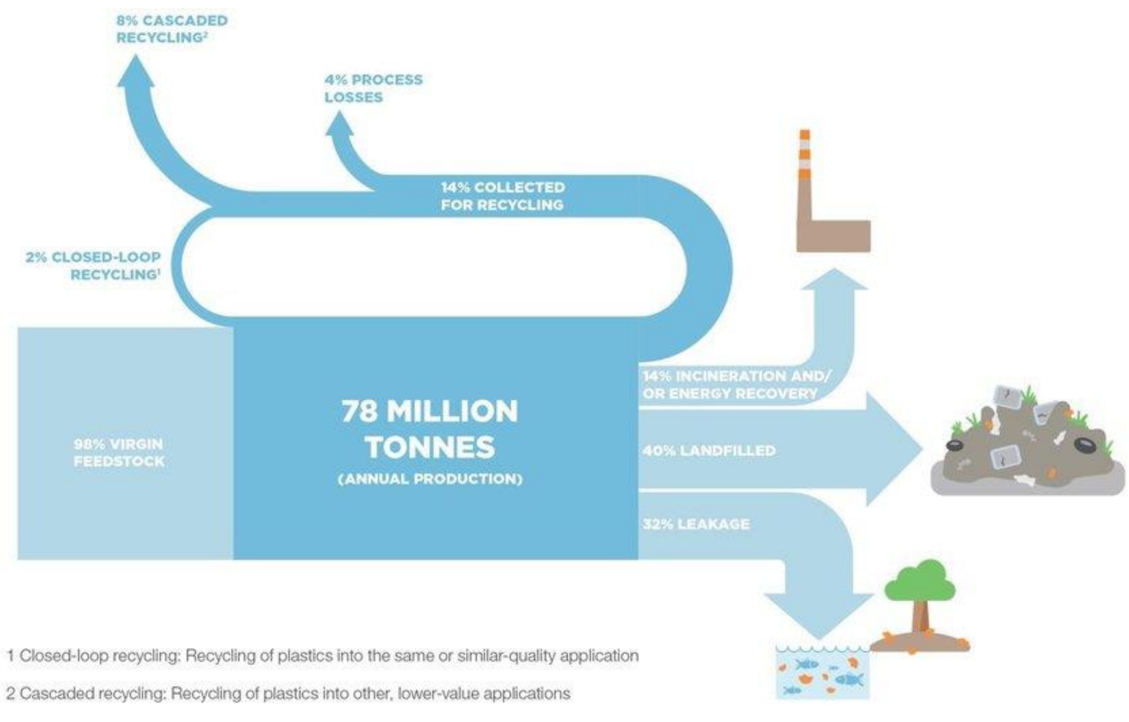


Figure 6 – Global flows of plastic packaging materials in 2013 (Ellen Macarthur Foundation, 2017)

3.4.3. Market Acceptance

As aforehand mentioned, the awareness of need for changing habits has been increasing in the past years, and packaging has become “the store front, experience service and product for direct-to-consumer or D2C brands. It replaces the store as the place where an emotional relationship is made and reinforced every time with the customer” (Raconteur, 2019).

As the spending power of millennials (largest demographic in the workforce) increases and digital technologies rise, consumers behavior and habits also change, becoming more influential with time and demanding expectations to be met (Environmental Journal, 2018).

Currently, the global packaging market is worth around **500 billion EUR**, being food and beverages packaging the main uses for packaging production (BASF, 2016) and, according to Raconteur (2017), “Consumers want packaging that helps them become more sustainable, even if it costs more – now brands must respond”. Moreover, a study performed by BillerudKorsnäs, a leading developer of sustainable packaging for consumer goods, states that 3 in 4 consumers worldwide say they are willing to pay for sustainable packaging, in particular, if it increases profitability for brands while reducing their environmental impact (Raconteur, 2017). This is the case for Europe as well, and figure 7 shows the customer’s willingness to pay more for sustainable products in the European countries with the most plastic demand.

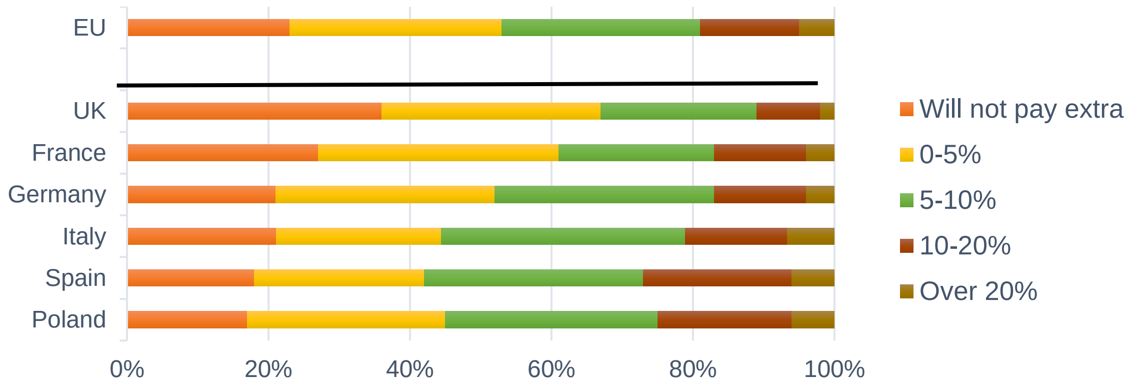


Figure 7 - % of consumers willing to pay more for a product if it means that the packaging has less impact on the environment (Adapted from Raconteur, 2019)

As a consequence of the previously mentioned statistics, companies are now forced to rethink their business for sustainability, materials and processes, environmental impact and recyclability of products (Environmental Journal, 2018), since “Eco-friendly packaging is becoming a ticket to the game, rather than just being a game-changer” (Raconteur, 2019). Therefore, more and more the issue becomes how to create a cost-competitive supply chain that meets the clients’ demands and is sustainable from cradle-to-cradle, as products more sustainable will provide greater competitive advantage (Environmental Journal, 2018).

It is not easy to redesign such a supply chain, however, the long-term benefits are tremendous, as “Making your brand differentiate with sustainability benefits in packaging will have quick impact in

Asia today, and will happen shortly in Europe and the US, so brands have to start taking action now", leading to the urgent drive to adopt circular economy practices (Raconteur, 2017).

An example of this fast-pace change is the fact that 50% of European consumers have already changed brands over packaging and, other 50% support taxation on packaging as a way to force brands to adopt eco-friendly alternatives, having only 7% of consumers objecting (Raconteur, 2019). Therefore, the feeling of sustainability is becoming intrinsic for consumers leading brands to do exactly what they want in order to stay profitable and running.

The point being made is that buying cheap and convenient products made from non-eco-friendly materials is not enough for companies to survive, as they will lose customers over that decision. Companies must then invest in natural material products, which are definitely more expensive, but will allow them to keep or increase their customer base. Moreover, the companies that are willing to put in the effort to change will take advantage of a "halo effect", as "Moving from plastic to cartons can help reposition a brand towards the premium end of the market", for example (Raconteur, 2019).

A survey performed on the consumers' preferences for each type of materials shows that plastic consumers are mostly interested in lightweight packaging, easiness to store and robustness, all factors that are also provided by sustainable alternative packaging solutions (Raconteur, 2017). Therefore, sustainable packaging companies must strive to offer similar product characteristics in order to acquire more customers in the long-term.

However, despite consumers' influence, "The average consumer still has little awareness of the early stages of the supply chain, so positive consumer behavior cannot be relied on to absorb the cost. The initiation of greening early-door secondary supply chains will therefore likely come in the form of tax breaks and other incentives" (Raconteur, 2019). Moreover, according to Raconteur (2019), the following are the 5 major consumer barriers for purchasing of environmentally sound products:

1. Greater cost (44%)
2. Lack of environmental awareness (33%)
3. Lack of awareness, knowing what is/is not environmental (31%)
4. Lack of information (29%)
5. Lower quality (25%)

3.5. Natural Sustainable Packaging Drawbacks

Transitioning from plastic to natural sustainable packaging alternatives provides major benefits for the environment. This transition is not, however, without a few drawbacks, which are listed in the following sub-sections 5.5.1 and 5.5.2.

3.5.1. Shelf Life

As great as sustainable packaging is for the environment, a major drawback, compared to plastic or other unsustainable packaging materials is the product's shelf life.

Understandably, natural materials tend to have a shorter life span than other materials, in particular plastic, which takes over 500 years to decompose into microplastics (Ecoware, 2019). For this reason, the shelf life of plant-based packaging products is shorter.

Ecoware's products, as example, last between 18 and 24 months, if stored currently, which is also recommend to all the other packaging materials in order to safeguard the properties of the products being protected. This is not, however, something turning plant-based packaging into a worst option than oil-based packaging, as 24 months is still a long time and a significant portion of the products using natural sustainable packaging are food products having, therefore, shorter shelf lives than other types of products. Moreover, despite smaller shelf life, these natural materials work just as well as plastic, with the benefit of not leaking hazardous substances to food, in particular, in food packaging (Vegware, 2019).

Therefore, the main idea to retrieve is the need to properly store all products, despite its material, having to pay closer attention to the needs of plant-based materials.

3.5.2. Composting

Just like plastic, it is not enough to use better materials, knowing how to recycle them plays an even bigger role when it comes to sustainability and environmental footprint. For example, if a plastic water bottle is bought, after its use it must be collected, so it can be either recycled, landfilled or incinerated, being landfill the least used option nowadays.

With natural sustainable packaging the same must happen, the packaging itself must be collected so it can be properly disposed of. Therefore, in order to make sure the packaging is being composted, it must be sent to commercial or industrial composting facilities, as these provide the correct conditions for the decomposition of the packaging, creating then a compost that is good and nutritious for the soil and can be used for distinct purposes.

Whether a material must be sent to commercial or industrial compost, or can be home composted instead, depends on the manufacturing guidelines, as different products and materials will have different composting needs.

In order to meet the European composting standards, the products must (Ecoware, 2019):

1. Biodegrade 100%
2. Biodegrade into completely non-toxic by-products
3. Biodegrade within 90 days

The label "compostable" requires specific collection and composting conditions (Amcor, 2019). Hence, the optimal conditions to achieve the previous standards are mostly found in commercial or industrial composting, as not being able to be achieved through home composting, as it requires “high temperature (on average 65°C), sufficient moisture and air, and the right population of microorganisms to chew down the waste” (Ecoware, 2019).

However, there is a common misconception on what biodegradation and composting actually mean, being wrongly used interchangeably. Both have the same process, but distinct breaking down speeds. Compostable “means that packaging can break down in under 12 weeks in composting conditions and is, therefore, suitable for industrial composting”, with biodegradable products taking tremendously more time to break down (Vegware, 2019).

A significant problem of the need of special composting conditions is that most people and country areas do not have the accessibility or are not equipped with these necessary conditions, hence the products will be sent to landfill or incineration, which will cause them to not decompose. However, even if this is the waste management route these sustainable packaging products take, a significant amount of emissions is still saved, as the packaging material is plant-based which does not happen with the traditional oil-based packaging (Ecoware and Vegware, 2019). Figure 8 presents the problem with obtaining better disposal needs.

For Portugal, in particular, only 3% of urban waste goes through organic valorization after collected, with 32% being sent to landfills and 21% incinerated (APA, 2019).

A point to emphasize is that compostability is not the best option for all cases (Vegware, 2019) and, in the cases where composting is not possible, these packaging should be disposed of through general waste where, if sent to incineration, energy will be produced, with PLA producing more heat than newspapers, wood or even food waste, leaving little residues and giving off fewer toxic gases. In case it is sent to landfill, compostable packaging is inert, not giving off methane (Vegware, 2019).

As end-of-life solutions alone are not enough to move us toward sustainable packaging production, the packaging systems themselves have to be redesigned, in order to use the least amount of materials and energy, maximize the recycling content and also increase the potential for reuse (Clean Metrics, 2019).

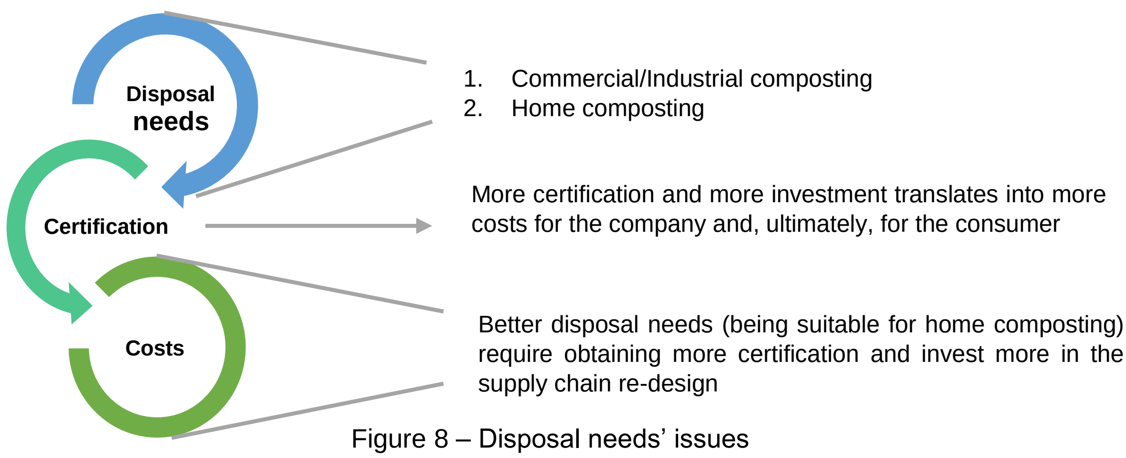


Figure 8 – Disposal needs’ issues

3.6. Circular Economy Operationalization

Despite circular economy being a fairly recent concept and the existing relevant research regarding this topic being reduced, many companies have already given the first steps towards making the change to shift the current waste paradigm, as they realized stakeholder and consumer demands' can be viably met, in the long-term, while still addressing sustainability issues (Sonneveld et al., 2005).

"Producers want to ensure their packaging decisions to meet consumer demands for performance, cost savings and sustainability also do not have unintended consequences" (PAC Next, 2017). Therefore, developing sustainable alternatives for current packaging possibilities is of significant impact in a supply chain, as every product is packaged, either for protection or appearance purposes (Lee and Xu, 2005).

Having aforehand thoroughly discussed the principles, building blocks, barriers and the ability to implement a circular economy, section 3.6.1. will provide a clearer vision of circular economy solutions' implementation in product packaging. Three distinct real cases will be presented in section 3.6.2, being each one referent to a specific building block previously discussed.

3.6.1. Packaging Examples

In section 2.3 a wider view of current sustainable packaging options, in addition to other positive solutions, was provided, to present the basis to understand what can be achieved regarding SDG achievement efforts.

As "CE practices and related business can help achieve several of the SDGs' targets" (Schroeder et all, 2018) by directly and indirectly contributing to the achievement of twenty-one and twenty-eight targets (out of one-hundred and sixty-nine, 169), respectively, it is of extreme importance to be able to relate the implementation of these CE practices with specific SDG targets, and the overall goals themselves.

Table 5 gathers further examples of sustainable packaging solutions, in alternative to plastic or other unsustainable material options. These companies were chosen as they fully represent innovative solutions with significant impacts, in addition to clearly displaying its connection to, at least one, specific building block of circular economy.

The Ecovative solution relates to circular design as it utilizes raw material (mushrooms) to produce compostable packaging, meaning its nutrients will go back to the soil for regeneration, providing no material waste (Ellen Macarthur Foundation, 2019).

Replenish imposes a new business model, as it innovates form the regular buying of thousands of plastic bottles to a new concept of only buying the essential in the product, which is the liquid concentrate (Ellen Macarthur Foundation, 2019). As such, consumers face more conscious buying choices and the fact that most of the product is kept at home disrupts the current retail business models.

The reformulation of Coca-cola Enterprises processing facilities encloses the reverse cycles building block as its collecting and reprocessing innovation in the process allows for re-use of what else would be waste and thus, reducing the need for virgin materials. On the other hand, it also includes enabling conditions as it plays a role in education of the population and collaboration with other entities to be able to increase transparency and overall achievement of the implementation of circular economy and fully taking advantage of its benefits (Ellen Macarthur Foundation, 2019).

Table 5 – Real examples of ecological packaging solutions and its impact

Company	Solution	Impact	Building Block
Ecovative	Packaging made of mushroom mycelium (vegetative part of a fungus) grown in and around agriculture by-products with low economic value, which can be composted at the end of use	• Re-use of agriculture feedstock waste • Reduction of product cost	Circular design
Replenish	Packaging platform for liquid concentrates: reusable bottles are attached directly to a concentrate refill pod, since in a typical bottle of cleaner, only less than 10% is actually valuable ingredients, the remaining is water	• Durable bottle, conserving valuable resources; • Less energy usage; • Less plastic waste produced; • Reduction of 80-90% of CO2 emissions; • Cheaper alternative in the long run	New business models
Coca-cola Enterprises	Plastic reprocessing facility for collecting and reprocessing plastics as a joint venture with ECO Plastics, to maximize the usage and value of the plastics used in a bottle production	• Reduction of 25% of material used by 2020; • Usage of more renewable content • Reduction of 33500 tons of CO2 produced per year	Reverse cycles; Enabling conditions

3.7. Circular Economy's Key Performance Indicators' Analysis

"Until now, there has been no established way of measuring how effective a company is in making the transition from 'linear' to 'circular' models, nor have there been any supporting tool" (Ellen Macarthur Foundation, 2015).

Having aforehand stressed the urgent need to implement the circular economy concept, it is now important to understand how to assess the progress of such execution. In order to do so, methods of measurement, such as key performance indicators, or KPI, are needed, to support internal decision making or investment choices.

Businesses “are finding circular processes and products can reduce costs, enhance customer and employee relationships, differentiate from competition and spur innovation” (WBCSD, 2018). Therefore, they want to measure how far into circularity they are, due to five main reasons:

1. Drive business performance or strategy
2. Justify achievement externally
3. Integrate circularity across the business
4. Manage risks associated with the existing linear business model
5. Know the impact of their circular activities

However, measuring this progress is nothing short of difficult and challenging as “these different uses will require different types of metrics, based on different sets of data” (Ellen Macarthur Foundation, 2015). These measurements depend on the objective, scope and audience of circular economy adopters. Therefore, several different frameworks have emerged with companies often adopting their own framework (WBCSD, 2018).

In order to have a universal framework to measure circularity achievements, the Ellen Macarthur Foundation (2019) has developed the *Circularity Indicators Project* which consists of a methodology and tools for businesses to assess their progress. Some of these indicators measure material circularity – its main indicator-, how restorative the material flows are and impacts and risks (Ellen Macarthur Foundation, 2019).

Ultimately, measuring circular economy implementation is a continuous effort. However, to be able to compare the progress amongst businesses, it is important to have a standard measure and, therefore, moving forward to a standard use of the Ellen Macarthur’s methodology and tools is just a matter of time, as “Companies increasingly see opportunity in Circular Economy business models, which allows them to capture additional value from their products and materials, and mitigate risks from material price volatility and material supply” (Ellen Macarthur Foundation, 2019).

3.8. Chapter Conclusions

The current take-make dispose linear system is rapidly endangering our planet as resources are rapidly depleting due to its main sources being non-renewable materials and energy. This unsustainable resource utilization must be changed, and the solution is implementing a circular economy which is restorative by intent and design, guided by Earth’s systems and making use of technical and biological cycles.

A pre-requisite to SDG targets' achievement is implementation of a circular economy, as it provides a disruptive approach to the major issues currently affecting society, being them developmental or environmental, mainly related to resource's overconsumption. Therefore, CE is able to completely change businesses and provide simple approaches to problems by using Earth's interactions as a guideline. However, not all pressing issues are going to be solved through this implementation as most SDG targets are not related to CE, but to efficiently implement the transition, knowledge sharing, capacity building, technology development, sources of financing, innovation and multi-stakeholder partnerships are needed.

Despite the gains outweighing the effort and risk, fully achieving this transition is no simple task. Therefore, the transition must be supported by a cleaver leveraging of circular economy's building blocks, as a successful implementation depends on it.

The particular case of implementing sustainable packaging alternatives through circular economy is still a topic of minimal research with feasible results, as only a few companies worldwide actually supply these options. Moreover, the consumer's lack of knowledge regarding sustainability is still a barrier for sustainable packaging alternatives.

However, the companies that have kept striving for change are beginning to transform the packaging industry and are ready to collect major results from the disruptive change, which is multiplying day by day.

4. Research Methodology

The current chapter describes, in detail, the research methodology chosen to attain the goal of this dissertation. The methodology employed encompasses both a qualitative and quantitative analysis, as the former allows for in-depth understanding of a particular aspect while the latter supports the generalization of results from a sample (ATLAS.ti, 2019).

The research methodology comprises several distinct research methodologies and strategies, which combined, led to obtaining a final solution proposal that connects circular economy with the sustainable development goals. Consequently, the research methodology entails a literature review, case-study analysis, swing weighting methodology, semi-structured interviews and a quantitative analysis.

Figure 9 illustrates the timeline of the employed methodologies to achieve the final proposed solution, followed by a detailed explanation of each step.

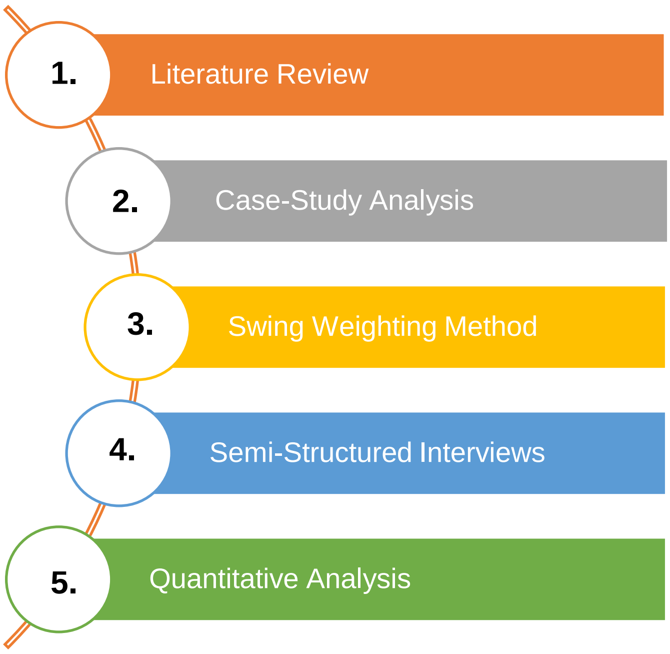


Figure 9 – Research methodology employed

4.1. Literature Review

First, a comprehensive literature review to devise a knowledge foundation by facilitating theory development and uncover further investigation needs was undertaken (Webster and Watson, 2002).

The literature review carried out intended to understand what has been done, establish the context of the topic being studied, identifying main methodologies and data collection tools, as well as having a body of knowledge to relate this research findings with (Heart, 2018). Furthermore, and in particular, it aimed to understand the relation between SDGs and circular economy, in addition to the current issues each one conveys.

The latter, being considered an economic system, and the biggest contributor for the innovation intended to achieve through the work at hand, has smoothed the finding of a more academic research in parallel with significant work from foundations and organizations, with focus on the Ellen Macarthur Foundation which works solely on CE implementation. Therefore, table 6 systematizes the sources of information retrieved related to this regenerative approach to economy, including the particular case of packaging

Table 6 – Sources for circular economy literature review

Academic Papers	Foundations and Organizations
Grönman et al. (2013)	Ellen Macarthur
Korhonen et al. (2018)	Packaging Europe
Korhonen, Honkasalo and Seppälä (2018)	Sustainable Packaging Coalition
Lee and Xu (2005)	WBCSD
Nordin and Selke (2010)	**Consultancy Reports**
Prieto-Sandoval, Jaca and Ormazabal, 2018	Arcadis (2016)
Ritzén and Sandström (2017)	Mckinsey & Company (2016)
Schroeder et all (2018)	PAC NEXT (2017)
Sonneveld at al. (2005)	**Websites**
Svanes et al. (2010)	(RE)THINK

4.2. Case-Study Analysis

“Case study is an ideal methodology when a holistic, in-depth investigation is needed” (Tellis, 1997). Moreover, it is used to discover details from different data sources and answer questions such as “why” or “how”, as part of an exploratory research to generate theory (Yin, 2003).

According to Research Methodology (2019), performing a case study analysis entails several advantages such as “data collection and analysis within the context of phenomenon, integration of qualitative and quantitative data in data analysis, and the ability to capture complexities of real-life situations so that the phenomenon can be studied in greater levels of depth”. However, as it targets the analysis of specific issues within boundaries, it also leads to data analysis challenges and lack of rigor (Research Methodology, 2019).

Despite its limitations, the methodology allows for the connection of theory and field investigation, with a based generalization of particular cases (Tellis, 1997). As such, a case-study analysis methodology was the selected methodology, focusing on the analysis of companies working with natural materials, preferably in the sustainable packaging industry.

This case-study analysis had the main goal of collecting information regarding materials and companies in the sustainable packaging industry to use as benchmark for the decision of the most suitable packaging option.

The first step to collect data was performing a thorough research on natural materials used for packaging, which retrieved several results. Upon information systematization, 9 distinct materials were chosen, and a more attentive research was employed on these materials, focusing on material characteristics, advantages and disadvantages, production and waste quantities and relevant data regarding the use of packaging made from these materials.

Moreover, research on companies working with such materials was the second step of data collection. Several results were retrieved which required an initial assessment. From these results, thirty-five companies were selected as they were the most relevant for the dissertation, meaning these companies sell sustainable packaging for Europe and other continents being, therefore, possible candidates for partnerships to introduce natural sustainable packaging in Portugal, as Europe is where some the most innovative projects related to sustainable packaging take place (100Bio, 2019).

Consequently, these companies are the sample analysis present in table 7, which systematizes the most common materials these companies currently work with, allowing the understanding and quantification of which materials are the most used in the sustainable packaging industry.

Table 7 – Companies information systematization

Company	Bagasse	Bamboo	Banana Leaf	Cassava	Coconut	Mushroom	Palm Leaf	PLA	Seaweed
1	x	x		x				x	
2									x
3									x
4							x		
5				x					
6								x	
7	x						x	x	
8	x						x	x	
9	x								
10	x							x	
11				x					
12	x	x						x	
13	x								
14						x			
15	x	x						x	
16					x				
17	x								
18	x						x	x	
19									x
20								x	
21	x						x		
22								x	

23							x		
24						x			
25			x						
26							x		
27	x						x	x	
28									x
29								x	
30									x
31				x					
32					x				
33	x							x	
34				x					
35	x						x	x	
Total	14	3	1	5	2	2	9	14	5
Total (%)	**40%**	9%	3%	14%	6%	6%	**26%**	**40%**	14%

4.3. Swing Weighting Method

For the intended solution to present in this dissertation, several materials were selected to be further investigated and compared amongst each other, in order to find the best packaging material.

Despite swing weighting having higher probabilities of error values when compared with other similar methods, it allows for better comparison of quantitative inputs, which were the preferred inputs for this dissertation. Therefore, swing weighting is a better method to use in this particular case (Goodwin & Wright, 2004).

The used of this method intends to obtain a Global Index (GI) which will indicate what the best material alternatives are, considering the preferences of the decision-maker regarding specified criteria, accessing the relevance of each criterion through questions on a comparison process. In order to develop this indicator, it was necessary to choose one or multiple decision-maker(s) (from here on referred to as DM) and the criteria to be accessed.

It was decided to have each of the interviewees posing as the decision-maker (DM) to reduce the subjectivity involved in the coefficient calculations, as distinct companies face distinct challenges and realities. Consequently, on the 13th of September, a skype call with all the interviewees was performed in order to assess the weights for the selected criteria.

From the distinct types of material found, a decision on the most relevant materials to further investigate must be made. In order to do so, the following criteria was chosen, due to its relevance for the solution intended to achieve:

- **Material quantity of waste generation**, being evaluated in tons of material waste or if it is infinitely available, meaning there is more waste than can ever be used or the material can be infinitely grown

- **Frequency of use** in sustainable packaging companies, evaluated by the number of times the material was used by the companies in the study sample
- **Diversity of product portfolio able to achieve**, evaluated by the percentage of product types being sold by the companies in the study sample, being product types bowls, cutlery, plates…

The following procedure was employed to generate the GI:

1. **Creation of a value function** – Identification of the most and least preferred scenarios and also an intermediate one in order to guarantee a universal scale so the criteria values can be evaluated upon, as each criterion is evaluated in an individual scale that differs from the others

2. **Weighting methodology** – Swing weighting method to obtain weights for the selected criteria

3. **Calculation of final scores –** Calculation of the indicator score for every alternative

Value function

To create this function, the DM decided on best and worst scenarios for the criteria, as well as an intermediate scenario, that was equidistant to both the previous scenarios. The decision value points were all attributed based on collected data regarding the materials (here referred to as alternatives).This method was chosen as a way to transform all the values in each criterion into one single comparable scale so they can be directly equated without violating the swing weighting method rule that all data has to be expressed in the same unit to be applicable. Therefore, it becomes an important step to achieve a good indicator, which would not be able to achieve otherwise.

Consequently, the best, intermediate and worst scenarios were given 100, 50 and 0 points, respectively, being represented in tables 8, 9 and 10.

Table 8 - Value function of frequency of use indicator

Value (points)	Frequency of use (%)
100	40
50	20
0	0

These values where decided by the DM based on the percentage of companies that currently use the materials being investigated, which is represented in table 7.

Table 9 - Value function of waste generation indicator

Value (points)	Waste generation (ton)
100	Unlimited
50	8
0	0

This result was drawn from the DM decisions, being the best scenario considered the one in which waste generation will always be superior than demand. The worst scenario happens when no waste is generated being, therefore, impossible to use for production of sustainable packaging. The intermediate scenario defined by the DM was chosen according to the current waste generation values of the materials being analyzed, as what is intended is to reflect on the more materials relevant to further investigate based on real current values.

Table 10- Value function of portfolio indicator

Value (points)	Portfolio (%)
100	80
50	40
0	0

Here the values were once again attributed by the DM based on the percentage of portfolio products used by the companies in work sample.

Weighting methodology

Firstly, all the alternatives of one of the selected criterion are considered to be on their worst possible levels, being the reference scenario. Then, the DM identifies which criterion he/she considers to be the most relevant, meaning the one which the swing from worst to best will have the most impact, giving it 100 points. Following, the DM is asked to perform the same activity, leaving out the criterion already chosen. For this, fewer points will be awarded with the process continuing until the criteria has points attributed.

The same process is completed for each criterion, as the most relevant swing will be chosen first, being attributed 100 points, with the rest of the criterion swings being compared to this first one and attributed points (from 0 to 100, excluding 100). This will culminate in a decrescent order of criterion relevance for the DM.

It was then accessed that the non-normalized weights (w_i) associated with each indicator were ordered as follows:

$$w_2 > w_1 > w_3$$

The next step was questioning which weight to attribute to the swing from worst to best on criterion 1, regarding the swing from worst to best of criterion 2. The DM decided the suitable weight was 90 points.

The same question was posed regarding the swing from worst to best in criterion 3 comparing to the swing of criterion 2, which was given a weight of 75 points.

Therefore, the non-normalized weights for indicators 3 and 1, respectively, are as follows:

$$w_3 = \left(\frac{90}{100}\right) w_2$$

$$w_1 = \left(\frac{75}{100}\right) w_2$$

Consequently, the normalization of the weights was performed, to the sum is 1. This calculation is represented by equation (1):

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}, \forall\ i = 1,2,3 \qquad (1)$$

Where:

w_i: Points of criterion i on the non-normalized scale

W_i: Weight of criterion i normalized

To conclude the process, the swing weights must be normalized so they can sum to 1 (Goodwin & Wright, 2004; Mustajoki, Hämäläinen and Salo, 2005).

Upon using equation 1, the following results were obtained, which are summarized in table 14:

$$W_1 = \frac{75}{(75 + 100 + 90)} = 0{,}28$$

$$W_2 = \frac{100}{(75 + 100 + 90)} = 0{,}38$$

$$W_3 = \frac{90}{(75 + 100 + 90)} = 0{,}34$$

Calculation of final scores

In order to calculate the indicator that will allow the calculation of the material alternatives' scores equation (2) was employed:

$$V(GI) = \sum_{i=1}^{3} W_i\ v_i(GI) \qquad (2)$$

Where:

V(GI) : Represents the value of the indicator

v_i (GI) : Represents the partial value of the indicator

being v_i (best) = 100 and v_i (worst) = 0

W_i : Represents the normalized weight

being $\sum_{i=1}^{2} W_i = 1$ and $W_i > 0$ (i=1, 2, 3)

For every material alternative, a value v_i will be attributed to each criterion, so a final score can be attributed for that specific alternative.

4.4. Semi-Structured Interviews

Despite already existing several companies in the natural sustainable packaging industry segment, a limited amount of information is available regarding the specificity of the business and its practical approach. Therefore, and in order to obtain relevant data to pursue this study, semi-structured interviewing was the strategy chosen, being one of the "most common forms of qualitative research" (Mason, 2002).

Semi-structured interviews are based on pre-defined questions, mostly open-ended and hypothesis-directed, which will guide the interviewer (Flick, 2009). As semi-structured, flexibility is key to obtain the interviewee's perspective, providing a foundation for interpretation of significant findings and generation of hypotheses to be further supported by quantitative studies (Flick, 2009). Moreover, semi-structured interviews allows interviewees to answer questions based on their current knowledge and theoretical presuppositions.

Nevertheless, despite exploring subjective topics, this type of research strategy allows the validation of the collected empirical material.

However, in order for the interviews to occur, an interview guide must be written, containing open, hypothesis-directed and confrontational questions (Flick, 2009).

4.5.1. Interview Guide

The interview guide elaborated considered the information needed to introduce natural sustainable packaging options in Europe, leading, therefore, to a circular economy business.

The questions composing the interview guide are subsequently explained, grouped according to the main interest areas encountered: challenges, logistics and costs.

- **Challenges**

  In order to understand the viability and the struggle to provide natural sustainable packaging options, it is important to be aware of the main challenges companies already operating in the sector face, so future issues can be prevented while setting up the business model.

  1. Why did you choose to work with this material? What are the disadvantages?

2. What do you think is the potential for entry in the packaging market?
3. What are the entry barriers?
4. What are your main challenges?
5. How do you differentiate from your competitors?
6. How easily do you find customers? Why?

- **Logistics**

  To understand the extent of the needed resources to set up the business, logistic issues must be known, particularly when the intended packaging is related to food packaging having, therefore, specific laws and guidelines to be followed. Therefore, questions regarding warehousing times and needs, production, material's location and treatment must be understood.

7. How do you obtain your raw materials?
8. Are these materials easily found? Why?
9. Do you license the product or produce it yourselves?
10. Where are your production factories located?
11. What is your production capacity?
12. What is your lead time?

- **Costs**

  Lastly, despite the focus on sustainability and circular economy, a major part of the feasible supply of the packaging alternatives rely on costs and on what it entails for the supplier, distributor and consumer.

13. What are your material costs?
14. What are your transportation costs?
15. What extra costs do you have?
16. How do you transport/send the product to final customer?

4.5.2. Interviews

In order to obtain collect information regarding distinct businesses and achieve a more complete information collection of the industry, it was decided to contact the sample of companies previously stated in table 7.

All 35 companies in table 11 were emailed twice and, out of these, 5 replied positively, allowing the interview. The interviews were performed via skype call, except with company 19, which took place via email exchange.

Table 8 summarizes the information regarding the interviewee and the company, showing that most interviewees hold important managerial or foundation roles within the companies, guarantying the validity and reliability of the information collected, as all had deep knowledge regarding the processes and materials.

Table 11 – Interviews information

Company	Interviewee	Position	Date
15	I1	Spanish Distributor	05/08/2019
34	I2	Managing Director	06/08/2019
1	I3	President	06/08/2019
24	I4	Owner	29/08/2019
19	I5	Creative and Marketing Manager	30/08/2019
35	I6	Portuguese Distributor	05/09/2019

To better understand the companies' business model and to better conduct the interview, research on each one of the companies was performed prior to each interview, being all held via skype, as almost all of the interviewed companies do not have a head office or distributer located in Portugal.

Data collection through interviews encompasses three stages: recording the data, editing it, and "constructing a new realty from the produced text" (Goodwin & Wright, 2004). Consequently, notes were taken during the interviews with posterior systematization of the former combined with information collected from the companies' websites, brochures and catalogs sent for further analysis.

4.6. Quantitative Analysis

As further assessment of the materials previously selected is needed, KPI drawn from the three pillars of sustainability, environmental, social and economic, will be used, in order to ensure the most sustainable option is chosen.

Therefore, a price assessment comparation amongst the three materials was performed, to clarify the prices amongst materials, and products within each type of material, hence portraying the economic pillar. Moreover, the environmental pillar is represented by the CO_2 emissions assessment of the transportation routes of the company's manufacturing sites towards Portugal, where the products are intended to be delivered.

In this section, a quantitative analysis of the unit cost of packaging products made from each type of material is presented, as well as a quantification of the CO_2 emissions from transportation of such products from manufacturing sites in Asia to Portugal.

5. Natural Sustainable Materials

As aforehand mentioned, the goal of this dissertation is to decide, upon the results obtained, the best natural sustainable packaging options to substitute plastic packaging, in Portugal.

To do so, research regarding the entire packaging lifecycle is essential, mainly across the material sourcing, production, transport, recyclability and reusability (1 Million Women, 2019).

The current chapter focuses, therefore, on the gathering of data to support the decision making. Section 5.1. presents individual material characterization, for each of the selected natural materials with a systematization of the information. Section 5.2. provides the results of the alternatives' analysis followed by the interviews findings in section 5.3. Subsequently, using the information collected, a quantitative analysis of the prices and CO_2 emissions is employed in section 5.4. with chapter conclusions presented in section 5.5.

5.1. Raw Materials

The current section presents, in detail, information regarding distinct natural sustainable materials suitable for packaging which was collected through case-study analysis of current options already being implemented in the industry, having aforehand being presented in table 7. Moreover, these materials can be composted after the product's end-of-life reducing, therefore, its ecological footprint.

As all the investigated materials are natural raw materials, several impactful benefits are obtained, as they are renewable, sustainable, biodegradable and not toxic, therefore, there will not be any chemicals transferred to food and the carbon footprint of manufacturing can be up to 75% lower than usual plastic manufacturing (Green Home, 2008).

5.1.1. Bagasse

Sugarcane plants are often used for sugar production. For this to happen, sugarcanes are squeezed, being bagasse the residual fibers (Green box, 2019). Bagasse can be identified as a by-product or waste, as it was often used as fuel for plant production on factories' ovens. However, as it has been increasingly used for plastic alternatives, its value has increased (Green Box, 2019).

Bagasse is a very sturdy and stable material, however, not very flexible. It has good thermal property, withstanding temperatures ranging from -25 to 220 Celsius degrees. Moreover, it has good water repellency and greaseproof, requiring little energy and water to produce, while still being a very strong material (Green Box, 2019).

Commonly found in countries with high sugar production, it is available in Brazil, Vietnam, China, Thailand and many more, meaning mostly tropical zones (Green Box, 2019). Moreover, the top 10 sugarcane producing countries, in 2017, produced over 1.5 billion tons of sugarcane, being Brazil, by far, the biggest producer worldwide (World Facts, 2017). According to Zafar (2019), in

Philippines alone, 380 000 hectares of land are devoted to sugarcane cultivation which recovers 1.17 million tons of sugarcane waste and 6.4 million tons of surplus bagasse from sugar mills.

Sugarcanes can grow from three up to five meters and re-grow in five months. Moreover, it is a very sustainable material as “100 tons of sugarcanes generate about ten tons of sugar and thirty-four tons of valuable bagasse”, leading to over 50 million tons of bagasse waste worldwide.

Its variety of uses include building and packaging materials, disposable tableware, and napkins, toilet paper and cardboards, replacing wood fibers in the paper industry (Green Box, 2019). Moreover, it is also used as fuel in factories, making the process more environmentally friendly, due to not releasing hazardous substances to the atmosphere (Green Box, 2019).

As an example, researchers from the University of Valencia and San Paolo State University have created, in laboratory, concreate made from sugarcane agriculture waste, making the process much more economic and environmental, as cement is the “most expensive and most polluting ingredient of concreate” (Asociacion RUVID, 2016).

5.1.2. Bamboo

According to Inbar (2019), “Bamboo is a vast untapped development resource that provides climate-smart mitigation and adaptation solutions” and therefore, it is considered one of the eco-friendliest materials.

There are over 1000 bamboo species and it is a very versatile, durable and resistant material as its strength-to-weight ratio is very high with greater compressive strength than concrete (Pyzyk, 2018). Moreover, promotes soil conservation where planted and, if “harvested correctly, bamboo doesn’t require replanting afterward” (Dell, 2019), being able to retain high amounts of carbon dioxide and producing “35% more oxygen than its equivalent size of trees” (Lewis Bamboo, 2019).

Bamboo easily adapts to the most challenging conditions, being found all around the world except in Europe and Antarctica (Pyzyk, 2018), and requiring no pesticides, chemical fertilizer or irrigation (Econation, 2019).

Such a sustainable material provides several benefits and incentives for usage. Firstly, a bamboo pole can grow a maximum of 1.21 meters, per day, which allows for rapid and frequent harvesting lowering, therefore, risks of disaster and flexibility. Its harvesting only takes three to six years, being highly renewable, as the income earned is faster than with other tree species (Inbar, 2019).

One particular advantage of using bamboo instead of other raw materials or synthetic ones is that its fiber production comprises less environmental impact (Econation, 2019), which is one of the goals of the material to be chosen by the work at hand.

However, one drawback of its usage is the need for treatment against insects and rotting, as absorbing water while untreated induces fast deterioration and can incite swelling and cracking (Pyzyk, 2018).

Due to its endless advantages, bamboo is applied in a vast portfolio of industries. It is used for buildings, roads, medicines, clothes, food, paper and fuel (Econation, 2019). Furthermore, it is also used for medicinal purposes and bamboo beer production (Roy, 2009)

Currently, the value of the bamboo and rattan industry is around 60 billion American dollars (Inbar, 2019).

5.1.3. Cassava

“Cassava is a tropical root crop, originally from Amazonia that provides the staple food of an estimated 800 million people worldwide. Grown almost exclusively by low-income, smallholder farmers, it is one of the few staple crops that can be produced efficiently on a small scale, without the need for mechanization or purchased inputs, and in marginal areas with poor soils and unpredictable rainfall” (FAO, 2013). Moreover, it is commonly referred to as manioc or tapioca, which are both starch derivates of the cassava plant root (National Plant Germplasm System, 2019).

When produced under good conditions, it can reach up to 80 tons per hectare and, despite cassava roots being constituted by 60% of water, the dry percentage is extremely rich in carbohydrates. Therefore, it is “one of the world’s most reliable food security crops” (FAO, 2013).

Cassava crops are located mainly throughout the tropics (National Plant Germplasm System, 2019). For the past ten years, Nigeria has been the biggest producer of Cassava, being Africa the continent with the highest production share (FAO, 2019). Furthermore, Nigeria is set to produce up to 150 million tons of cassava by 2020, thus being the world’s largest producer (TAAT Africa, 2019). In particular, for every ton of processed cassava, 10-15% is waste, being lost as wet peels which are poorly utilized or burnt (TAAT Africa, 2019). This means that in Nigeria alone, over 15 million tons of cassava could be used to create sustainable packaging.

For optimal food consumption, the root must be harvested about 8 to 10 months after planting. However, higher starch yields require a longer time, and this can go up to 2 years, being beneficial for packaging production.

Duo to its versatility and natural characteristics, cassava is used in several distinct industries such as “food manufacturing, pharmaceuticals, textiles, plywood, paper and adhesives, and as feedstock for the production of ethanol biofuel” (FAO, 2013).

However, a significant drawback of this material is that it can only be used for dry food or fast consumption, as the humidity will degrade the packaging itself (eCycle, 2019). Moreover, as most of the other material being analyzed, its cost of production is far higher than current plastic and its environmental pollution is very significant as cassava processing produces large amounts of waste (Penh, 2015).

5.1.4. Coconut

Coconuts are considered drupes, which are fruits with hard and stony covering protecting the seed (TNAU Agritech portal, 2019).

Coconut is a very tough material due to its high content in lignin, while being, at the same time, extremely elastic, with fibers barely deteriorating, making it, therefore, a very valuable and durable material for a wide variety of uses. Moreover, it does not require high levels of technology to produce packaging options and is a water-proof material in addition to being “impervious to hard knocks, salt and heat, and it keeps its electrolyte-rich interior water fresh and coconut meat cargo protected and ready-to-consume (or take root and grow)” (Fehrenbacher, 2010).

However, its high resistance is very negative when trying to dispose of coconut shells. Most of the coconuts are used, as aforehand mentioned, in the food industry, being the shells and husks usually discarded. To solve this issue, “Some companies douse the waste in kerosene to burn it up. When the piles are left sitting, the pith in the husks can soak up 10 times their weight in water and create breeding grounds for mosquitoes” (GreenBiz, 2010).

According to Enkev (2019), coconut palms grow in the tropics, in an area of about 10 million hectares. It is largely found in Asia (around 84% of production share) with Indonesia, Philippines and India being the main producers in the past ten years (FAO, 2019). However, only a reduced percentage of the crop is used for industrial purposes (Enkev, 2019).

Its harvest area has been rapidly increasing (FAO, 2019), therefore increasing the waste of coconut husk which can be reused and transformed. The main buyer is the food industry which “focuses on the coconut meat, jettisoning the fibers as a waste product” (Enkev, 2019). However, coconut husks are also used in agriculture, horticulture, packaging, bedding, flooring and insulation (Marshall and Meidis, 2018).

Its crop is permanent, therefore being available all year round, with constant supply and waste that can be reuse (Zafar, 2019). Additionally, each coconut palm can produce around eighty coconuts and can last up to ninety years (Cantinho Verde, 2019).

Rich McEachran (2015) states that 10 kilograms of fiber can be produced out of only 1000 coconuts, with a harvest every 30 to 45 days. Moreover, “Approximately 500 million coconut trees in the Philippines produce tremendous amounts of biomass as husk (4.1 million tons), shell (1.8 million tons), and frond (4.5 million tons annually)” (Zafar, 2019).

Therefore, with 500 million trees producing around eighty coconuts each, 40 000 million coconuts are available, which can produce close to 4000 million tons of fiber.

5.1.5. Leaves

Distinct leaf options are currently being utilized in the industry. This section will analyze the two most commonly used types of leaves, being the banana and palm leaves.

For thousands of years leaves have been commonly used for food wrapping as “Packaging has begun with natural materials such as leaves” (ASD, 2013) due their largeness, thickness and easiness to use. However, not all leaves can be used for packaging neither can all products be packaged with leaves, due to their natural properties and specificities. In order to be safely used for packaging, leaves must be carefully harvested, cleaned, pressured washed and scrubbed, and finally sun dried and heat pressed into desired shape (Green Box, 2019).

The main difference between leaf types is their availability, as its scarcity leads to increased prices (Forbes, 2019) and the main benefits of using leaves for wrapping are the fact that they don’t contain any toxins or chemicals, are quite flexible, resistant and waterproof (Casey Ng, 2015). Additionally, leaves are mostly used in their natural form and not transformed as most other raw materials, therefore, they allow for a glimpse of personalization in each package.

One particular point to mention is that the use of leaves “keep alive the traditions that make us different from the rest of the world. They help to maintain alive the diversity of big leaves that characterize the tropics” (Casey Ng, 2015).

According to Leafware (2019), the process of transforming leaves into tableware or packaging is simple, as fallen leaves are collected to then be pressure washed, scrubbed, sun dried and compressed by heat into the desired shape. It is then followed by sterilization to be ready to be sold. After its use, the product is ought to be composted, returning nutrients and vitamins to the soil, thus performing a circular process (Leafware, 2019).

5.1.5.1. Banana Leaf

Usually, banana leaves can be acquired for free in tropical locations due to its abundance. However, in other locations, it can be rather expensive. Therefore, favoring local products is extremely important (Forbes, 2019).

“Banana plants are large, herbaceous perennials that produce pseudostems from underground rhizomes. Pseudostems are fleshy, upright stalks that serve as the functional trunks for the plants. Each pseudostem produces only one banana cluster before dying; however, new stalks are continuously produced from the rhizome to take their place. Consequently, plants will continue to make more bananas for several years” (McLachlan, 2019).

Banana plants grow extremely fast as its planting takes from 10 to 20 months and its harvesting can be done after about 80 to 180 days (McLachlan, 2019). Its leaves are thick and flexible, facilitating, therefore, produce coverage and maintenance of temperature. Moreover, they are easy to compost, adding nutrition to the soil and making it more fertile (Enviro Total Solutions, 2019).

America Latina is by far the biggest banana exporter in the world (WEF, 2019).Moreover, since 2010, the number of harvested bananas has been increasing (FAO, 2019) leading, therefore, to the increased potential for unused banana leaves which can then be used for packaging purposes, as they would otherwise be wasted.

Currently, over 100 million of bananas are produced every year (Broom, 2019). In 2012, in Philippines alone, banana plantations could generate over 300 000 tons of fiber (McEachran, 2015). Moreover, “Around a billion tons of banana plant stems are wasted each year” while 37Kg of these steams alone are able to produce 1Kg of fiber (McEachran, 2015), meaning over 27 million tons of natural fibers are being wasted every year.

According to The Jakarta Post (2019) and Food Logistics (2019), Indonesia, Vietnam and Thailand are currently using banana leaves instead of plastics, as a packaging alternative for vegetables and fresh produce.

5.1.5.2. Palm Leaf

Palm Trees grow best in high humidity areas or warm and dry ones, having two well-known distinct types of trees: date and coconut, which grow in the warm climate. This plant grows up 25 meters and its most valuable part is the leaves, which can be up to 2 meters long and from four to seven times annually, during growth (Green Box, 2019). They are very good for packaging solutions as they are stable and sturdy with water repellency and good thermal properties (Green Box, 2019).

Just like bananas, palm oil fruit is mainly found in Asia (around 86%), in particular in Indonesia (FAO, 2019) and in 2000, re-plantation of such plants generated roughly 8.36 million tons of dried biomass (Abdullah and Sulaiman, 2013).

The leaves are usually used for nutritional feed for livestock, roof thatch which can last from 5 to 10 years, production of oil and wax, garden beds and fencing, paper, woven baskets, hats and fuel (McGee, 2019).

Leaves are collected during the dry season (Green Box, 2019) and its harvesting has also been increasing; therefore, more plants are cultivated and there is increased potential for use of fallen leaves (FAO, 2019).

5.1.6. Mushroom

Mycelium is the fungal threadlike network of fungi and it is found in its root structure of mushrooms. This raw material is infinitely available and acts as a natural glue binding organic waste to originate the final product (Krown, 2019).

Mushroom-based packaging is easily created, as the process comprises pressing agricultural waste into the desired shape, which is then seeded with mushroom spores and lastly, heat-threated being, therefore, able to be produced worldwide, lasting from a few days to a few weeks. “The result is a material that has the same properties of polystyrene packaging in form, function and cost, with the added benefit of being able to decompose in your very own garden after its function has been fulfilled” (Manning, 2017). Moreover, as it is made from scratch, it is infinitely available.

Despite being a fairly recent material being used as a plastic substitute, and due to its natural properties, the feasible applications of mushroom root are endless. The main benefits are reusing agricultural waste that can't be used as food source, being able to be molded into any desired shape and being cost-competitive. Moreover, its low density and light weight, competitive strength and reduced energy consumption make it an incredibly sustainable material.

This material has the potential for carbon dioxide (CO_2) sequestration, if done at large scale, is inherently safe and able to prevent formation of spores (Jiang, 2014).

However, a few drawbacks are the need for longer production times, less variability of applications and less fire resistance when compared to the currently used plastic (Manning, 2017). Moreover, it has high production costs and can potentially compete with resources that could otherwise be used for food production (eCycle, 2019).

5.1.7. PLA

Polylactic acid or PLA, as more commonly referred to, is a plant-based resin (100Bio, 2017), a "plastic material that is either derived from biological raw materials (known as being bio-based), or biodegradable, or both" (Packaging 360, 2019). It is obtained through the fermentation of sugars, more commonly derived from corn, into lactic acid which is then polymerized (Knope, 2019). All the characteristics of these obtained materials can be changed by using innovative techniques such as copolymerization.

PLA is a bioplastic which, according to Saran Gibbens (2018), "simply refers to plastic made from plant or other biological material instead of petroleum. It is also often called bio-based plastic".

PLA has excellent mechanical characteristics with high-strength, high-modulus polymer (Packaging 360, 2019) and therefore, is commonly use in cosmetics, bottles, pens, glass, cutlery, automotive parts, coffee cups and many other applications (eCycle, 2019). Moreover, it is incredibly sustainable to produce, despite the high level of technology involved, as it is made from waste products from materials easily grown (Greenway, 2018), being the least expensive bioplastic but the only one that can form foam to substitute the polyurethane currently used (100Bio, 2019).

The main benefits of this type of substitute are the fossil resources' saving, reduction of carbon footprint and increased resource efficiency when compared to commonly used plastics (European Bioplastics, 2016). Moreover, it is tasteless and heat-resistant (up to 40 Celsius degrees), being able to be shape into several shapes or sizes, including film (Bio4pack, 2019)

Figure 10 presents the different types of existing bioplastics, in particular, the material being investigated need to be bio-based and biodegradable being, therefore, represented in the upper right quadrant.

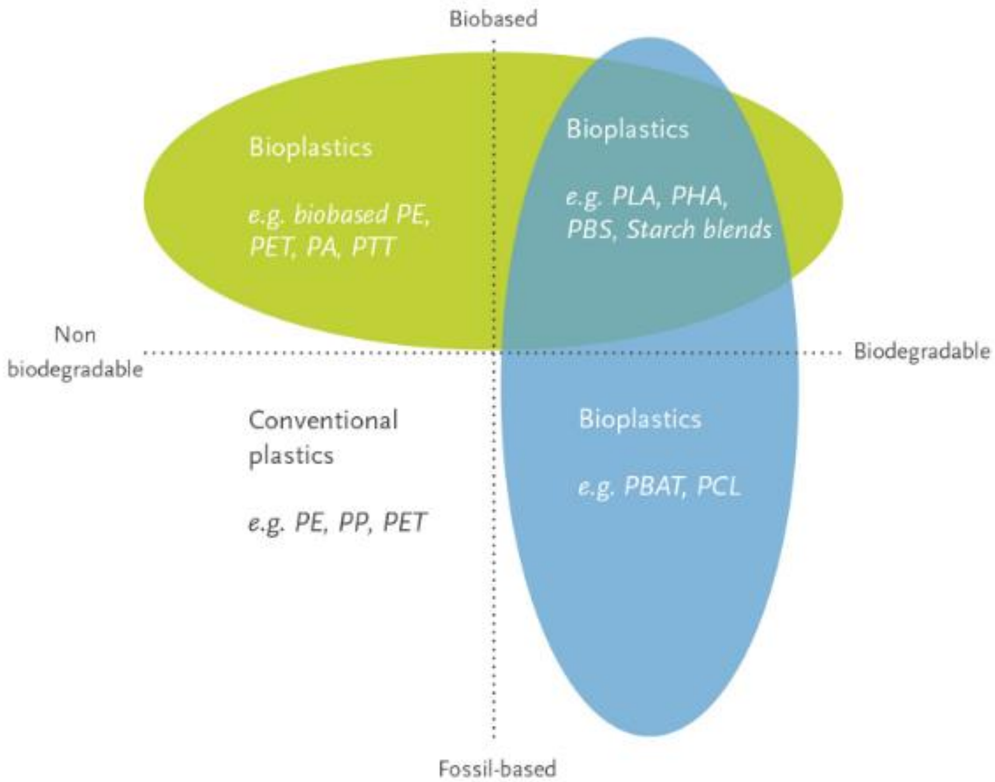


Figure 10 – Bioplastics (European Bioplastics, 2019)

Packaging made of PLA is recyclable and biodegradable. If correctly disposed of, it is harmless as it is easily degradable by water. However, in order for this correct degradation to occur, PLA products must be composted with favorable conditions, which usually does not happen, leading to decomposition in landfill, with methane emissions being, therefore, as harmful as the typical types of plastic currently used (eCycle, 2019). Moreover, production of PLA is still highly costly.

Most PLA plastics are Ingeo biopolymer, which is produced by the American company NatureWorks LLC (BioMass Packaging, 2019).

According to Green Box (2019), for their production of 400 packaging of bowls, by using PLA instead of typical polyethylene (PE), they are able to reduce 62% of the CO_2 emissions, corresponding the CO_2 absorption of close to 375 tree per hectare of forest, and use up to 50% less energy.

5.1.8. Seaweed

Seaweed is the ordinary name given to algae and marine plants growing in water. Despite the spectrum of its size being vast and varying from microscopic species, such as phytoplankton, to massive ones, as kelp, the most common seaweed found has an intermediate size and colors range from red to green, brown or black (National Ocean Service, 2018).

The algae comprises vast benefits, and they vary from several types of vitamins and minerals to fiber, anti-inflammatory and anti-microbial agents and medicinal effects. Furthermore, it also carries good water and oil holding (Patil, 2019) and it is possible, in only one hectare of ocean, to produce "40 tons of dry seaweed annually" (Clancy, 2017).

Due to its ecological importance, seaweed is the foundation for most food-chains in marine life. It can be found worldwide and there is no register of poisonous species. Therefore, most of the seaweed found is edible, being mainly appreciated in Asian countries (Seaweed, 2019).

The cycles of seaweed production are significantly shorter than most terrestrial plants, being around 45 days (Mulyono, 2019) and the largest producer of seaweed is China, followed by Indonesia, with production values increasing 30% yearly (Mulyono, 2019). However, Indonesia alone, produces 10 million tons of seaweed per year and aims to produce 19 million by 2020 (Minh, 2019).

"The farming of seaweed has expanded rapidly as demand has outstripped the supply available from natural resources. Commercial harvesting occurs in about 35 countries, spread between the Northern and Southern Hemispheres, in waters ranging from cold, through temperate, to tropical" (McHugh, 2003). Furthermore, in 2012, around 3 billion tons of dried seaweed were produced, with an annual value over 6 billion dollars (Fehrenbacher, 2017). Moreover, "A 2016 report from the World Bank estimates that the annual global seaweed production could reach 500m dry tons by 2050 if the market is able to increase its harvest 14% per year. Hitting that 500m mark would boost the world's food supply by 10% from the current level, create 50 million direct jobs in the process and, as a biofuel, replace about 1.5% of the fossil fuels used to run vehicles" (Fehrenbacher, 2017).

"Growing up to 1m per day, it doesn't compete with food crops, doesn't need fresh water or fertilizer and actively contributes to de-acidifying our oceans" (NotPla, 2019). Moreover, "Because it is so abundant, just 0.03% of the brown seaweed in the world could replace all the polyethylene terephthalate (PET) plastic bottles used every year" (Daigneault, 2018).

As seaweed grows quickly, it is able to absorb up to twenty times more carbon dioxide than land-based forest and "Only 9% of seaweed farms' ocean coverage would be enough to capture 53 billion tons of CO_2" (1 Million Women, 2019), which helps to mitigate ocean acidity, with biodegradation occurring, usually, between 4 to 6 weeks, in soil (Daigneault, 2018).

Agar, which is a gelatinous substance in certain seaweeds, is used in the food industry as a thicker or vegetarian gelatin due to its gelatinous consistency (UNLEASHED, 2018). However, seaweed applications extend beyond the food industry, to industrial applications, in particular fine biochemicals, cosmetics and even organic fertilizers (Seaweed, 2019) due to, according to Patil (2019) its versatile and effective binding agents (emulsifiers) and popular softeners (emollients). Furthermore, it is commonly used in seaweed baths, wraps and treatments and, in the scientific field as it carries a porous and feathery structure, thus being extremely light despite its volume (Araki, 2016).

Several current examples of the implementation of seaweed in solving environmental issues can be depicted, as the innumerous possibilities of these plant are being discovered. For example, NotPla, an England based startup, is manufacturing edible and biodegradable water pouches, Ooho which are being used in events and sports such as the London Marathon (NotPla, 2019). “They have developed manufacturing processes that make this both more efficient and cheaper than producing plastic bottles. The process produces 5x less CO_2 and uses 9x less Energy vs PET production” (Greenway, 2018). This is extremely important, as it will allow the reduction of the 50 billion plastic bottles produced every year (Knope, 2017). Moreover, NotPla also sells material cartridges to co-packers and event’s organizers as a way to produce and sell local manufactured products.

5.1.9. Systematization of Information

Having, in section 5.1.1 to 5.1.8, characterized each of the materials, table 12 presents the systematization of the relevant information. Moreover, table 13 intends to show the relevant advantages and disadvantages of each material allowing a better understanding of the challenges each material might represent.

Table 12 – Systematization of material’s relevant information

Material	Waste (per year)	Production	Location
Bagasse	6.4 million tons	1 559 500 thousand metric tons	Brazil
Bamboo	-	Extremely high growth rate	India, China
Banana leaf	27 million tons of fibers	1 billion tons of stems	Latin America
Cassava	15 million tons are waste (peels or poor utilization)	150 million ton by 2020	Nigeria
Coconut	husk (4.1 million tons), shell (1.8 million tons), frond (4.5 million tons)	-	Indonesia, Philippines, India
Mushroom	-	Infinitely available	-
Palm Leaf	8.36 million tons in 2000	-	Malaysia
PLA	-	-	America
Seaweed	-	3 billion tons of dried seaweed, in 2012	China, Indonesia

*It is not necessarily the main production location, in most cases, but has relevant production values

Table 13 – Advantages and disadvantages of each natural material

Material	Advantages	Disadvantages
Bagasse	• Re-grows in 5 months • Requires little energy and water • High strength and insulation	• Dependent on the sugar extraction from sugarcane
Bamboo	• Adapts to challenging conditions • Does not require chemicals or irrigation • Frequent harvest • Durable, resistant and great compressive strength	• Need for treatment against insects and rotting
Banana Leaf	• Large leaves • Thick and flexible	• Need treatment
Cassava	• Stable crop • Grows on poor soils • Versatile • Rich in carbohydrates	• 60% water • Can only be used for dry food or fast consumption • Harvesting can take 2 years
Coconut	• Permanent crop • Tough, durable and elastic material • Waterproof	• Difficult to dispose of waste • Separation of fiber
Mushroom	• Infinitely available • Easily molded into any shape • Low density and light weight • Competitive strength • Low energy consumption	• Price
Palm Leaf	• Large leaves • Stable and sturdy • Water repellency • Good thermal properties	• More adequate for ready to eat food
PLA	• Uses biological waste • High strength • Sustainably produced • Reduced CO_2 emissions and energy	• Need high levels of technology for production • Takes longer time than other materials to decompose
Seaweed	• Gelatinous properties • Good water and oil holding • High absorption of CO_2 • Rapid growth	• Still difficult to produce high volumes of packaging

5.2. Criteria Analysis: Swing Weighting

From the application of the swing weighting method explained in section 4.3. and based on the preferences of the DM, the normalized weight coefficients to be used to calculate the Global Index were found, being shown in table 14.

Table 14 – Normalized weight coefficients

Indicator	Weight
W_1 – Frequency of use	0,28
W_2 – Waste generation	0,38
W_3 – Portfolio products	0,34

Table 15 – Evaluation attributed per material for selected criteria

	P1	P2	P3
Bagasse	95	50	85
Bamboo	25	80	30
Banana Leaf	7	90	20
Cassava	30	60	40
Coconut	15	35	10
Mushroom	15	100	90
Palm leaf	70	75	50
PLA	100	98	100
Seaweed	35	98	95

Calculation of final scores

By applying the weights obtained to equation (2), the indicator is finally represented by equation (3):

$$V(GI) = 0{,}28 * v_1 + 0{,}38 * v_2 + 0{,}34 * v_3 \quad (3)$$

Having the GI already designed, the next step is then applying it to each of the material types, which are the alternatives to be evaluated upon this indicator, in order to understand which material is the best, according to the selected criteria and DM preferences.

For each material alternative, a value of v_1, v_2 and v_3 was attributed by the DM, which summed up led to the results in figure 11. One important point to emphasize is that the considered equation is intended to find the materials with the highest scores as they will be the most versatile and better to use for the purpose of the work at hand.

Despite most materials scoring close to 50 or above in the GI, for the purpose of this dissertation, it was decided to only further analyze the materials with the most significant scores in the GI. Moreover, when comparing these results with the disadvantages presented in table 10, it is understandable that the materials needing specific treatment to be able to be used for packaging, or that can only be used for cold, hot or dry foods, scored less than the other materials.

By analyzing figure 11, two main groups of GI scores can be depicted: a) score hove 65 and b) score under 65. For the purpose of this dissertation, it was decided to only further analyze the materials with the most significant scores in the GI, meaning option a). Moreover, when comparing these results with the disadvantages presented in table 10, it is understandable that the materials needing specific treatment to be able to be used for packaging, or that can only be used for cold, hot or dry foods, scored less than the other materials.

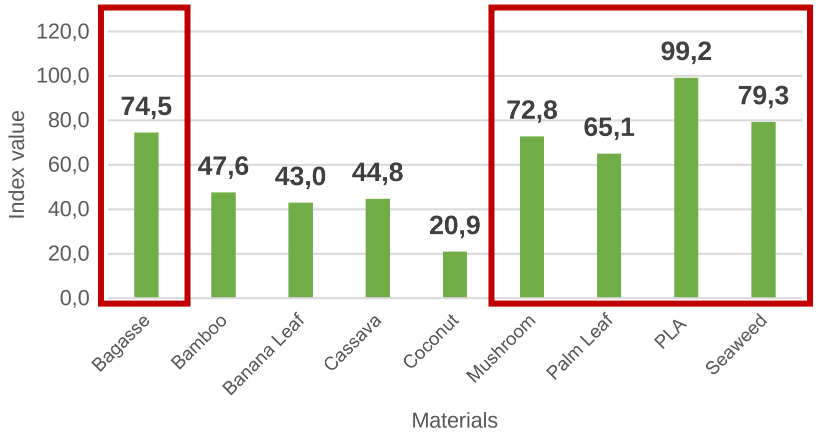


Figure 11 - Index values for each material alternative

What is interesting to note it that despite the other materials having significant disadvantages, they are outweighed by its benefits. For example, the problem with using mushroom is that it is still too expensive comparing with other materials, however, its almost limitless availability and ability to be shaped in almost any form transforms it into a high score material.

Other example is PLA, and despite needing a high level of technology for production and taking longer to decompose than the other materials being evaluated, its properties, large availability, use of almost any type of waste to be produced and ability to create endless packaging options turned this material into one of the most used and most sought out materials in the sustainable packaging industry and, in particular, the best scoring material in this analysis..

Consequently, the advantages or disadvantages of the materials are not static nor dependent on what is expected out of the material chosen, as different strengths can outweigh major negative aspects. Therefore, all packaging materials must be chosen according to what they are going to be used for and according to the company's goals, being analyzed against other factors besides the ones in the criteria used for the swing weighting method, for a more thorough study.

The materials further analyzed were bagasse, mushroom, palm leaf, PLA and seaweed.

5.3. Interviews

Having already understood the materials individually, its characteristics, advantages and disadvantages, and having applied the swing weighting method to rank the alternatives, it became evident that the theoretical knowledge needed concerning the materials was already retrieved. However, the practical knowledge on why these materials are used by the companies in the industry was still uncertain and poses as key information, considering the main goal of this dissertation, in order to draw robust and, as close to the industry's reality as possible, conclusions.

Therefore, the most relevant information needed is related to the challenges of the companies and why they used particular materials, due to being information that mostly cannot be retrieved from the literature review. Consequently, and in order to validate the results from figure 10, semi-structured interviews were performed.

5.3.1. Interview Findings

This section summarizes the information retrieved from the interviews performed, focusing only on the cluster "challenges" from the interview guide, as the most valuable information to answer the question "What is the best material?".

The following data results from the analysis and processing of the collected information during the interviews and only the data regarding the materials with the most significant scores in the GI will be covered, as these interviews will provide a better understanding of these materials and why their scores were higher than the rest.

- **Question 1**: **Why did you choose to work with this material? What are the disadvantages?**

Overall the responses amongst all interviewees were similar, as the materials were chosen due to their availability (mostly agricultural waste, unused leaves or by-products) and being suitable for packaging manufacturing with great favorable characteristics. Moreover, it was also agreed on that there is a reason why most companies diversify their portfolio of raw materials used, as climate change and different needs for packaging solutions demand vast raw material availability and most crops take long until they can be harvested and sent to the manufacturing site. Accordingly, this diversification allows for risk prevention, as a disease or spoiled crop would prevent companies to meet their customer's demand and prices would drastically increase, which is an undesirable scenario for all parties involved, being the use of only one type of raw material unsustainable for the company's survival.

Interviewee 6 started by stating that the most frequently used materials are the ones that can be acquired more easily, with a fair price and with preference for those that can be sourced locally, in order to reduce hazardous emissions and empower local communities.

For interviewee 4, the use of mushroom mycelium was due to its ability to be infinitely grown in very short periods of time with the bonus of being easily molded into any shape, making it easy to create any type of sustainable packaging or product. However, in order to use mushroom, all packaging must be, at least, 1 centimeter thick, which makes it more suitable for products with more volume than food packaging.

Interviewee 5, on another note, stated that seaweed has been used for a long time in the most diverse industries and its geographic dispersion made it easy to have abundant raw materials that can be used sustainably. However, depending on the companies, and in particular for its own, seaweed packaging companies often cannot meet the demand for products, as their manufacturing capacity is not enough to produce more volume with lower costs for the company and ultimately for the customer. Moreover, so far it is mostly used for smaller packaging items, such as sachets or straw and its thinner thickness makes it not suitable for the most single-use packaging products other companies currently offer.

Interviewees 1 and 6 pointed out the great benefits of using PLA, as it is the material that performs closest to plastic, being able to be produced for almost any types of packaging. However, despite being the cheapest bioplastic, the one with the most varied benefits and the only able to substitute Styrofoam, it is still quite expensive comparing with other available options, such as bagasse. Moreover, is it very sensitive to heat .This only confirms why interviewee 3 added that bagasse is one of its preferred materials besides PLA, as it is cheaper and has a similar performance. Moreover, this interviewee also uses palm leaves which are a great option, mostly for tableware, despite being much more expensive than the rest of the options.

Both interviewee 3 and 6 agree that bagasse is a great material substitute for PLA as it is cheaper and holds almost the same characteristics. Other products also tend to be cheaper than PLA, but often do not perform as much, such as bagasse or even bamboo. Moreover, as PLA prices are increasing due to companies not being able to meet the demand, driving bagasse to become a more increasingly used raw material.

- **Question 2: What do you think is the potential for entry in the packaging market?**

All interviewees share the same point of view regarding this particular question, as demand for sustainable materials, in particular sustainable packaging, is increasing and companies are not being able to meet the demand. Therefore, the more companies exist, the more options will be available whether regarding materials available or portfolio of products, which will allow customers to more easily have access to such products. Moreover, more innovation will be required to compete with other businesses, driving more research and knowledge.

- **Questions 3 and 4**: **What are the entry barriers? What are your main challenges?**

The answers to questions 3 and 4 were grouped, since the answer is related. The biggest barrier for sustainable packaging is definitely the price competitiveness with plastic products, according to interviewee 3, as raw materials sustainability sources will always be more expensive than plastic, which is a material that has been used and researched for years now and its disposability, accessibility and advantages of use make it hard to compete with, price wise. Moreover, interviewee 1 states that manufacturing capacity is currently one of their main challenges and was a barrier initially while the demand was not as high as it currently is as they did not have the money to expand their manufacturing capacity.

Interviewee 2 has also stated that since they are a small company they are not able to decrease the costs, which is their main current issue.

- **Question 5: How do you differentiate from your competitors?**

Interviewee 1 stated his company differentiates with their vast manufacturing capacity combined with thorough certification and carbon-neutral transportation and manufacturing.

Interviewee 2 mentioned it is the only company in Asia producing only cassava products, with the benefit of being a family owned company that in its prior years selling distinct (and unsustainable products), has kept most of its clients through the years of business.

For interviewee 3, the fact that her company is a research company, allowed them to find the best materials and work with their suppliers to be able to give their customers fair prices and as low as possible.

On the interviewee 4 case, packaging grown from mushroom mycelium, providing the most diverse applications is what sets them apart. Moreover, they do ship their products internationally, however, the company's business model encompasses the implementation of a manufacturing site in the country with the demand for the packaging. This allows for the great reduction of the environmental footprint, the transference of know-how with jobs creation and the usage of local agricultural waste, all methods to deeply contributing to the achievement of SDG and the implementation of a circular economy.

For interviewee 5, there are not that many seaweed packaging companies currently operating in the industry and their tight relationships with seaweed farmers in Asia makes them one of the major companies for seaweed packaging.

Lastly, interviewee 6 believes that being one of the major sustainable packaging companies in Europe with 25% of their materials' sourcing taking place locally is what gives them the edge over their competitors, complemented by their vast portfolio of products and raw materials used.

- **Question 6: How easily do you find customers? Why?**

Again, all interviewees stated that mostly customers come to them, in particular retailers looking for sustainable packaging alternatives, making it easy for the companies to collaborate with other businesses worldwide, fighting for a better future. Therefore, little time is spent looking for customers, only more manufacturing partnerships and distributors.

5.3.1. Interviews Findings Systematization

This section systematizes the most important findings collected from the answers to the previous interview questions. The main ideas retrieved are the following:

1. Portfolio diversification with products made from distinct materials is extremely important to reduce the company's risk due to climate change related issues and demand volatility.
2. The main barrier to enter the industry is price competitiveness with plastic products and the main challenge is meeting the demand with current manufacturing capacities

3. Finding customers is not an issue at the moment, as demand for natural sustainable packaging is increasing.
4. Despite its cost and heat sensitivity, PLA is currently one of the mostly used materials
5. Currently, seaweed packaging companies are not able to meet the demand and mostly produce small size packaging products such as sachets or straws.
6. Bagasse is a very good substitute for PLA due to its close performance and cheaper prices
7. Mushroom packaging must be at least one centimeter thick, which is very beneficial for most types of packaging, but not for food packaging. Therefore, this material will not be further discussed.
8. Palm leaf is probably the most expensive of all the materials addressed. However, it is a very good material for tableware and often used by many companies.

After careful analysis of the information retrieved from the company interviews, it was decided to cease further analysis on mushroom and seaweed, as they do not fit the range of packaging options intended to address with the goal of this dissertation.

5.4. Quantitative Analysis

As the three pillars of sustainability are the environmental, social and economic dimensions, further assessment of the materials previously selected, bagasse, palm leaf and PLA, must be assessed with KPI drawn from these pillars, in order to ensure the most sustainable option is chosen.

Therefore, a price assessment comparation amongst the three materials will be presented in section 5.4.1., to clarify the prices amongst materials, and products within each type of material, hence portraying the economic pillar. In section 5.4.2., the environmental pillar will be represented by the CO_2 emissions assessment of the transportation routes of the company's manufacturing sites towards Portugal, where the products are intended to be delivered.

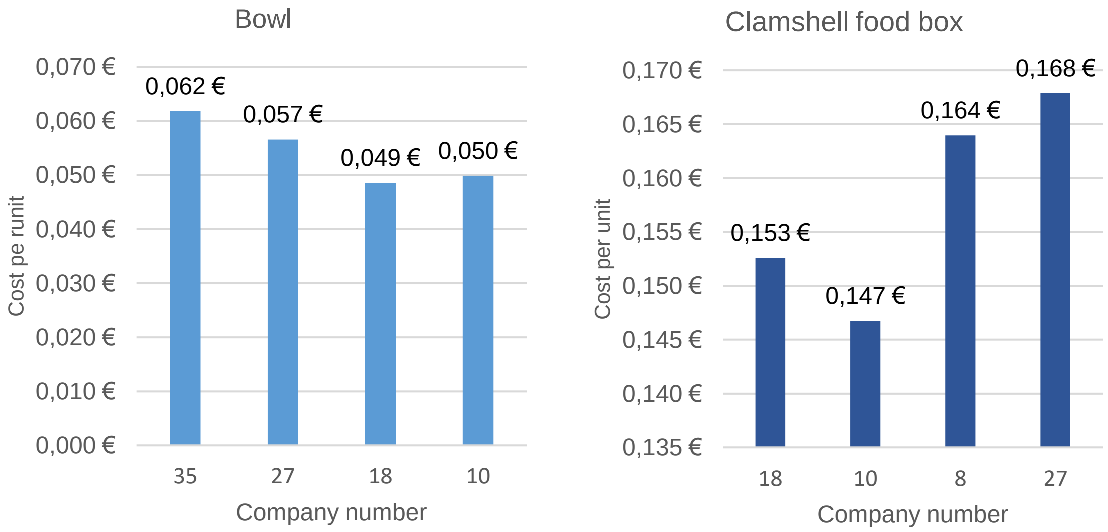
In this section, a quantitative analysis of the unit cost of packaging products made from each type of material is presented, as well as a quantification of the CO_2 emissions from transportation of such products from manufacturing sites in Asia to Portugal.

5.4.1. Price Assessment

In the present section, the unit cost of packaging made from the distinct materials is compared. Despite the companies analyzed not being equal across all graphics, and it is not intended to analyze which is the cheaper or more expensive company, the point to be taken is that not every company sells the same product, hence conclusions will be drawn upon the prices practiced in the industry, per material type, not in a specific company. Therefore, figures 12, 14 and 16 assess the cost difference amongst each packaging product and material.

Following the assessment of the unit cost per material and packaging product, a calculation of the price variation within each material was performed in order to understand which is the most volatile material regarding price. Therefore, figures 13, 15 and 17 present the cost variation amongst companies within each product made from the same material.

As expected, overall a clamshell food box is more expensive than a bowl, both made out of bagasse, as the cost difference is mostly related to the quantity of material need. Moreover, distinct companies have different prices points and for different products, the company with the highest and lowest cost is not the same. For example, for the clamshell food box, the lost cost is from company 10 and for the bowl is company 18.



.Figure 12 – Unit cost of bagasse packaging products

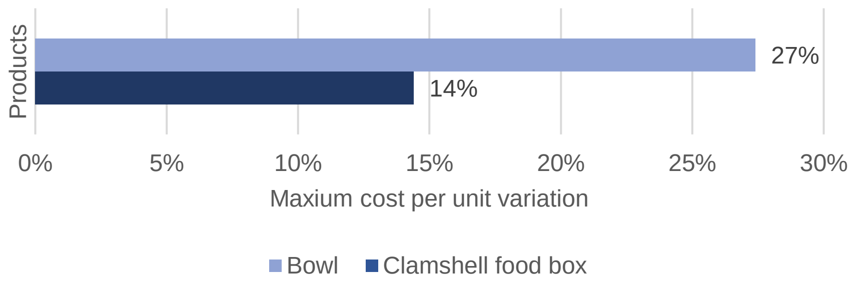


Figure 13 – Price variation of bagasse packaging products

From figure 13 it is understandable that there is a price variation of 27%, translating into a variation of 0,013 € per unit, when comparing the least and most expensive prices shown in figure 12 for the bagasse bowl, while the same variation for the clamshell food box presents a value of 14%. 0,021€ per unit.

Consequently, despite the bowl having a bigger price variation in percentage, the variation of the cost per unit is lower.

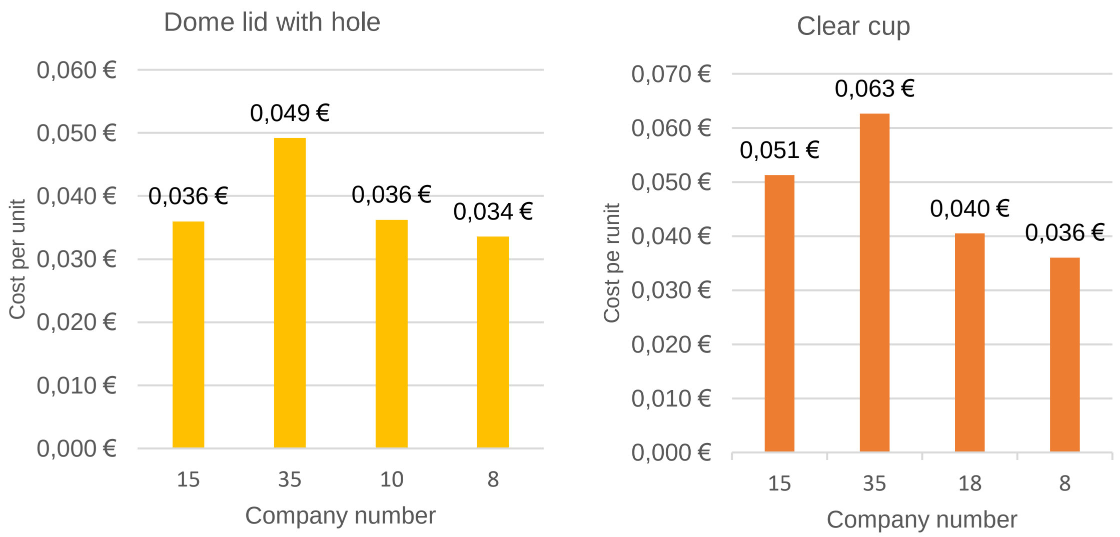


Figure 14 – Unit cost of PLA packaging products

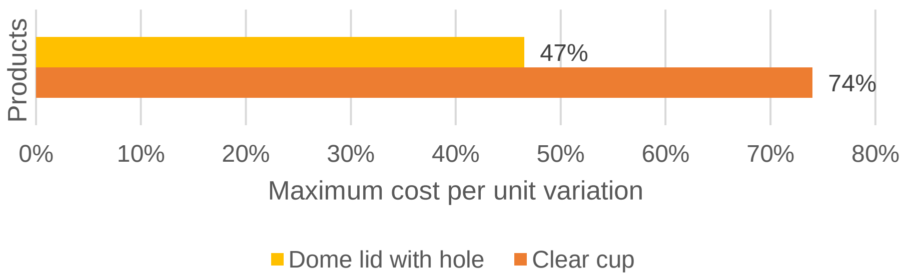


Figure 15 – Price variation of PLA packaging products

For PLA, the dome lid is overall cheaper than the clear cup, as less material is necessary to produce it. However, unlike bagasse products, the same companies present the same rank of pricing, meaning company 35 presents the highest price for both PLA products, while company 15 presents the second highest price and company 8 the lowest price, also for both products. Hence, pricing is both product and company dependent, presenting distinct results for distinct combinations of products and companies.

For PLA products, the maximum price variation is 74% in the price of the clear cup for the considered companies. This 74% variation translates into a 0,027€ variation per unit. Moreover, for the dome lid with hole, the maximum variation is 47%, translating into 0,013€ per unit.

For this case, as prices for both products were actually similar, the biggest percentage variation translated into the biggest variation in price per unit.

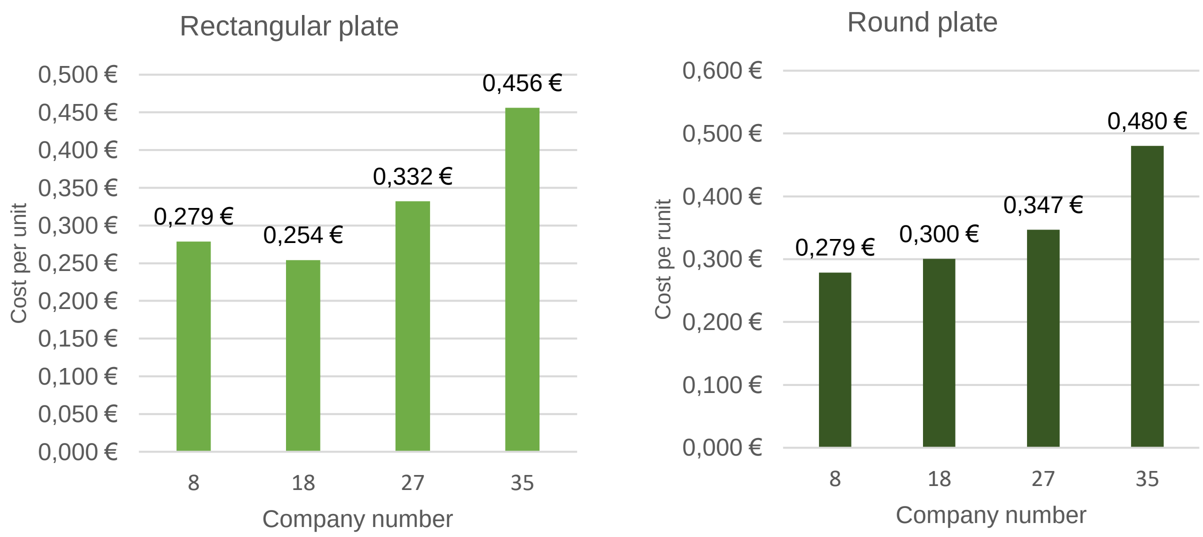


Figure 16 – Unit cost of palm leaf packaging products

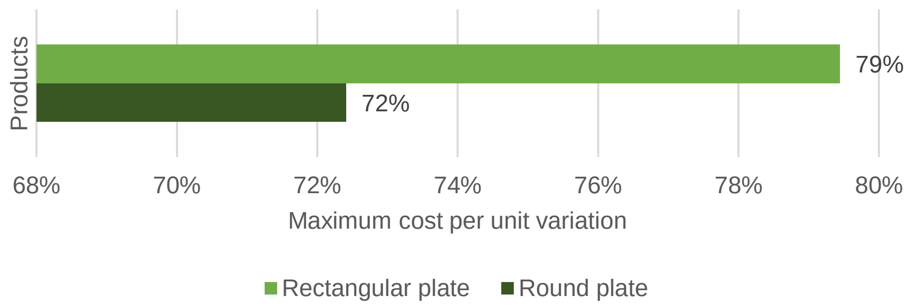


Figure 17 – Price variation of palm leaf packaging products

For palm leaf packaging products there is a maximum variation of 79% in the price of the rectangular palm leaf plates, translating into a variation of 0,202€ per unit. For the round palm leaf plate, the maximum variation is 72%, translating into 0,201€ per unit. Therefore, it is confirmed that for products with similar prices, changes in the price variation translate into similar changes in the price per unit.

Following the analysis aforehand presented, further investigation was performed in order to assess, out of the 6 companies considered, whether these variations depend on the type of products each company sells, its location and even what are the companies with the cheaper and most expensive packaging products present in the former tables. From this analysis, 5 main conclusions were drawn:

1. The 2 companies with the average lower prices for the considered products both have its head office in the United Kingdom, as have the companies presenting the highest prices

2. All former companies sell products made from the 3 types of materials being considered

3. The 2 intermediate companies regarding prices do not have an office in Europe and do not sell palm leaf products which are the most expensive ones
4. The biggest price percentage variations occur in palm leaf products and PLA, being the former the most significant difference in actual cost variation per unit
5. From the products analyzed, and in spite of being very different, bagasse was the cheaper material, followed by PLA and, lastly, palm leaf, which was the most expensive.

Therefore, price variations in products and across material types do not depend on where the companies are located nor the types of products sold, as companies with the most diverse portfolio have prices in both sides of the pricing spectrum.

It is expected that these price differences arise from the logistic and transportation costs companies incur, in addition to the sourcing cost of the materials, as distinct locations with distinct materials or waste availability will exercise different prices. This will not, however, be explored in this dissertation, as further in deep analysis is required.

5.4.2. CO_2 Emissions Assessment

As aforehand mentioned, one of the KPI used to further analyses the materials is a CO_2 emission analysis of the transportation route of products from Asia to Portugal.

According to the European Commission (2019), international shipping is a “growing source of greenhouse gas emissions” (GHG), with the transport sector being responsible for 27% of Europe’s greenhouse gas emissions (EEA, 2019).

Despite road transport being the most significant means of transportation regarding emissions, in 2018, maritime transport had a 13.6% in the transport gas emissions, being the second most polluting transportation mode. Moreover, maritime transport emits, yearly, close to 940 million tons of CO_2, being responsible for 2.5% of the global greenhouse gas emissions (European Commission, 2019).

Currently, following the “business-as-usual scenario”, it is expected for shipping emissions to increase between 50% and 250% by 2050, by dangerous and undermining the goals of the Paris Agreement (European Commission, 2019).

Accordingly, companies must strive to reduce their GHG emissions both during their manufacturing processes and the means of transportation of the products to its clients.

By using natural materials, the total of emissions produced is already lower than using plastic or other unsustainable materials. In particular, by using PLA instead of its comparable manufacture products, the GHG emissions are reduced by roughly 80%, lowering the product’s carbon footprint (Ecoware, 2019).

From all the collect data, it was understandable that most manufacturing sites are found in Asia, with the exception of one company that also has a manufacturing site in England. Figure 18 shows the locations previously mentioned with the respective distances connecting with Portugal, hence exemplifying the transportation route. Moreover, a calculation of the amount of CO_2 emitted by every route was performed, and is presented in table 15, in order to understand the differences the distinct manufacturing locations pose during the transportation of the products.

The calculations were made taking into consideration the values attributed to CO_2 emissions in modern sea ships of 10 to 40 grams per ton-kilometer, obtain from Fluglaerm (2019), the emergency community of airport entrepreneurs of Hamburg.

However, as the most common used ships are older rather than new, the value chosen was 40, using the worst scenario way of thinking.

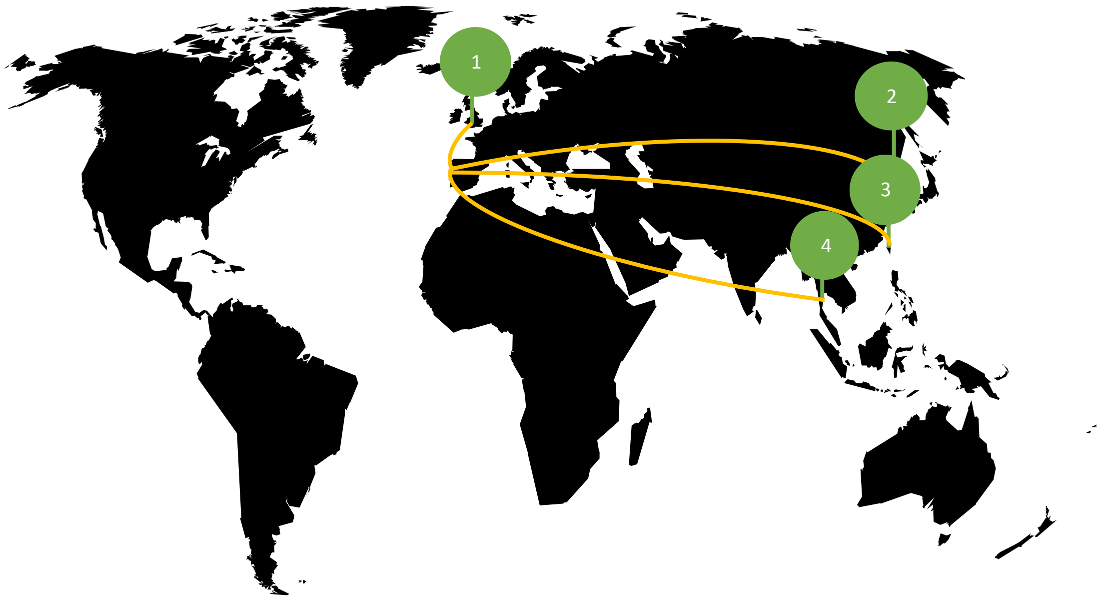


Figure 18 - Manufacturing locations worldwide with connection to final destination

Table 16 - Calculation of the amount of CO_2 emitted by every route

Number	Location	Distance (Km)	CO_2 emissions per metric ton of freight (Kg)
1	United Kingdom	1 826	73,040
2	China	17 509	700,360
3	Taiwan	16 444	657,760
4	Malaysia	13 442	537,680

As expected, the differences are significative, depending on the distance from the manufacturer to the customer. However, it is almost impossible to financially compete with manufacturing in Asia, as most raw materials are found there, and labor and other expenses are less costly.

To put in perspective the amount of gases emitted only during the transportation of the products, which is the most emission intensive stage of the whole process of natural sustainable packaging production, the amount of CO_2 emitted by the transportation of one metric ton of freight from China to Portugal, for example, is equivalent to 1290 times the average waste going to landfill per person, per year and the transportation from the United Kingdom to Portugal emits as much CO_2 as running the gas barbecue for 9 months.

Therefore, is not relevant which material is transported, as the majority of materials are found in Asia and these emissions are route dependent. The difference, however, is on much CO_2 the production of sustainable packaging can reduce. For example, and as previously mentioned, by changing from typical plastic packaging to PLA, it is possible to reduce 62% of the CO_2 emissions, and here is where the difference amongst material types can be noted. This will also not be assessed during this dissertation. However, an in deep analysis of manufacturing process with distinct material is ought to be performed to understand which is the most emission efficient material.

5.5. Chapter Conclusions

Currently, there are several natural raw materials which are sustainable, safe and suitable for packaging usage.

One main benefit across all the aforehand materials analyzed if the ability to be composted in the end-of-life of the product it contains, which is imperative in a sustainable material intend to reduce the produced waste to the minimum.

Unfortunately, one of the biggest barriers for the general use of natural sustainable packaging alternatives is the price, as it is not yet competitive when comparing with the current plastic options. These costs vary depending on the company, the type of product and even the material of the product, being palm leaf and bagasse the materials where the biggest variance in price amongst companies occurs for the same type of product. This happens due to the availability of the raw material and the amount of work necessary to process that material into a packaging final product.

Furthermore, GHG gas emissions, in particular CO_2, affect the environmental dimension of each of the aforehand considered companies which, despite not having direct consequences to the consumer as pricing does, still affect the company's reputation and certifications obtained, as sustainable packaging companies promote less hazardous environmental practices.

All in all, despite all the drawbacks, sustainable packaging benefits far outweigh the disadvantages, being an innovative way to work towards sustainable development. Moreover, packaging made from bagasse, PLA and palm leaf are a particular good way to start changing harmful habits and take one of the first steps toward reducing individual's environmental footprint and work collectively on solutions to reduce the current environmental crisis. Moreover, it is not possible to choose just one type of material, as portfolio diversification is crucial for risk prevention whether is price increase and being able to meet the demand, hence being used by the majority of the companies in the industry and is vital for the companies' survival.

6. Connecting Natural Sustainable Packaging, Circular Economy and Sustainable Developments Goals

As already mentioned in chapter 3, circular economy and the sustainable development goals are deeply connected towards achieving a sustainable development, meaning reducing inequalities, fight climate change and reducing resource scarcity.,

Natural sustainable packaging is the main topic throughout this dissertation and one of the single biggest changes that can be done individually to reduce/avoid plastic consumption. However, it has not been mentioned, thus far, what is its implication with the aforehand mentioned topics. Therefore, in this section, an understanding of how the three main elements of this dissertation are connected is provided, in order to understand the main synergies drawn and how distinct implications contribute to one main goal: sustainable development.

Natural Sustainable Packaging & Sustainable Development Goals

Natural sustainable packaging is extremly important when tackling the 2030 Sustainable Development Agenda, as sustainable development cannot take place by itself, it requires "collective commitment to shared goals" (Ecoware, 2019).

For the previosuly stated reason, most companies in the sustainable packaging industry are already trying to tackle SDGs by seting goals on which SDGs they want to work towards achieving and impact positively, hence helping building a better future for everyone.

In particular, company 15 of the work sample, has aligned its materiality topics with the United Nations' Sustainability Goals to use as a guide to set its own goals and has set out to work towards impacting six distinct SDGs:

- **Number 8:** Good jobs and economic growth
  Target 8.4: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programs on sustainable consumption and production, with developed countries taking the lead.

- **Number 9:** Innovation and infrastructure
  Target 9.2: Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.

- **Number 11:** Sustainable cities and communities
  Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

- **Number 12:** Responsible consumption and production

  Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources.

  Target 12.5: By 2030, substantially reduce waste generation through preventio, reduction, recycling and reuse.

  Target 12.6: Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

- **Number 13:** Climate action

  Target 13.3: Improve education, awareness-raising and human and institutuional capacity on climate change mitigation, adaptation, impact reduction and early warning.

- **Number 15:** Life on land

  Target 15.2: By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

From these 6 SDGs, the company drew goals on 5 main areas, with individual targets, as follow:

1. **Zero waste**

   1.1) Increase our advocacy for developing the availability of commercial compost facilities in New Zeland

   Example: Launch of bamboo EcoBin (certified compostable bin liners) for use in cafes and fast-casual dining and creation of a collection point for customers to drop off packaging

   1.2) Increase consumer knowledge and understanding of compostable packaging and its correct disposal

   Example: Implementation of 9 front-of-house initiatives for foodservice operators to educate consumers to build awareness and educate. In particular, one of the initiatives was a compost machine activation in a coffee festival

   1.3) Educate and upskill our customers on sustainability and waste concepts

   Example: Publication of 12 educational blogs communicated through social media

2. **Products**

   2.1) Become Forest Stewardship Counsil (FSC) Chain of Custody certified for at least 50% of our paper SKUs in 2018

3. **Supply Chain**

   3.1) Develop a formalised scorecard that includes sustainability criteria for supplier evaluations

Example: Screening of suppliers' specific credentials such as Environmental Management Standard (ISO 14001:2015), Quality Management Standard (ISO 9001:2005), Forest Stewardship Council (FSC) and compsoting certificates

4. **Operations**

   4.1) Reduce our carbon emission itenity despite predicted growth with Enviro-Market solutions carbonNZeo certification

   Example: Partnership to measure and offset company's emissions and strategic freight/shipping strategies that led to the reduction of 45% of emissions itensity

5. **People**

   5.1) 100% of staff will participate in volunteering at least twice this year

   5.2) Offer five Lunch& Learns to provide opportunities for employees to develop existing skills as well as learn new skills outside their role. The aim is to continue upskill and motivate our employees.

This is a great example on how global guidelines can shape company's goals to act towards a sustainable future and take advantage of business opportunities, as sustainable packaging is an industry said to be in the development and growth phase with technology in the forefront of innovation and plenty of business opportunities to improve the current processes and materials.

All the above are also aligned with the SDGs chosen as goals to impact positively with this dissertation, meaning being able to set a strategy to achieve some targets of the previously set SDGs by introducing natural sustainable packaging, in particular in Portugal, where it mostly only exists for some health and beauty items sold at sustainable or bulk stores but it is rarely sold as food packaging.

Moreover, in order to assess the progress towards achieving particular SDGs, three previously mentioned tools are particularly important, being the GRI, SPI and Gapframe.

Firstly, the SPI is used to frame a country's improvement dimensions, helping decions-makers to allocate resources and drive actions responsibe and inclusive growth with prioritization for the most pressing issues. For example, on the foundations of wellbeing dimensions, exists an indicator under Environmental quality which is "greenhouse gas emissions", evaluated by CO_2 equivalents per GDP, which is extremely helpful for companies in the sustainable packaging industry to undestand how the variation of this indicator changes year after year and compare the changes to other countries.

The next step is using the GapFrame methodology. The global gapframe score is 5.1 (out of 10), with the priority dimension being governance and the average of the 4 dimensions being 5.4. Therefore, the global situation is in the critical stage. Following, taking the case of Western Europe, where Portugal is inserted, the GapFrame methodology indicates that the gapfram score is higher than the world's, being 6.4, with planet as the priority dimension and the average of the 4 dimensions being 7.1. Therefore, it is still on the critical area, but much closer to the watchlist. Therefore, Western Europe's position is better than the World's.

Then, when assessing the score for Portugal, it was noted that Portugal registered a similar position to Western Europe, with a framework score of 6.2 and the planet priority dimension, but with the average of the 4 dimensions being 6.7, meaning that is on the watchlist stage.

Consequently, focus was given to the planet dimension. Here, from the 8 distinct criteria, 2 were found to be related to natural sustainable packaging and also being 2 out of the 3 most pressing issues for the country, with individual score lower than 5, which is the the threat stage:

1. Waste treatement, which is related to SDG 11
2. Carbon quotient, which is related to SDG 13

Now, the priority areas are set and the next step is to set goals the business goals intented to achieve.

After the goal setting, the GRI is ought to be used to track the business performance and support the decision making, while understanding and communicating their impact on pressing sustainability issues.

Taking on the example of company 15 again, its annual report covers 26 discosures across 10 distinct senctions, ranging from general disclosures, to topic-specific standards for economic, environmental and social dimensions.

In particular, the supply chain section covers disclosures from the general discloures, as well as the economic and social dimensions, as listed bellow:

Supply Chain:

- Disclosure 308-1: New suppliers that were screened using environmental criteria
- Disclosure 102-9: Supply-chain description
- Disclosure 204-1: Proportion of spending on local suppliers

By following the available GRI disclosures, company 15 is able to create a more complete report and increase its transparency, which will utlimatly improve its relationships with stakeholders and create positive synergies.

Circular Economy & Sustainable Deveopment Goals

The innovation and economic opportunities available through circular economy, used as a drisruptive change, are one particular way of accelerating the achievement of the 2030 Sustainable Development Agenda (Ritzén and Sandström, 2017), as previously mentioned, due to its inclusion of social and economic sustainability as a way to reach a sustainable development.

Moreover, according to WEF (2015), the connection of circular economy with the Sustainable Development Agenda is simple: "providing a profitable opportunity to move away from resource-intensive processes, whilst maximizing the use of existing assets and creating new revenue streams".

Nonetheless, "Responsible business and investment – rooted in universal principles - will be essential to achieving transformational change through the SDGs. For companies, successful implementation will strengthen the enabling environment for doing business and building markets around the world" (UN Global Compact, 2019).

However, and as expected, this connection is not one-sided, as often achieving an SDG target will contribute to enhance CE, as seen in figure 19.

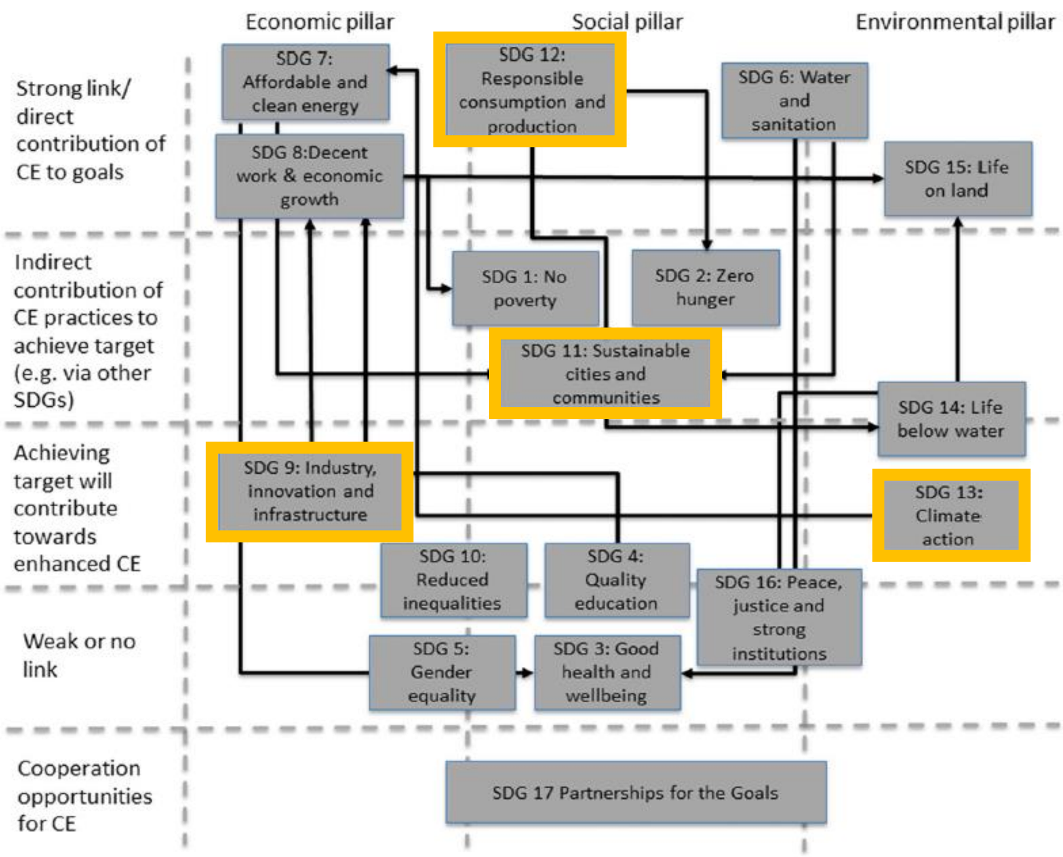


Figure 19 – Connections between SDGs and Circular Economy (Adapted from Schroeder, 2018)

The highlighted SDGs represent the aforehand selected SDGs that will be most impacted by the implementation of natural sustainable packaging. Moreover, each pillar, economic, social and environmental, are represented by at least one of these pre-selected SDGs, which are also represented across all levels of contribution amongst SDGs and CE.

Illustrating, achieving goals of targets 9 and 13, will contribute towards enhanced CE while implementing CE is directly related to achieving goals of target 12 and indirectly related with achieving goals of target 11.

Therefore, it represents the importance of the implementation of natural sustainable packaging as a circular economy strategy leading to the achievement of SDG targets that will, on its turn, enhance circular economy, in a synergy for a sustainable development and, above all, a sustainable future.

Natural Sustainable Packaging & Circular Economy

As aforehand mentioned, the key to fully transition to a circular economy is being able to balance the consumer demand and perception with new technology and materials to provide more ecological packaging and reduce its waste (PAC NEXT, 2017).

Packaging is needed to store and transport products and protect food. However, the resource intensive consumption keeps rising, with packaging waste posing as a major threat for the environment. By introducing a circular economy, which is restorative by design, the products, and in particular packaging are forced to be redesigned in order to make processes more efficient and minimize waste, working in a synergy system to derived benefits from all interactions.

Accordingly, sustainable packaging plays a fundamental role in supporting a circular economy, as it strives for sustainable material sourcing, based on generated waste and not virgin materials, with efficient manufacturing processes reducing in less than 75% the CO_2 emissions (Green Home, 2008) and using 50% less energy (Green Box, 2019), therefore saving valuable scarce resources. Moreover, the end-of-life of the process is harmless, as packaging is composted, returning important nutrients to the soil, rather than creating more waste.

In addition, natural sustainable packaging requires technology innovation, more efficient sustainable supply chains and more sustainable transportation solutions, driving, therefore, innovation and business opportunities.

The demand for sustainable products is growing more than most companies can handle, however, greater costs when compared to plastic options and lack of environmental awareness from the consumers is preventing a wider adoption of such products.

In spite of the drawbacks, “Eco-friendly packaging is becoming a ticket to the game, rather than just being a game-changer” (Raconteur, 2019) .Therefore, more and more the issue becomes how to create a cost-competitive supply chain that meets the clients’ demands and is sustainable from cradle-to-cradle, as products more sustainable will provide greater competitive advantage

6.1. Chapter Conclusions

All in all, a collaborative effort is necessary to achieve sustainable development and improve the current course of action.

Companies are currently aligning their goals according to the United Nations 2030 Sustainable Development Agenda as an effort to attain a positive impact and helping building a better future for everyone, using tools such as GRI, SPI and Gapframe to help them maximize their efforts towards achivieng particular SDGs.

Moreover, these innovative packaging materials are vital to fully transition to a circular economy, being a close regenerative cycle, causing less harm than current practices and obtaining incredible benefits, including cost savings, an important business driver for global companies.

Circular economy and SDGs interactions create important synergies, as achieving goals in one of the topics will enhance the achievements of the other, through direct or indirect contributions.

Lastly, figure 20 summarizes the aforehand mentioned connections amongst the three main elements of the work at hand, being the natural sustainable packaging, sustainable development goals and circular economy,

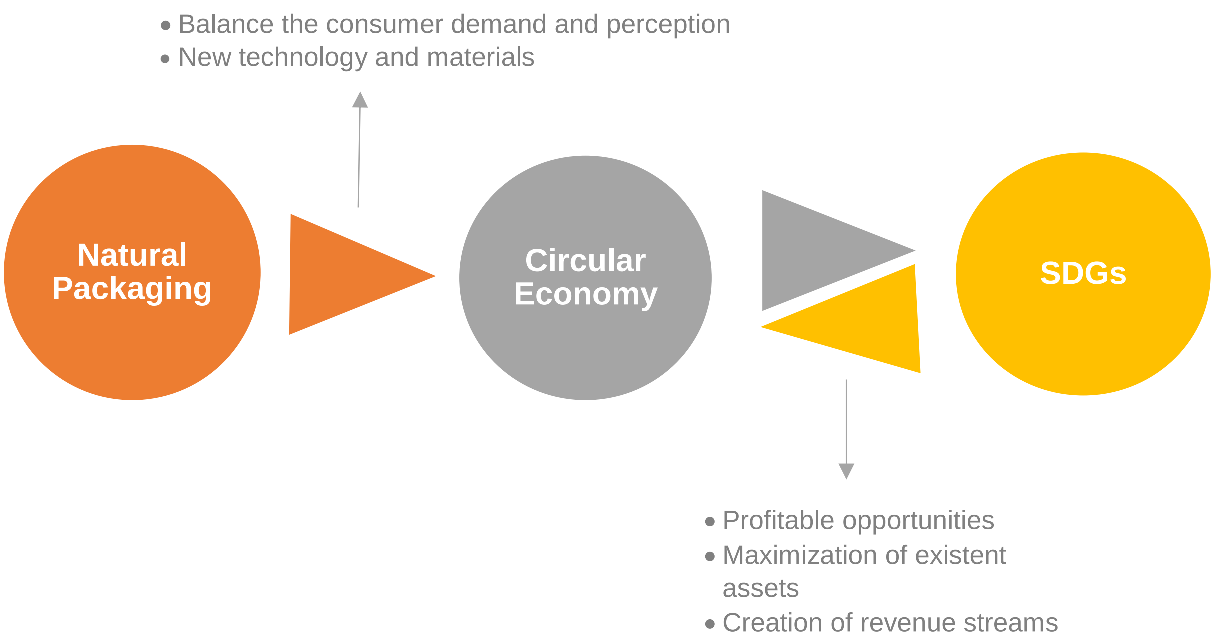


Figure 20 – Summarization of the connections amongst the three main topics of the work

7. Final Conclusions and Future Work

The next decade is crucial for changing habits in order to save Earth, before a tipping point is reached. Sustainability, more than a recent trend, has become inevitable in all industries and sectors, if companies want to remain competitive in the market.

The literature review shows that despite circular economy being a recent concept, it is growing and becoming essential for business to keep competitive in the market, as it requires disruptive changes and radical innovations, leading to innovation, business opportunities and economic benefits. Moreover, this is a pre-requisite to successfully implementing and accelerating the achievement of the SDG, as it will be based on how well countries are able to provide knowledge sharing platforms to increase diffusion, capacity building, specially related to technology and technical capabilities and, lastly, innovation as a way of adaptability to each country's needs.

There are 2 particular SDG that connect these three main topics, being goal 12 (responsible consumption and production) and goal 13 (climate action), as making changing in processes and supply chains and rethinking consumption will lead to actions towards climate action and reversing the current hazardous status-quo.

Despite plastic waste being a current critical matter, there will always be a need for packaging, in particular, food packaging. Therefore, as a global effort, everyone must try to reduce their waste, in particular, the amount of plastic consumed and where reusable is not possible, certified compostable must be the option, as a mean to cause less harm to the environment. Moreover, the demand for such type of products is already present with 75% of customers being willing to pay extra for sustainable packaging as a way to reduce their environmental impact.

For the Portuguese case, the best materials are, therefore, bagasse, palm leaf and PLA, as their characteristics allow for robust packaging, made from natural materials. Moreover, companies can currently meet the demand for this types of packaging, which plays a huge role in the decision.

One important point to keep in mind is that the best option derives from a portfolio diversification, meaning choosing packaging made from all the 3 types of materials would allow risk mitigation, better prices and better meeting of customer needs.

All in all, no option is perfect and there is not one perfect material for sustainable packaging. Many solutions work differently for different companies, as the opportunities and needs are drawn by different factors. Moreover, companies must use reporting tools, such as GRI, to increase their transparency, increase brand awareness and sustainability awareness and create a benchmark for growth and best practices. Therefore, many solutions work towards the same goal, achieving a sustainable development. Nothing changes overnight, and major changes need time to be implemented and see its positive results, which can only happen if collaborative work is implemented across all industries.

Not to be mistaken, circular economy or sustainable packaging or the SDGs are not the perfect solutions to solve the global crisis. However, at the moment, these are the best tools we have to fight it, so they must be used to its fullest and for sure, in a few years, better tools will be created, which will not be the best as well, but they will be one step ahead to reach a sustainable development than what is possible to achieve today.

The most important point is that collaboration is key for disruptive changes and companies must work together with other companies, other industries, policy-makers and customers to find the best solutions that are cost-efficient and lucrative for all stakeholder, and that harm the environment as little as possible, so a tipping point is not reached.

As the work at hand had limited goals to achieve, main areas for future research and improvement are suggested.

First, by using different and more complete methods to evaluate the materials, new points of view will be found, as the solution obtained is subjective to the decision-makers opinion, Moreover, using more quantifiable criteria will also help achieving a more thorough analysis, with more precision and producing a robustness analysis would also help understanding the confidence in the results obtained.

Another point is to conduct the studies mentioned in chapter 5 such as the in-depth price analysis on companies logistic and transportation costs across distinct manufacturing facilities and the analysis of the manufacturing processes of the distinct materials to understand which the more ecological ones are and draw best conclusions on how to further reduce the emissions.

Secondly, Europe is an innovation hub when it comes to sustainability and SDG collaboration. Therefore, synergies must be formed to test the European market, in particular Portugal, for these natural packaging alternatives, as in most European countries, the demand is increasing year by year, but distinct products and types of materials and prices are accepted differently by the consumers, with major differences being notice from country to country..

Lastly, a study and analysis of the implementation of a manufacturing factory in Portugal should be performed, as raw materials are vastly available due to the intense farming culture in the country, and it would increase employment in the area and, the most important aspect, drastically reduce the environmental footprint of packaging, as transportation would decrease over 95%, regarding the distance to the final consumer. This would also fast-track the achievement of sustainable development goals and drive innovation, business opportunities and sustainable growth in Portugal.

References

1 Million Women (2019). Seaweed farms might help stop climate change. Available at: https://www.facebook.com/1MillionWomen/videos/2479359778973396/. Accessed August 2019.

1 Million Women (2019). What's the most planet-friendly food packaging?. Available at: https://www.facebook.com/1MillionWomen/videos/696863964101517/?v=696863964101517. Accessed August 2019.

100Bio (2019). http://onehundredbio.com/about-us/. Accessed June 2019.

Abdullah, N. and Sulaiman, F. (2013). The Oil Palm Wastes in Malaysia. IntechOpen.

Amcor (2019). More Sustainable packaging: 5 common questions. Available at: https://www.amcor.com/about/media-centre/blogs/more-sustainable-packaging-five-common-questions. Accessed September 2019.

Asociacion RUVID (2016). More environmentally friendly concrete made suing sugarcane residue. Available at: https://phys.org/news/2016-01-environmentally-friendly-concrete-sugar-cane-residue.html. Accessed September 2019.

APA (2019). Dedos sobre resíduos Urbanos. Available at: https://apambiente.pt/index.php?ref=16&subref=84&sub2ref=933&sub3ref=936. Accessed September 2019.

Arcadis (2016). The Circular Economy- What Is It and What Does It Mean for You ?. Report. Available at: https://www.arcadis.com/media/9/D/3/%7B9D33B0CB-3F9D-4C16-9C74-B763D4BA442C%7DBriefing%20Paper%20-The%20Circular%20Economy_002.pdf. Accessed January 2018.

ASD (2013). http://ambalaj.org.tr/en/environment-history-of-packaging.html. Accessed June 2019.

ATLAS.ti (2019). Qualitative and Quantitative Research. Available at: https://atlasti.com/quantitative-vs-qualitative-research/. Accessed August 2019.

BASF (2016). How can we make packaging sustainable?. Available at: https://www.youtube.com/watch?v=IfF7QO7F_p0. Accessed September 2019.

BioMass Packaging (2019). Bioplastics. Available at: http://www.biomasspackaging.com/education/bioplastics/. Accessed June 2019.

Bio4pack (2019). https://www.bio4pack.com/about-us-2/. Accessed September 2019.

Budenheim (2019). Bottleing & packagings (PET, PP & PE). Available at: https://www.budenheim.com/en/solutions/plastics/bottling-packagings-pet-pp-pe/. Accessed August 2019.

Cantinho Verde (2019). https://batatadoceira.blogspot.com/2018/06/cocos-nucifera-coqueiro.html. Accessed June 2019.

Clean Metrics (2019). Packaging carbon footprint analysis. Available at: http://www.cleanmetrics.com/html/packaging_carbon_footprints.htm. Accessed October 2019.

Costa, S. (2019). (RE)SET Accelerator Arrives To Boost The Circular Economy. Available at: http://rethink.beta-i.pt/2019/03/25/reset-arrives-boost-circular-economy/. Accessed February 2019.

Costa, S. (2019). The 7 R's Of The Circular Economy. Available at: http://rethink.beta-i.pt/2019/02/15/7-rs-circular-economy/. Accessed February 2019.

Costanza, R. et al. (2009). Beyond GDP: The Need for New Measures of Progress. The Pardee Papers. Boston University, 4(4), 1–46.

Daigneault, A. (2018). In 2018, Seaweed Is The New Plastic. Available at: https://thespoon.tech/in-2018-seaweed-is-the-new-plastic/. Accessed June 2019.

Dell (2019). Bamboo — Nature's Eco-friendly Packaging Solution. Available at: https://www.dell.com/learn/us/en/uscorp1/corp-comm/bamboo-packaging. Accessed May 2019.

Deloitte (2018). The Social Progress Index 2018. Available at: https://www2.deloitte.com/pt/pt/pages/about-deloitte/articles/social-progress-index-2018.html. Accessed December 2018.

Earth Day Network (2018). Top 20 Countries Ranked by Mass of Mismanaged Plastic Waste. Available at: https://www.earthday.org/2018/04/06/top-20-countries-ranked-by-mass-of-mismanaged-plastic-waste/. Accessed August 2019.

Econation (2019). https://econation.co.nz/bamboo/. Accessed June 2019.

Ecoware (2019). FAQs. Available at: http://ecoware.nz/. Accessed September 2019.

eCycle (2019). Embalagens sustentáveis: o que são, exemplos e vantagens. Available at: https://www.ecycle.com.br/6316-embalagens-sustentaveis.html. Accessed June 2019.

EEA (2019). Greenhouse gas emissions from transport in Europe. Available at: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-11#tab-related-briefings. Accessed October 2019.

EEA (2019). Preventing plastic waste in Europe. Available at: file:///C:/Users/HP/Downloads/TH-AL-19-006-EN-N%20Preventing%20plastic%20waste.pdf. Accessed August 2019.

Ellen Macarthur Foundation (2013). TOWARDS THE CIRCULAR ECONOMY. Report. Available at: https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an-accelerated-transition. Accessed March 2019.

Ellen Macarthur Foundation (2015). Circularity Indicators: An Approach to Measuring Circularity Report. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pd. Accessed March 2019.

Ellen Macarthur Foundation (2015). Towards a Circular Economy: Business Rationale for an Accelerated Transition. Report. Available at: https://www.ellenmacarthurfoundation.org/publications/towards-a-circular-economy-business-rationale-for-an-accelerated-transition. Accessed March 2019.

Ellen Macarthur Foundation (2017). Achieving "Growth Within"'. Report. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Achieving-Growth-Within-20-01-17.pdf. Accessed March 2019.

Ellen Macarthur Foundation (2017). Cities in the circular economy: An initial exploration. Available at: https://www.ellenmacarthurfoundation.org/publications/cities-in-the-circular-economy-an-initial-exploration. Accessed January 2019.

Ellen Macarthur Foundation (2019). Circularity Indicators. Available at: https://www.ellenmacarthurfoundation.org/resources/apply/circularity-indicators. Accessed April 2019.

Ellen MacArthur Foundation (2019). Increasing post-consumer plastic content in packaging. Available at: https://www.ellenmacarthurfoundation.org/case-studies/increasing-post-consumer-plastic-content-in-packaging. Accessed April 2019.

Ellen MacArthur Foundation (2019). Schools of thought. Available at: https://www.ellenmacarthurfoundation.org/circular-economy/concept/schools-of-thought. Accessed August 2019.

Enkev (2019). Cocolok. Available at: https://www.enkev.com/en/product/cocolok_19/. Accessed June 2019.

Environmental Journal (2018). "Generation Green": How millennials will shape the circular economy. Available at: https://environmentjournal.online/articles/generation-green-how-millennials-will-shape-the-circular-economy/. Accessed August 2019.

Enviro Total Solutions (2019). Supermarkets in Bali to Vietnam Use Banana Leaf Packaging. Available at: https://www.itsmartenviro.co.id/2019/04/supermarkets-in-bali-to-vietnam-use-banana-leaf-packaging/. Accessed August 2019.

European Bioplastics (2016). What are bioplastics?. Available at: https://docs.european-bioplastics.org/2016/publications/fs/EUBP_fs_what_are_bioplastics.pdf. Accessed June 2019.

European Commission (2018). Plastic Waste: a European strategy to protect the planet, defend our citizens and empower our industries. Available at: https://europa.eu/rapid/press-release_IP-18-5_en.htm. Accessed August 2019.

European Commission (2019). Reducing emissions from the shipping sector. Available at: https://ec.europa.eu/clima/policies/transport/shipping_en. Accessed October 2019.

FAO (2013). Save and Grow: Cassava. A guide to sustainable production intensification. Available at: http://www.fao.org/3/a-i3278e.pdf. Accessed June 2019.

FAO (2019). Crops. Available at: http://www.fao.org/faostat/en/#data/QC/visualize. Accessed June 2019.

Fehrenbacher, J. (2010). Natural Packaging: The Coconut Husk Solves Shipping Problems!. Available at: https://inhabitat.com/natural-packaging-the-coconut-husk-solves-shipping-problems/. Accessed June 2019.

Fehrenbacher, K. (2017). Meet the new US entrepreneurs farming seaweed for food and fuel. Available at: https://www.theguardian.com/sustainable-business/2017/jun/29/seaweed-farms-us-california-food-fuel. Accessed June 2019.

Flick, U. (2009), An Introduction to Qualitative Research, SAGE Publications Ltd, London, UK, 4th Edit.

Fluglaerm (2019). Climate killer aircraft. Available at: https://www.fluglaerm.de/hamburg/klima.htm. Accessed October 2019.

Food Logistics (2019). Banana Leaves Substitute Plastic Packaging in Asia. Available at: https://www.foodlogistics.com/sustainability/news/21074016/banana-leaves-substitute-plastic-packaging-in-asia. Accessed August 2019.

Forbes (2019). Thailand Supermarket Ditches Plastic Packaging For Banana Leaves. Available at: https://www.forbes.com/sites/trevornace/2019/03/25/thailand-supermarket-uses-banana-leaves-instead-of-plastic-packaging/amp/. Accessed May 2019.

GapFrame (2019). http://gapframe.org/. Accessed February 2019.

Geisendorf, S. and Pietrulla, F. (2018). The circular economy and circular economic concepts—a literature analysis and redefinition. Thunderbird International Business Review, 60(5): 771–782.

Ghisellini, P., Cialani, C. and Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production. Elsevier Ltd, 114, 11–32.

Gibbens, S. (2018). What you need to know about plant-based plastics. Available at: https://www.nationalgeographic.com/environment/2018/11/are-bioplastics-made-from-plants-better-for-environment-ocean-plastic/. Accessed June 2019.

Global Footprint Network (2019). Ecological Footprint. Available at http://www.footprintnetwork.org/our-work/ecological-footprint/#worldfootprint. Accessed March 2019.

Goodwin, P. & Wright, G. (2004). Decision Analysis for Management Judgement (3rd edition).

GRI (2019). About GRI. Available at: https://www.globalreporting.org/Information/about-gri/Pages/default.aspx. Accessed January 2019.

GRI (2019). Benefits of Reporting. Available at: https://www.globalreporting.org/information/sustainability-reporting/pages/reporting-benefits.aspx. Accessed January 2019.

GRI (2019). Business reporting on SDG. Available at: https://www.globalreporting.org/information/SDGs/Pages/Reporting-on-the-SDGs.aspx. Accessed October 2019.

GRI (2019). GRI and the SDG. Available at: https://www.globalreporting.org/information/SDGs/Pages/GRI-and-SDGs.aspx. Accessed January 2019.

GRI (2019). GRI's History. Available at: https://www.globalreporting.org/information/about-gri/gri-history/Pages/GRI's%20history.aspx. Accessed January 2019.

GRI (2019). GRI Standards Download Center. Available at: https://www.globalreporting.org/standards/gri-standards-download-center/. Accessed March 2019.

GRI (2019). Sustainable Development Goals. Available at: https://www.globalreporting.org/information/SDGs/Pages/SDGs.aspx. Accessed March 2019.

GreenBiz (2010). Coconut Husks Find New Life as Packaging. Available at: https://www.greenbiz.com/news/2010/09/20/coconut-husks-find-new-life-packaging. Accessed June 2019.

Green Box (2019). Bagasse (Sugarcane). Available at: https://www.biologischverpacken.de/en/bagasse-sugarcane. Accessed June 2019.

Green Box (2019). Sustainable packaging. Brochure. Available at: http://www.biologischverpacken.de/media/pdf/d8/4c/d0/greenbox-infofolder-sustainability.pdf. Accessed June 2019.

Green Home (2008). The Pros and Cons of Bioplastics. Available at: https://greenhome.co.za/the-pros-and-cons-of-bioplastics/. Accessed June 2019.

Greenway, S. (2018). 13 Plastic Packaging Alternatives. Available at: https://www.innovationexcellence.com/blog/2018/07/02/13-plastic-packaging-alternatives/. Accessed June 2019.

Grönman, K. et al. (2013). Framework for sustainable food packaging design. Packaging Technology and Science.

Gupta, J. and Vegelin, C. (2016). Sustainable development goals and inclusive development. International Environmental Agreements: Politics, Law and Economics. Springer Netherlands, 16(3), 433–448.

Heart, C. (2018). Doing a Literature Review: Releasing the Research Imagination. 2nd edition [ebook] Sage Publications, 1-314. Available at: https://books.google.pt/books?hl=pt-PT&lr=&id=ff1BDwAAQBAJ&oi=fnd&pg=PP1&dq=why++literature+review&ots=iBLQiOarTd&sig=z5vd-aVfQeIuZDeZzyXBPJApqX0&redir_esc=y#v=onepage&q=why%20%20literature%20review&f=false. Accessed August 2019.

Inbar (2019). Bamboo facts: What makes bamboo a strategical resource for green economy development. Available at: https://www.inbar.int/bamboo-facts-what-makes-bamboo-a-strategic-resource-for-green-economy-development/. Accessed May 2019.

Inbar (2019). SDG 12: Sustainable Production and Consumption. Available at: https://www.inbar.int/programmes/sdg12-sustainable-consumption-production/#2. Accessed May 2019.

Inequality (2019). https://inequality.org/facts/global-inequality/. Accessed April 2019.

Institute for Strategy & Competitiveness (2019). Social Progress Index. Available at: https://www.isc.hbs.edu/research-areas/Pages/social-progress-index.aspx. Accessed April 2019.

International Monetary Fund (2019). Sustainable Development Goals. Available at: https://www.imf.org/en/Topics/SDG. Accessed December 2019.

Jha, A. et al. (2016). Accelerating achievement of the sustainable development goals a game changer in global health. BMJ (Online), 352, 1–2.

Knope, L. (2017). We use 50 Billion Water Bottles Per Year. Here’s An Edible Container That Can Stop The Insanity. Available at: https://thespoon.tech/are-edible-balls-the-future-of-water/. Accessed June 2019.

Korhonen, J. et al. (2018). Circular economy as an essentially contested concept. Journal of Cleaner Production. Elsevier Ltd, 175, 544–552.

Korhonen, J., Honkasalo, A. and Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. Ecological Economics. Elsevier B.V., 143, 37–46.

KPMG (2017). Edge of Page - The KPMG survey of corporate responsibility reporting 2017. The road ahead - The KPMG Survey of Corporate Responsibility Reporting 2017, (10), 1–58. Accessed August 2019.

Krown (2019). https://www.krown.bio/. Accessed May 2019.

Leafware (2019). http://www.leafware.com/. Accessed July 2019.

Lee, S. G. and Xu, X. (2005). Design for the environment: life cycle assessment and sustainable packaging issues. International Journal of Environmental Technology and Management, 5(1), 14.

Lewis Bamboo (2019. Why Bamboo? (Green Solution). Available at: https://lewisbamboo.com/why-bamboo-green-solution/. Accessed June 2019.

Lu, Y. et al. (2015). Brief for GSDR – 2016 Update Five priorities for the UN Sustainable Development Goals. Nature, 520, 432–433.

Manning, A. (2017). Ecological Alternatives to plastics?. Available at: https://www.greenbatch.com/blog/2017/10/10/mushrooms-an-ecological-alternative-to-plastics. Accessed June 2019.

Marshall, S. and Meidis, F. (2018). Coir Fiber. Available at: https://www.spearcoco.com/coconut-fibre-based. Accesses June 2019.

McEachran, R. (2015). Forget about cotton, we could be making textiles from banana and pineapple. Available at: https://www.theguardian.com/sustainable-business/sustainable-fashion-blog/2015/mar/03/wearable-pineapple-banana-fruit-fashion-material. Accessed June 2019.

McGee, K. (2019). Uses of Palm Leaves. Available at: https://www.hunker.com/13428206/uses-of-palm-leaves. Accessed June 2019.

McHugh, D. (2003). A guide to the seaweed industry. Paper. Available at: http://www.fao.org/3/a-y4765e.pdf. Accessed June 2019.

Mckinsey & Company (2016). The circular economy: Moving from theory to practice. Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/The%20circular%20economy%20Moving%20from%20theory%20to%20practice/The%20circular%20economy%20Moving%20from%20theory%20to%20practice.ashx. Accessed January 2019.

McLachlan, C. (2019). How Many Times a banana Tree Can Produce Bananas. Available at: https://www.hunker.com/13426672/how-many-times-a-banana-tree-can-produce-bananas. Accessed June 2019.

Michael Green (2019). https://www.socialprogress.org/about-us. Accessed January 2019.

Minh, T. (2019). Making eco-friendly packaging available to all. Available at: https://oceanchampions.ca/category/in-the-news/government-action/. Accessed August 2019.

Muff, K., Kapalka, A. and Dyllick, T. (2017). The Gap Frame - Translating the SDGs into relevant national grand challenges for strategic business opportunities. International Journal of Management Education. Elsevier Ltd, 15(2), 363–383.

Mulyono, N. (2019). Edible packaging from seaweed. Available at: https://www.freshplaza.com/article/9081843/edible-packaging-from-seaweed/. Accessed June 2019.

Mustajoki, J., Hämäläinen, R., and Salo, A. (2005). Decision Support by Interval SMART/SWING-Incorporating Imprecision in the SMART and SWING Methods. Decision Sciences, 36(2).

National Plant Germplasm System (2019). Manihot esculenta Crantz. Available at: https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?id=431678. Accessed 9 June 2019.

National Ocean Service (2018). What is seaweed?. Available at: https://oceanservice.noaa.gov/facts/seaweed.html. Accesses May 2019.

Ng, C. (2015). Plant leaves in food preparation and packaging. Utar Agriculture Science Journal, 1(4).

Nordin, N. and Selke, S. (2010). Social aspect of sustainable packaging. Packaging Technology and Science.23, 317-326.

NotPla. (2019). https://www.notpla.com/technology/. Accessed May 2019.

PAC NEXT (2017). Packaging Towards a Circular Economy: Addressing Today's Top Packaging Challenges. Report. Available at: http://www.pac.ca/ePromos/promos/pac0894/factsheet-primer.pdf. Accessed March 2019.

Packaging 360 (2019). https://packaging360.in/insights/polylactic-acid---a-sustainable-bioplastics-packaging-option. Accessed June 2019.

Packaging Europe (2017). IS SUSTAINABLE PACKAGING THE KEY TO A CIRCULAR ECONOMY?. Available at: https://packagingeurope.com/is-sustainable-packaging-the-key-to-a-circular-economy/. Accessed March 2019.

Packaging Europe (2019). ACHIEVING A CIRCULAR ECONOMY THROUGH PACKAGING AND PACKAGING WASTE. Available at: https://packagingeurope.com/achieving-a-circular-economy-through-packaging-and-packaging/. Accessed March 2019.

Patil, K. (2019). 15 Impressive Benefits of Seaweed. Available at: https://www.organicfacts.net/seaweed.html. Accessed May 2019.

Penh, P. (2015). Cassava Handbook. Available at: https://www.moc.gov.kh/tradeswap/userfiles/Media/file/Projects/EIF/CEDEP%20II/Cassava%20Component/7-References/Cassava%20handbook.pdf. Accessed July 2019.

Plastics Europe (2016). Plastics – the Facts 2015. Available at: https://www.plasticseurope.org/application/files/3715/1689/8308/2015plastics_the_facts_14122015.pdf. Accessed July 2019.

Plastics Europe (2018). Plastics – the Facts 2017. Available at: https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf. Accessed August 2019.

Plastics Europe (2019). Plastics – the Facts 2018. Available at: https://www.plasticseurope.org/application/files/6315/4510/9658/Plastics_the_facts_2018_AF_web.pdf. Accessed August 2019.

Polymer Properties Database (2015). Plastics Industry Facts. Available at: http://polymerdatabase.com/polymer%20classes/Plastics%20Industry%20Facts.html. Accessed August 2019.

Prieto-Sandoval, V., Jaca, C. and Ormazabal, M. (2018). Towards a consensus on the circular economy. Journal of Cleaner Production. Elsevier Ltd, 179, 605–615.

PWC (2012). Sustainable packaging: myth or reality. Revisiting the debate two years on. Available at: https://www.pwc.pt/pt/sustentabilidade/images/publica/pwc-sustainable-packaging-report.pdf. Accessed September 2019.

Pyzyk, K. (2018). 5 of the world's most eco-friendly building materials. Available at: https://www.smartcitiesdive.com/news/most-eco-friendly-building-materials-world-bamboo-cork-sheep-wool-reclaimed-metal-wood/526982/. Accessed May 2019.

Raconteur (2017). Three in four consumers will pay for packaging sustainability. Available at: https://www.raconteur.net/sponsored/three-in-four-consumers-will-pay-for-packaging-sustainability. Accessed August 2019.

Raconteur (2019). Future of packaging. Available at: https://www.raconteur.net/future-packaging-2019 . Accessed August 2019.

Research Methodology (2019). Case Studies. Available at: https://research-methodology.net/research-methods/qualitative-research/case-studies/. Accessed August 2019.

Ritzén, S. and Sandström, G. Ö. (2017). Barriers to the Circular Economy - Integration of Perspectives and Domains. Procedia CIRP. Elsevier B.V., 64, 7–12.

Roy, R. (2009). 15 creative uses of bamboo. Available at: https://matadornetwork.com/change/15-creative-uses-of-bamboo/. Accessed June 2019.

Sachs, J. D. (2012). From Millennium Development Goals to Sustainable Development Goals. The Lancet, 379(9832), 2206–2211.

Schoeder, P. et al. (2018). The Relevance of Circular Economy Practices to the Sustainable Development Goals. Journal of Industrial Ecology.

SDG Tracker (2018). https://sdg-tracker.org/. Accessed December 2018.

Seaweed (2019). http://www.seaweed.ie/. Accessed May 2019.

Social Progress Imperative (2017). SOCIAL PROGRESS INDEX 2017. Report. Available at: https://www.socialprogress.org/assets/downloads/resources/2017/2017-Social-Progress-Index.pdf. Accessed February 2019.

Social Progress Imperative (2017). The Contribution of the Social Progress Index to the 2030 Agenda. Report. Available at: https://www.socialprogress.org/assets/downloads/resources/2017/2017-Social-Progress-Index-Contribution-to-the-SDGs.pdf. Accessed January 2019.

Social Progress Imperative (2019). https://www.socialprogress.org/about-us/faq. Accessed January 2019.

Sonneveld, K. et al. (2005). Sustainable Packaging: How do we Define and Measure It?. Symposium A Quarterly Journal In Modern Foreign Literatures, 1–9.

Stafford-Smith, M. et al. (2017). Integration: the key to implementing the Sustainable Development Goals. Sustainability Science, 12(6), 911–919.

Statista (2019). Plastics industry – Statistics & Facts. Available at: https://www.statista.com/topics/5266/plastics-industry/. Accessed August 2019.

Sustainable Development (2016). Sustainable Development Goal 1. Available at: https://sustainabledevelopment.un.org/sdg1. Accessed November 2018.

Sustainable Development (2016). Sustainable Development Goal 3. Available at: https://sustainabledevelopment.un.org/sdg3. Accessed November 2018.

Sustainable Development (2019). https://sustainabledevelopment.un.org/sdgs. Accessed January 2019.

Sustainable Packaging Coalition (2011). Definition of Sustainable Packaging. Report. Available at: https://sustainablepackaging.org/wp-content/uploads/2017/09/Definition-of-Sustainable-Packaging.pdf. Accessed March 2019.

Svanes, E. et al. (2010). Sustainable packaging design: A holistic methodology for packaging design. Packaging Technology and Science, 23, 161-175.

TAAT Africa (2019). From Waste to Wealth: How cassava peels processing technology is improving livelihoods in Nigeria. Available at: https://taat-africa.org/from-waste-to-wealth-how-cassava-peels-processing-technology-tellisis-improving-livelihoods-in-nigeria/. Accessed July 2019.

Tellis, W. (1997). Application of a Case Study Methodology. The Qualitative Report, 3 (3), 1-19. Available at: https://nsuworks.nova.edu/tqr/vol3/iss3/1. Accessed August 2019.

The Guardian (2017). Throwaway culture has spread packaging waste worldwide: here's what to do about it. Available at: https://www.theguardian.com/environment/2017/mar/13/waste-plastic-food-packaging-recycling-throwaway-culture-dave-hall. Accessed May 2019.

The Guardian (2018). Humanity has wiped out 60% of animal populations since 1970, report finds. Available at: https://www.theguardian.com/environment/2014/sep/29/earth-lost-50-wildlife-in-40-years-wwf. Accessed May 2019.

The Jakarta Post (2019). Bali supermarket ditches plastics packaging for banana leaves. Available at: https://www.thejakartapost.com/life/2019/04/29/bali-supermarket-ditches-plastic-packaging-for-banana-leaves.html. Accessed August 2019.

TNAU Agritech portal (2019). Coconut-Botany. Available at: http://agritech.tnau.ac.in/horticulture/horti_pcrops_coconut_botany.html. Accessed September 2019.

UN Global Compact (2015). SDG Industry Matrix. Available at: https://www.unglobalcompact.org/library/3111. Accessed February 2019.

UN Global Compact (2017). Business Reporting on the SDGs: An Analysis of the Goals and Targets. Available at: https://www.unglobalcompact.org/library/5361. Accessed March 2019.

UN Global Compact (2019). How your company can advance each of the SDG. Available at: https://www.unglobalcompact.org/sdgs/17-global-goals. Accessed October 2019.

UNEP (2015). Three Dimensions of Sustainable Development. Available at: http://web.unep.org/ourplanet/march-2015/unep-work/three-dimensions-sustainable-development. Accessed March 2019.

UNEP (2015). Product Sustainability Information: State of Play and Way Forward. Available at: https://www.lifecycleinitiative.org/wp-content/uploads/2015/07/PSI_28.7.15-web.pdf. Accessed August 2019.

UNEP (2018). SINGLE-USE PLASTICS: A Roadmap for Sustainability. Report. Accessed September 2019.

UNGSII (2017). SDG Commitment Report 100: Tracking companies' efforts to contribute to the Sustainable Development Goals. Available at: https://www.cbd.int/financial/2017docs/un2017-scr100.pdf. Accessed January 2019.

UNLEASHED (2018). 8 Eco-Friendly Packaging Alternatives for Your Shipping Needs. Available at: https://www.unleashedsoftware.com/blog/8-eco-friendly-packaging-alternatives-shipping-needs. Accessed May 2019.

UNLEASH (2019). PackLess. Available at: https://unleash.org/solutions/packless/. Accessed March 2019.

UNLEASH (2019). PETr PAN. Available at: https://unleash.org/solutions/petr-pan/. Accessed March 2019.

UNLEASH (2019). Sachet Sorting and Collection. Available at: https://unleash.org/solutions/sachet-sorting-collection/. Accessed March 2019.

United Nations (2015). History of the UN. Available at: https://www.un.org/un70/en/content/history/index.html. Accessed May 2019.

United Nations (2015). Millenium develoment goals. Available at: http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015. Accessed January 2019.

United Nations (2019). Sustainable Development Goals. Available at: https://sustainabledevelopment.un.org/?menu=1300. Accessed January 2019.

United Nations (2019). What we do. Available at: https://www.un.org/en/sections/what-we-do/index.html. Accessed January 2019.

Vegware (2019). https://www.vegware.com/. Accessed June 2019.

Walpole, S. et All. (2012). The weight of nations: an estimation of adult human biomass. BMC Public Health. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3408371/pdf/1471-2458-12-439.pdf. Accessed August 2019.

WBCSD (2018). A joint report on the current landscape of circular metrics use and recommendations for a common measurement framework Circular Metrics Landscape Analysis Executive summary. Report. Available at: https://docs.wbcsd.org/2018/06/Circular_Metrics-Landscape_analysis.pdf. Accessed March 2019.

Webster, J. and Watson, R. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Quarterly, 26 (2).

WEF (2015). How the circular economy can help us achieve the Global Goals. Available at: https://www.weforum.org/agenda/2015/10/how-the-circular-economy-can-help-us-achieve-the-global-goals. Accessed September 2019.

WEF (2018). 90% of plastic polluting our oceans comes from just 10 rivers. Available at: https://www.weforum.org/agenda/2018/06/90-of-plastic-polluting-our-oceans-comes-from-just-10-rivers/. Accessed August 2019.

WEF (2019). Here are 5 of the biggest threats to our oceans, and how we can solve them. Available at: https://www.weforum.org/agenda/2018/06/5-ways-we-can-improve-ocean-health?utm_source=Facebook%20Videos&utm_medium=Facebook%20Videos&utm_campaign=Facebook%20Video%20Blogs. Accessed August 2019.

WEF (2019). This lethal fungus is threatening to wipe out the world's bananas. Available at: https://www.weforum.org/agenda/2019/08/this-lethal-fungus-is-threatening-to-wipe-out-the-world-sbananas?utm_source=Facebook%20Videos&utm_medium=Facebook%20Videos&utm_campaign=Facebook%20Video%20Blogs&fbclid=IwAR0qesvaLSeuT7d0XbCgWylLCX_NGjcLUw53z5QLmCp-g_AQR9kyBLSRWFY. Accessed August 2019.

World Facts (2017). Top Sugarcane Producing Countries. Available at: https://www.worldatlas.com/articles/top-sugarcane-producing-countries.html. Accessed August 2019.

Worldometers (2019). Europe Population. Available at: https://www.worldometers.info/world-population/europe-population/. Accessed August 2019.

Worldometers (2019). Current World Population. Available at: https://www.worldometers.info/world-population/. Accessed August 2019.

Yin, R. (2003). Case study research: Design and methods.3rd editions. Thousand Oak: Sage.

Zafar, S. (2019). Energy Potential of Coconut Biomass. Available at: https://www.bioenergyconsult.com/tag/coconut-husk/. Accessed July 2019.