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Sustainable Packaging: Finding an environmentally friendly solution for AZEMAD products

Francisco da Assunção Contins

Master in Management of Services and Technology

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Acknowledgement

The ending of this Master Thesis represents a lot to me. It represents the moment of transition between the academic journey and professional career. It symbolizes the ending of an intensive journey of academic studies, divided between Católica Lisbon School of Business & Economics and ISCTE-IUL. The move to ISCTE-IUL to take a master degree surprised me in a very positive way, where I could meet friends that I will take for life, and social and studying experiences that I will not forget.

I want to thank my supervisor Prof. Isabel Cristina de Almeida all the help and support during the development of this thesis, and my family and friends for supporting me during this journey, it meant a lot to me.

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Resumo

A produção em massa, inovação tecnológica e aumento do poder económico provocaram grandes disparidades nos domínios social e económico, bem como o esgotamento dos recursos, a produção de resíduos e o aquecimento global.

A crescente preocupação da sociedade com as questões ambientais e a necessidade urgente de um desenvolvimento sustentável colocaram a embalagem na vanguarda de uma área essencial a desenvolver, pois os consumidores estão cada vez mais conscientes dos problemas ambientais.

A cultura "retirar-produzir-deitar fora" gerou a necessidade de uma economia mais sustentável, uma vez que os recursos são limitados e a procura não para de aumentar. Assim, a nova economia circular exige soluções criativas que contribuam para a minimização dos resíduos e a eficiência dos recursos, conduzindo a níveis mais baixos de danos ambientais e a um maior desenvolvimento económico.

As soluções de embalagens sustentáveis são mais do que uma tendência, são consideradas um dos mais importantes motores de desenvolvimento ambiental e económico. A revisão de literatura explica a atualidade do desenvolvimento sustentável e da indústria de embalagens sustentáveis, mostrando exemplos de boas práticas e respetivo impacto no ambiente e na economia.

Esta dissertação inclui um estudo de caso, que começará por fazer uma avaliação comparativa das opções de materiais disponíveis para a nova conceção da embalagem, comparando critérios, com o apoio de métodos e ferramentas.

Por fim, depois de chegar a um resultado adequado, serão criados vários cenários do projeto, para compreender as possibilidades do resultado do projeto para a empresa, onde serão futuramente propostas soluções.

Palavras-chave: Embalagem, Sustentabilidade, Economia Circular, Design Sustentável

Classificação JEL: M11; O44

Abstract

Mass production, technological innovation and increased economic power have caused major disparities in the social and economic areas, as well as the depletion of resources, the production of waste and global warming.

The growing concern of society over environmental issues and the urgent necessity of sustainable development have placed packaging at the forefront of an essential area to develop since consumers are becoming more and more conscious about environmental concerns.

The “take-make-dispose” culture generated the need for a more sustainable economy since the resources are limited, and the demand doesn’t stop increasing. As is, the new circular economy demands creative solutions to contribute to waste minimization and resource efficiency, leading to lower levels of environmental damage and increased economic development.

Sustainable packaging solutions are more than a trend, they are considered one of the most important drivers of environmental and economic development. The literature review explains the current situation of sustainable development and the sustainable packaging industry, showing examples of good sustainable practices and their impact on the environment and economy.

This dissertation includes a case study, that will start by doing a benchmarking of the current material options available for the new packaging design, and many types of criteria are evaluated and compared, with the support of methods and tools.

Lastly, after reaching a suitable result, several scenarios of the project will be created, to understand the possibilities of the outcome of the project to the company, where further solutions will be proposed.

Keywords: Packaging, Sustainability, Circular Economy, Sustainable Design

JEL Classification: M11; O44

Contents

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List of Abbreviations

CE: Circular Economy

CEO: Chief Executive Officer

CO2: Carbon Dioxide

DM: Decision Make

EU: European Union

GOTS: Global Organic Textile Standard

KG: Kilograms

KPI: Key Performance Indicator

MCDA: Multi-Criteria Decision Analysis

MOQ: Minimum order quantity

MPa: Megapascal

OCS: Organic Content Standard

PET: Polyethylene Terephthalate

RPET: Recycled Polyethylene Terephthalate

RQ: Research Question

R&D: Research and Development

SCM: Supply Chain Management

SPC: Sustainable Packaging Coalition

US: United States

1. Introduction

1.1 Theme relevance

1.1.1 Packaging Industry

Packaging materials are an important component of our lives, due to their regular use. They are critical in ensuring that items are preserved during handling, transportation, and storage (Ibrahim et al., 2022).

All businesses that handle products require effective packaging solutions since these have an impact on the company's efficiency in both internal and external flows. Industrial packaging requires a detailed analysis of all potential effects throughout the design and development stages (Silva & Pålsson, 2022).

Companies are putting a lot of effort into making sure their packaging is environmentally friendly. They are expected to look at size-optimized packaging to cut emissions in transportation, as well as increase the use of recycled and recyclable materials, with many investigating reusable and returnable packaging solutions (Dobson, 2023).

This trend is justified by the fact that companies are under pressure from both customers and governments to utilize environmentally friendly packaging for their products. People are becoming increasingly concerned about the environmental impact of packaging (Nguyen et al., 2020). Also, as there is increasing pressure from the governments, companies must be aware of the fast rate of regulatory development, since noncompliance may result in tax increases or fines (McKinsey&Company, 2022).

1.1.2 Trends in Packaging History

Packaging trends have been changing over the years since consumers' and companies' values and concerns are constantly changing.

According to an article written by Feber et al. (2022), posted on the McKinsey & Company website, it was found that since 2000 we have been in three eras of packaging trends. Those findings state the three eras are divided by the year 2000 until 2009, 2009 until 2020, and 2020 until now.

In the first era (2000-09), more flexible packaging and rigid plastics were used to substitute rigid such as metal, paper, and glass. The aim was to meet the customer desire for convenience, by being smaller, easy to port, and lower production costs for the companies.

In the second era (2009-20) the great financial crisis arrived, representing a period of uncertainty and instability. Besides that, the crisis motivated packaging players to develop there, and at the end of the era, consumer awareness of sustainability increased significantly, as well as policymakers' pressure, where emerged the European Union's single-use directive, plastic bag fees and full prohibitions in several US states, and Chinese rules on foodservice packaging. With this, it increased the market recyclability commitments to substitute plastic usage.

In the last era, the current one, CEOs should consider sustainability in a comprehensive approach. They should expedite their plans to minimize greenhouse gas emissions in operations and throughout the supply chain, establishing a sustainable product portfolio. It is currently witnessed increased efforts to commercialize packaging technologies, as well as improved marketing of their effectiveness, new products of the businesses must be more sustainable and less expensive.

1.1.3 Innovative Packaging Solutions Based on Sustainable Materials

As sustainable development ideas are increasingly included at many levels within industrial and organizational platforms, packaging sustainability concepts have expanded too. The packaging industry is currently being impacted by several concepts, such as plastic pollution, packaging waste, declining air, soil and water quality, climate change, and other contemporary challenges (Boz et al., 2020).

The material selection process by companies that respect the sustainable principles that have emerged must be carefully evaluated since the packaging is one of the major responsible for waste generation. The business movement to become “greener” made producers rethink their actions and tactics to waste management concepts, such as the adoption of packaging materials and designs that allow recycling, reusing and reduction (Parra, 2008).

Material sustainability is determined by a variety of aspects ranging from the economic to the environmental, including costs, the usefulness of aesthetic features, manufacturing through end-of-life processing, and effects on a local to global scale (Reichert et al., 2020).

1.2 Research Problem and Research Question

1.2.1 Problem Definition

AZEMAD is the roller hockey world market leader, due to the high quality of the products sold, as well as the focus on the diversity of hockey products produced by the company. Despite that, the weak point of the company is the packaging design that the company has, something that could be improved. As no alternative has yet been identified as sufficiently sustainable, the following problem needs to be addressed:

There are no adequate or sustainable packaging options available for AZEMAD’s products.

The theme relevance is justified by being a necessity of the company, directly referenced in the first approach with AZEMAD. The company considers that consumers are getting more focused on the sustainability of the products consumed, so they felt the necessity of getting on that “sustainable wave" that is emerging in the economy. From the scientific point of view, the project is expected to be useful since there are not many studies in what relates to comparing the characteristics of the materials, including not only financial but environmental ones.

1.2.2 AZEMAD Context, Challenges and Limitations

After ensuring the collaboration with AZEMAD, on the first in-person meeting, AZEMAD spoke about the necessity of creating a new type of packaging for their orders, mainly the shoebox, since the company is only selling the roller hockey boots in default cardboard boxes, with a little printed design, something that is not that attractive to the consumer. To solve this problem and ensure that AZEMAD keeps improving the dedication and quality of the company, it was decided that the focus of this study would be to analyse new packaging solutions.

The purpose of changing the packaging is to reduce the quantity of paperboard to ensure a more sustainable design of the packaging. An idea emerged in a meeting with AZEMAD R&D Manager Diogo Martins, who considers that despite the company has already some sustainable practices, it still has a lot to improve. The idea would be to create a packaging design where a new sustainable cardboard box design would be inserted in a sustainable bag that would be further reused by the customer. After that brainstorming phase, it was concluded that the purpose of this Master Thesis would be to analyse the material solutions for the bag.

1.2.3 Research Question

With this problem explained, a research question emerged, that will be solved with the help of the theoretical basis provided by the Literature Review, and the conclusions of the study done with the methodology chosen.

RQ: What is the best sustainable material for the new AZEMAD sustainable bags?

1.3 Objectives

According to the problem of the project, to figure out which will be the best material to package the AZEMAD products, some objectives were defined to achieve the results:

- Access the environmental sustainability of the current packaging materials, to understand where to improve;
- Search for sustainable material alternatives;
- Examine the characteristics of the new material options and what implications they have for packaging;
- Compare and conclude which packaging material is the one that fits best the interests of the company.

The goal of this thesis was twofold: first, to give a broad examination of the benefits and drawbacks of various packaging materials, and second, to analyse different outcomes of the project for AZEMAD.

1.4 Methodological Approach Summary

As for the methodology, this thesis follows the guidelines of a case study. According to Yin (1994), the following three criteria should be taken into consideration while choosing a research methodology:

I. Research question format;
II. How much control and influence does a researcher have over actual behavioural events;
III. The degree to which contemporary events are emphasized over historical ones.

Since the researcher does not influence behavioural events, case study research, as indicated in Table 1.1, poses a question about "how" and "why." the researcher prefers to focus on current events. As mentioned in Chapter 1.2, this thesis answers the question "how". Additionally, because he will be concentrating on current occurrences, the researcher won't need to exert any control over or influence behavioural events.

Table 1.1- Relevant situations for different research methods, according to Yin (1994)

Research Method	1. Form of Research Question	2. Requires Control of Behavioural Events?	3. Focuses on Contemporary Events?
Experiment	how, why?	yes	yes
Survey	who, what, where how many, how much?	no	yes
Archival Analysis	who, what, where how many, how much?	no	yes/ no
History	how, why?	no	no
Case Study	how, why?	no	yes

This thesis is expected to contribute to the literature by proposing different sustainable packaging scenarios. These scenarios will be explained through other cases to illustrate the present case study research method. The methodological approach consists of four steps, briefly presented below:

i. Scope definition and benchmarking is the first step of the research process; responsible for analysing the most relevant information about each possible material for the project.
ii. The second step of the research process is selecting the suitable material for the project's needs. To select the most suitable material, Multi-Criteria Decision Analysis (MCDA) is selected as the main methodology. MCDA will be complemented with Swing weighting methodology, and supported by an Interview Guide Tool, applied in an interview with Diogo Martins, the Decision-Maker.
iii. The third step is to proceed with the case study using a scenario-driven analysis. In this step multiple packaging scenarios are evaluated. The options will be focused on the acceptance and adherence of the new sustainable bags by AZEMAD in the market, assuming three different possible scenarios.
iv. As part of the 4th research step, solutions will be proposed for the possible problems that the scenarios might generate.

1.5 Thesis Structure

Chapter 1: The theme relevance is explained, where it gives some context to the current situation of the packaging industry. Then, the context of AZEMAD is developed and the research problem is defined, leading to the definition of the Research Question and the key objectives. This chapter is completed with the methodology thesis structure definition.

Chapter 2: Concerning the Literature Review. The theoretical framework is defined to support the evolution of the project. The most important themes related to sustainable packaging are developed and carefully analysed.

Chapter 3: Where the methodology will be defined. In this chapter, the four steps of the methodology will be carefully explained, as well as the sub-steps of each. This chapter will be responsible to explain how the result of the master thesis will be reached.

Chapter 4: This chapter is a completion of Chapter 3. After the methodology is explained, it is put into practice and the results will be reached, and further analysed.

Chapter 5: The final step of the master thesis will consist of a conclusion about the learnings and outcomes of the project.

2. Literature Review

In this chapter, several concepts related to sustainable packaging will be deeply analysed to support the development of the project. The main themes examined will be the development of sustainability, and the correlation between a Circular Economy and sustainable packaging.

2.1 Sustainability in the Transition from Linear to Circular Economy

2.1.1 Sustainability as a Path to Circularity

The concept of sustainability first appeared in the community more than 30 years ago, in 1987, in the famous Brundtland Report, written by Mrs Gro Harlem Brundtland, Norwegian Prime Minister, that set the principles to understand the concept of sustainable development as we know today (E. Jarvie, 2014). According to Mrs Gro Harlem Brundtland, sustainable development is defined as meeting the needs of Humanity without compromising the ability of future generations to meet their own needs.

The truth is that humanity's demand for natural resources is exceeding the Earth's natural rate of regeneration, which has consequences in greenhouse gas accumulation, acidification of the ocean, and global warming, among others (Wackernagel et al., 2021). In 2022, the 28th of July was the Earth's Overshoot Day, that is the day that marks the year when the human demand for natural resources exceeds the natural regeneration of resources of the planet, which means that we are using 1.75 times more resources that we should have been using in a year, and that keeps happening every year, with an increasing tendency (Duncan, 2022). By 2050, the population of the globe might reach 10 billion, so there are many reasons why sustainable development is so important, especially in keeping the stability of the economy (Fokkema et al., 2005).

Sustainability is composed of three pillars: environmental (by preserving ecosystem resilience and environmental quality), economic (by maintaining production of vital goods and services over the long term), and social (by maximizing human health and well-being) (Geiger & Swim, 2021). A positive impact on the environment can lead also to a positive impact on the economy. For example, when the amount of packaging material decreases, usually the overall costs decrease too, and it leads to saving costs, so there are direct connections between the pillars of sustainability that can be useful to the companies (Gu, 2021).

The Linear Economy model emerged with the industrial revolution, more than 200 years ago. It is a model that can grow the economy of a country, but not in a sustainable way (Vieira, 2015). It is a take, make, use, dispose system that takes the raw materials from the Earth, transforms them into real products, that are sold to the consumers and, further thrown away, generating waste (Vickers, 2019). Despite Linear thinking leading to a huge growth of the economy, it is also one of the reforms of the sustainability problems that we have today, due to the production of large quantities of waste, destroying the environment (Jørgensen & Pedersen, 2018).

So, after observing how fast society is using natural resources, compared to their natural growth, it was felt the need of adopting a more sustainable model, that allows a better management of the natural raw materials.

The concept of Circular Economy emerged and is now considered one of the most transformational tendencies in the last years, which started as an organizational hype, and now is definitely a global trend (Nobre & Tavares, 2021). The Circular Economy model is an alternative to the Linear Economy, built on the replenishment of resources previously consumed (Roleders et al., 2022). It can combine the economic gains and at the same alleviate the pressure that the overuse of resources is making on the natural ecosystems. It represents the most recent attempt with the objective to integrate economic activity and environmental wellbeing.

Ellen MacArthur, the creator of her own foundation (Ellen MacArthur Foundation) that has the purpose to accelerate the world's transition to a circular economy, states that Circular Economy is based on three principles (Ellen MacArthur Foundation, 2015):

- Eliminate waste and pollution
- Circulate products and materials
- Regenerate nature

In an interview in 2019, with Yubei Gong and Jianne Whelton, Ellen talks about the major advantage of the Circular Economy:

"When we talk about the circular economy at the Foundation, we talk about an opportunity. There is a massive amount of opportunity—for the economy, but also for society and the environment—to build a regenerative and restorative economy. It's about innovation, design, material science, different business models, new businesses, and emerging innovators." (Gong & Whelton, 2019, p.249).

The circular economy model is a transitional to renewable energy and materials, being a system that has advantages not only for the environment but at the same time to businesses and people, focusing on the three pillars of sustainability (Economic, Environmental and Social) (Ellen MacArthur Foundation, 2015). The three-pillar model of sustainability, which is commonly represented by three intersecting circles with overall sustainability at the centre, has become widely accepted (Purvis et al., 2019).

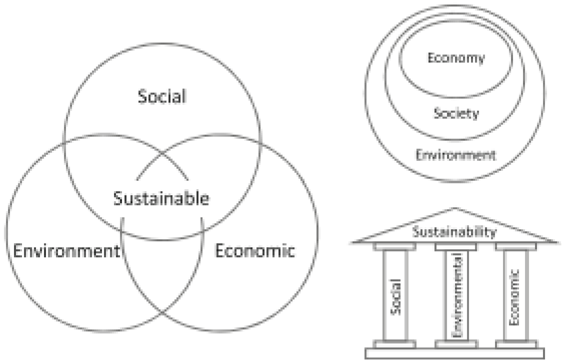

Figure 2.1– Different approaches to the three pillars of sustainability (Purvis et al., 2019).

Figure 2.1 represents different approaches to the "Three pillars of sustainability" concept, being the one on the left the most used.

The transition from a Linear to a Circular Economy demands a fundamental adjustment in how products and services are produced and consumed. It includes modifying the way we develop goods, consume resources, and dispose of waste. This transformation is critical for attaining sustainable development and tackling global issues including climate change, biodiversity loss, and socioeconomic inequalities.

2.1.2 The Butterfly Model

The butterfly model is the Circular Economy Model Diagram that explains the two sides of the system. The focus of the model is emphasizing the need to shift from a linear economy of "take-make-dispose", and showing the many possibilities to do so, depending on the type of resource that people are dealing with.

There is the biological side on the left, which explains that the nutrients that are provided by the biodegradable materials are returned to Earth, for a renewal of the raw materials. And then on the right, is the technical side, where the resources (in this case, finite materials) can be reused, recycled, remanufactured, or repaired, to become available to be used again. (Ellen MacArthur Foundation, 2015).

This model, visually represented further in Figure 2.2, promotes the conservation of resources, waste minimization, and environmental benefits, being the basis of sustainability, while at the same time generating economic opportunities. This system generates benefits not only for the planet but also for the people.

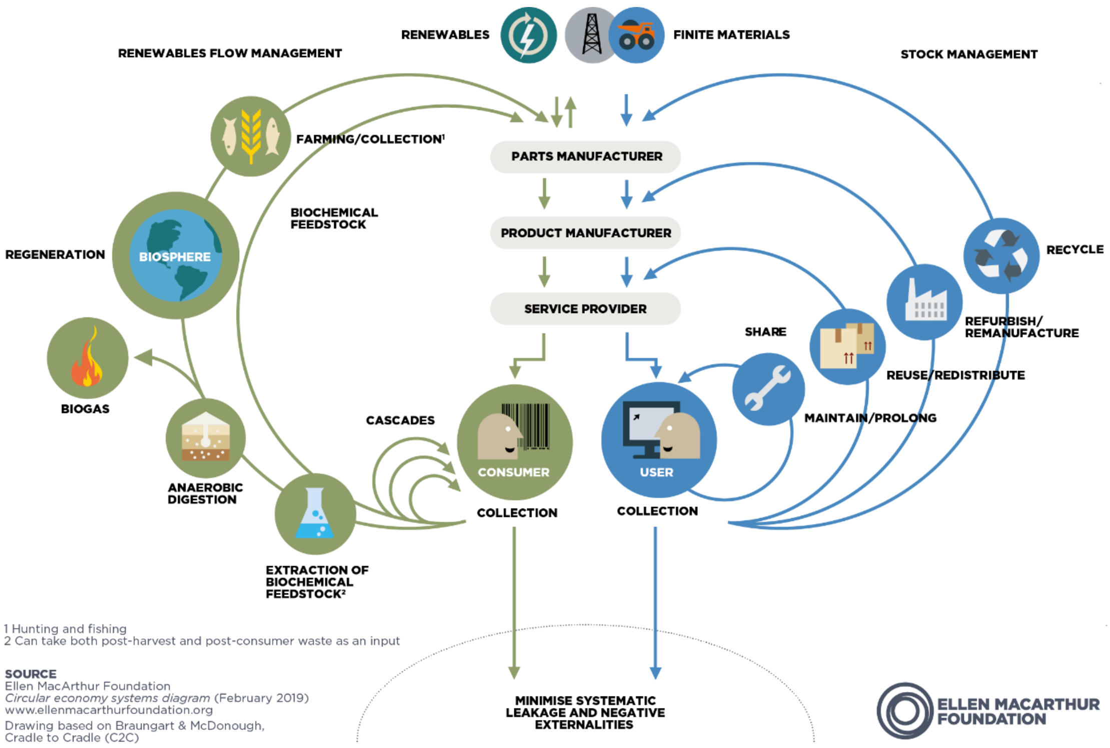

Figure 2.2- The Butterfly Model (MacArthur, 2019)

In summary, this diagram helps to perceive how finite materials and materials with natural renewable characteristics can keep circulating in the economy, showing different examples of ways to renew the usage of the resources, depending on their characteristics, saving the extraction of new raw materials.

2.1.3 Legal Framework of the Circular Economy in EU and Portugal

EU is focused on the transition from the Linear Economy to the new sustainable Circular Economy Model. In 2015, European Commission adopted its first Circular Economy Action Plan, to make the transition to a Circular Economy. This report is focused on a diversity of themes, such as plastic use, food waste, critical raw materials, construction and abolition, and biomass and bio-based products.

"The transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe." (European Commission, 2015, p.2)

The Report from the Commission to the European Parliament stated that all 54 actions proposed in the action plan were completed or are already in execution in March 2019 (DGAE-Direção-Geral das Atividades, 2022).

Following the 2015 Action Plan, the European Commission adopted a new Circular Economy Action Plan in March 2020, one of the main foundations of the famous European Green Deal. This plan has the goal of setting an ecological future for the economy, keeping competitiveness in the market and being aware of the consumer's rights (DGAE-Direção-Geral das Atividades, 2022).

In what it takes to Portugal's situation, our country follows the Portuguese Circular Economy Action Plan, which has the goal of redefining a national strategy for CE focused on the waste disposal, reuse, repair, and renovation of energy and materials (DGAE-Direção-Geral das Atividades, 2022).

By analysing the most recent numbers in the Portuguese Circular Economy Action Plan, the Circularity Rate in Portugal is 2.2%, while the EU average tax is 9.5%, so our country is far behind the major rest of the countries of the European Union (Agência Portuguesa do Ambiente e Direção-Geral das Atividades & Económicas, 2022).

2.2 Green Logistics and Sustainable Supply Chain

The most cited definition of Green Supply Chain Management is given as "integrating environmental thinking into supply-chain management (SCM), including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life" (Srivastava, 2007).

Then, a sustainable supply chain is based on the integration and implementation of not only the environmental object but also the social and economic objects into the chain strategy (Tundys, 2020). The business should try to consider the effects of its goods' trip through the supply chain, from the procurement of raw materials through the manufacture, storage, and distribution of their products, as well as every transportation connection in between. The purpose of this concept is to minimize the impact of possible prejudicial practices on the environment of factors such as energy usage, water consumption, CO2 emissions and waste production (Luther, 2021).

As an example of the power of the supply chain of the company on sustainability, of nine ESG initiatives highlighted by senior executives in a 2020 industry survey, most either directly affect the supply chain or have a big impact on how the supply chain is set up (Henrich et al., 2022). According to the numbers of 2016, a typical company's supply chain is responsible for more than 90 percent of the impact on air, land, water, biodiversity, and geological resources, so the focus on supply chain sustainability is mandatory to reduce those values (Bové & Swartz, 2016).

Companies must now implement sustainable measures by offering products that are less harmful to the environment because stakeholders hold firms accountable for their activities because of environmental challenges. And is also due to these external forces, that businesses are now researching circular economies (Sarkis et al., 2010).

2.3 Sustainable Packaging

2.3.1 Packaging and the packaging system

In a general definition, "packaging" is a coordinated system made up of any materials of any nature, with the purpose to be used for preparing goods for containment, protection, transport, handling, distribution, delivery and presentation (Hellström et al., 2016).

As analysed in the beginning, sustainability is getting more and more important in society, and environmental considerations are now being given more weight in package development trends worldwide. Unfortunately, after being used, the packaging usually becomes waste, which can have a serious negative influence on the environment (Kozik, 2020).

According to the New Circular Economy Action Plan, written in 2020, the number of materials used in packaging is growing continuously, and in 2017 packaging waste in Europe reached a new record, with an amount of 173 kg per inhabitant. With this, the EU wanted to reinforce the mandatory essential requirements for packaging to be allowed on the EU market, with measures that focus on reducing packaging size and waste, with designs focused on reusability and recyclability (European Commission, 2020).

2.3.2 Sustainable Packaging Criteria

The focus of sustainable packaging is the circularity of the materials that the package is made of. Packaging needs to be circular to save energy and materials, so when packaging is no longer required, it should be reused and recycled, so materials should also be kept in a circular supply chain (Noakes, 2021).

According to Nordin and Selke (2010), implementing strategies to address social and environmental issues related to product/packaged systems throughout their entire lifespan at every point in the supply chain is the major part of sustainable packaging development, which entails integrating the broad goals of sustainable development to business considerations.

Sustainable packaging refers to packaging with a decreasing environmental footprint. When it comes to this matter, sustainability can be achieved in three possible ways (Kumar Gupta, 2022):

- The materials used: 100% recyclable, eco-friendly raw materials used for packaging.
- The production method: Production process and supply chains with fewer carbon footprints.
- To be recyclable: A growing economy with the lifecycle and packaging usefulness extended.

One of the most complete sustainable packaging definitions that have been considered is the one from the Sustainable Packaging Coalition (SPC), an American organization (Sustainable Packaging Coalition, 2011). SPC considers that sustainable packaging is one that:

1. Is beneficial, safe and healthy for individuals and communities throughout its life cycle;
2. Meets market criteria for performance and cost;
3. Is sourced, manufactured, transported, and recycled using renewable energy;
4. Optimizes the use of renewable or recycled source materials;
5. Is manufactured using clean production technologies and best practices;
6. Is made from materials healthy throughout the life cycle;
7. Is physically designed to optimize materials and energy;
8. Is effectively recovered and utilized in biological and/or industrial closed-loop cycles.

These sustainable measures are important to be applied in the sustainable packaging businesses, since the amount of packaging materials is increasing over the years, a consequence of the single-use packaging that many supply chains have adopted, due to the simplified logistics advantages (Coelho et al., 2020).

From the customer's point of view, sustainable packaging has three dimensions: packaging materials (biodegradability and recyclability), manufacturing technology, and market appeal (such as attractive design and price). Since there is less knowledge about manufacturing technologies by the consumers, they mostly focus on the materials and the market appeal of packaging (Nguyen et al., 2020).

2.3.3 Sustainable Packaging and Eco-Design Impact on SC Operations

Above and above its basic purpose of protecting, confining, and keeping the product, the functions of packaging are numerous and complicated, and the description here may be connected to three major areas, namely logistics, marketing, and the environment. Table 2.1 represents, according to Jönson (2000), the three different packaging functions, namely logistical function, marketing function and environmental function, with further description of each function.

Table 2.1- An overview of the packaging functions, according to Jönson (2000)

Function	Description
Logistical Function	• Make distribution easier • Safeguard both the product and the environment • Give details on the conditions and locations.
Marketing Function	• Graphic design, layout • Legislative requirements and marketing • End-user requirements/consumer convenience, as well as distribution
Environmental Function	• Recovery/Recycling • Dematerialisation • Reusable vs. one-way packaging • Toxicity

Molina-Besch and Katrin (2014) state that packaging is an important component in logistics because it transports the product from the point of filling to the site of consumption. Consequently, it is perceived that including logistical and supply chain concerns in the process of creating packages would enhance the economic and environmental performance of the supply chain.

An effective package design may boost supply chain efficiency by avoiding damages, decreasing waste, and simplifying the handling and storage process. By delivering an aesthetically pleasing and useful package, it may help improve brand image and generate a positive consumer experience.

Eco-design has the potential to improve environmental performance by lowering waste and emissions while strengthening environmental commitment (Rehema et al., 2016). The fundamental goal of eco-design is to reduce environmental effects. However, other benefits include cost savings, entry into new markets, and the introduction of new goods, resulting in greater competitiveness and financial performance (Knight & Jenkins, 2009).

2.3.4 Reusable Packaging

Reuse, which means using a product again for its original purpose (conventional reuse) or to fill a different function (creative reuse) without reprocessing, can be considered a more ecologically responsible approach than recycling. Reuse is one of the earliest methods of managing solid waste, existing long before recycling was physically feasible (NYC, 2017). In contrast to recycling, which diverts waste from landfills or incinerators, this idea extends the usable life of items and keeps them out of the waste stream by distributing and circulating them locally. (Monteiro, 2018)

Reuse and waste avoidance measures are given high priority when it comes to waste management and policy, according to the EU waste hierarchy (Article 4 WFD) (European Environmental Bureau (EEB), 2018).

Reusing packaging provides a significant opportunity to keep the functioning of the material and product while possibly achieving significant savings in material consumption and environmental implications (Coelho et al., 2020). Lightweighting and recycling have been the primary reaction techniques to minimize the amount and effect of material consumption. Yet, reusable packaging is acknowledged as a more effective choice for reducing the volume of packing materials and energy needed while preventing industrial emissions (Coelho et al., 2020).

2.3.5 Costumer Willingness to Pay for Sustainable Packaging

The most recent surveys confirm that consumers are willing to be greener in their buying decisions. In 2019, a survey done by Accenture (multinational management consulting, information technology and outsourcing company), states that almost 72% of respondents reported buying more eco-friendly products than they had five years earlier, and 81% expect to buy even more in the next five (Accenture, 2019).

Packaging plays a crucial role in what it takes to consumer perception of the sustainability of a product. Consumers are increasingly mindful of what it takes to circularity capacity of the packaging of the product bought (Lim & Jie, 2021).

According to the Global Buying Green Report 2022 (Trivium Packaging, 2022), conducted by the Boston Consulting Group and based on more than 15,000 consumers across the world, 77% of the consumers are willing to spend more for products in sustainable packaging, 4% more than the previous year, and the numbers are even higher by reducing the sample to only younger consumers (between 14 and 44 years old). This means that in the next years, the willingness to pay for sustainable packaging products will keep on growing, due to the conscientization of the population in what it takes to sustainability and circular economy.

2.5 Branded Bags

2.5.1 Importance of Branded Bags

Branded bags are essential in marketing because they act as mobile announcements for a company and its goods. Bags are very portable and visible, making them an excellent tool for promoting a brand and reaching a large audience, so are very useful to help a business to create a powerful and memorable brand image.

A carefully designed bag made from high-quality materials may transmit a sense of quality and professionalism, which can help with the development of a positive brand image. Additionally, by using environmentally sound materials and sustainable design principles, a company may show its commitment to environmental management, which might enhance the reputation of its brand.

Another benefit of branded bags is that they can last a long time. Bags, unlike other forms of advertising such as print or online ads, have the advantage that they can be used repeatedly and over time (obviously depending on the quality and type of material) effectively extending the reach and impact of a company's marketing efforts.

To advertise, boost exposure, and strengthen corporate/product brand equity, marketers can make use of the bag by putting the company name and logo on it (Gan, 2012). To ensure the effect of the bag it is important to put the company’s logo visible and clear in the bag, so when a bag is being transported, the brand is unintentionally announced and promoted to everyone nearby. If a brand is highlighted in a store, it immediately becomes associated with eco-friendly practices, which, as previously explained, attracts customers. This is in line with the brand's goal of becoming an eco-friendly brand.

The next survey represents the potential that reusable bags can have on brand recognition, according to values from Statista (2022).

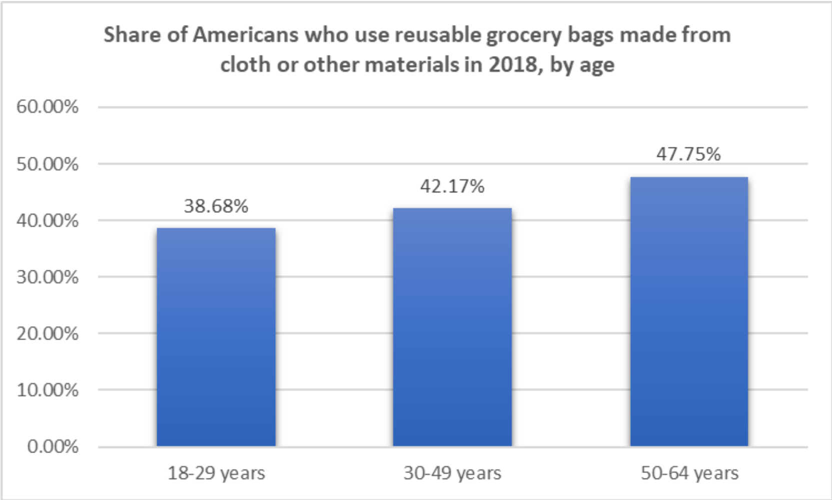

Figure 2.3- Share of Americans who use reusable grocery bags made from cloth or other materials in 2018 (Adapted from Statista, 2022)

Figure 2.3 gives an example of the impact that a branded bag might have on a business. Almost half of the citizens (Americans in this case), use grocery bags made from cloth or other materials, such as the ones that are intended to be created for AZEMAD, and being used as a grocery bag is only one of a diversity of different uses in the afterlife of the branded bag.

The Independent Retailer Conference's co-founder and publisher Nicole Leinbach Reyhle has an inside scoop on how packaging and branding are related:

"When a merchant invests in branded bags, they are also investing in continued marketing for their business. Once that bag exits the store, it begins a journey that may connect with simply a few or even many consumers along the way. From potential customers seeing it on the streets to the user of the bag repurposing it again, the journey may not be clear, but it certainly guarantees continued brand exposure." (Cvetkovic, 2022).

In conclusion, branded bags are a quick and affordable method for companies to connect with and engage with their target market. By raising brand awareness, cultivating a positive brand image, acting as a marketing tool, and having a long lifespan, might be very profitable to a business.

2.5.2 Practical Example of Successful Eco-Friendly Packaging Clever Little Bag by PUMA

Puma approached San Francisco-based design studio Fuseproject to redesign their shoe box, polybags, and hang tags, in an eco-friendly way. The objective was to minimize the environmental effect and cut costs wherever feasible because boxes contribute to millions of tons of garbage annually and are finally thrown out, despite claimed second uses (Fuseproject, 2012).

After spending two months understanding where and how the current packaging was made, how it was transported, handled, packed, and stored, Fuseproject was able to create a new box design, with much less cardboard in its constitution (around 65% less), and with a rPET bag, that can be recycled or reused.

According to Fuseproject (2012):

"We designed an innovative solution called the clever little bag, which saves 20 million megajoules of electricity, 1 million litters of water, 500,000 litters of diesel fuel (lighter weight), and 8,500 tons of paper per year. At the same time, the solution is reusable for the consumer, and fully recyclable at the end of its life."

Figure 2.4- Clever Little Bag by PUMA (Fuseproject, 2012)

This innovative packaging, represented in Figure 2.4, allowed Puma to improve in all three pillars of sustainability, by reducing costs (Economic), reducing energy, water, fuel, and cardboard (Environmental) and generating brand loyalty and marketing in the further usage of the bags (Social).

2.6 Literature Review Summary

In this literature review, it was made an explanation of the most important concepts to perceive to develop this project. It began with an analysis of how the circular economy concept emerged in the economy, until the specification of what should be the characteristics of the future materials chosen.

The conclusion taken is that circular economy and sustainable packages are concepts that are connected, and that connection keeps getting stronger due to the current global environmental challenges that are occurring. Packaging sustainability is one of the most critical components of the circular economy concept, which is a systematic approach that seeks economic growth by eliminating waste and preserving resources, by closing the flow of materials, energy, and water.

To follow this perspective, sustainable packaging seeks resource preservation by promoting the use of environmentally friendly materials and circularity of materials, by recycling and reusing the resources. Adopting circular economy principles in packaging design and production has the potential to significantly reduce packaging's environmental impact and promote the use of environmentally friendly materials.

This can be accomplished by optimizing resource use, reducing waste, and encouraging the reuse and recycling of packaging materials. As a result, sustainable packaging is an essential component of the transition to a circular economy, and its development and implementation are critical for achieving a more sustainable future.

This literature review was profitable to complete knowledge about how sustainability is perceived nowadays, and what features should be included in the development of the project, to make the most realistic proposal of materials possible. It was understood the importance of including the three pillars of sustainability (economic, environmental, and social perspective) in a company since there are major medium-long-term advantages to the company itself and the economy. There is a clear need in society for sustainable development, and everything starts with the way each company thinks and works, so it will be important to show the company during the development of the study the importance of this mindset.

3. Methodology definition

This chapter will be responsible for the description of the methodology used in this Master Thesis, which will be explained by detail each research step and the respective sub-steps included in each. Proposing a new type of sustainable packaging for a company evolves a long research process to understand which will be the most viable alternative. The methodology of this project has different steps, each one having a different but important role.

To create the best solution for the project for AZEMAD, it is needed an intensive analysis of the possibilities available, that evolves different criteria analysis, such as environmental, economic, and physical ones. The analysis evolves the selection of a variety of materials that would possibly fit the necessities of the AZEMAD project. Then, a quantitative and qualitative analysis of each material, considering both economic, environmental, and physical characteristics.

The best fit for the project should be the one that not only ensures a sustainable production process, aligned with good availability of resources worldwide, that allows easier supplies with lower costs, as well as good physical characteristics that permit the reusability of the bag. To make the right evaluation and to choose the right material according to a realistic criterion, the Multi-Criteria Decision Analysis (MCDA) methodology will be adopted.

Furtherly, after achieving the results of the Multi-Criteria Decision Analysis and concluding which material fits best the project, a discussion will take place, by analysing the results of the MCDA and comparing characteristics with the key concepts analysed in the Literature Review on Chapter 2.

To complete the methodology, three possible scenarios of the outcome of the project will be created, and analysed, and further solutions will be proposed.

The methodology chosen evolves 4 steps, defined and described in the Table 3.1:

Table 3.1 – Methodology Systematization

Nº	Step	Objective
1	Scope Definition and Benchmarking	Collecting, organizing, selecting, and analyzing qualitative and quantitative data
2	Material Selection	Select the suitable material for the project's needs, using Multi-Criteria Decision Analysis (MCDA) and Swing Weighting
3	Result Discussion and Scenario-Driven Analysis	Analyze the result provided and proceed with the creation of a pessimistic, neutral and optimistic scenarios of the project
4	Solutions Proposal	Solutions proposal for the scenarios created

1. Scope definition and benchmarking are the first step of the process; this involves collecting, organizing, selecting, and analysing qualitative and quantitative data about sustainable packaging

products made from various materials, and comparing their advantages and disadvantages. It is intended to develop an environmentally friendly and sustainable package as part of a pilot project for AZEMAD.

2. The second step of the research process is selecting the suitable material for the project's needs. It is well known that several variables can affect the results of qualitative and quantitative analyses, making them inconclusive. Hence, it is essential to use a method appropriate for analysing other criteria in a decision-making situation. As an alternative method for selecting material suited for packaging, Multi-Criteria Decision Analysis (MCDA) is selected. Swing weighting will be applied to several specific criteria to determine the appropriate material option from an eco-design perspective. Through this process, it is possible to evaluate whether updating and providing more sustainable packaging for AZEMAD products will improve sustainability performance. The material option with the highest score will be selected for the project.
3. The third step is to proceed with the case study using a scenario-driven analysis. Using the results of the MCDA in step two, different scenarios will be created, representing the outcome of the project. Based on the selected material, multiple packaging scenarios are evaluated. The options will be focused on the acceptance and adherence of the new sustainable bags by AZEMAD in the market, to try to understand whether this project is a good or bad investment for the company. The scenarios assume neutral, optimistic, and pessimistic assumptions from the viewpoint of the company.
4. As part of the 4th research step, solutions will be proposed that will help improve the packaging of the company's products based on the results of the scenario-based analysis conducted as part of the third research step.

3.1 Scope definition and benchmarking

Scope definition and benchmarking are the first steps of this research process.

Collecting, organizing, selecting, and analysing qualitative and quantitative data is the base of the methodology. The process evolves into intensive research, where the collection is done through a variety of methods, such as scientific research articles, website databases or statistical evidence. Due to the variety of data-collecting techniques, it is crucial to properly organise the data to make it easier to retrieve and do further research on the data. The abundance of information suggests a careful selection of the relevant details, therefore it's important to restrict the attention to the information that will affect the methodology chosen. To sum up, there will be material that is not precisely defined but is still helpful. Information analysis is crucial to solving this problem since it helps to make the data understandable and relevant.

To understand which is the most suitable sustainable material for the AZEMAD reusable bags, the process is to start by investigating the options available in the market.

The benchmarking is done to well perceive the current situation of the tote bag market and understand the current characteristics of the best solutions that already exist. The tote bag market is growing every year, due to the reusability advantages that the product provides. The market is made up of a wide range of materials that all serve the same goal, but their qualities differ, thus some materials are better suited to specific tasks.

As already analysed, branded bags have a variety of advantages for the businesses that adopted that strategy, even more, when being part of the business' packaging. Despite that, for a project like that to be successful, it has a diversity of criteria that it must follow. Chapter 2.4 allowed us to understand the characteristics of the materials that should be searched to reach the sample of materials that will be analysed further.

A variety of materials were selected to be studied in this project, the most part natural fibres, produced in sustainable conditions, that will be analysed further. The selection of the materials followed some requirements, such as:

- Being natural fibres or composed of recycled fibres/materials.
- Currently used and approved in the tote bag market.

The material selection will be performed by online research, by defining keywords that would allow those findings, such as "sustainable tote bag materials", "reusable fabric materials" and "alternative tote bag". Due to the good availability of information and since there are a limited number of materials that would fit the necessities of this project, it was easy to establish the possible materials to work with. All the materials chosen are sustainable and each one has different characteristics in the production process and the material aspect, such as the source of production, physical material characteristics, and different environmental impacts on the production.

3.1.1 The purpose of the qualitative and quantitative data

The benchmarking of the production process of fibres requires a detailed analysis of both quantitative and qualitative data. Qualitative data gives vital insights into the social and environmental aspects of the manufacturing process, whilst quantitative data provides concrete indicators of performance.

The qualitative analysis of the materials is based on the environmental impact of the production process and the physical characteristics of the materials. For instance, a qualitative analysis of the production of natural fibres may examine the impact of deforestation, the use of pesticides, or other harmful activities on the environment. On the other hand, a qualitative analysis of a recycled fibre manufacturing process may evaluate how well the recycling process reduces waste and pollution. A review of the physical characteristics is mandatory to ensure that the material fits the necessities of this project, such as flexibility and simplicity and allows the purpose of further reusability of the packaging. The qualitative information will be converted into an overall value, that will be defined further, considering the fitness of the project.

In the evaluation of the quantitative criteria of each material, some KPIs were analysed, such as the unitary price of each material, greenhouse gases and water footprint of the production (CO2 emissions and litters amount per kilogram of fibre produced, respectively) of the production process, strength measure, that would be further summarized in a table to easily perceive the sustainable and economic impact of the production of each, to furtherly take conclusions.

3.2 Material Selection

The material selection process will be divided into 3 sub-steps, outlined in Figure 3.1:

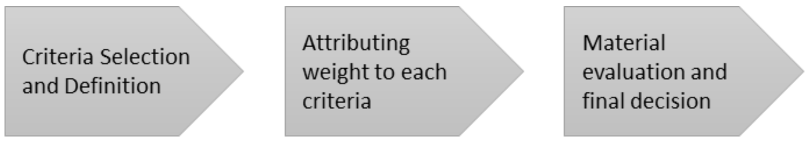

Figure 3.1– Research Step 2: Sub steps definition

The evaluation and comparison of the different material options involves the analysis of different variables, that will be further defined. As said previously, the analysis of different qualitative and quantitative criteria many times leads to inconclusive results, due to the number of different criteria that are analysed. To solve this issue, it was decided that will be used an MCDA methodology (Multi-Criteria Decision Analysis) in the development of this project, since it is the method that fits best the purpose of the project, among the options available, so it will be responsible for selecting the best individual alternative between the options available.

To complement the MCDA methodology, by establishing weighting to each criterion defined, it will also be used the Swing Weighting Methodology. This method entails weighing the criteria to represent their relative value, with the weights adding up to one, and scoring each alternative based on its rating on each criterion, which is normally in the range of 0-100. The performance of each option throughout the criteria is aggregated using an additive equation to generate a 'total score' in the range of 0-100, with the alternatives ordered according to their scores (1000minds, 2021).

To ensure an accurate result of the MCDA according to the needs of the company, the weight attribution of each criterion, which will be done through a conversation with Diogo Martins (the Decision Maker), will be supported by an interview guide tool.

The three methodological steps are defined in Figure 3.2, according to their position and relevance in the methodology.

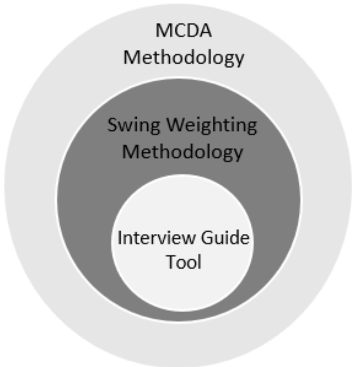

Figure 3.2- Methodologies and Tools for the Research Step 2

Afterwards, the evaluation is done and the sustainable material with the highest final score will be selected.

3.2.1 Criteria Selection and Definition

The decision of which criteria to choose to make the best choice of sustainable material was done during the process of online research of the characteristics of each one. During the process, it was decided that the environmental quantitative KPIs were mandatory to understand the environmental impact of the production. Qualitative and quantitative physical characteristics were also chosen to understand the practical fitness to the project of each material. And finally, a cost estimative was mandatory to be chosen. The criteria and respective definition are furtherly described in Table 3.2.

Table 3.2- Criteria Definition

Criteria	Definition and Evaluation Measures for MCDA purposes
Unitary price	• Acquisition price of a bag of each material according to a supplier sample. It was decided that it is the most trustable source of information found in order to compare the prices of each sustainable material. • Expressed in euros.
Carbon footprint	• Refers to the equivalent of Carbon Dioxide emitted to the atmosphere during the process of each fibre. The variation depends on the types and quantities of chemicals used, as fertilizers, and it wasn't considered the transportation between the production sectors. • Expressed in kilograms.
Water footprint	• Refers only to the blue and grey water footprint. The blue water footprint refers to the water used in irrigation and industrial process, and the grey water footprint refers to the quantity of freshwater necessary to dilute and digest contaminants produced by human activity. • Expressed in Litres.
Tensile Strength (MPa)	• The strength of a fibre is expressed in MPa (megapascals). MPa is the metric unit of pressure measurement, and the higher value it has, the more resistant and durable is the material. • Expressed in megapascals.
Physical Characteristics	• An overall of the other physical characteristics, such as aesthetics, softness, between others. • Evaluated from 1-5 according to the fitness to the project.
Washability	• Evaluation of the availability to wash the bag, that allows a cleaner reusability. • Evaluated from 1-5 according to the fitness to the project.
Other sustainable characteristics	• Evaluation of other sustainable characteristics of the production process referred in the benchmarking, energy such as water pollution, absorption levels of CO2, or other specific characteristics of the production phase. • Evaluated from 1-5.
Production Region	• Evaluation of the region of production of each material, according to the distance from Portugal. • Evaluated from 1-5.

3.2.2 Attributing weight to each criterion

Swing Weighting will be the methodology used to allow the evaluation of the weight of each criterion.

Swing Weighting is a method of finding weighting factors indirectly by comparing characteristics against the one regarded to be the most essential. It is made up of two main activities: (1) ranking attributes based on the relative value of incremental changes in attribute values while taking into account the entire range of possibilities; (2) choosing the most important attribute as a reference point and assess how much less important the other attributes are in comparison to the reference point (Ezell et al., 2021).

According to Ezell et al (2021), in terms of steps, this methodology evolves into 4 different steps to reach the final values:

- **Step 1: Rank Order Attributes** – Responsible for ranking the different criteria by importance.
- **Step 2: Establish the Reference Attribute -** Choose a criterion as a reference, the most valuable one, and attribute 100 points to it.
- **Step 3: Score Attributes Relative to the Reference Attribute -** Experts are asked to judge how much less essential the other traits are in comparison to the fixed reference attribute. For example, if the most essential characteristic is utilized as the reference point and has a reference score of 100 points, experts will be asked to determine how many points should be assigned to each other attribute.
- **Step 4: Calculate Weights -** The final phase is to determine attribute weights using the point scores supplied to each of the criteria in Step 2.

The normalization into weights will be done according to the formula:

$$W_i = \frac{s_i}{\sum_{i=1}^{n} s_i}, \forall \text{ i} \in \text{I}$$

Where:

- I: Includes the entire set of criteria
- W_i: Weight of i criterion in the normalized scale
- s_i: Score of criteria i on the non-normalized scale
- n: Total number of criteria

3.2.3 Interview Guide Tool Process for Swing-Weighting Methodology

The weighting decision will be made by the R&D Manager Diogo Martins, where the DM (Decision Maker) will decide the weightings in an online interview. The steps will be done following the description of the Swing Weighting process described before. An Interview Guide tool will be used to facilitate the unroll of the interview with Diogo Martins. The guide will be composed of two steps, the first is a small introduction and then an evaluation process.

Interview Step 1 – Introduction

- "Following the purpose of the sustainable bag project, consider the following set of criteria. Considering that every criterion available is at its worst performance level".

Interview Step 2 – Criteria Evaluation

- ✓ "If there was the possibility to swing one criterion from the worst to the best performance level, which criteria would be chosen first?".
- ✓ "If there was the possibility to swing another criterion from the worst to the best performance level, which criteria would be chosen?".
- ✓ "Consider now that the first criteria chosen are worth 100 points".
- ✓ "By comparing to the first criteria chosen, which is worth 100 points, what is your evaluation of the comparative importance of the second criterion chosen, according to the purpose of the project, from 0-100 (excluding 100)?"
- ✓ "Repeat the process, until there are no criteria left".

3.2.4 Material evaluation

The final sub-step of the Research Step 2 is responsible for the final evaluation of each material, to reach a result that allows the decision.

To make that decision, the MCDA methodology will be applied, using the qualitative and quantitative analysis of the characteristics of each sustainable material. It will be used a scale from 1 to 5 for an easier and simplified evaluation of each criterion. In terms of the qualitative data, it will be assumed quantitative values (from 1 to 5), to be applied those criteria in the MCDA process. In the evaluation of the qualitative criteria that will be turned into quantitative values from 1 to 5, the numbers are described as:

1 – Very Low; 2 – Low; 3 - Average; 4 - High; 5 – Very High

There are two types of criteria: beneficial and non-beneficial criteria. The beneficial criteria are the ones that higher values are desirable, and non-beneficial criteria are the ones which smaller values are preferable. The score of each criterion will be done according to the formula:

$$v_i \begin{cases} \frac{Min\ x_i}{x_i} * 5\ , if\ i\ \in \mathrm{NB} \\ \frac{x_i}{Max\ x_i} * 5\ , if\ i\ \in \mathrm{B} \end{cases}$$

Where:

- v_i: Score of criteria i
- x_i: Value of criteria i according to the data acquired.
- NB: Non-Beneficial Criteria
- B: Beneficial Criteria

So, the final Global Index score of each sustainable material can be calculated according to the formula:

$$V(GI) = \sum_{i=1}^{n} W_i \, v_i \text{ , } \forall \text{ i} \in \text{I}$$

Where:

- V(GI): Value of the sustainable material
- n: Total number of criteria

3.3 MCDA Result Analysis and Discussion

This research step will include a detailed analysis of the results of the MCDA Methodology, by comparing different results of each material. The analysis will provide a strong justification of why the material chosen is, in fact, the best fit for the project.

4. Results Analysis

4.1 Research step 1 - Scope Definition and Benchmarking

According to the methodology steps defined for this project, the first step is responsible for analysing the results of the benchmarking process. The current chapter focuses on gathering data that will support the decision-making process of the material. This section presents the characterization of the different individual materials, and then the systematization of qualitative and quantitative information will be done, which allows easier comparison between the hypotheses.

The information will be systematized in two different tables. Table 4.1 refers to the systematization of the qualitative information and Table 4.2 refers to the quantitative information, where first one systematizes the advantages and disadvantages of each material.

4.1.1 Sustainable Materials

There was selected five sustainable material options, were either natural fibres or recycled material fibres.

To substitute harmful materials, eco-friendly bags have been introduced as alternatives to plastic bags with the help of research and technology. These bags are reusable, recyclable, and have very few effects on the environment (Agyeman & Badugu, 2017).

Reusable bag materials come in a variety of forms and have many benefits. In the end, every material used to make reusable bags is "green". Although all of the many materials can be utilized to create excellent eco-friendly tote bags, each material behaves differently depending on the situation. (FactoryDirectPromos, 2017).

After intensive research, there were taken conclusions that the best sustainable materials used in tote bags are:

- Organic Cotton
- rPET
- Hemp
- Jute
- Bamboo fibre

Agriculture has a significant impact on greenhouse gas emissions and climate change, so agricultural techniques that are climate resilient and ecologically benign are seen as a part of the solution to combat climate change, despite some agricultural practices being part of the problem (Binta BA & Barbier, 2015). So, to choose the right materials, it is important to analyse the production process of each material to choose the most eco-friendly one, that at the same time complements the needs of AZEMAD.

Organic Cotton

The production practice of "organic agriculture," also referred to as "ecological agriculture or biological agriculture" aims for environmentally friendly production, the development of plant resistance, and soil preservation (Eyupoglu, 2019).

In 2020/21, only eight nations generated an estimated 97% of worldwide organic cotton: India (38%), Turkey (24%), China (10%), Kyrgyzstan (9%), Tanzania (6%), Kazakhstan (4%), Tajikistan (4%), and the United States (2%), and the remaining other 13 organic cotton-producing countries contributed for 3% of total production (OCMR, 2022).

Particularly, organic farming had a commercial component in the 1980's as consumer demands rose. Genetically modified cotton seeds are not utilized in organic cotton farming, and the foundation of it is that microwave energy and radiation are not applied to cotton seedlings. All agricultural practices that promote the development of eco-friendly fibres fall under the category of organic cotton agriculture (Eyupoglu, 2019). Organic may be a good solution for growers because it prohibits the use of the majority of pesticides while giving growers rewards (Delate et al., 2020).

Organic cotton produces around 46% less CO2 compared to conventional cotton (Swedish Linens, 2017). On average, 1,000 kg of organic cotton fibre production produces 978 kg of CO2 (0.978 kg of CO2 per kilogram of organic cotton), but the same quantity of conventional cotton production produces 1,800 kg of CO2 (Fibre2Fashion, 2016). The water footprint of organic cotton is 444 litres per kilogram of fibre produced (Safaya et al., 2016).

There is a variety of laws once cotton leaves the farm. However, commercial organizations that produce standards have created voluntary guidelines that control the organic cotton's chain of custody from the starting to the finished good. The Global Organic Textile Standard (GOTS) and Textile Exchange's Organic Content Standard (OCS) are the two most popular finished product standards, and Portugal is in the top 7 in the world in what relates to Certified Facilities of both standards (OCMR, 2022). Despite that, according to the Organic Cotton Market Report, Portugal is not a producer of organic cotton, so it means that the material is all imported.

Products made from GOTS-certified organic cotton cost on average 20–30% more than those made from regular cotton. Although, purchasing organic cotton might be the best option for a company that values a product that is not only secure but also contributes to environmental protection and ethical apparel manufacture. (International Trade Center, 2022).

In what it takes to tote bags, organic cotton is one of the materials that offer a good image to the company:

“Just like organic bags are good for the environment, they are also good for your company’s brand. Adding a logotype to a tote bag is an incredibly affordable way of marketing your brand – and the usage of organic cotton works well with your company’s eco-policies. When using organic cotton bags as a part of your marketing, you are helping your brand to be perceived as eco-friendly while saving the planet.” (Dispak, 2021).

These are the quantitative advantages of organic cotton, compared to conventional ones, according to Christinee (2022).

- Uses 91% less water.
- 46% fewer greenhouse gas emissions since the soil isn’t loaded with pesticides and can absorb CO2 from the atmosphere.
- 26% lower soil erosion.
- 98% reduction of water pollution since synthetic chemicals aren’t used.
- 95% of the water used to grow cotton is rain or groundwater.

Organic cotton is washable, but there are many recommendations in terms of temperature and specific detergents. Because it is not chemically treated to reduce heat shrinkage, 100% organic cotton may shrink slightly when washed. In terms of aesthetics, the material is completely attractive to the eyes of the consumer, being a soft cloth.

RPET

Polyethylene terephthalate, commonly known as “PET,” is an economical material that is 100% recyclable without loss of attribute. “PET” waste can be recycled to create polyester fibres, which are known as recycled polyethylene terephthalate (rPET) fibres (Kiriş & Yilmaz, 2021).

With a 29% share, the packaging industry accounts for the majority of global polyethylene terephthalate (PET) usage. After use, PET items are discarded, producing significant volumes of garbage, including 73% of all environmental waste (Kiriş & Yilmaz, 2021a).

RPET is 100% recyclable, meaning it can be reintroduced into the loop many times, decreasing the need for resource extraction. Mechanical recycling produces the majority of rPET since it is the cheapest technique accessible on a big scale (Manteco, 2022).

Using rPET decreases carbon footprint significantly by eliminating the need to utilize energy to extract and make fresh raw plastic material. In the process of sorting, washing, and flaking post-consumer PET to develop new rPET uses 75% less energy than producing raw plastic (RPlanetEarth, 2022).

In terms of greenhouse emissions, according to a study done by the PET Recycling Team GmbH in Wöllersdorf, the business produces rPET with a carbon footprint of 0.45 kg CO2 equivalent per kilogram of rPET. The CO2 equivalent of virgin PET, or new material, is 2.15 kg per kilogram. This equates to a CO2 equivalent of 1.7 kg or a 79% reduction in greenhouse gas emissions for rPET (Petrecyclingteam, 2016).

Due to its durability, resistance to different temperatures, waterproofing, and flexibility, sports brands are increasingly opting for rPET clothing in the textile sector, and the same characteristics match up to rPET bags (RepetCo, 2022). The usage of rPET material also encourages the adoption of reuse and recycling cultural behaviours and norms in society.

RPET is not only a durable material but also capable of being recycled at the end of the life cycle. The rPET fibre is also completely easy to wash since it is a non-permeable material, and it will not shrink after the process.

Hemp

Hemp fabric is a form of textile manufactured from fibres extracted from the stalks of the Cannabis sativa plant. For millennials, this plant has been recognized as a source of highly tensile and durable textile fibres (Sewport Support Team, 2023)

Due to its renewable, biodegradable, and recycling features, hemp, has attracted substantial interest as a reinforcement in polymer matrices over this recent decade (Ahmed et al., 2022).

Hemp is a crop produced throughout Europe. Figure 4.1 represents the EU land area used for hemp cultivation, and it is possible to analyse that the area allocated to hemp growing in the EU has expanded dramatically in recent years, from 19,970 ha in 2015 to 34,960 ha in 2019 (a 75% increase), having a low decrease in 2021 (European Commission, 2022).

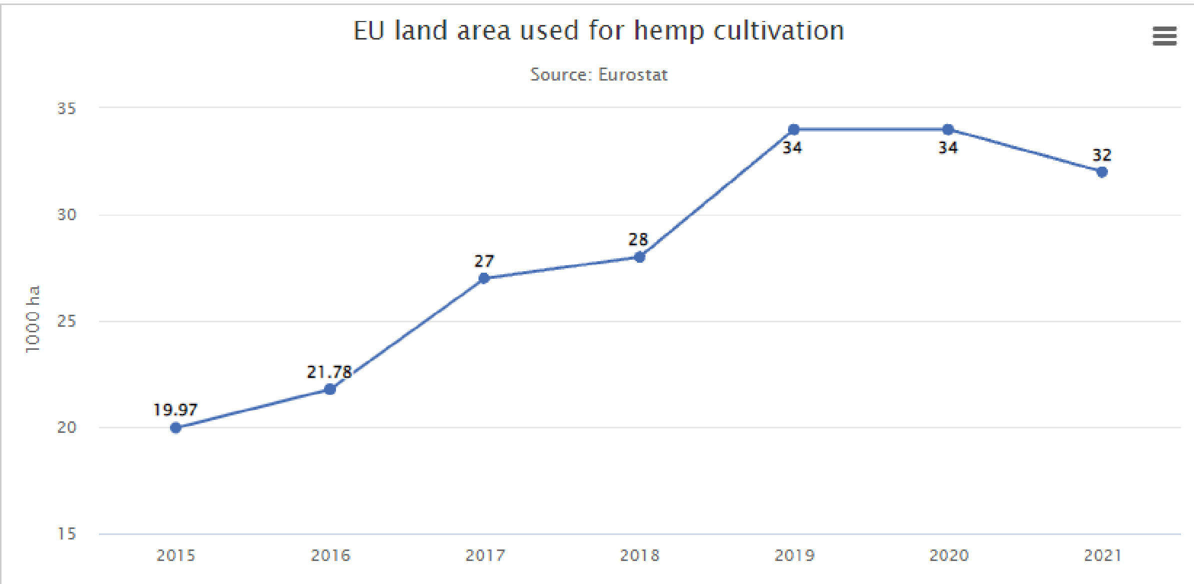

Figure 4.1– EU land area used for hemp cultivation (European Commission, 2022)

Inseticides and herbicides can be avoided in the production of hemp, because there is a lack of hemp natural predators (European Commission, 2022).

The water footprint of hemp is 624 litres per kilogram of fibre (Mekonnen & Hoekstra, 2010). In terms of greenhouse gas emissions during the production process the carbon footprint of hemp production, is equivalent to around 0.300 kg of CO_2 per kg of hemp fibre produced, depending on the type of fertilizer including fibre processing, transport to the field to processing, pesticides, seeds and field operations (Carus et al., 2019). In terms of Tensile Strength, organic cotton has a value of 584 MPa (Célino et al., 2014).

A Cambridge University research states that a hectare of hemp may absorb between 8 and 15 tonnes of CO_2, compared to the 2 to 6 tonnes absorbed by forests (Hunter, 2022).

Hemp is a very specialized crop, and the raw hemp material supply might be limited, resulting in higher raw material prices. In terms of physical characteristics, the fibre is breathable, light, sturdy, long-lasting, and resistant, important to the reusability of the bag. Hemp fibre can be easily washed, despite a couple of recommendations on how the fabric should be cleaned, to not shrink or lose colour.

Jute

Jute is a golden fabric that is totally natural. The fabric is made from raw jute and is environmentally friendly, used to make a variety of items such as bags, handicrafts, textiles, garments, and furniture. Despite cotton being the most abundant plant-based fibre, jute is a close second.

India, Bangladesh, China, and Thailand are the world's leading jute producers. India is the world's largest producer of raw jute and jute goods, accounting for more than 50% and 40% of global production, respectively (NationalJuteBoard, 2023). The country is also the leading exporter of jute bags, accounting for 43.7% of total exports in 2018 (ExportGenius, 2020).

In terms of greenhouse gas emissions during the production process, the carbon footprint of the jute production is equivalent to around 0.375 kg of CO_2 per kg of jute fibre produced, also including fibre processing, transport to the field to processing, pesticides, seeds and field operations (Carus et al., 2019). In India, only about 15% of jute land is irrigated, while the rest is rainfed (Ravindra Muchhadiya, 2019). The water footprint of jute is 250 litres per kilogram of fibre (Mekonnen & Hoekstra, 2010).

In terms of Tensile Strength, organic cotton has a value of 583 MPa (Célino et al., 2014).

As well as hemp, one hectare of jute plants absorbs around 15,000 tonnes of CO_2 from the atmosphere, which minimizes the impact of greenhouse gas emissions during the production process.

Despite that, there are some downsides of the material that are “red flags” to the project. It is not washable, since when jute fibres get wet, they lose strength. Also, it has no brightness, which may be a downside since it is not very attractive to the eyes of the consumer. Finally, the material is not very flexible, which is something needed for the reusability ideas for the bag.

Bamboo

Bamboo is another good natural fibre because it is renewable and easily accessible in many continents. It is widely available throughout Asia, Africa, parts of North and South America, and Oceania (Munde et al., 2022).

Bamboo has numerous advantages, including high yield, natural antibacterial, biodegradable, and UV protection (Jais et al., 2023). Bamboo is a tree-like grass that grows quickly and is organically renewable. It takes less maintenance because it does not require pesticides or herbicides and requires very little water to grow (Carter, 2021). In terms of Tensile Strength, bamboo has a value of 185 MPa (Célino et al., 2014).

Also, it improves soil quality, reduces soil erosion, uses little water, and has high CO2 absorption and oxygen release. Bamboo has a lot of advantages when transformed into a textile, since its fibres are biodegradable, and they produce a soft and flexible material that is ideal for tote bags (bkbags, 2021).

According to the International Bamboo and Rattan Organization (2017), a new report outlines a scientifically validated process for evaluating the green credentials of bamboo-based products, where it is showed how products made from bamboo can be carbon neutral over their lifecycle.

In terms of washability, bamboo does shrink when washed, so there are some recommendations to do that process.

4.1.3 Systematization of Information

Table 4.1 reflects the systematization of qualitative information according to the research done in Chapter 4.1., divided into advantages and disadvantages of each material according to the purpose of the project. Moreover, Table 4.2 represents the systematization of the relevant quantitative information, also acquired in Chapter 4.1.

Table 4.1- Benchmarking systematization of qualitative information

Material	Advantages	Disadvantages
Organic Cotton	• No use of insecticides or pesticides • Low water pollution • Low irrigation needed • Biodegradable • GOTS and OCS certification is important to the consumer • Aesthetic, flexible and soft • Can be washed and dried	• More expensive than conventional cotton • Less availability in the market • Biodegradable • Produced in Asia
rPET	• Less waste of resources in the production • Made of recycled objects and recyclable at the end of life • Low water spent in the production • Cheap material to acquire • Less energy used in the production • Resistance to different temperatures • Waterproof	• Non-biodegradable
Hemp	• Low use of insecticides, herbicides, and fungicides • Produced in Europe • High levels of CO_2 absorption during the growth phase • Breathable, light, resistant, flexible	• High average cost • Growing market but still low availability
Jute	• Good availability in the market • Low irrigation needed • High levels of absorption during the growth phase	• Not washable • No brightness • Not flexible • Produced in Asia
Bamboo	• No use of insecticides or pesticides • High levels of CO_2 absorption during the growth phase • Biodegradable • Soft and flexible	• Shrinkable when washed • Produced everywhere but Europe

Table 4.2- Benchmarking systematization of quantitative information

Material	Unitary price (euros)	Water footprint (liters per Kg of fibre)	Carbon Footprint (Kg per Kg of fibre)	Tensile strength (Mpa)
Organic Cotton	2.020	444	0.978 Kg	500*
rPET	1.303	100*	0.450 Kg	550*
Hemp	4*	624	0.300 Kg	584
Jute	3*	250	0.375 Kg	583
Bamboo	3*	200*	0.200* kg	185

**Estimations for the MCDA purpose (no information available)*

4.1.4 Quantitative Information Explanation

Most of the quantitative information is referred on the benchmarking done in Chapter 4.1. To complete all the information needed for the quantitative data, it was assumed some values, for the future MCDA purpose.

The unitary prices were achieved after conversations with the company BeFre. According to their website, the company is “a pioneer and specialist in the design, manufacture and marketing of reusable, sustainable and eco-friendly bags, shopping bags and packaging.”. It was delivered by BeFre with two quotations of reusable tote bags with the specific size of the current AZEMAD packaging (see Annex 2). The quotations delivered were for an organic cotton bag and rPET bag, with the unitary costs represented in Table 4.2. The values were assumed for a MOQ of 2000 pieces, and the printing costs aligned. Despite it was not possible to get the information about the other materials, the company stated by email (available in Annex 2) that:

“RPET and organic cotton will be for us the best choice. Jute and Bamboo are wonderful matters but also more expensive.”

Also, hemp bags were not available not for sale in the company. In this case, it was assumed a higher cost for the material, since it was researched that the material, in comparison with the others, is much more expensive due to the limited availability of hemp in the market, as stated in the benchmarking in Chapter 4.1. There were analysed several sustainable bag businesses and it was concluded that hemp bags cost at minimum two to three times more than organic cotton bags.

The water footprint of rPET is assumed as a very low value in comparison to the other materials since it is not a natural fibre, so it demands very low levels of water to be produced.

In terms of tensile strength, the jute, hemp, and bamboo values were taken from the same source. For the organic cotton tensile strength value, it was researched that the fibre is stronger than regular cotton since the chemicals used during harvest and processing might harm regular cotton fibres. As a result, organic cotton fibres are longer and have stronger and smoother connections (Cariki, 2021). So, it was assumed a slightly higher value compared to the regular cotton tensile strength value referred to in the source. The rPET value, it was assumed a higher value than organic cotton, after comparison research between both, where it was referred that rPET is more resistant (A. M. Custom Clothing, 2021).

The carbon footprint of bamboo is considered very low, since the information researched states that the carbon footprint of bamboo is very low, due to the low chemical use in the growth phase of bamboo. Relatively to the water footprint, a low value was assumed, because irrigation is only necessary during the winter, and the bamboo system is utilized for crops that require relatively little water (Centre for Science and Environment, 2023).

4.2 Swing Weighting and MCDA Methodology

4.2.1 Weighting and MCDA Results

Table 4.3 represents the output of the interview with the Decision-Maker Diogo Martins, which was clear and led to the following results:

Table 4.3- Swing-Weighting Methodology Results

Criteria	Swing Weighting Values	Weight (Wi)
Unitary Cost	100	0.350877193
Carbon Footprint (kg per kg of fiber	30	0.105263158
Water Footprint (liters per kg of fiber)	30	0.105263158
Tensile Strenght (Mpa)	50	0.175438596
Physical Characteristics	30	0.105263158
Washability	10	0.035087719
Other sustainable characteristics	30	0.105263158
Production Location	5	0.01754386
Total	285	1

According to the DM, the unitary price is by far the first choice, since this is a huge investment of the company, so the price/quality relation of the bag is very important for them. The tensile strength is in second place, not as important as the price, but since the KPI represents the resistance of the material, it is one of the most important criteria of the project.

Then, the DM evaluated the criteria related to production sustainability with 30 points, which includes both footprints and "other sustainable characteristics", attributing some importance to the environmental impact of the material production process, which will impact the consumer choice.

The washability was the second least important choice for the DM since that is very dependent on the material that will be chosen.

Finally, the production location was not considered very important, since most of the materials are produced far away from Portugal, and every possible supplier has its material suppliers, so it will not impact the choice at this stage of the project.

Table 4.4 represents the results of the MCDA Methodology. The quantitative criteria scores, and the total score were calculated according to the statistical formulas elaborated in Chapter 3.2.4 (see Annex 1), combined with the results of Swing Weighting provided by the interview with the Decision Maker.

Table 4.4- MCDA Methodology Results

			Organic cotton		rPet		Hemp		Jute		Bamboo	
Swing Weighting	Weight (Wi)	Criteria	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)
100	0,35	Unitary Cost (Euros)	**3,22**	2,02	**5**	1,30	**1,63**	4	**2,17**	3	**2,17**	3
30	0,11	Carbon Footprint (kg per kg of fiber)	**1,02**	0,98	**2,22**	0,45	**3,33**	0,30	**2,63**	0,38	**5**	0.20*
30	0,11	Water Footprint (liters per kg of fiber)	**1,12**	444	**5**	100*	**0,8**	624	**2**	250	**2,5**	200
50	0,18	Tensile Strenght (MPa)	**4,28**	500*	**4,71**	550*	**5**	584	**4,99**	583	**1,58**	185
30	0,11	Physical Characteristics	**3**	Average	**4**	Very High	**4**	High	**2**	High	**4**	High
10	0,04	Washability	**3**	Average	**5**	Very High	**4**	High	**2**	High	**3**	Average
30	0,11	Other sustainable characteristics	**4**	High	**4**	High	**4**	Very high	**4**	High	**4**	High
5	0,02	Production Location	**1**	Very Low	**4**	High	**4**	High	**1**	Very Low	**2**	Low
285	1	**Total Score**	**2,97**		**4,43**		**2,94**		**2,84**		**2,81**	

After the Swing Weighting Methodology was completed, it was possible to define the result of the MCDA Methodology, ending with rPET as the chosen material.

4.2.1 MCDA Result Analysis and Discussion

The methodology used in the last two chapters led to the conclusion of the research question of the master thesis “What is the best sustainable material for the new AZEMAD sustainable bags?”.

RPET is, according to the methodology, the sustainable material that fits best the purpose of this project. In the literature review, respectively in Chapter 2.1, it is referred to the importance of the circularity of the materials for the sustainable development of the economy. RPET fibre is, as already stated before, an abbreviation of recycled polyethylene terephthalate fibre, and as the name indicates, it is made of post-consumer waste generated. Despite the purpose of the creation of the bag is to be further reused by the customer to do some marketing for the company, the material can be recycled at the end of its lifetime repeatedly without losing quality and strength. That capability has a huge number of advantages, such as reducing waste, being cost-effective, or being energy efficient.

RPET has a huge advantage against the other sustainable materials analyses because it is the only one that doesn’t need the consumption of new resources. As already analysed, the natural fibres evolve in a growing process, with chemical, water and energy spent. Which relies on increasing costs. Unlike rPET, the other natural sustainable materials evolve extraction, processing, and manufacturing processes of new resources, which evolves a supply chain with more costs aligned, for the producer and the environment.

As stated in Chapter 2.1.1 of the Literature Review, “eliminate waste and pollution” and “circulate products and materials” are both principles that Circular Economy is based on, according to Ellen MacArthur, and the rPET bag will allow the fulfilment of those principles.

The cost-effectiveness and energy efficiency of the production of rPET fibre is traduced on the price that was offered by the supplier BeFre which only shows that the acquisition cost of the material is substantially lower compared with the other fibres, which satisfies “the most important criteria for AZEMAD” according to the Decision-Maker Diogo Martins.

RPET also follows the three principles of sustainable packaging, which are “materials used: 100% recyclable”, “production process and supply chains with fewer carbon footprints” and “lifecycle and packaging usefulness extended”, according to Kumar Gupta (2022).

The fact that it is the only non-permeable material also gives a good advantage against the material competitors, since gives more consistency to the materials and more ideas for the reusability of the bags by the customers.

4.3 Scenario-driven analysis

The scenario-driven analysis is the third step of the methodology, by following the results of the MCDA methodology.

According to Balaman (2019, p. 113):

“Scenario analysis is conducted, to analyse the impacts of possible future events on the system performance by taking into account several alternative outcomes, i.e., scenarios, and to present different options for future development paths resulting in varying outcomes and corresponding implications.”

This method is the most suitable way to forecast the social and economic results of this project. This scenario-driven analysis will be focused on how often the customers reuse the AZEMAD sustainable rPET bags, and the success of this project will be dependent on the customer acceptance of the bags since AZEMAD will make a financial investment in this, so improvements in the number of customers and brand recognition will be needed.

This analysis will be composed of three different scenarios, to understand the outcome possibilities of the development of this project, and further solutions proposals to prevent the issues that might come with the launch of the rPET AZEMAD bags in the market.

4.3.1 Optimistic Scenario

In the optimistic scenario, it is supposed that the customers do the reusability solutions provided by the bag, which means that after the acquisition of the bag they reuse it for a diversity of functions. As previously analysed, the reusability of the branded bag has several economic and environmental advantages, and in this scenario AZEMAD will benefit from the advertising and reusability done by their customers while reusing the bag, by displaying the company’s logo, which increases brand visibility and awareness. The rPET material allows a long lifespan due to its durability characteristics, combined with the washability easiness.

In this scenario, the company improves its reputation for eco-friendliness and sustainability, while its customers actively support the idea of reusing AZEMAD bags. The regular reusability of the company’s bags contributes to the reduction of single-use plastic bags, and this positive environmental impact is one of the key points of the success of this investment. This positive view of the company’s values attracted a large client base, promoting long-term growth and market domination.

The success of the movement towards sustainability by a market leader such as AZEMAD will incentivise engagement by other companies to follow that environmentally friendly wave, leading to a more sustainable economy.

4.3.2 Neutral scenario

In the neutral scenario, the adherence to the AZEMAD bag’s reusability is mixed. A portion of the customers will understand the positive environmental impact that the reusability of the bags has, while approving the quality and design of them, and opt to use them in their daily activities, contributing to waste minimization and elevating the company’s reputation.

On the other hand, a significant number of customers will choose the other path, by opting for convenience and not engaging in the sustainable movement. The bags will keep contributing to the main function of the new packaging design, being still more attractive to the eyes of the consumer than the previous default packaging, but the further impact on AZEMAD visibility and brand recognition will remain moderate.

This scenario results in a moderate environmental impact, and the non-adherence to the bag reusability by some customers contributes to a neutral return on the investment made by AZEMAD, where the company doesn’t face any huge negative consequences, but also doesn’t benefit much from the bags reusability.

4.3.3 Pessimistic Scenario

In the pessimistic scenario, the investment in sustainable bags backfires completely in economic and sustainable terms. Despite AZEMAD’s intention to promote bag reusability, most of the customers will not contribute to the reusability of the bags and will consider them disposable, so the bags will be discarded after the first use or even forgotten.

The AZEMAD environmental promoting attempt might fall apart, since if the customers don’t respect the sustainable purpose of the packaging, the customer loyalty and brand reputation will not increase, and the company might be a target of criticism by wasting resources, and the business will have to further cover the financial loss of the investment.

The company will further be forced to evaluate sustainable practices and try other solutions to improve its brand image and mitigate the unsuccessful investment in rPET branded bags.

4.4 Solutions Proposal

The scenario is focused on the customers' decision whether to reuse or not the sustainable bags provided by AZEMAD included in the new packaging design, and the proposals will be focused on incentivising the customers to adhere to the reusability options that the bag offers.

The first solution can be a marketing campaign. To make the customers aware of the reusability options that the bag offers, and to make them perceive the quality and design of the rPET bag, some social media advertising can be considered mandatory. The social media presence in the first moments of the launch of the new packaging can incentivise not only sales but the post-use of the sustainable bag.

To complement the marketing campaign, it could be a good fit for this necessity an initial investment in video-making, where a video advertising to post on social media could be made, exemplifying the number of reusability options that the bag will allow in daily life. A visual exemplification can offer a better understanding of the advantages that the rPET bags bring, and since social media is now the most successful way of advertising, a social media marketing campaign could be the best fit for the project's success.

Also, AZEMAD could invest in sensibilization campaigns, centred on environmental sustainability, to raise awareness about the disadvantages of single-use plastic bags, in terms of waste and pollution. It is important to make the potential customers aware not only of the advantages of reusing rPET bags but also to include incentives to recycle the bag at the end of the life cycle.

Then, another solution is the awareness of the reusability options present in the bag design. The idea is to print in each bag a small design of some reusability ideas, and that visual communication can incentivise the reuse. Small design ideas such as grocery shopping, roller hockey equipment transportation, or keeping and transporting toys for the kids can be options that might contribute to reusability.

Another option proposed is the customization of the bag. AZEMAD already invested in customized roller hockey sticks, where the customers can print their name in the design printed on the product. The same idea can be applied to the sustainable bag, where the customized customer name, combined with the brand name in the bag, can certainly incentivise the customer to reuse the bag. It is important to analyse the fact that a good percentage of the customers are from younger ages, and the motivation to go to the training sessions with customized materials is higher, so it is a good investment opportunity.

5. Conclusion

The literature review shows that the circular economy is having an increasingly positive impact not only on the environment but also on the economy. Businesses are constantly adopting new sustainable measures to implement in their businesses, and being sustainable is becoming mandatory for businesses to keep their competitiveness in the market. Sustainable innovations related to waste minimization and conservation of resources are a key factor for many businesses since companies understand that those measures can be profitable for them and the environment.

The impact that packaging design has on the customer perception of the business was crucial for the development of the project since the customers are focusing more and more on the sustainable measures implemented by the businesses, that generate customer satisfaction and loyalty.

There is no perfect decision about which is the best material to choose for sustainable bags. Every material has its advantages and disadvantages, and it is believed that the decision taken was the most suitable for the project, due to the diversity and importance of the criteria defined for the evaluation.

The methodology chosen applied perfectly to answer the RQ "*What is the best sustainable material for the new AZEMAD sustainable bags?"*, since the ability to compare different criteria of different materials, with a final quantitative term of comparison allowed to choose the material that fits the best. The MCDA, Swing-Weighting and the Interview Guide were different methodologies and tools that complemented each other in the best way.

So, it is possible to define "RPET is the best sustainable material to be used for the new AZEMAD sustainable bags" as an answer to the RQ.

The concepts analysed in the Literature Review provided relevant information to support the Methodology and contributed to the author's knowledge about a diversity and sustainable concepts. MCDA, combined with Swing Weighting, appeared as a very versatile methodology, as it seems to be easily appliable to similar studies, where criteria should be qualified to support decisions.

The company showed satisfaction with the benchmarking done about the possible materials to be used, which saved time and work for them, and all the criteria, calculations and results were sent to AZEMAD, and it is expected an analysis of the output, and a good contribution of this Master Thesis for the possible project of the company.

Visual representations, as figures and tables, seemed necessary to complement the explanation and reasoning of the concepts and data across this Master Thesis.

This thesis had some limitations, and for future research, it is suggested a further analysis of other criteria between different suppliers of the material chosen. Despite rPET being chosen as the most suitable material for the project, the characteristics of the material will depend on the supplier the company is dealing with, since there are different production processes, prices, or environmental impacts on the supply chain. Due to this factor, an MCDA analysis between suppliers is recommended for further development, where should be analysed a variety of possibilities, considering environmental, economic, and social factors.

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Annex 1 – MCDA Calculations

			Organic cotton		rPet		Hemp		Jute		Bamboo	
Swing Weighting	Weight (Wi)	Criteria	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)	Score (vi)	Criteria value (xi)
100	0,35	Unitary Cost (Euros)	**(1,3/2,02)*5 = 3.21**	2,02	**(1,3/1,30)*5 = 5**	1,30	**(1,3/4)*5 = 1,63**	4	**(1,3/3)*5 = 2,17**	3	**(1,3/3)*5 = 2,17**	3
30	0,11	Carbon Footprint (kg per kg of fiber)	**(0,2/0,98)*5 = 1,02**	0,98	**(0,2/0,45)*5 = 2,22**	0,45	**(0,2/0,30)*5 = 3,33**	0,30	**(0,2/0,38)*5 = 2,67**	0,38	**(0,2/0,20)*5 = 5**	0.20*
30	0,11	Water Footprint (liters per kg of fiber)	**(100/444)*5 = 1,12**	444	**(100/100)*5 = 5**	100*	**(100/624)*5 = 0,8**	624	**(100/250)*5 = 2**	250	**(100/200)*5 = 2,5**	200
50	0,18	Tensile Strenght (MPa)	**(500/584)*5 = 4,28**	500*	**(550/584)*5 = 4,71**	550*	**(584/584)*5 = 5**	584	**(583/584)*5 = 4,99**	583	**(185/584)*5 = 1,58**	185
30	0,11	Physical Characteristics	**3**	Average	**4**	Very High	**4**	High	**2**	High	**4**	High
10	0,04	Washability	**3**	Average	**5**	Very High	**4**	High	**2**	High	**3**	Average
30	0,11	Other sustainable characteristics	**4**	High	**4**	High	**4**	Very high	**4**	High	**4**	High
5	0,02	Production Location	**1**	Very Low	**4**	High	**4**	High	**1**	Very Low	**2**	Low
285	1	**Total Score**	**2,97**		**4,43**		**2,94**		**2,84**		**2,81**	
			2,97 = 3.21*0.35+1,02*0.11+1,12*0.11+4,28*0,18+3*0,11+3*0,04+4*0,11+1*0,02		4,43 = 5*0.35+2,22*0.11+5*0.11+4,71*0,18+4*0,11+5*0,04+4*0,11+4*0,02		2,94 = 1,63*0.35+3,33*0.11+0,8*0.11+5*0,18+4*0,11+4*0,04+4*0,11+4*0,02		2,84 = 2,17*0.35+2,67*0.11+2*0.11+4,99*0,18+2*0,11+2*0,04+4*0,11+1*0,02		2,81 = 1,17*0.35+5*0.11+2,5*0.11+1,58*0,18+4*0,11+3*0,04+4*0,11+2*0,02	

Annex 2 – Befre Bags: rPET and Organic Cotton Unitary Price Proposals

Quotation # 230324-0391

Quotation Date: 24 March 2023

Expiration: 08 April 2023

Salesperson: Stephane Willem
stephane.willem@befre.eu

DESCRIPTION	QUANTITY	UNIT PRICE	TAXES	TOTAL
Fabric : Recycled PET (100% recycled material) non-woven & non-laminated - 120gr/m² Dimensions : W-27x G-12 x H-32 cm Handles : 2 handles in same material as bag - 2,5 x 50cm - same color as body bag - cross stitching Construction : main sided & bottom in 1 piece-1PMS (1artwork) Bindings : same material as bag + topfold (3 cm). 1 PMS Thread : 1 Pantone CO2 neutral label sew in between handles (2.5 x 3 cm)	2,000.00	1.303	0%	2,606.00 €

Quotation # 230329-0407

Quotation Date: 29 March 2023

Expiration: 13 April 2023

Salesperson: Stephane Willem
stephane.willem@befre.eu

DESCRIPTION	QUANTITY	UNIT PRICE	TAXES	TOTAL
Fabric :Organic cotton GOTS certified (Ecru) - 200 gr/m² Size : W-27 x G-12 x H-32 cm handles : 2 handles in cotton - 3x 65 cm Construction : inside overcasting CO2 neutral label sew in between handles (2.5 x 3 cm) GOTS label sew outside (2.5 x 3 cm)	2,000.00	2.019	0%	4,038.00 €

Stéphane Willem <stephane.willem@befre.eu>
para mim

inglês > português Traduzir mensagem

Dear Mr Contins,

Thank you for your demand.
Paper, RPET and organic cotton will be for us the best choice. Jute and Bamboo are wonderful matters but also more expensive.