U.PORTO

MASTER
IN ECONOMICS OF BUSINESS AND STRATEGY

Transition towards sustainable packaging solutions: the case of dst logistics center

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M

2024

FACULDADE DE **ECONOMIA**

U.PORTO

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UNIVERSIDADE DO PORTO

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Internship report
Master's in Economics of Business and Strategy

Supervised by
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2024

Acknowledgements

I admit I do not have a way with words, and who knows me knows that. That's why I make an effort with my actions. Yet, this part is a mix of both. Therefore, please understand that I have the best intentions behind my words.

First, I want to express my thankfulness to my supervisor Ruben Fernandes for the time he took off his busy schedule to guide me throughout this internship's report. Thank you for your guidance and attention provided, the recommendations given and the support I felt behind my ideas.

Secondly, I would like to thank Dr. Cláudia Duarte from dstgroup for the support and the idea exchange and availability in answering every single one of my questions. Thank you for the opportunity and the confidence boosts provided.

To my friends, I want to say this master wouldn't have been as good as it was without you. The patience you had for me, especially for all the questions I asked, it made a difference. So, thank you for being there for me.

To my family who has put up with me since 1999, I don't say it enough times, but you are the most important thing in my life. I appreciate all the times you heard me complain about whatever, but only grumble a few of them. Thank you for encouraging and supporting me every day without failing.

To everyone who in some way made my day better or laughed at my silly jokes, I want to say thank you.

Last, but not least, I want to thank me, "for believing in me", "for never quitting", for putting in the work, and pushing through the hard times.

Agradecimentos

Admito que não grande jeito com palavras e quem me conhece sabe disso. Por causa disso, eu faço um esforço para deixar que as minhas ações falem mais alto que as palavras. No entanto, esta parte é uma mistura dos dois. Desta forma, entendam que o que vou dizer a seguir é com a melhor das intenções.

Primeiro, quero expressar o meu agradecimento ao meu orientador, Ruben Fernandes, pelo tempo disponibilizado em ajudar-me ao longo do tempo de escrita deste relatório. Obrigado pela orientação e atenção dada, pelas recomendações fornecidas e pelo apoio que senti nas minhas ideias.

Em segundo lugar, gostaria de agradecer à Dra. Cláudia Duarte, da dstgroup, pelo apoio e pela troca de ideias, e pela disponibilidade em responder a qualquer hora às minhas mais variadas perguntas. Obrigada pela oportunidade e pela confiança proporcionada.

Aos meus amigos, quero dizer que este mestrado não teria sido tão bom sem vós presentes. A paciência que tiveram comigo, especialmente quando fazia perguntas sobre algo que não compreendia, fez a diferença. Agradeço por terem estado lá para mim.

À minha família que me atura há anos, sei que não o digo vezes suficientes, mas vós sois o mais importante na minha vida. Agradeço por todos os dias que me ouviram a queixar e só resmungarem de vez em quando. Obrigado por me encorajarem e darem o apoio todos os dias sem falta.

A todos que de alguma forma melhoraram o meu dia ou riram das minhas piadas que nem sempre têm piada quero dizer o meu muito obrigado.

Por último, mas não menos importante, quero agradecer a mim mesma, "por acreditar em mim", "por nunca desistir" mesmo quando parecia mesmo apetecível, por me esforçar e superar os tempos difíceis.

Abstract

Climate change has been felt throughout the planet, and action to deal with this new reality has been called upon by important organizations like the United Nations (UN). The use of plastics, namely of single-use plastics, is identified as one of the problems organisations need to deal with in times of climatic crisis. This is the kind of plastics used by the dst logistics center (henceforth referred to as dstgroup), where the work for this internship's report was done. In this organisation, plastic film is used to secure pallets that are shipped to construction sites, as engineering and construction is the main activity of the company. Through the lens of sustainability and its dimensions – economic, environmental and social –, this work aims at finding an alternative to plastic film.

The methodology used in this work was based on the triple-bottom line approach. For each of the three dimensions of this approach – economic, environmental and social –, several indicators were selected to assess different alternatives to plastic film. Data about most of these indicators was collected via a survey administered to suppliers of alternative solutions pre-validated by dstgroup. Secondary data was also used in this exercise.

The results of this work recommend the substitution of the plastic film solution with a rigid plastic pallet box. This recommendation comes from the application of the triple bottom line approach to the case of dstgroup, in addition to the need to comply with some requirements that have been set by the company (namely, the need to find a waterproof solution for the safe transport of pallets and its adequate storage).

The approach followed in this work adds to other similar research carried out in the past, not only because it included more indicators, but also because more solutions were assessed. The chosen solution was specific for the dstgroup, in the sense that it took into consideration the packaging process in place in the company.

Keywords: Sustainability, Triple-Bottom Line, Alternatives, Plastics, Pallets, Reuse.

Resumo

As alterações climáticas têm sido sentidas em todo o planeta e organizações importantes como a ONU têm solicitado ações para lidar com esta nova realidade. A utilização de plásticos, nomeadamente plásticos de uso único, é identificada como um dos problemas com que as organizações precisam de lidar em tempos de crise climática. É este o tipo de plástico utilizado pelo centro logístico da dst (doravante dstgroup), onde foi realizado o trabalho deste relatório de estágio. Nesta empresa, o filme plástico é usado para o acondicionamento de paletes que são expedidas para locais de obras, sendo a construção a atividade principal da empresa. Através da ótica da sustentabilidade e das suas dimensões - ambientais, económicos e sociais -, este trabalho pretende encontrar uma alternativa ao filme plástico.

A metodologia utilizada neste trabalho baseou-se na abordagem do tripé de sustentabilidade. Para cada uma das dimensões desta abordagem – ambiental, económica e social - foram selecionados diversos indicadores para avaliar as diferentes alternativas ao filme plástico. A informação sobre a maioria dos indicadores foi recolhida através de um inquérito feito aos fornecedores das soluções alternativas pré-validadas pela dstgroup. Dados secundários também foram utilizados neste trabalho.

Os resultados deste trabalho recomendam a substituição de filme plástico por uma caixa-palete plástica rígida. Esta recomendação advém da aplicação da abordagem do tripé de sustentabilidade ao caso da dstgroup, para além da necessidade de cumprir alguns requisitos que foram definidos pela empresa (nomeadamente, a necessidade de encontrar uma solução impermeável para o transporte seguro dos paletes e o seu correto armazenamento).

A abordagem seguida neste trabalho acrescenta-se a outras pesquisas semelhantes realizadas no passado, não só porque inclui mais variáveis, mas também porque foram avaliadas mais soluções. Além disso, a solução final foi específica para a dstgroup, no sentido em que teve em consideração o processo de embalamento em vigor na empresa.

Palavras-chave: Sustentabilidade, Tripé de Sustentabilidade, Alternativas, Plásticos, Paletes, Reutilização

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Abbreviations & Acronyms

AR – Action-Research

CO_2 – Carbon Dioxide

CP – Cardboard Packaging

CPP – Carbon Positive Plastic

CSRD – Corporate Sustainability Reporting Directing

EU – European Union

ESG – Environmental, Social and Governance

GHG – Greenhouse Gas

HDI – Human Development Index

HDPE – High-Density Polyethylene

LCA – Life Cycle Assessment

LDPE – Low-Density Polyethylene

LLDPE – Linear Low-Density Polyethylene

NFRD – Non-Financial Reporting Directive

NSDI – National Sustainable Development Index

MCDA – Multi Criteria Decision Analysis

MP – Mushroom Packaging

PET – Polyethylene terephthalate

SD – System Dynamics

SDG – Sustainable Development Goals

SME – Small and Medium Enterprises

SSI – Sustainable Society Index

SUP – Single Use Plastics

TBL – Triple Bottom Line

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

3P – People, Planet, and Profit

3R – Reduce, Reuse, and Recycle

1. Introduction

1.1. Context

In 2023, in a press conference, the United Nations' (UN) secretary-general António Guterres, claimed that the "global boiling era has arrived", after temperature numbers for summertime have broken previous records and are on track to getting only higher (Niranjan, 2023). Adding to this, the amount of CO_2 emissions linked to energy worldwide has reached a new record of 37.4 billion tonnes in 2023 (IEA, 2023). This reinforces the need to work on achieving the Sustainable Development Goals (SDG) that have been in place since 2015 (United Nations, n.d.) to build a more prosperous future for the living generations and the following ones.

In 2015, 196 countries signed the Paris Agreement at the UN Climate Change Conference, in which the primary commitment is to "hold the increase in the global average temperature to well below 2ºC above pre-industrial levels", and ideally keep the rise to 1.5ºC (UNCC, n.d.). Also, on the Sustainable Agenda of UN, there are 17 SDG created by the UN, with the participation of many countries, following decades-long work (United Nations, n.d.). They represent the commitment of many countries to protect the environment, eradicate poverty, and make sure that everyone lives a free and secure life by 2030 (UNDP, n.d.). Also, the least developed nations are given the highest priority regarding their development.

Sustainability has never been more important to corporations. For instance, IBM (n.d.) shared that when seeking a brand, the environmental impact and the sustainable practices and solutions of the respective companies play a part for "55% of consumers", showing that incorporating sustainability in their business models captivates the interest of customers. The same article states that this mindset can also be applied to employees, who rather work for a company that has a mission to be sustainable in its operations. Furthermore, sustainable practices can translate to numbers that can capture the attention of owners and investors (as can be exemplified by the Mahindra Group (Pandey, 2024), that saved Rs 100 million through energy conservation programs in only one year). Even though the investment at the beginning of the implementation of more sustainable business models might be considerable, the eventual rewards will out-weight the initial costs.

Sustainable packaging is the green practice that this work revolves around. First, it is essential to recognize the significance of packaging and its benefits. The purpose of packaging is to through the use of a container, a product can be protected and confined, which facilitates how it is distributed, identified, stored, promoted, and used (Pahwa, 2021). According to Lambert et al. (1998), when the packaging is done properly and effectively, it enhances handling, lowers expenses, and boosts service as well as improves overall warehouse productivity.

With the pressure to satisfy the customers and follow the guidelines of the UN for sustainability, companies are being compelled to develop and implement sustainable practices within their business, as well as along their supply chain. So far, choices made by companies include applying alternative energy sources for more efficient use of energy (Dey et al., 2011; IBM, n.d.), finding substitutes for the plastic used in packaging (Dey et al, 2011; Ramanathan et al., 2014), just to name a few. Such choices bring several benefits (such as the reduction of the carbon footprint[1]), which ultimately add a competitive advantage to companies.

In Portugal, the work towards achieving the goals for the 2030 Agenda proposed by the UN in 2015 is in progress. 101 out of the 170 indicators analysed by the Statistics Portugal showed favourable growth (Carvalho, 2023). Portuguese companies have followed this trend and have incorporated sustainability in their businesses, especially large enterprises (Dias, 2023). Nonetheless, the same study indicates that the environmental component has been the hardest to balance between the perceived significance and the actual achievement, implying that there is still room for improvement.

1.2. Curricular Internship

The work presented in this report is the output of the curricular internship developed in the logistics department of dstgroup, a company based in the North Region of Portugal, and it has been implementing sustainable solutions in its business. As part of its journey to sustainability, dstgroup intends to replace the plastic of single use (SUP), which in this case is plastic film, with a more sustainable solution. This type of plastic is the primary way of securing or packing pallets that carry materials or equipment to transport to places where they are needed. In this case, the transportation is done mostly to construction sites.

[1] A person's or an entity's carbon footprint is the total quantity of greenhouse gases (CO_2, CH_4, etc.) emissions from all their actions (Badamasi, 2024).

dstgroup (Domingos da Silva Teixeira) is a Portuguese company born in the 1940s (dstgroup, n.d.-a), starting its business in the construction sector, through the extraction of aggregates. Nowadays, engineering and construction is the primary business activity, but they have successfully expanded into other areas, such as the environment, renewable energy, telecommunications, real estate, and ventures. Their operations reach not only countries in Europe, but also countries in other continents like Angola and Venezuela.

Culture is of utmost significance to the company, and their mission is to "Build sustainable corporate projects that add value to the community" (dstgroup, n.d.-b). Last year, it was rewarded with the Top Employer 2023 Certification for the dedication and putting the employer first.

Regarding the road towards a sustainable future, in the company's Sustainability Report for 2022 (dstgroup, 2023) it is reported that even though their greenhouse gas emissions are higher than the previous year, it is actually lower in percentage per M€ in business volume (about 5% lower). The company has increased by 11% the production of clean energy in the campus and decreased waste production by 14%. This and additional data reported show the company's work and the commitment with the environment.

As this internship report regards the logistics centre of the dstgroup, the area of focus explored for the literature review was the logistics department. Note that this department can determine the success of a company. Therefore, the right logistics strategy can offer a unique advantage over the competition (Heskett, 2014).

1.3. Research Objectives

This internship report focus on sustainable alternatives to replace the plastic film used for packaging by the company under study. Therefore, the work combines 4 objectives:

(i) analysis of the current packaging option of dstgroup;

(ii) identification of sustainable packaging alternatives;

(iii) evaluation of the suggested solutions through the three pillars of sustainability;

(iv) proposal of a new packaging solution that is more sustainable to the company.

To achieve these objectives, it is important to have an in-depth understanding of sustainability and packaging solutions. Each stage of the research carried out within the scope

of this internship contributes to achieve the purpose of selecting the best sustainable packaging solution for the company.

1.4. Methodological Approach

The methodological approach used is action-research (AR), a "multidisciplinary approach" that employs a range of qualitative and quantitative procedures and instruments at the same time (Erro-Garcés & Alfaro-Tanco, 2020). In essence, action research is "learning by doing" (Villegas, 2024).

More specifically, the first step is to identify the problem that needs to be addressed: plastic film is the current packaging method used by dstgroup; however, this is not a sustainable solution, therefore an adequate and sustainable alternative has to be found to be implemented in the company. Then, knowledge was gathered through a literature review on the topic. At the same time, the reality of the company was studied, namely regarding the use of plastic film in the business. After that, the alternatives suggested were thoroughly analysed, with the assessment of the impact of the three pillars of sustainability (economic, environmental and social) through a multi-criteria decision analysis. To operationalize this approach, stakeholders were involved, namely the employees of the company where the internship was held. The goal was to add some knowledge or point of views regarding the possible solutions for the research. Finally, conclusions were drawn, and comments were made regarding the sustainability of the alternative packaging solutions found to company.

1.5. Report Structure

This report is structured in 6 chapters. Chapter 1 provides a quick overview of work developed at dstgroup within the context of the curricular internship. It presents the topic of the internship – sustainable packaging –, the main objectives of work developed for dstgroup, and the methodology used to accomplish these objectives.

Chapter 2 is dedicated to literature review on sustainability in general, including EU regulations on this matter to accelerate the transition towards a more sustainable world. It then focuses on the topic of packaging, tackling the issues related to the use of plastics, namely of plastic film, in industry, and reviewing some of the existing green solutions that have been already developed for packaging by some corporations. The chapter concludes with an overview of methodologies that can potentially be used to assess and compare different packaging solutions along the main axes of sustainability.

Chapter 3 provides granular information regarding plastic film and the different sustainable packaging solutions that can be used by a company such as dstgroup to replace the existing plastic film solution. Each of the solutions found in the literature or in real-life applications are briefly described and discussed.

Chapter 4 delves into the methodology used in the internship to assess different packaging solutions along three dimensions of sustainability, namely the economic, environmental and social ones. The methodology is commonly known in the literature as the triple bottom line (TBL) approach. For each of the selected sustainability dimensions, different indicators were selected. These were then used to set up a decision matrix for multi-criteria assessment.

Chapter 5 presents the challenges faced by dstgroup, as well as the way the operations are carried out in the company. It also details the sample of indicators used in the decision matrix to the different sustainable packaging solutions that could be potentially adopted by dstgroup as an alternative to plastic film. In this chapter, the results of the multi-criteria assessment are presented and discussed.

Finally, chapter 6 capitalises on the results of the previous chapter to select an alternative and sustainable solution to dstgroup. Such selection took into consideration a number of requirements that have been initially set by the company. This chapter also presents the limitations of the methodology employed in the research and lays out the next steps that must be taken to improve the decision matrix.

2. Literature review

2.1. Sustainability

Based on three pillars, sustainability is derived from the complex combination of the preservation of environmental wellness, the achievement of social justice, and the conservation of financial stability, which create the conditions for a strong and healthy society worth living in and leave for future generations (UCLA, n.d.).

Mollenkamp (2023) explains interconnections of then three pillars occur. When looking at the economic pillar first, the focus is on making use of natural resources to generate profit and set economic production, while still protecting those resources, whether they classify as renewable or non-renewable. This is connected to the social pillar, which addresses how the economic system of each country affects people at a more direct level, as well as at a broader level the initiatives to end social injustices as inequalities. Finally, environmental sustainability consists of ensuring that resources needed for economic growth and human well-being are properly used, so that the future of the next generations is not compromised.

Throughout the years, companies have been searching for ways to implement green and socially responsible practices in their activities, as these are crucial for both environmental preservation and long-term business continuity. Sustainability can be incorporated in the different departments of a company, including the logistics department. Since transportation is a significant part in logistics, there is quite a range of studies performed to evaluate the implementation of sustainability in this particular sector. Dey et al. (2011), while providing a vast series of green practices for each part of the supply chain, promote vehicle technology that is environmentally friendly via enhancing the daily operational efficiency of automobiles and converting to "alternative or hybrid fuel" resources. Even though this is very relevant and could be extended in more specific practices, the green practice aimed to be studied in this report regards packaging, which will be approached further in this literature review.

Behind the success of the implementation of the strategies, some articles point out the role of top management teams in driving sustainability initiatives in logistics and supply chain management. Clear commitment from top management can resolve conflicts between working for sustainability and the optimization of profits (Bretzke, 2011), asking logisticians

to estimate or calculate the expenses, and considering the implications of energy consumption and greenhouse gas emissions on business models. Zhang and Zhao (2012) go even further and propose two levels of management strategies for the implementation of green packaging to be successful, namely the government level and the firm level. Regarding a firm's role, the action of the logistics managers can promote low packaging costs and speed up the process of implementing green packaging in the system.

Since January 5th of 2023, the EU has implemented the Corporate Sustainability Reporting Directing (CSRD), which requires some small and medium enterprises (SME's) and large companies to provide information regarding the way their businesses can affect who is around it and what can potentially be viewed as an issue regarding sustainability (Directive 2022/2464). This report will reflect the effects of company's activities from an environmental, social, and governance (ESG) perspectives. The intention behind CSRD is to help stakeholders comprehend and keep up with how a company is performing in the sustainable goals set previously and identify possibilities to reduce costs and promote efficiency within the company. Another key point of this Directive is that an external or independent auditor must certify the sustainable reports of the firms to verify the authenticity and reliability of the information and follow the standards of the directive. This new directive comes to substitute the Non-Financial Reporting Directive (NFRD), due to the smaller range of enterprises covered and the low depth of the issues regarded by the NFRD (Aplanet, 2024) and better the way companies do ESG reporting (Conmy, n.d.).

2.2. Plastic use

460 million tons represent the amount of plastic that was produced in 2019, according to data released by Ritchie et al. (2023), and about 7.7 million is estimated to end up in rivers, coastal areas, and the ocean (Ritchie, 2023a). By 2050, there will be more plastic waste in the ocean than fish, according to a post from the Observador (2023). The production of plastic has increased exponentially throughout the years, and the reason behind it concerns its benefits, which on the downside are also the reason why its use is so wrong. Because plastics are made from essentially fossil fuels, some of its benefits are durability, possibility to shape it into any form wanted (and related scale of production) and, thermal isolation (APIP, n.d.). These qualities work together to make its use extremely desirable.

The environmental hazard that comes from plastic waste achieves new levels every year, as it directly relates to problems in human health. Even though scientists haven't

determined thoroughly the impact on our health, microplastics have already been identified in the bloodstream of humans (Lemos, 2022). Other studies show that animals have been endangered or killed by plastics, and some plastics have even infiltrated the reproductive systems of certain species and caused a smaller production of eggs, like in oysters (Parker, 2024). Furthermore, during the lifecycle of plastics (from production to disposal), greenhouse gas (GHG) are released into the atmosphere GHG being responsible for the increase of the temperature of the earth's surface (Ritchie, 2023b).

The EU has addressed the single use plastic products, as their use is quite negatively impactful, in a Directive on single use plastics (Directive 2019/904). Under this directive, it was created a ban on certain types of SUP's products such as food containers, plastic bags and packets, and wrappers, and, on the other hand, provided accessible and sustainable options. Following this Directive, the Portuguese Parliament established that from the first of November of 2021, the same ban started to be applied in our markets, so that the environmental goals are met (Decreto-Lei n.º 78/2021).

According to Plastics Europe (2022), in 2021, the plastic industry produced 390.7 million tons of plastic, of which forty four percent goes to the packaging sector, being the biggest consumer of plastic. Yet, statistics estimated that 350 million tons of plastic waste is produced every year and the projections for 2060 are three times higher than that number (Alves, 2024). The processes to dispose of plastic waste are, among others, landfilling, recycling, reusing, and incinerating. In 2019, about 15% of the plastic waste produced was collected to be recycled (Alves, 2023), revealing that sustainability isn't strongly present in the plastic industry. Mwanza and Mbohwa (2017) report that technology, market share, and cost and capacity are some of the obstacles identified in establishing recovery and recycling of the management of plastic waste.

In light of all of this and to reduce plastic waste, it is crucial that this society increases the application of 3R's policy and circularity strategies.

2.3. Green packaging

Besides protecting the product and keeping the content untouched in order to not lose its functionality, packaging can also be suggestive and draw interest of customers (Rundh,2016). The study of Wells et al. (2007) showed that packaging aided 73% consumers when deciding what to buy.

When the attention is on the relationship between packaging and logistics, it should be noticed that it eases the distribution of goods, (which is key in long distance transportation, grants protection to the content and provides information about the product and how to handle it (Lambert et al., 1998).

As previously stated, the packaging sector is the main consumer of plastic. Because of the pollution generated, packaging is one of the activities that demand change. Hence, the introduction of green packages has been growing throughout the years, which has been visible, especially in the food industry, as more companies develop and use eco-friendly packages. In 2022, the market size for sustainable packaging was estimated at USD 244.30 thousand million globally (Straits Research, n.d.). The research of Zhang and Zhao (2012) explains green packaging as "appropriate packaging that can be reused or recyclable, or degradation, corruption does not cause pollution in humans and the environment during the product life cycle." In the study of Iroegbu et al. (2021), "green plastics" is defined as a substitute polymeric material that is not only biodegradable but also biocompatible and has a "net neutral or positive impact on the environment."

It is important to account for other methods of lowering plastic waste, such as the commonly known 3R principles, consisting of reducing, reusing and recycling, to which can be added other principles, such as reclaim and degradability (Zhang & Zhao, 2012). The reduction of plastics is advised due to the association to help logistics, and sales, implying that companies should improve their packaging designs to be more lightweight or use less plastic.

Studies performed in recent years have shown different points of view regarding this matter. Wandosell et al. (2021) show that the interest in examining new strategies with green packaging has been increasing for both researchers and consumers. Also, this study expressed that certain features of green packaging, such as the biodegradability and the recyclable nature of the packaging materials influence the choice of buyers. Price also plays a considerable role in the final decision. Hao et al. (2019) suggest that manufacturers should concentrate on not only the price but also the "environment, green packaging quality and commodity", as these factors can alter the willingness-to-pay of a customer. Nevertheless, the same authors in addition to the study by Mahmoud et al. (2022) show that consumers have poor awareness over the eco-friendly packaging and its benefits, which indicate that this type of packaging does not have any positive effect on "consumer's purchase decisions".

In the last years, sustainable packaging has been studied by companies to improve their performance from a sustainability perspective. There are a few examples worth mentioning. First, Midas Safety lowered the plastic use, even though they believe that their packaging methods cannot totally be carried out without plastic (Asim et al., 2022). Moreover, they have investigated biodegradable packaging but encountered some issues with it. Packaging materials composed by ortho-biodegradable components can do more harm than good to the environment due to the fact that when broke down into microplastics, it can enter the human body and be very dangerous, as mentioned before. Finally, the study provided some insight about the slow progress it was made over implementing sustainability in the packaging methods, recognizing the unpreparedness of local suppliers to the required change.

On another note, there are some drawbacks regarding sustainability and the related practices, which were explored in the study by Turkcu and Tura (2023). When surveyed a few companies, the researchers found that end-of-life management of sustainable products is one of the main issues faced, as it is a substantial cost strain and requires significant changes in the operations and infrastructures of the sustainable packaging industry. It was also studied some strategies to tackle the challenges faced, including the collaboration with other organizations, carrying out life cycle assessments (LCAs) and obtaining certifications (Turkcu and Tura, 2023), showcasing that companies in different parts of the supply chain and of any size can thrive in this sustainable era with fewer cutbacks.

In 2021, a few big firms, like Microsoft, Cisco, and the Éstee Lauder Companies, developed the Stretch Wrap Alternative Project (SWAP), along with the Ellen MacArthur Foundation (Microsoft, 2022). They investigated three approaches for recycling, composting, and reusing as alternatives for the single use plastic film, to achieve a circular solution with a positive impact on the environmental and economic sides, and the potential to be scalable. The results showed that there isn't always a single optimal choice, as it varies on the characteristics of the product, circumstances, and the whereabouts of the product, from where it comes from to where it ends.

2.4. Tools for sustainability assessment

In principle, any sustainability assessment tool should be based on the three pillars of sustainable development – environmental, economic and social.

Rodríguez-Serrano et al. (2016) stated that most of the approaches evaluate sustainability in part at the regional level, addressing one or two of the three pillars. Nonetheless, the research of St Flour and Bokhoree (2021), whose purpose was to highlight several tools available for assessing sustainability at the national level that incorporated the three factors, showed that 4 tools fit that requirement, within 7 that were selected to be studied. The 4 frameworks are Sustainable Society Index (SSI), National Sustainable Development Index (NSDI), System Dynamics (SD), and Multi Criteria Decision Analysis (MCDA).

Approaching the first framework, SSI distributes 21 indicators through 3 dimensions – human wellbeing (HUW), environmental wellbeing (ENW), and economic wellbeing (ECW) –, and the respective strategy is to outline the advancement of the nation regarding its sustainable efforts (Larson, 2021). Instead of using arithmetic means, which would probably compensate some lower numbers in one of the indicators with a good score in another, the calculations employ geometric means.

NSDI was developed to replace the Human Development Index (HDI), which was introduced by a Pakistani economist and adapted by the UN to evaluate the sustainable development of a country (Wikipedia, 2024c). The computation of the NSDI is the quotient between the "development index", which considers education, life expectancy, and income indexes, and the "ecological impact index", which measures how much the CO_2 emissions surpass the "per capita planetary boundaries" (Hickel, 2020).

Another tool that handles complex systems exploring sustainability in 4 dimensions (human needs, economic, environmental, and life services structure) is the System Dynamics methodology (St Flour & Bokhoree, 2021). In the 1950s, business managers used system dynamics to gain a better understanding of industrial processes (Wikipedia, 2024a). Two unique notations in the foundation of SD models are stock and flow, and causal-loop diagrams (Abdelkafi, & Täuscher, 2015). Sterman (2000) believed that SD is properly used when is dedicated to issue solving instead of modelling a system. Also, the model is an open box that stimulates learning as opposed to a closed box that promotes policy viewpoints.

The approach known as MCDA aids in decision-making by comparing possible options or solutions based on pertinent, sometimes contradictory criteria (Estrada, 2024). This method is very efficient as it assesses the alternative solutions through the division of a

complex problem into smaller portions and the selection of important criteria to choose the most suitable option (Lombardi & Todella, 2023). One aspect characteristic of this method is the involvement of relevant stakeholders, as these may provide pertinent knowledge to research projects (Estrada, 2024; Lombardi & Todella, 2023). Nevertheless, their part can be restricted to weighting the criteria, because the model requires a significant investment of "time, people and money" (Estrada, 2024).

There are also frameworks that evaluate individually the pillars of sustainability, such as the Impact Assessment, which integrates a Social Impact Assessment, an Economic Impact Assessment, and an Ecological Impact Assessment. Any of these frameworks grant companies to measure the efficiency and significance of their activities of the present or potential new ones ("What is an Impact Assessment? A Complete Introduction", 2022). It takes into account the effects those actions have on the business, the people involved, and the environment and allows for room to make arrangements in advance to address the good or bad outcomes.

3. Packaging solutions: plastic film and sustainable alternatives

This chapter explores the characteristics of plastic film and how this current solution is used by the company. Also, it will also include the alternative solutions sighted to substitute the plastic film. A small number of alternatives are addressed and briefly examined, but they won't be included in the proposed solutions either because they are not available in Portugal or because there is no scale for its supply.

3.1. Plastic film

The varieties of plastic are different in the polymers in their formation and are also different in creation method (Rhodes, 2018), along with some other distinctions. This section focuses on the usage of plastic packaging, namely single-use plastics (SUP) — category of plastic film used in packaging —, the object of this report. They have a small life span and, therefore, generate waste quite fast, contributing to higher pollution levels (Chen et al., 2021).

Plastic film is also known as wrap film or stretch wrap. This kind of plastic is utilized for packaging, commonly used in logistics companies to pack materials or equipment in pallets so that their transportation can be done in a safe way.



Figure 1 – Plastic film (transparent)
Source: Packstore (2024)



Figure 2 – Pallets wrapped in plastic film
Source: MCD Express, Inc (2024)

In the company where the internship was hosted, there are two plastic films used that differ mainly in colour, one is black or opaque and the other is transparent. Both types are made of Linear Low-Density Polyethylene (LLDPE), which is a linear polymer with numerous short branches (Wikipedia, 2024b). The characteristics and properties of the stretch film used by the company are presented in the following tables (Table 1 and Table 2), which summarize information from the technical specification sheets provided by the supplier of plastic film. According to these sheets, both plastic films are 100% recyclable.

Characteristics	Stretch Film
Average thickness	23 μm (±1μm)
Width	500 mm (±2%)
Core Weight	1.8 Kg (±5%)
Features	- Adhesivity in the internal face; - Good adherence and high loading stability.

Table 1 – Characteristics of stretch film made from LLDPE.

Properties[2]	Stretch Film
Dart drop impact	80 g. (ASTM D-1709)
Pre-Stretch (guaranteed)	150% (highlight teste machine)
Tensile Strength Break	MD>36N/mm2MD (Highlight test machine)
Tensile Elongation Break	330% MD (Highlight test machine)
Elastic Modulus	MD 98 MPa (Highlight test machine)

Table 2 – Properties of stretch film made from LLDPE.

The wrapping method can vary, as plastic film can be applied manually or automatically through a pallet wrapping machine. This has implications for the amount of film necessary to wrap a pallet, as wrap machines are essential to get the optimal stretch rate (Robopac USA, 2024). Manual wrapping is considered less efficient and less uniform than automatic wrapping, which leads to fewer pallets being wrapped with one roll. Moreover, the method may differ based on the confinement force necessary. For example, if the transportation route is lengthy or takes place on a bumpy road, more layers of film will be needed to ensure that the pallets are packed tightly.

The list of damage that can happen to a product during its transportation is extensive, (Emblem, 2012). Some vibrations may cause, for example, the packages to fall down the pallet, if not properly secured. Also, environmental agents, such as humidity and high temperatures, can affect the materials causing corrosion and drying out the paper boxes. Moreover, during the transportation route, the goods can sometimes be left unsupervised, which may reason the loss of them. So far, there is one solution that conceives protection

[2] The definitions of the properties are in the Annex A.1.

for all these problems, the plastic film solution. Its use secures the safety of the products that are moved around, promotes stability, and preserves their transportation (Volmar Packaging, 2023). Costs also weigh on the scale when compared to other alternatives. According to bvse – Federal Association for Secondary Raw Materials and Disposal, the market price of LLDPE plastic film was around 1190-1230 €/t in December 2023 (Probst, 2024).

Currently, LLPDE is the type of plastic film used by the dstgroup to wrap pallets (standard European size: 1,200m*0,8m*0,144m). The plastic film can be either applied in the warehouse where the materials are stored, or it can be sent to the construction site and then be used there. The application of the plastic film is manual, both in the warehouse, when preparing the orders as well as on the construction site. Because the logistics department attends mainly to the needs of construction work, the materials or equipment requested are packaged in the warehouse and placed in the transports selected. Then, the transportation leaves the premises and takes off to the respective construction site(s).

3.2. Sustainable Packaging Alternatives

Chhabra et. al. (2017) examined potential green alternatives for a company in India in the automobile industry and concluded that a material that classifies as Carbon Positive Plastic (CPP), which is "a poly-air material made from sugar cane and uses photosynthesis to absorb CO2 and release oxygen", is the best solution towards more sustainable packaging. In the analysis, it is compared with two other different types of material for packaging: mushroom packaging (MP) and cardboard packaging (CP). The MP placed second. It is a material based on waste generated in local agriculture mixed in the mycelium and can be decomposed in just a few months. As for the CP, which ranked in last place, it represents the type of packaging that is already mainly used in the industry. Besides the costs evaluated, the factors that supported this analysis were "Green efficiency", "Factor of Safety", and "Ease of Operation". MP only scored higher than CPP in the Ease of Operation factor, but overall score, when all criteria is considered, is higher for CPP.

Another green alternative that has been developed in recent years is nanocellulose and its characteristics and applications have been studied. Thomas et al. (2018) emphasize how the low permeability and potent barrier-forming properties of nanocellulose against gases like oxygen are driving up interest in employing this material for environmentally friendly food packaging. Its hydrophobicity is increased by surface changes, and the multilayer packaging designs offer more resistance to certain liquids. In Portugal, Alves et al.

(2022) conducted a study on nanofibrillated cellulose, and the results showed a viable prospect for the material to be applied at a larger scale in the future.

- Alternative 1: **HexcelStretch**

Some alternatives in the market are paper based. The company Hexcel Pack, which has been developing packaging solutions to substitute SUP products, has created a "cost-effective and sustainable shipping solution", which is called HexcelStretch (Hexcel Pack, 2024). The technology behind this new packaging alternative offers the highest level of protection and adherence to guarantee the integrity of the cargo during transit.



Figure 3 – Alternative HexcelStretch, wrapping products in a pallet
Source: HexcelPack (2024)

This paper-based packaging solution allows the wrap to be considerably strong, sturdy, flexible, and stiff by stretching into form and is described to be recyclable. Figure 3 shows a pallet wrapping with this proposed solution made with industrial roll – kraft. Also visible in the figure is the machinery used to wrap the paper around a pallet, which is similar to machines that wrap plastic film. Nevertheless, it is recommended that any pallets that weigh above 1250 pounds (or 567 kilograms) should have a grip sheet.

- Alternative 2: **Pallet Covers**

Lay & Palit (2020) and Guirola (2010) show that pallet covers can be a sustainable alternative, after testing the impact along the three pillars of sustainability, using the Triple Bottom Line approach. Some pallet covers are made of mesh constructed from plastic fibers, which allows them to be reusable (with a lifespan of about 3-4 years) and recyclable. It can also stack and fasten boxes onto a pallet, as well as the plastic film does. Figure 4.A shows the application of the pallet covers, which is similar to how a belt is applied around boxes. It

takes around 40 seconds to apply. Lay & Palit (2020) concludes that the pallet covers is a viable solution, scoring higher than stretch wrap, when performing an economic, social, and environmental analysis.



Figure 4 – Pallet covers wrapping boxes in pallets
Source: Bollison (n.d.)

According to the same authors, the only setback of this alternative is that it can't provide flexibility when needed to be handled because the size of the products on the pallet must be specific. Nevertheless, Figure 4.B shows that this solution can be adaptable to the products placed in the pallet and provide full protection of the load.

- Alternative 3: **Straps**

Straps are another method that allows for pallets to be secured. These can be made of diverse types of plastic materials, such as, nylon, polyester, and polypropylene. Common to all types, they are reusable, which translates into a more sustainable solution. Also, they are equipped with a metal seal or buckle to adjust the tension needed. When comparing the different straps available, nylon straps score higher impact strength and resistance to abrasion than the other products Furthermore, studies show that it is the best cost-benefit result, even though the initial cost can be high (Automation, 2020). Nylon can also be more flexible than polyester. Still, Petty (2022) concludes that polyester can resist better to certain weather conditions, such as, UV lights or any moisture, keeping its structure and being resistant to creases. In Packaging (2023), it is reported that polyester strapping is categorized as the strongest among all plastic straps, and provides good elongation in case of shifting load, which results in a great solution for the transportation of medium to heavy loads, characteristic of construction materials. Polypropylene structure is more appropriate for

small cargo or small routes of transport. This is because it can't recover in case of shifting load or other events that may happen during transportation. It is also characterized by a smaller strength (when compared to other similar solutions). Figure 5 shows polyester straps (left hand picture) and the accommodations of cargo in pallets (right hand picture).



Figure 5 – Examples of straps indicated for the transportation of pallets and materials
Sources: A – Amazon (n.d.), B – Palband (n.d.)

- Alternative 4: **Nets**

Longo's (2020) research suggests that nets are the best alternative to plastic film. It is recommended to develop a net made from recyclable PET (acronym for Polyethylene terephthalate, common name Polyester). Among all the other choices, this is the one that seems to accommodate better different mixes of materials, it is more malleable and still guarantees that the materials are well secured. Besides, it can sustain certain weather conditions and UV lights (Nets4You Limited, 2024).

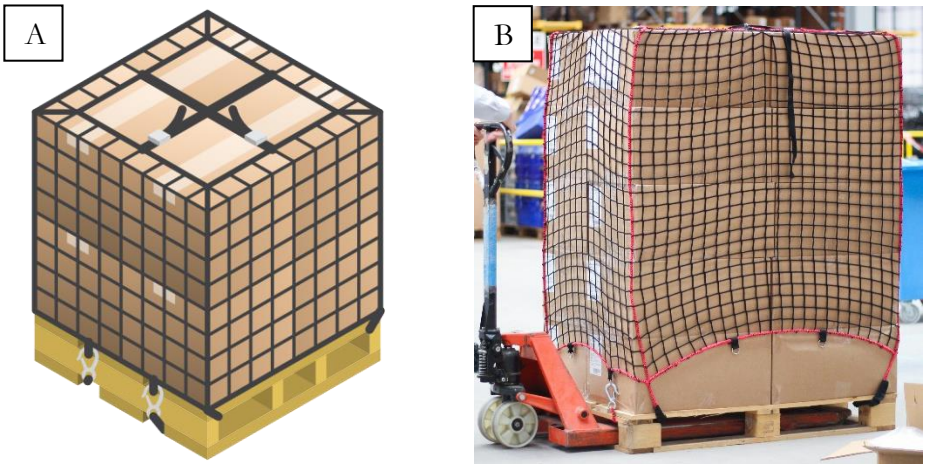


Figure 6 – Representation of a net properly applied onto a pallet
Sources: A – MaxPack (2022), B – Exporta (2023)

One kind of net that is often used for transportation is cargo nets. This are usually made of polyester, but some can be a mixture of polyester and mesh (*A Guide to Cargo Netting Material*, n.d.).

The benefits of using cargo nets are that these are flexible, have multiple sizes (not only the net itself but also its mesh), and they can be reusable (with a lifespan of about 5 years) (Longo, 2020), allowing to cut financial and environmental costs, despite the initial high CAPEX (PCNets Pallet Netting, 2023). Concerning the assembly (as shown in Figure 6.A), the load can be secured in three steps: set the net over the load, lock the catches under the pallets, and adjust the straps on the top (this step only applies to nets that have top straps instead of additional net). This is faster than plastic wrapping.

- Alternative 5: **Adhesive**

Adhesive can also be used to palletize materials. Guirola (2010) concludes that using a water-based adhesive, in addition to a pallet cover for extra support is the best way to hold boxes and secure them on a pallet for transportation, as well as warehousing.

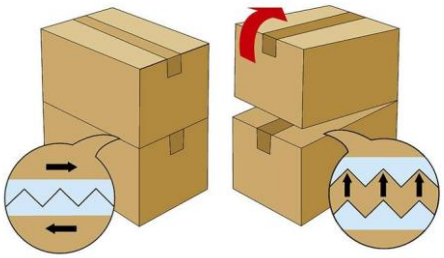


Figure 7 – Representation of how an adhesive works
Source: Lock n' Pop (n.d.)

As shown in Figure 7, its application is quite easy, not to mention the "dismount", lowering the time to put it together. Depending on the technology, the adhesive can be made (or not) with hot melt, but, either way, it can be stronger than stretch wrap (*Lock n' Pop*, n.d.), specially when combined with low tensile strength to smooth the separation of the boxes. *Lock n' Pop* advertises that the packages won't suffer any tearing or damage because of the adhesive. Also, this material is toxic-free and recyclable. It can be applied to distinct types of packaging, including boxes, bags, and other types of packaging.

- Alternative 6: **Grip sheet or anti-slip sheet**

Similar to the adhesive in function and the way it works, the grip sheet or anti-slip sheet is a method created to help with the transportation of materials on a pallet. A grip sheet

is placed between layers of materials to enhance the security and stability of goods, preventing shifting on pallets during transit (*Papel antiderrapante,* 2024).



Figure 8 – Examples of grip sheet and how it works
Sources: A – Sercalia (n.d.), B – ER&GE (n.d.)

The anti-slip characteristic is present in both verses of the sheet, and it prevents the load to not sliding until an angle of 40º (this can differ between selling companies). Its application is quite easy (as shown in see Fig. 8B), consisting on applying one sheet on top of the layer and repeating the procedure until the last layer (*Placa antideslizante | RAJA*, n.d.). The sheet is sometimes made of cardboard 100% recycled (*Placa antideslizante | RAJA*, n.d.). The number of workplace accidents can be substantially lower with the use of the grip sheet.

- Alternative 7: **Rigid Plastic Pallet Box**

Rigid plastic pallet box is a solution slightly different than the previous ones as it also substitutes the need for a pallet, but with the guarantee to be picked up by forklifts. Its lifespan can be very long if they are appropriately handled and taken care of, which means that it allows the carbon footprint of this solution to be kept at a quite low level. Plus, one rigid plastic box can be stacked on top of another, which normally doesn't happen with regular pallets, as these can carry uneven weights or diverse types of packaging. This leads to more loads occupying the same space, which results in less transportation needed, allowing for a smaller environmental impact. Additionally, it allows for materials to be placed in the box without any type of packaging.

These containers are made of high-density polyethylene (HDPE), which confers them strength and rigidity (Palletower, 2022). Regarding the size or capacity, it can vary between suppliers. For example, the box presented in Figure 8-B can hold around 600 litres, and its size is of 1000*1200*760mm. When it comes to the weight of a plastic box, as this is

the heaviest solution analysed in this report, adding to the cargo around 40 kilograms, which can affect transportation since different trucks take on different weights.

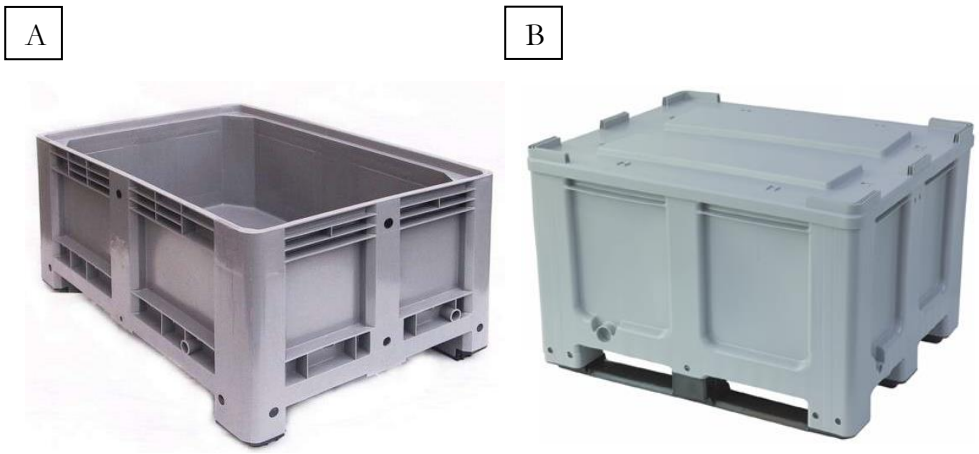


Figure 9 – Examples of rigid plastic pallet boxes (one without lid and the other with lid)
Sources: A – Exporta (2023), B – Stillage Net (n.d.)

Among the benefits of this solution are its high resistance against weather conditions, the easiness to be cleaned and the possibility to be recycled at the end of its lifespan (Palletower, 2022). Concerning the option to have a lid or not, this adds another layer of protection, which is necessary in open truck transportation and while the materials are stored on the construction site.

3.3. Preliminary analysis of the suggested alternatives

Chhabra et. al. (2017) regards an alternative solution (CPP) that show promise yet won't be tried or evaluated. Also, nanocellulose, tested by Thomas et al. (2018), or nanofibrillated cellulose studied by Alves et al. (2022) won't be regarded for this project, because it doesn't exist at scalable size and its applications are not yet well developed but will be advised for further research.

The primary reason for the host company to use plastic film for the pallet wrapping is to ensure that the materials carried are safe and protected from anything that can interfere in the transportation (the company uses fundamentally open trucks) and storage of them, including weather conditions. Therefore, protection against climate elements and discretion about the content of the materials transported are important characteristics to look for when choosing and alternative solution. Bearing this in mind, this analysis is merely guiding as every alternative will undergo the requested evaluation.

Hexcel Stretch is advertised as waterproof. However, pallets covers like the one in Figure 4.A doesn't provide the needed impermeability to the pallets and their load, yet the one in Figure 4.B does. So, to overcome the issue of the cover in Figure 4.A, it would be necessary to add another product to that. The same problem arises with straps (whether these are made from nylon, polyester or polypropylene), nets, adhesives and grips sheets. Nevertheless, the rigid plastic pallet boxes have this function, providing the required impermeability not only during the transportation and but also during the storage periods in the construction sites.

The analysis of the technical information of each solution allows to anticipate that the least expensive alternative would be the grip sheets, and the most expensive one would be the rigid plastic pallet boxes. However, the initial investment can be compensated in the long run.

Finally, since flexibility is one of the traits of plastic film, it seems logical that an alternative should also present this feature. The application of nets and anti-slip sheets is perceived to be easy, because of its flexibility. The same cannot be said of pallet covers and rigid plastic pallet boxes.

4. Methodology

4.1. Approach

This chapter presents the methodology approach selected for the work developed in the internship. This focus mainly on the comparison of different alternatives to the existing packaging solutions used by dstgroup, by assessing its impacts along the three axes of sustainability - economic, environmental, and social.

- **Tripple Bottom Line Approach**

In the process of choosing how to assess the mentioned different impacts, it became evident that the most adequate approach would be the Triple Bottom Line (TBL), formulated by John Elkington in 1997 (Clayton, 2018). It consists of the method of evaluating the performance of a company through the pillars of sustainability, subtly changed to 3 P – People (social pillar), Profit (economic pillar), and Planet (environmental pillar). These pillars overlap two at a time as displayed in Figure 10, it can show the effects of relating one with another.

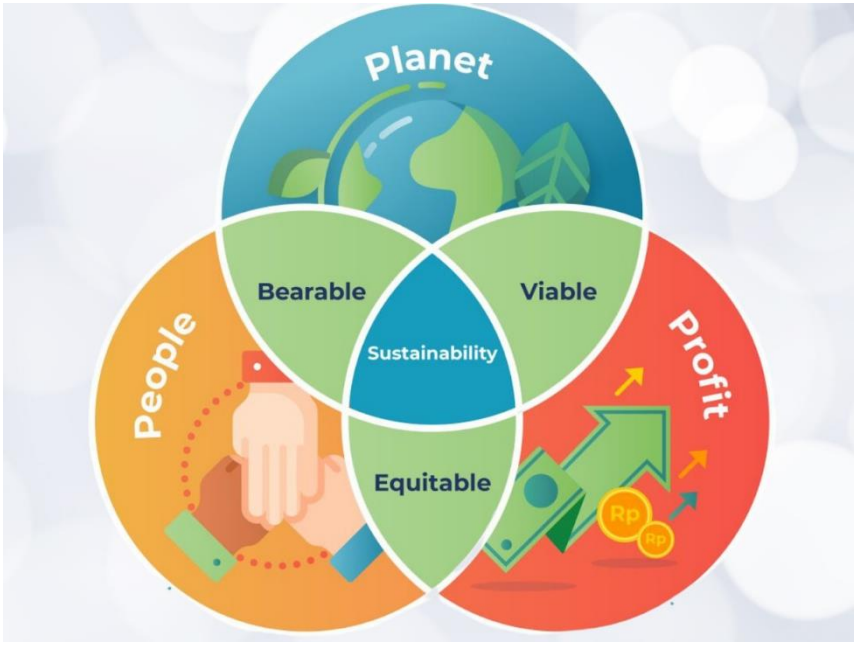


Figure 10 – Triple Bottom Line framework
Source: Miles (2024)

The development is classified as equitable when "profit" and "people" overlap, bearable when "profit" and "planet" overlap, and viable when "people" and "planet" overlap. Sustainable development occurs when all three dimensions overlap. There aren't

precise parameters to compute the TBL (Slaper & Hall, 2011). To operationalize TBL, indicators were selected and computed for each of the three pillars and a MCDA was conducted.

The TBL shares a similarities with the ESG rationale. Even though both methods consider the environmental and social elements, one of the differences is the fact that TBL weighs the economic impact of the activities of the business or project while ESG is a non-financial approach, adding an administrative factor. Besides, the TBL emphasizes the more general objective of sustainable growth, which aims to address the three variables with a holistic view, whereas ESG is focused on analysing the success and risk of a business (Ribeiro, 2023). According to Sustainable Business Strategy cited by Miller (2020), it was already proved that higher financial returns can be accomplished by companies with promising ESG measures.

i. Economic pillar

As most businesses have the goal to be as lucrative as possible (Miller, 2020), economic sustainability is key to supporting a sustainable strategy leading to economic growth in the long-term with the correct utilization of natural resources.

Before moving to the parameters chosen, it is important to mention that there are many driving factors for economic development that support both a strong economy and an improved standards of living. Extended economic progress is mostly driven by technological improvement (Blanchard (2017) cited by Kyzy (2019)). Increased productivity and competitiveness, in addition to economic growth are the result of adopting "innovation, research, and development" projects (Almansour, 2023). Besides that, it is possible to generate job opportunities by promoting investment, supported by both local and international capital. Different industries favour the creation of an inviting business climate (Almansour, 2023), which results in the formation of supply chains, technology transfer, and information exchange.

On the other hand, one of the problems with achieving economic sustainability is that companies prefer to purchase a product that is not environmentally friendly because this is typically less expensive than a similar product with a lower environmental impact (Chouinard, 2017). Companies that support their business on a low-cost strategy will face more difficulties to adapt to the change needed to move to a sustainable economic system.

Several aspects were taken into consideration to determine which pallet packaging method was the most cost-effective. The parameters selected to assess this impact are the following:

a. Cost of the product - price at which it is sold (€);
b. Number of utilizations until the alternative has to go to waste;
c. Cost associated with reuse: additional cost of tracking;
d. Cost associated with reuse: additional cost for transportation;
e. Cost associated with reuse: cost of keeping the alternative reusable;
f. Ratio of price/utilizations;
g. Simplicity of usage - Time it takes to secure properly the pallet (minutes);

ii. Environmental pillar

Environmental pillar was the first pillar considered in the conceptualisation of sustainability because of the widely negative impacts of development in the natural capital and ecosystems of the planet (Direção-Geral da Ação Climática, n.d.). Hence the urgency to implement suitable practices and laws that will gradually conserve and safeguard the natural environment. Bosson (2024) states that when this concept is applied to a business, it means that the business operates without endangering the environment in any way.

In fact, companies can benefit from the implementation of environmental sustainability on different levels. For example, reducing waste and enhancing the energy efficiency of company operations can lower business expenses (Bosson, 2024).

Kenton (2023) considers that this pillar of the TBL is arguably the most challenging factor to quantify, since it requires organizations to understand the diversity of impacts that their activities have on the environment.

With this in mind, the attributes considered to assess the environmental impact of different packaging solutions are the following:

a. Amount of raw material consumed to produce each alternative;
b. Amount of GHG emissions produced by each alternative (KgCo2eq);
c. Amount of waste generated after the use of each alternative (Kg);
d. Noise produced in the application of each alternative;
e. Rate of recycling.

iii. Social pillar

Frequently disregarded is the social dimension of the three pillars of sustainability (ADEC ESG, 2024). The key is prioritizing the welfare of individuals and communities. This pillar is about advocating for fairness, equality, adequate labor, and facilitating access to healthcare and education (Enel Group, 2023).

Integrating this into the business means all stakeholders are to be considered. Firms that have implemented socially conscious practices have more positive image in the eye of the public and are more capable to boost the morale of their employees. Murphy (2024) reveals that more and more people say that is important for them to work for a company that is socially sustainable. Some studies point to the fact that socially engaged companies can have higher production levels and profitability, mainly because of increased motivation, which is key to reduce absenteeism (Murphy, 2024).

The importance of social sustainability is more easily recognized even if social impacts are more difficult to measure (ADEC ESG, 2024). Also, the usual indicators considered in a social impact evaluation are the "unemployment rate", "female labor force participation rate" (Slaper & Hall, 2011), and "fair access to products by the customers" (Kenton, 2023). Yet, because of the difficulty of measuring some of these indicators, for a single department or activity of a company, they have not been considered in the social impact assessment of different packaging solutions. Instead, the indicators used were the following:

a. Health risks that affect the user/ Level of safety of use;
b. Employee education – specific training required for the application of the alternative;
c. Company's social responsibility – inclusion of people from the local community in the alternative's production team;
d. Company's social responsibility – investment in community development programs;
e. Company's social responsibility – percentage of young people (18 - 29 years old) working in the company;
f. Company's social responsibility – promotion of sustainability through awareness programs;
g. Company's social responsibility – reporting on sustainability.

When evaluating the different variables, the weight attributed to each pillar is going to be the same as each share the same importance in regard to sustainability, and then each

variable from each pillar is going to have equal weight. As one of the characteristics of MCDA is the stakeholder's involvement, for the selection of the indicators only one stakeholder was involved, which is the dstgroup.

4.2. Data Collection

The aim of all data collecting methods is to enable extensive data analysis and to gather evidence to the researchers question and objectives (Kabir, 2016). The focus of this stage is on making sure that data collection is reliable and precise, preserving the investigation's validity.

There are two categories of data: qualitative and quantitative. Qualitative data is represented by non-numerical and nominal information. Kabir (2016) explains that this type of data employs informal methods of data collection with the goal of answering questions such as the "how" and "why". Some of the methods to gather this data involve interviews and focus groups (Kabir,2016; Suthar, 2024). The downside of qualitative data is that the results depend mostly on the involvement of a few individuals, leading to less generic results that vary according to the people involved in the data gathering process (Kabir, 2016).

Numerical data collection is the key component of a quantitative approach. It may include computing the data in a mathematical manner, with the aim of quantifying and assessing correlations and patterns (Suthar, 2024). For this kind of data, Kabir (2016) alludes to the "what" question that needs to be addressed regarding the research. One advantage to consider about quantitative methods is that they provide standardization, which facilitates comparisons and allows for the measurement of the magnitude effect. Surveys and experiments are some of the most used data collecting methods (Kabir, 2016; Suthar, 2024).

Kabir (2016) explores the mixed methods in his study, consisting of qualitative and quantitative data gathered approaches, with the intent of maximizing the advantages and minimizing the disadvantages of both of them. By collecting both subjective experiences and more general patterns in the data, researchers can have a more holistic understanding of the research issue (Suthar, 2024). Nevertheless, the combination of qualitative and quantitative methods is very time-consuming to operate and accomplish without fault.

Data can also be classified as primary data vs secondary data. The main difference regards the person who performs the data collected. Primary data is gathered through a "first-hand experience" (Kabir, 2016), guaranteeing trustworthiness and objectiveness to the

project, and providing for a better validity to the project. Secondary data is, in turn, information that was gathered for another research for perhaps a different purpose. While research can rely solely on primary data, the same cannot be said for secondary data, as this isn't considered as reliable and unbiased as primary data (Kabir, 2016).

In the case of this report, primary data was mainly collected via the conduction of a survey. A survey is a tool in which participants are asked to answer some questions, through paper questionnaires, the phone, personal interviews, etc (Totten et al., 1999). The purpose of this method is to obtain perceptive opinions, factual information, or practical insights so that goals are met, decision-making is assisted, and the viewpoints of a target audience are comprehended (Kanika, 2024).

Because they can be quickly and cheaply used to collect data, surveys are a great research tool (SurveyCTO, 2024; Totten et al., 1999). One benefit is the way the questions are organized in a structure which facilitates the analysis (SurveyCTO, 2024). On the other hand, the fact that participants may be restricted to predetermined response choices lead them to not be able to elaborate on the answers. This is usually perceived as a disadvantage. Response bias is another potential problem, because participants may give responses that are socially acceptable but not true (SurveyCTO, 2024).

The survey developed in the context of this report aimed mainly at collecting the indicators mentioned before concerning the economic, environmental, and social dimensions of the impact methodology. The first six questions of the survey focus on the identification of the products that each respondent sells. The following two questions are about characteristics of the alternatives. The rest of the questions regard the other variables under study. Some questions required an open answer, and others an affirmative/negative answer or a 5-point rating scale option. This shows that the data collected conveys a mix of qualitative and quantitative data. The survey is detailed in Annex A.2.

The survey was conducted using the Google Forms tool. An adapted version of the survey (displayed in Annex A.3.) was sent to the plastic film supplier of the company to help compare the results. The results of the survey are presented in Annex A.4. For information that was not able to be collected via survey, secondary data sources were used (e.g, the data required by the environmental indicator rate of recycling was collected from the research of Karidis (2023) and Statista (2024)).

The data collected for this report was done mostly through a non-probabilistic purposive sampling method. The purposive sampling method is a non-random strategy to select individuals or a group of people that have a certain feature aligned with the objective of the study (Nikolopoulou, 2022). In this case, the people selected for the study were the suppliers of the alternatives mentioned in the previous chapter, found through an internet search or using previous contacts done by the company.

4.3. Data Treatment

Data treatment allows for an effective analysis and interpretation of the data, leading to improving the inferences.

For this part of the study, the approach chosen to carry out was a univariate statistical analysis. This method is characterized by examining and interpreting the features and behaviour of each variable separately (Kapil, 2022). The multiple indicators of the economic, environmental, and social impacts were analysed individually, allowing for a straightforward understanding of the data.

The fact that the Google forms tool allows for the answers to be downloaded to a Microsoft Excel sheet, made the treatment of the data easier. Each answer given to the questions was then separated by the different alternatives and a comparison of the answers was done.

5. Results

5.1. General overview of dstgroup

As mentioned before, there are two types of plastic film used by the logistics department of dstgroup where the internship was developed, only contrasting in colour: black or transparent. Black film is used when the transportation is done with an external company and/or with an open truck, which might stop at a service station, where theft can happen. When the transportation is done in-house, the company uses transparent films.

Over the last 5 years, the logistics centre has used more black plastic film than transparent one, as Table 3 shows. Before 2020, the department did not use any transparent film. It is important to mention that the length of a plastic film roll is about 5.500 m, which means that one roll can be used to film a few pallets. Even though the measure unit is 1 roll, sometimes the company registered half of a roll, because it wasn't used the whole roll in the construction site. The figures for 2024 were not considered because the internship started in the middle of the first trimester, which implied that the information available was not representative of the whole year.

	2019	2020	2021	2022	2023
Black plastic film (rolls)	**1000**	**982,5**	**709,5**	**1024**	**965**
Transparent plastic film (rolls)	**-**	**414**	**494**	**699**	**831**

Table 3 – Quantity of rolls of plastic film used in the last 5 years.

The analysis of Table 3 shows that the quantity of transparent plastic film neededhas been growing throughout the years. Giving that one roll can be used in multiple pallets, depending on the quantity of materials that is placed on a pallet, there is not a direct correlation between the no. if rolls and no. of pallets. The quantity of black plastic film decreased in the beginning of the decade, which matches the first time of the purchase of transparent film and also with the pandemic period. By looking at the financial figures (dstgroup, 2022), it is possible to state that the business volume didn't grow much in 2020, in comparison to 2019, recovering a little in 2021, which explains the stability in the quantity of rolls used in this period (2019 – 21).

In order to deal with plastic film that reaches its end-of-life, the company has placed big recycling bins in every construction site, either through big bags or metal trash bin, where

used and ripped plastic films can be placed. After its storage, it is taken to or by a Portuguese waste management operator, Euro Separadora, which pays dstgroup for the plastic consumed. dstgroup received on average 130,75€/ton in 2022, 134,65€/ton in 2023, and 114,23€/ton in 2023.

When it comes to measure the greenhouse gas emissions of the activities of the company, the sustainability department uses the Spend-based activities at the moment. This method calculates the emissions based on the amount in euros that is spent, which is simple, quick but not very precise (Whiting, 2023). Low emissions only mean that less money was spent on the activity performed, reflecting a reduction of activity, which only happens if the business level decreases. Since the company does not produce plastic, but acquires plastic film from suppliers, the emissions come from buying the film. Therefore, related emissions fall under the scope 3 of GHG protocol.

To overcome the constrains of the Spend-based approach, this report uses the GHG calculator provided by the UNFCCC Secretariat (2022). This allowed to consider the emissions produced for the material use and waste disposal of plastics of LDPE & LLDPE, since the latter type is the one used by dstgroup (as displayed in Table 4). The numbers[3] inputed in the calculator were the sum of the ones on Table 3 times 1,8, as this is the core weight in kg of one roll, and the estimation requires the amount in tonnes of the product used.

	2019	2020	2021	2022	2023
Material Use (kg Co2eq)	**4681.15**	**6538**	**5632.98**	**8597.7**	**8407.86**
Waste Disposal (kg Co2eq)	**16.02**	**22.38**	**19.28**	**29.43**	**28.78**
Total emissions (kg Co2eq)	**4697.17**	**6560.38**	**5652.38**	**8627.13**	**8436.64**

Table 4 – GHG emissions produced by the use and waste of LLPDE plastic film.

5.2. Indicators collected via survey

The survey to collect indicators along the three axes of sustainability was sent to 64 suppliers of alternative packaging solutions to plastic film. Of these, 12 answers were received, which corresponds to a 18,75% response rate.One of the contacted suppliers input an answer that had to be eliminated because the solutions presented was not among the ones

[3] This considers the following phases of the use of the plastic: the extraction, primary processing, manufacturing, and transporting materials to the point of scale.

under analysis. 7 suppliers answered more than once because they provide multiple packaging solutions. Even though 11 answers was enough to do the evaluation of the possible solutions, for a more rigorous analysis it would be adequate to gather the same number of answers for each alternative. The company Hexcel Pack, which sells Hexcel Stretch, did not respond to any contact attempt. Therefore, it was not possible to collect information regarding this alternative.

64% of the suppliers shared information about more than 1 product and 36% advertised to sell 1 product only. When it comes to the products, 55% of the suppliers provided cover pallets, 64% marketed straps, 27% retail adhesives, 27% sell plastic pallet boxes, 18% advertise nets and 18% provided grip or anti slip sheets.

The first two indicators about the cost related to reusing the alternatives (cost of tracking and cost of transportation) were determined within the company. The indicators related to the amount of raw material consumed to produce each alternative was not able to be determined - suppliers were not able to provide an answer to the respective question. Therefore, this indicator was disregarded. The amount of GHG emissions produced by each alternative (KgCo2eq) were estimated using the GHG Emissions Calculator made available by the United Nations Climate Change Convention (UNFCCC Secretariat, 2022). Only the material use factor was considered, as no information was provided regarding transportation and reuse of the solutions. To provide an easier interpretation of the results, the PET straps and the Nylon straps were analysed separately.

5.3. Application of the TBL approach

As previously stated, in this report it was decided to apply the same weight to each sustainability pillar. So, each pillar had 1/3 of the total weight, and then the same weight was distributed among the different variables. The indicators of the economic pillar weighted 4,76%, to the ones of the environmental pillar were attributed 8,33%, and the indicators of the social pillar reunited 4,76%.

As the answers to the surveys can vary among suppliers, direct treatment of the data was required. To qualitative data, such as type of material of each alternative or any A/F question, was applied a method in which the answer with the most frequency was selected. The numerical data was treated through an arithmetic mean. It is important to mention that

if any number provided showed a significative deviation from other answers, that data was considered as an outlier, therefore disregarded.

This approach required for performance standards to be established so that the options available can be scored and compared. To the standardized values, it is multiplied the weights and using the sum function the final performance scores can be determined.

The Table 5 presents the results of multi-criteria analysis for each of the proposed packaging alternatives.

Indicators	Plastic film	Pallet Covers	PET Straps	Nylon Straps	Nets	Adhesives	Anti-slip sheets	Pallet Boxes
Economic								
a.	0.0063	0.0008	0.0010	0.0014	0.0004	0.0476	0.0242	0.0001
b.	0.0000	0.0112	0.0000	0.0312	0.0476	0.0000	0.0000	0.0433
c.	0.0476	0.0011	0.0476	0.0011	0.0011	0.0476	0.0476	0.0011
d.	0.0476	0.0119	0.0476	0.0238	0.0159	0.0476	0.0476	0.0095
e.	0.0476	0.0238	0.0476	0.0238	0.0238	0.0476	0.0476	0.0238
f.	0.0002	0.0095	0.0000	0.0476	0.0189	0.0018	0.0009	0.0056
g.	0.0004	0.0012	0.0003	0.0005	0.0005	0.0003	0.0016	0.0476
Subtotal	0.1498	0.0595	0.1443	0.1294	0.1082	0.1927	0.1696	0.1311
Environmental								
b.	0.0294	0.0294	0.0190	0.0246	0.0247	0.0247	0.0833	0.0234
c.	0.0001	0.0041	0.0012	0.0014	0.0040	0.0167	0.0833	0.0002
d.	0.0417	0.0417	0.0833	0.0417	0.0417	0.0417	0.0833	0.0417
e.	0.0025	0.0025	0.0189	0.0013	0.0038	0.0038	0.0833	0.0126
Subtotal	0.0738	0.0778	0.1225	0.0689	0.0741	0.0868	0.3333	0.0779
Social								
a.	0.0238	0.0238	0.0476	0.0476	0.0238	0.0476	0.0238	0.0238
b.	0.0476	0.0476	0.0476	0.0476	0.0238	0.0476	0.0476	0.0476
c.	0.0476	0.0476	0.0476	0.0476	0.0476	0.0476	0.0476	0.0476
d.	0.0476	0.0238	0.0476	0.0476	0.0476	0.0476	0.0476	0.0476

e.	0.0272	0.0286	0.0395	0.0476	0.0476	0.0340	0.0000	0.0340
f.	0.0238	0.0238	0.0238	0.0238	0.0476	0.0238	0.0476	0.0476
g.	0.0238	0.0238	0.0238	0.0238	0.0238	0.0476	0.0476	0.0476
Subtotal	0.2415	0.2190	0.2776	0.2857	0.2619	0.2959	0.2619	0.2959
	Plastic film	Pallet covers	PET Straps	Nylon Straps	Nets	Adhesives	Anti-slip sheets	Pallet Boxes
Total	0.4651	0.3563	0.5443	0.4840	0.4442	0.5754	**0.7649**	0.5050

Table 5 – Final scores of the alternatives.

The analysis of the table shows that the pallet covers have the lowest score (0.3563) and the anti-slip sheets score the highest (0.7649). Therefore, the grip or anti-slip sheets are the most sustainable alternative to the usage of plastic film.

The anti-slip sheets score the highest in all four environmental indicators (the amount of GHG emissions produced (KgCo2), the amount of waste generated after usage, the noise produced during the application), in 3 economic indicators (all regarding the costs associated with reuse), and 5 social indicators (employee education, inclusion of people from the local community, investment in community development programs, awareness programs, reporting on sustainability). More than that, it should be also noted that the recycling rate of the material – paper – used in this solution is of 66% when compared to the 2% recycling rate of plastic film.

Nevertheless, as mentioned in Chapter 3, the anti-slip sheets do not protect the loads of a pallet from weather conditions, which means it would have to be complemented with another alternative or a solution that would add this characteristic. In this case, the complementary solution would be the pallet covers. For a better assessment of this possibility, an additional analysis was conducted to understand if the score of the pallet covers and the slip sheets is higher than the score of rigid plastic pallet boxes (best waterproof alternative). The sum of each number (for the pallet covers and the slip sheets) was done for the economic and the first two environmental indicators. For the rate of recycling indicator, the lowest number was considered. Regarding the rest of the indicators, most of the numbers coincide and for the ones which do not, the highest number was used. The final score of 0.4191 is obtained, which is lower than the pallet boxes score (0.5050). So, due to the fact that the waterproof condition is an important feature for the company, and the pallets and their load might have to stay at the construction site for a certain period under whatever

conditions, the HDPE pallet boxes are the most adequate and sustainable alternative for the company.

Regarding the rigid plastic pallet box, the overall score was pushed down by the economic indicator "cost per unit", which scored the lowest. This is because the suppliers shared the cost of buying only one unit. Therefore, the analysis did not consider economic of scale that would make this solution more affordable, and, therefore, more attractive. The initial cost would be high, but it would have a high return rate in the long run.

Finally, it is acknowledged that the results presented in this report are highly influenced by a number of events, such as:

- The limited number of answers received for each solution, as different number of answers were given to each diverse alternative;
- The lack of reliability of some indicators, because of the subjectiveness of the answers provided;
- The decision regarding the weights attributed to each indicator can make a difference in the final results;
- The difficulty comparability of the answers provided by different suppliers.

6. Conclusion

6.1. Final considerations

"Immediate climate action" is called by António Guterres, the UN secretary general (Niranjan, 2023), as the temperature of the atmosphere has been higher than ever before. The GHG emissions that come from the life cycle of plastics make an impact on the rise of the level of temperature (Ritchie, 2013). Thereupon, the use of plastics must be reduced, especially single-use plastics, as their use has been prohibited by the EU.

Sustainability has started to cause certain changes in companies' activities. Green practices have been implemented throughout the supply chain (Dey et al., 2011), such as green packaging. For some companies, eco-friendly packaging is essential for their business, since it can be a cover for the product they sell. Customers are gradually increasing their interest in green packaging, as the concern for the environment is a priority for them.

At the dstgroup, the company where the internship took place, plastic film is the solution for packaging. The company is committed to improving its sustainability, which includes searching for an alternative and more sustainable packaging solutions.

When analysing the current packaging method used by dstgroup, it was understood that the logistics center uses plastic film to pack and secure the pallets and the load that is carried in them. This action is necessary to them transport the pallets to, primarily, construction sites, as the main activity of the dstgroup is engineering and construction. Sometimes, the pallets stay on the construction site for a way, hence the requirement to have a solution that provides waterproofing the load, as the conditions to which the pallet is subjected to can be uncertain. Besides, this characteristic is also needed during the transportation of pallets because these can be carried in open trucks. The plastic film combines all of these characteristics and others, hence the choice to use it. Nevertheless, the estimation of the related GHG emissions show that plastic film is harmful to the environment.

To find an alternative to plastic film, a literature review was carried out. By taking into account the requirements set forth by the company, the following solutions were found: Hexcel Stretch, pallet covers, straps, nets, adhesives, grip sheets, and rigid plastic pallet boxes. To choose the most sustainable (environmentally, economically and socially), but also

suitable, alternative packaging solution to dstgroup, the TBL approach was used. Its operationalization relied on the applications of a MCDA method.

The results showed that the grip or anti-slip sheets scored the highest value through the analysis of the indicators of the pillars, as they all share the same relevance from a sustainability point of view, but when taking into account the operations' perspective, the advised alternative is the rigid plastic pallet box. When compared to other studies, the adhesives also had a high score, like the results in Guirola (2010), which suggested replacing the plastic film with adhesives along with pallet covers to make the best solution. Although the anti-slip sheets could benefit from the addition of pallet covers, the final scores when calculating the mean between both methods had a lower score than the pallet box. However, in contrast with the result of Lay & Palit (2020), the pallet covers had a worse score than the plastic film, which determines that this solution alone would not be a more sustainable alternative than plastic film.

Finally, the rigid plastic pallet box appear to be the most adequate solution to address the companies' problem, i.e., the need to replace the use of a single use plastic, with a greener option from a sustainability point of view, while also considering how the company operates the transportation and storage.

6.2. Limitations and future research

This study like many has its limitations and some recommendations that can be point in the direction of a better result. To begin with, even though the responses made available by suppliers were enough for the analysis to be done for this internship report, the number of answers might be considered inconsistent or not representative enough as some researchers tend to prefer. Thus, carrying out more standardized research may be advisable. Furthermore, some operations variables were not considered in this report as its assessment would require more time and deeper knowledge of the logistics activities, so the final solution, the rigid plastic pallet box, will have to go through some other tests to finally be implemented. The listed reasons for the potential interference in the results of the analysis are also some of the limitations of this research. It can be used more standard and easier data to compare indicators, and variables where subjectivity does not play a part in the responses.

Also, the MCDA is a method which stakeholders are required to be involved in the definition of the indicators. For this study, there were not many stakeholders asked to

participate, only employees who the decision would affect in some manner their functions. The weights considered for the analysis can make a difference in the final results.

Since Hexcel Stretch could not be considered in the analysis, it is recommended that research is done to determine if this alternative should be applied in logistics companies to replace plastic film, as the technology behind it looks promising. Furthermore, new materials are being developed and tested, such as Carbon Positive Plastic (CPP) or nanocellulose, which show that these materials can be a future solution for the replacement of plastic film, therefore the investigation must be continued. Further research is advised to take into account a wider range of packaging options.

For this research to approach the ideal outcome, it could be used a different methodology, one which would take in consideration different variables of the operations that surrounds packaging. Using the information regarding the transportation and storage in construction sites and making a plan that would enable multiple strategies to be used for the various variables that are attached to this activity of the company.

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Annexes

A.1 – Definitions of the properties of Table 2

Dart drop impact - conventional technique to assess a plastic film's impact strength or toughness. In this test, the dart weight is varied while maintaining a single drop height and dart configuration (*Drop Dart ASTM D1709, ISO 7765*, n.d.).

Pre-Stretched (guarantee) – percentage of how much the plastic film can for sure stretch beyond its rolled point (Polymer, 2019).

Tensile Strength Break – measures the highest stress a plastic sample can sustain while being stretched until it breaks (*Tensile Strength - Definition, units, formula & test methods*, n.d.).

Tensile Elongation Break - It is the plastic material's capacity to withstand form changes without breaking (*Elongation at break: Formula & Technical properties of plastics*, n.d.).

Elastic Modulus - quantifies how resistant a material is to elastic deformation under stress or stiffness, establishes a material's ability to support weight and maintain its shape (Xometry, 2023).

A.2 – Survey on alternatives to plastic film

Thank you for your willingness to answer this survey.

This form serves to obtain some information about some alternatives to plastic film, more specifically products that you sell in your company, such as: covers or pallet covers, plastic or nylon straps, nets, stickers or sheets, plastic pallet boxes solid. This information is very important, as dstgroup will choose the best option to replace the plastic film and proceed with the purchase. Try to answer all the questions with the information you have.

Consider a European standard size pallet.

The data will be confidential, anonymous and for exclusive use for the aforementioned analysis.

If necessary, don't hesitate to get in touch: Patrícia Oliveira (patricia.oliveira@dstsgps.com)

E-mail address *

_____

1.1- Do you sell pallet covers? *

Affirmative

Negative

1.2- Do you sell plastic or nylon straps? *

Affirmative

Negative

1.3- Do you sell nets? *

Affirmative

Negative

1.4- Do you sell adhesives? *

Affirmative

Negative

1.5- Do you sell grip sheets? *

Affirmative

Negative

1.6- Do you sell rigid plastic pallet box? *

Affirmative

Negative

If you answered positively to the question 1.6, consider both the pallet box and its lid in the following questions.

2- Type of material that composes the product that is sold (PP, LDPE, Nylon, etc.) *

3- Unit weight of the product being sold (in kilograms) - weight of a unit *

4- Product's unit cost - the price per unit sold (in euros) *

5- Number of utilizations until the product needs to be recycled (If you don't know with precision, estimate the value) *

6- Does your product have a serial number that allows to track each unit of the product? *

Affirmative

Negative

7- Describe the required maintenance level to assure an adequate reuse of the product (Select from 1 to 5, considering that (1) nothing needs to be done, (2) the product needs to be shaken, (3) it needs to be wiped, (4) needs to be wiped down with a special cleaning product, and (5) the product needs to be washed and dried.) *

	1	2	3	4	5	
No maintenance needed	○	○	○	○	○	A lot of maintenance

8- Quantity (in kilograms) of raw material consumed to produce your product (e.g., fossil fuel, iron or metal, cotton) *

9- Amount of greenhouse gas emissions during the production of your product (in KgCo2) If you can't answer this question, go to question 10.

9.1- If you answered question 9, indicate which assessment method you used.

10- Estimate the noise produced when applying your product on a loaded pallet. (Select from 1 to 5, considering that (1) doesn't produce any noise at all, (2) produces a little noise, (3) produces some noise, (4) produces quite some noise, (5) produces a lot of noise.)

	1	2	3	4	5	
No noise	○	○	○	○	○	A lot of noise

11- Does your product allow the cargo packed on a pallet to be totally waterproof? *

Affirmative

Negative

12- How long does it take (in minutes) would take for an operator to apply your product to a pallet? (Consider a European-sized pallet, with a load, consisting only of boxes, 1,5m high.) *

13- Describe the level of health risk associated with the application of your product on a pallet (e.g., tendency for tendonitis or back pain) (select from 1 to 5, with 1 being low associated risk and 5 being high associated risk) *

	1	2	3	4	5	
Low associated risk	○	○	○	○	○	High associated risk

14- Is any type of specific training necessary to apply your product to a pallet? *

Affirmative

Negative

14.1- If you answered positively to the previous question, indicate what the training consists of.

Regarding social responsibility, please answer the following questions.

15- Does your product's production team include people from the local community? *

Affirmative

Negative

16- Does your company invest in community development programs, such as education programs or Food Bank initiatives? *

Affirmative

Negative

16.1- If you answered positively to the previous question, provide an example.

17- What is the percentage of young people (18-29 years old) employed in your company? *

18- Does your company promote education and awareness programs about the importance of sustainability? *

Affirmative

Negative

18.1- If you answered positively to the previous question, provide an example.

19- Has your company started to report on sustainability? *

Affirmative

Negative

19.1- If you answered positively to the previous question, which standard was used? (e.g.: GRI, ESG, IIRC, SASB, ...)

A.3 – Survey sent to the plastic film supplier

Thank you for your willingness to answer this survey.

We need to gather information about plastic film to analyse its production and use.

Consider a European standard size pallet.

The data will be confidential, anonymous and for exclusive use for the aforementioned analysis.

If necessary, don't hesitate to get in touch: Patrícia Oliveira (patricia.oliveira@dstsgps.com)

The questions asked are the ones from the survey on alternatives for plastic film – Annex A.2 – minus questions 1 (1.1., 1.2, 1.3, 1.4, 1.6), 5, and 7. These alterations occur because question 1 approaches the different alternatives, which is not important to the suppliers of plastic film, and questions 5 and 7 are about the reuse of the product, which is not possible with plastic film.

A.4 – Responses to the survey sent to the alternative's suppliers

	Q. 1.1	Q. 1.2	Q. 1.3	Q. 1.4	Q. 1.5	Q. 1.6
R1	Affirmative	Affirmative	Negative	Affirmative	Negative	Negative
R2	Affirmative	Affirmative	Negative	Affirmative	Negative	Negative
R3	Negative	Affirmative	Negative	Negative	Negative	Affirmative
R4	Affirmative	Affirmative	Negative	Negative	Negative	Negative
R5	Negative	Affirmative	Affirmative	Negative	Negative	Negative
R6	Affirmative	Negative	Negative	Negative	Negative	Negative
R7	Affirmative	Negative	Negative	Negative	Negative	Negative
R8	Negative	Negative	Negative	Negative	Affirmative	Negative
R9	Negative	Negative	Negative	Negative	Negative	Affirmative
R10	Affirmative	Affirmative	Affirmative	Negative	Negative	Affirmative
R11	Negative	Affirmative	Negative	Affirmative	Affirmative	Negative

Section about the affirmative answers to the question 1.1.

	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6
R1	PEDB recycled or paper	2,1 kg	5,45€	24	Affirmative
R2	PEDB	2 kg	1,59€ - 2,87€	2	Affirmative
R4	PP, PEDB	2	n.a.	n.a.	Negative
R6	PP	Depends	Depends	10 – 15	Negative
R7	PE	0,5 – 1,4	10,40€ – 21,70€ + VAT	Depends	Negative
R10	PP, PE, PEDB	≈3	80€ - 160€	1000 - 1500	Affirmative

	Q. 7	Q. 8	Q. 9	Q. 9.1	Q. 10	Q. 11	Q. 12	Q. 13
R1	1	1	-	-	2	Affirmative	2 min	1
R2	1	-	-	-	2	Affirmative	5 min	2
R4	1	n.a.	-	-	2	Affirmative	1 min	1
R6	3	-	-	-	3	Negative	1 min	2
R7	1	-	-	-	2	Affirmative	≤ 5 min	1
R10	2	-	-	-	2	Affirmative	≤ 1 min	2

	Q. 14	Q. 14.1
R1	Affirmative	Basic training on tension, stretching and product performance.
R2	Affirmative	-
R4	Negative	-
R6	Negative	-
R7	Negative	-
R10	Negative	-

Section about the affirmative answers to the question 1.2.

	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6
R1	PP, PET, textile	8	27€	1	Affirmative
R2	PP, PET	Depends	Depends	1	Affirmative

R3	PE, HDPE	10kg	40,99€	≥ 100	Negative
R4	PP, PET, Nylon	10kg	n.a.	n.a.	Negative
R5	Nylon	0.5kg	14,50€	1000 – 2000	Negative
R10	PET	±0.15kg	±15€	1000	Affirmative
R11	PP, PET	Depends	Depends	1	Affirmative

	Q. 7	**Q. 8**	**Q. 9**	**Q. 9.1**	**Q. 10**	**Q. 11**	**Q. 12**	**Q. 13**
R1	1	3	-	-	2	Negative	3 min	1
R2	2	n.a.	-	-	2	Negative	-	1
R3	1	n.a.	-	-	1	Affirmative	≤ 1 min	1
R4	1	n.a.	-	-	-	Negative	-	1
R5	2	-	-	-	1	Negative	10 sec	1
R10	1	-	-	-	1	Negative	≤ 1 min	2
R11	1	-	-	-	1	Negative	Depends	2

	Q. 14	**Q. 14.1**
R1	Negative	-
R2	Negative	-
R3	Negative	-
R4	Negative	-
R5	Negative	-
R10	Negative	-
R11	Affirmative	Know how to manufacture equipment

Section about the affirmative answers to the question 1.3.

	Q. 2	**Q. 3**	**Q. 4**	**Q. 5**	**Q. 6**
R5	PP	2,2 kg	46€ - 83€	1000 – 2000	Affirmative
R10	PP, LDPE, PVC	2 kg	70€ - 120€	1000 – 1500	Affirmative

	Q. 7	**Q. 8**	**Q. 9**	**Q. 9.1**	**Q. 10**	**Q. 11**	**Q. 12**	**Q. 13**
R5	2	-	-	-	1	Negative	20 – 30 sec	2

R10	2	-	41	-	2	Negative	≤1 min	2

	Q. 14	**Q. 14.1**
R5	Negative	Can be provided to speed up the application of the net
R10	Affirmative	Very basic step by step training via video or on site

Section about the affirmative answers to the question 1.4.

	Q. 2	**Q. 3**	**Q. 4**	**Q. 5**	**Q. 6**
R1	PP, PVC	0,2	0,8€	100	Affirmative
R2	PP, PVC	Sold in roll	0,4€	1	Affirmative
R11	Water-based adhesive	n.a.	Depends	1	Affirmative

	Q. 7	**Q. 8**	**Q. 9**	**Q. 9.1**	**Q. 10**	**Q. 11**	**Q. 12**	**Q. 13**
R1	1	0,5	-	-	1	Negative	0.5 min	1
R2	1	n.a.	-	-	2	Negative	-	1
R11	5	n.a.	-	-	2	Negative	Depends	1

	Q. 14	**Q. 14.1**
R1	Negative	-
R2	Negative	-
R11	Affirmative	Know how to manufacture equipment

Section about the affirmative answers to the question 1.5.

	Q. 2	**Q. 3**	**Q. 4**	**Q. 5**	**Q. 6**
R8	Cardboard 100% recycled	0,1 kg	1,18€	1 – 2 (depends on usage care)	Negative
R11	100% paper & PE cover	Depends	Depends	1	Affirmative

	Q. 7	**Q. 8**	**Q. 9**	**Q. 9.1**	**Q. 10**	**Q. 11**	**Q. 12**	**Q. 13**
R8	2	-	-	-	1	Negative	-	1
R11	4	n.a.	-	-	1	Negative	-	2

	Q. 14	Q. 14.1
R8	Negative	-
R11	Negative	-

Section about the affirmative answers to the question 1.6.

	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6
R3	PP, PE, HDPE	32 kg	187,99€	≥ 1000	Negative
R9	PP, HDPE	9,55 kg	222,35€	1000	Negative
R10	HDPE	40 – 50 kg	250€ – 400€	≥ 1500	Affirmative

	Q. 7	Q. 8	Q. 9	Q. 9.1	Q. 10	Q. 11	Q. 12	Q. 13
R3	1	-	-	-	2	Affirmative	n.a.	3
R9	3	5	-	-	3	Affirmative	2 min	1
R10	3	-	-	-	1	Affirmative	≤ 1 min	1

	Q. 14	Q. 14.1
R3	Negative	-
R9	Negative	-
R10	Negative	-

Answers regarding social responsibility

	Q. 15	Q. 16	Q. 16.1	Q. 17
R1	Affirmative	Affirmative	Banco Alimentar de Braga	40%
R2	Affirmative	Negative	-	10%
R3	Negative	Negative	-	40%
R4	Negative	Negative	-	15%
R5	Affirmative	Affirmative	Invest into the Sustainable business network, New Zealand.	50%
R6	Affirmative	Negative	-	30%

R7	Negative	Affirmative	We have sent pallets of products to Ukraine charities, camo tarpaulins to the army, fundraiser for cancer research.	10%
R8	-	-	-	-
R9	Affirmative	Affirmative	Support for surrounding sports associations	15%
R10	Affirmative	Affirmative	Rapid support at blue light events, litter picking, feeding the less able	20%
R11	Affirmative	Affirmative	-	n.a.

	Q. 18	**Q. 18.1**	**Q. 19**	**Q. 19.1**
R1	Negative	-	Negative	-
R2	Negative	-	Affirmative	-
R3	Affirmative	-	Negative	-
R4	Negative	-	Negative	-
R5	Affirmative	Ongoing education through the Sustainable Business network New Zealand	Negative	-
R6	Negative	-	Negative	-
R7	Negative	-	Negative	-
R8	-	-	-	-
R9	Affirmative	We won the Ecovadis 2023 award.	Affirmative	ESG
R10	Affirmative	We run sessions on how to reduce, reuse, recycle.	Negative	-
R11	Affirmative	-	Affirmative	-

A.5 – Response to the survey sent to the plastic film supplier

Q.1	**Q.2**	**Q.3**	**Q.4**	**Q.5**	**Q.5.1**	**Q.6**	**Q.7**	**Q.8**
LDPE	65 kg	Affirmative	10 kg	-	-	2	Affirmative	15 min

Q. 9	Q. 10	Q. 10.1	Q. 11	Q. 12	Q. 12.1
2	Negative	-	Affirmative	Affirmative	Donation of food and construction materials to associations

Q. 13	Q. 14	Q. 14.1	Q. 15	Q. 15.1
20%	Negative	-	Negative	-