Sustainable Packaging Solutions for the Retail Sector

Filipa Ferreira Nobre de Castilho

Thesis to obtain the Master of Science Degree in

Industrial Engineering and Management

Supervisor: Prof[a] Ana Isabel Cerqueira de Sousa Gouveia Carvalho

Examination Committee

Chairperson: Prof. Paulo Vasconcelos Dias Correia
Supervisor: Prof. Ana Isabel Cerqueira de Sousa Gouveia Carvalho
Members of the committee: Dr.Teresa Sofia Sardinha Cardoso de Gomes Grilo

January 2021

Declaration

I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Declaração

Declaro que o presente documento é um trabalho original da minha autoria e que cumpre todos os requisitos do Código de Conduta e Boas Práticas da Universidade de Lisboa.

Acknowledgments

First of all, I would like to thank to my professor Ana Carvalho who believed, guided, advised, and inspired me. It has been a long dissertation journey with some ups and downs but the support received by my professor what was kept me going further in order to finish my Master thesis.

Moreover, I would like to thank everyone that I successfully contacted and thus contributed for my study by providing valuable knowledge.

Last but not least, I would like to dedicate my thesis to my family, the people who changed my life. They have always encouraged and supported my education, but it was the values that they taught me that allowed me to finish this work, even in such a troubled year due to this pandemic. They always taught me not to give up and always try to do my best.

Making them proud of my work, motivates me to do my best and pushes me to continuously improve what I do.

Abstract

Mass consumption of plastic packaging, driven by its inexpensiveness, versatility, lightweight and current 'disposable' culture, along with mankind's inability to cope with its end-of-life, is one of the most serious problems facing the world today, as it results in mismanaged waste threatening the survival of all ecosystems. As a result, the concern for sustainability has become the new trend in consumption, forcing companies, particularly the large retail surfaces, to find sustainable packaging solutions to meet demand. Reusable packaging systems has been considered a possible solution to tackle the problem based on the success of this practice in zero packaging stores, providing equally balance profit generation, environmental protection and social empowerment. However, when in recent years several companies tried to implement these alternatives in the mainstream, these have not prevailed. In this context, a complete literature review on sustainable packaging solutions is carried out to analyse the different benefits that each allow as well as the potential reasons for the ineffectiveness of those already tested, in order to find research gaps for future research of a successful solution. Then by employing transformational sustainability research methodology, understand why reusable packaging systems are not working and propose logistical scenarios until a solution is found that, in a cost-effective and convenient way, helps to mitigate the packaging waste problem.

The results have proved that it is possible to find a scenario where all root causes are mitigated and that without major strategic and logistical changes it is possible to implement it in practice. However, final results for economic viability can only be ensured according to a proper case study, this being the proposal for future work.

Keywords: Reusable Packaging Systems, Zero Waste Management, Packaging Waste, Sustainability, Retail Sector

Resumo

O consumo em massa de embalagens de plástico, impulsionado pelo seu custo, versatilidade, leveza e a atual cultura "descartável", juntamente com a incapacidade de lidar com o seu fim de vida, é um dos problemas mais graves que o mundo enfrenta atualmente, resultando em resíduos mal geridos que ameaçam a sobrevivência de todos os ecossistemas. Como resultado, a preocupação pela sustentabilidade tornou-se a nova tendência no consumo, forçando as empresas, particularmente as grandes superfícies retalhistas, a encontrar soluções sustentáveis para satisfazer a procura. Os sistemas de embalagem reutilizáveis têm sido considerados uma possível solução para enfrentar o problema, com base no sucesso desta prática em lojas de embalagem zero, proporcionando uma geração de lucro igualmente equilibrada, proteção ambiental e empoderamento social. No entanto, quando nos últimos anos várias empresas tentaram implementar estas alternativas nas grandes superfícies retalhistas, estas não prevaleceram. Neste contexto, é feita uma análise completa da literatura sobre soluções sustentáveis para embalagens de plástico, de forma a analisar os diferentes benefícios que cada potencia, bem como as razões para a ineficácia das já testadas, a fim de encontrar lacunas para a investigação futura de uma solução bem-sucedida. Esta investigação visa então preencher a lacuna da literatura através do desenvolvimento de uma solução sustentável para embalagens. Depois, empregando uma metodologia de investigação de sustentabilidade transformacional, compreender por que razão os sistemas de embalagens reutilizáveis não estão a funcionar e propor cenários logísticos até se encontrar uma solução que, de forma rentável e conveniente, ajude a mitigar o problema dos resíduos de embalagens.

Os resultados provaram que é possível encontrar um cenário onde se mitiga todas as causas raiz e que sem grandes alterações estratégicas e logísticas é possível implementar na prática. Contudo, resultados conclusivos para a viabilidade económica só poderão ser assegurados consoante um devido caso de estudo, sendo essa a proposta de futuro trabalho.

Palavras-chave: Sistemas de reutilização de embalagens, Gestão de Resíduos, Resíduos de Embalagens, Sustentabilidade, Sector Retalhista

Table of Contents

List of Figures

List of Tables

List of Abbreviations

3PL	Third-party provider
B2B	Business-to-business
B2C	Business-to-consumer
BM	Business Model
BMC	Business Model Canvas
CAGR	Compound Annual Growth Rate
EC	European Commission
FTL	Full Truck Load
INE	Instituto Nacional de Estatística
PRM	Product Recovery Management
RL	Reverse Logistics
SBM	Sustainable Business Model
SCM	Supply Chain Management
SPA	Sustainable Packaging Alliance
SPC	Sustainable Packaging Coalition
TLBMC	Triple Layered Business Model Canvas
UN	United Nations
UNEP	United Nations Environment Programme
ZW	Zero Waste
ZWIA	Zero Waste International Alliance
ZWM	Zero Waste Management

1 | Introduction

1.1 | Problem Motivation

Massive consumption of plastic is one of the most serious problems the world is facing today, threatening all ecosystems, with more than 300 million tonnes of plastic being produced worldwide each year (Geyer *et al.*, 2017). What makes this material popular is its versatility, low cost and usefulness, which has made modern life possible. Although there is still production of durable and reusable plastics, most production is for disposable and single-use products (Geyer *et al.*, 2017), leading to a current culture of "throwaway" that is arguably one of the greatest challenges facing the environment (Geyer *et al.*, 2017; Ritchie and Roser, 2018). Much of this effect is due to packaging, with 40% of plastic production referring to packaging (PlasticsEurope, 2017), and its environmental impact is a major issue in the world as it is a very visible product in the waste stream, representing between 15% and 25% of the weight of household waste (INCPEN, 2007). From this perspective, several studies of sustainable solutions have been analysed over the years in order to solve the problem, however, they have not succeeded in the mainstream. The closest and considered the best potentially sustainable solution studied is reusable packaging systems, not only for its environmental benefits but also from an economic point of view. According to Ellen MacArthur Foundation (2017), replacing 20% of plastic packaging into reuse models is a USD 10 billion business opportunity that benefits customers while representing a crucial element for eliminating plastic waste and pollution. Nowadays, this solution has been gaining popularity with several local stores around the world adopting this new concept of selling, and the increased interest in it from consumers indicates that despite the advantages of using disposable packaging in some products, consumers do not always prefer pre-packaged products (Mordor Intelligence, 2019). However, it is still considered a niche market and even with large retailers not discarding the idea, there are still many barriers to its full adoption by conventional supermarkets, derived from the experience of many having tested it and the concept failing in this environment. (Beitzen-heineke, 2017). In addition to figuring out how to make these systems succeed in terms of reconfiguring activities along the supply chain, it is also imperative to figure out how to change the mindset so that the systems work but, essentially, are adopted on a permanent basis. An INCPEN (2017) study shows that 88% of people consider that there are disadvantages to plastic packaging, not all of them environmental, but 68% think that the benefits of packaging, such as hygiene, convenience, product protection and information, outweigh the benefits, thus leading to its continued use.

For a proper understanding of the matters involved in view of finding a solution to this problem, a thorough literature review on both Zero Waste Management, sustainable packaging and sustainable design methodologies has been conducted.

1.2 | Master Dissertation Objective

The aim of this work is to study the environmental consequences associated with packaging, analyse the sustainable solutions already developed in order to find gaps for future development and, finally, explore the recommended methodologies for the development of sustainable solutions. The project will be structured to reach the following intermediate objectives:

(1) Problem Identification: analysing the problem of plastic packaging waste in terms of its causes and future implications and understanding the developments done to try to solve the problem.
(2) Literature Review on Zero Waste Management, Sustainable Packaging and Sustainable Design Methodologies.
(3) Development of a solution for plastic packaging waste, more specifically in the mainstream retail sector, by understanding the reasons why it has not worked in the past, analysing the market while identifying best practices for packaging sustainable solutions, and testing various scenarios with the information collected, until a viable solution can be found.

1.3 | Master Dissertation Methodology

Regarding the dissertation structure, the project is constituted of six chapters. The first chapter consists of an introduction, including a contextualization of the problem analysed, an explanation of the reasons for the investigation and setting the objectives of the study.
The second chapter provides the problem contextualization, aiming at gathering exhausting information about packaging waste. After defining basic packaging concepts, the packaging market is characterised, followed by an analysis of its pass and future evolution to enable the reader to understand the resulting threats to the environment and the necessity of improving plastic waste management, highlighting the attempted solutions that have been implemented
The third chapter describes the state of the art of Zero Waste Management (ZMW) through packaging. A broad study on ZWM is executed to describe its concepts and outline its characteristics. Next, the concept of Sustainable packaging is reviewed with a focus on the four principles that distinguish it. Then, a short-detailed summary of developments in the sustainable packaging literature under each pillar perspective is conducted, along with a research gap analysis. Finally, the most common sustainable design methodologies are studied and characterised.
The fourth chapter includes the methodology that will be adopted to complete the objective of understanding the reasons why reusable packaging systems have not worked in the past, analysing the market and identifying best practices for packaging sustainable solutions and testing various scenarios with the information collected.
The five chapter includes the collection of data for the different analyses proposed by the methodology adopted and their assessment, with the aim of designing various scenarios until one is fitted for the problem.
Lastly, chapter six provides overall conclusions regarding the results achieved and includes the findings which can be derived from the entire work. Moreover, further research work is suggested to complement what was achieved with this dissertation.

2 | Packaging Waste

This second chapter provides the necessary knowledge on the context and subjects of the study. Starting with the basics to then be developed, in Section 2.1 the core about packaging, main definitions and concepts, is presented. Then, Section 2.2 portrays an overview of the packaging market, focusing on the dangers to society of the current exponential growth in production and consumption corroborated by the trends that have affected the market and those that are expected to further alter the status quo. Section 2.3 goes into more detail and sets out the severity of the consequences of this mass market, mainly because there are no effective ways of eliminating them. Finally, the chapter ends with Section 2.4 describing the alternatives that have been developed to curb this uncontrolled growth in plastic waste and the success they have been achieving, along with a concise sum-up of the information acquired along the chapter presented in Section 2.5.

2.1 | Packaging Fundamentals

Packaging has been around since the first humans began making use of tools. There are many first examples of 'packaging', from animal skins to the most common leaves (Emblem, 2012). Over time, as cities developed and humans became conscient of new needs, beyond immediate needs, the concept of packaging has also evolved. Nowadays, besides being a means of transporting goods and, to some extent, of protection and display, packaging has gained an important role in attracting and satisfying the end consumer (Emblem, 2012). Methods of preserving and distributing goods are the essential part of daily life, and it is there, where packaging takes a massive and irreplaceable role by offering the access to all needed products under the right conditions and at the right time. Packaging allows the transportation, storage, and consumption of products for longer than the natural degradation, moreover it also serves as a display of crucial information for clients, such as features and components of the product, which can be a turning point for the buyer decision process. Therefore, packaging is crucial to any business for branding, marketing, shipping, and selling products, but also for any consumer as nowadays no one can live without the right products at the right time (Natarajan and Kumar, 2014).

Over time, packaging has been defined in many ways, Encyclopaedia Britannica (2011, p.1) defines packaging as "technology and art of preparing a commodity for convenient transport, storage, and sale", or one of the most complete "Packaging is a structure designed to contain a commercial food product, i.e. to make it easier and safer to transport, to protect the product against contamination or loss, degradation or damage and to produce a convenient way to dispense the product"(Sacharow *et al*., 1980, p.12). However, the reference definition is that of the EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE 94/62/EC of 20 December 1994, defining packaging by any product made of any material for the purpose of containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, which will be the definition chosen for the relevant work.

Based on the functions described in the definition, these functions have been classified into 4 categories: protection, communication, convenience, and containment (Paine, 1991; Robertson, 1993). Each is extremely important throughout the supply chain since packaging provides invaluable service from the production of the goods till the delivery to end users. The first category, protection, it is the principal function of packaging, responsible for extension of shelf-life, and maintenance of quality and of safety of packaged food (Restuccia *et al*., 2010). The second category communication covers both informational and marketing aspects, besides serving as an identification of the product as above mention, it is a canvas for brands to distinguish their product to attract customers. Handling is the third category, this function is the most difficult, but it is where the benefits of the function are most seen when well performed, because time and money are gained. As handling products is the most time-consuming activity throughout the supply chain, packaging with its shape, weight, volume can be crucial for efficiency, the secret is to be the most convenient for all intermediaries along the supply chain, including the end user. For the last category, containment involves consolidation of unit loads for shipping, ensuring that a product is not spilled or dispersed. Nevertheless, these functions are not totally exclusive, for example, the communication function of the package through warning labels and cooking instructions can also help to enhance food protection and convenience (Yam *et al*., 2005; Wikström et al., 2019).

In terms of nomenclature, packaging exists at different levels, primary, secondary and tertiary. Primary packaging includes not just the materials that directly come in contact with the actual product, but all the packaging surrounding the product when the consumer takes it home. Examples of primary packaging are laminated pouches, plastic containers, thermoformed products, tin cans, parchment paper, among many others. Secondary packaging involves all those products used to group packs together for ease of handling and help secure mass quantities of primary packaging with the final product inside it. Examples are plastic crates, plastic trays, wooden crates and shrink wrap film. At last, tertiary packaging collate secondary packs for ease of transport. The most common are the pallets, roll cages and crates (Emblem, 2012; Natarajan and Kumar, 2015). Although they are not defined as a packaging level, no packaging industry will survive without tapes, adhesives, straps, labels, and printing inks. These can be label as ancillary packaging, consumables that allow the other packaging levels to efficiently and securely customize, organize, store and ship products (Natarajan and Kumar, 2015).

Using water as an example, the primary packaging would be a bottle, the plastic cap would be ancillary packing, the secondary packaging the carry packs, and the tertiary would include transit packaging such as a case, possible to visualize in Figure 1.

Figure 1: Packaging Types (TUDelft OCW, 2019)

2.2 | Packaging Market

Packaging comes in different forms, based on technical requirements throughout the supply chain, as well as marketing needs such as brand identity or consumer information and other criteria that define the material choice. Each packaging type has its own applications, a plastic bag is different from a glass container or a wooden pallet, that facilitates all the operations involved, turning packaging an essential component that affects virtually every industry. Every product, even the simplest, such as organic foods, needs some sort of packaging throughout the entire supply chain, ranging from protection during transportation to handling, storage and use. The packaging industry uses a wide variety of raw materials and printing technologies to produce packages that not only look good, but also help keep the actual product well protected (Emblem, 2012). The global packaging market uses five main categories of materials: plastics, paper and board, glass, metal and wood (textile is marginal), but it is the plastic that dominates due to the several advantages associated, such as low cost, reduced weight, great versatility, flexibility, transparency and sealing ability (Licciardello, 2017). The respective market shares are exhibit in Figure 2.

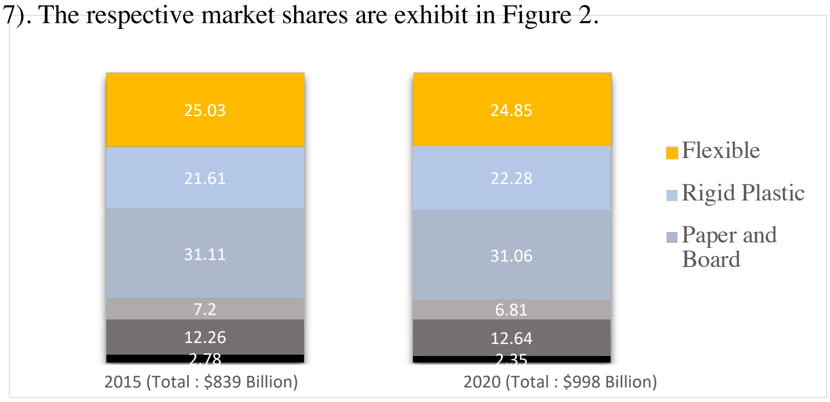


Figure 2: Share (%) of Material in Value (adapted from ALL4PACK, 2018)

In terms of primary packaging, the main packaging materials used are flexible materials (36%), paper and board (24%) and rigid plastic materials (20%). In terms of type, the most used are bags and sachets (875.59 billion units), bottles (810.32 billion) and cans (412.95 billion) (ALL4PACK, 2018). As shown, there are two major groups that over the years their market has been growing, flexible packaging and rigid packaging (Licciardello, 2017). As the name reveals, flexible packs can be modified or customized with ease, they are manufactured at low costs but offer minimal protection from compression or perforation. On the other hand, rigid packaging including tin cans, cardboard or plastic boxes, or glass containers, which are heavier and more expensive but offer better protection. The main differences lie in construction, durability, customizability, and pliability, which depending on the product, one or another can be more suitable (Hannay, 2002).

Regarding revenues, the global packaging market has increased by 6.8% from 2013 to 2018, mostly because of the shrink of less developed markets with more consumers moving to urban locations increasing the demand for packaged goods, as well as the boost of the e-commerce industry, with each order needing in its own packaging (Smithers, 2019). For the future, according to Zion Market Research (2018), the global rigid packaging market is set to cross $800 Billion by 2024 due to the previous trends, with focus on the growth of consumer needs and an increase in purchasing power, while the flexible packaging market is predicted to have a 3.95% growth rate to reach $299 Billion by 2024. The global packaging market is set to expand by 3% per annum, reaching over $1.2 trillion, between 2018 and 2028 (Smithers, 2019). This forecast is explained by the radical transformation that the packaging industry is supposed to face, changes that will also lead to growth. This transformation will be characterized by three key trends that will play out across the next decade: economic and demographic growth, consumer trends and demands, and sustainability (Value Line, 2017; Smithers, 2019).

According to United Nations (UN), Population Division (2019) the global economy is expected to continue expanding over the next decade, boosted by growth in emerging consumer market. Although there is likely to be some short-term disruptions from the impact of Brexit or the tariffs wars between the US and China, in general, the forecasts show the markets modernization with incomes expecting to rise, increasing thus the income for spending on packaged goods. The same way, the population, not only it will growth, with special attention to key emerging markets, such as China and India, but it is also expected the rise of life expectancy (UN, 2019). The global population expansion, combined with the continued growth of the rate of urbanisation, will allow an increased exposure to modern retail channels and the aspiration among a strengthening middle class to engage with global brands and shopping habits. Rising life expectancy will lead to an aging of the population, which, for examples, increases the need for healthcare and pharmaceutical products, important packaged goods, and thus the need for easy opening solutions and packaging adapted to the elders' capabilities (Smithers, 2019).

The consumer trend and demands have always been and will continue to be decisive for the packaging industry. The global market for online retailing not only will grow faster, driven by penetration of the Internet and smartphones, but consumers will also increasingly buy more goods online, at least until 2028, elevating the demand for packaging solutions (Meeker, 2019). Besides the online retailing, people are starting to prefer to consume products such as food, beverages, pharmaceuticals on-the-go, which also asks for packaging solutions that are convenient and portable, with the flexible plastics sector one main beneficiary (Meeker, 2019; Smithers, 2019).

The 21st Century is also characterized by consumers being less brand loyal, fomenting the brands to customised or versioned packaging and packaging solutions that can create an impact with them (Smithers, 2019). In the spectrum of the analysis that will be taken, a very important fact has been observed, more consumers – especially younger age groups – are inclined to go shopping for groceries more frequency, in smaller quantities. This behaviour is becoming even more common, and not only by younger age groups, essentially due to the awareness and interest for living healthy lifestyles, preferring quality over quantity, which will drive the demand for more convenient, smaller size formats (Janssen *et al.*, 2017).

Albeit, the trend and concern that is on the rise, and will continue to be, is sustainability. An ever-increasing demand for products, as well as more demanding product's features and capabilities, has put an immense pressure on industries resulted in negative impacts on the environment and society. Over the years, the concern over the environmental impact of products has become an important subject, however since 2017 there has been a revived interest in sustainability focussed specifically on packaging (Rajeev *et al.*, 2017). The two big non-sustainability problems when concerning packaging are plastic waste and food waste (EC, 2017). These two problems are particularly relevant for the packaging industry as they are the main drivers for its change, while not discounting the relevance of the second problem, this study will focus on the growing problem of plastic waste and the solution to combat it, developed in the chapters that follows.

2.3 | Plastic Packaging Waste

Packaging, despite its functions, has an associated cost. This cost is not only monetary, which derives from the material used in packaging, but it has also a cost in terms of the impact of the packaging itself (Simms and Trott, 2010). And it is a cost that has become a dangerous threat to ecosystems: over 40% of all plastic packaging produced over 150 years has been used once before disposal, only 9% has been recycled, less than a fifth has been reused and it is estimated that, every year, some 8 to 13 million tonnes of plastic reach the oceans (UNEP, 2018). Over the last 50 years, the role and importance of plastics in the economy has grown exponentially, with plastic largely replacing other packaging materials (Ellen MacArthur Foundation, 2017) with its production increasing twentyfold since 1960, reaching 322 million tonnes in 2015, value that is expected to be doubled in the next 20 years (EC, 2018). The most actualized data is from 2017, where the world plastic production almost reached 350 million tonnes, with Europe producing 18.5%, where 20 million tonnes were packaging referring to 40% as shown in Appendix A (PlasticsEurope, 2018).

In fact, over the last 50 years, plastic has largely replaced other packaging materials (Ellen MacArthur Foundation, 2017). The massive consumption of this material is directly related to the benefits it offers, where some are even environmental. Plastic packaging provides significant environmental benefits whether in the form of insulation material, saving energy and, substantially according to Verghese *et al.* (2015), it also enables food waste to be reduced along the distribution chain, due to the protection it provides both during transportation and during handling, while allowing to extend the shelf life of the product (EC, 2018). These allied with all the other amenities, such as inexpensiveness, versatility, lightweight and durability, make this material the predilection of the industry (UNEP, 2018).

However, despite these advantages and all the development offered to the packaging industry, with their unmatched functionalities at low cost, the massive production and consumption of this concrete material has an undeniably increasingly negative impact: plastic packaging waste that becomes pollution for various ecosystems (Ritchie and Roser, 2018). Today a large amount of plastic packaging waste ends up going into the landfills and as this material is not biodegradable, it breaks down very slowly, creating a significant waste disposal impact in the landfills. This results in some serious environmental problems: an increase in landfill burdens, an increase in toxic emissions to the environment and an increase in the use and production of non-renewable resources, as plastic production uses about 8% of global oil production (Emblem and Emblem, 2012).

The large number of plastics that ends up on landfills is due to the underperforming end-of-life treatment, the most critical concern regarding plastic packaging. The current way of using and disposing of plastic is considered a flaw in the 'circular economy' concept. There are three main types of plastic disposal, recycle, waste treatment by incineration and landfill disposal, yet none presents itself as a solution to the problem as current recycling is an inefficient and ineffective process and the rest creates serious environmental problems.

As can be consulted in Appendix B, in Europe, only 30% of all the generated plastic waste is collected for recycling, where half is exported to be treated in countries outside the EU, due to lack of capacity, technology or financial resources to treat the waste locally (Ellen MacArthur Foundation, 2016). Thereby, the remaining 70% end up being burned or discarded. The main environmental impacts involved with incineration are the production of carbon dioxide, which is a primary driver of climate change, and also the release of toxins into the air and surroundings (Gayer et al., 2017; Ritchie and Roser, 2018). Each year, the production and incineration of plastic emits about 400 million tonnes of CO2 globally (European Parliament, 2018).

One of the most alarming and visible signs of this underperforming end-of-life treatment problem is the millions of tons of plastic waste entering the oceans in a year, causing public concern to rise with more people embracing a sustainability trend. Globally, between 8 and 13 million tons of plastic (between 1.5 and 4% of global plastic production) enter the oceans annually (Jambeck et al., 2015; UNEP, 2018), while in Europe, varies between 150 000 and 500 000 tonnes per year (Sherrington et al., 2016).

Though underperforming end-of-life treatment is a crucial part of the problem, it is not the cause. In fact, the cause is the unbridled consumption of plastic. Specifying on packaging, one of the main reasons that concerns the plastic packaging waste, it is the extremely unnecessary use of packaging due to excessive packaging. Because plastic solved the problem of high packaging costs, extravagant packaging has become so prevalent in developed countries that unwrapping three layers of plastic and paper to eat a piece of biscuit is a regular practice (Zheng, 2013). Thus, nowadays, just to please the eye, vast quantities of products are over dressed, resulting on the main problems related to resource and wastage problems. In this sense, product packaging has immense impact across the supply chain (Song *et al*., 2015). For example, in terms of logistics, excessive packaging is naturally physically larger and heavier, which requires more planning, more space, thus incurring higher financial and environment costs, especially since over packaging is usually discarded quickly, ending up more quickly in landfills (Emblem and Emblem, 2012).

Returning to the initial idea, there are serious environmental costs when it comes to plastic packaging, furthermore it is possible to estimate this cost financially. The low share of plastic recycling in the EU means big losses for the economy, as estimates point to 95% of the value of plastic packaging material (between 70 euros and 105 billion euros annually) is economically lost after a short first-use cycle (Ellen MacArthur Foundation, 2017). The Ellen MacArthur Foundation (2017) estimates that uncollected plastic packaging waste alone is worth somewhere between 80 to 120 billion dollars a year.

2.4 | Plastic Packaging Solutions

Concerning the massive consumption of plastic and the serious consequences for all living beings, including humans, sustainability has come to the attention of society, with the various actors realizing that the current state cannot be carried on. Several strategies concerning packaging are advancing to address problems such as plastic waste. The strategies ranges from central government and municipal regulations, consumer attitudes and brand owner values communicated via packaging, creating this trend and concern for a sustainable lifestyle (EC, 2017). Due to the increased information available on climate change and other consequences of plastic pollution, sustainability has become a key motivator for consumers, leading brands business to create new products with packaging made of alternative materials and creating designs that facilitate their processing in recycling to demonstrate their commitment to the environment.

Looking at the advances developed in the last years in the packaging of products sold in large retail surfaces, sector accounting for two-thirds of the global total of packaging waste, during the early 1990's 'green design' was the main focus for improvements of this nature, focusing on the use of recycled materials. Then in the early 2000's as understanding progressed green design was superseded by 'ecodesign', recognised as being a more holistic approach tackling environmental issues at all stages of a product's life cycle, encouraging designers to think about new ways of designing packaging, considerable efforts were done not only on material selection but also on the use of light-weighting solutions (Darlow, 2003). So a packaging design that is quite common until today are self-contained refills which consists on consumers customer buying a self-contained refill, taking it home and puting into its durable dispenser, the parent pack, or using components of the parent pack to consume the refill (Lofthouse and Bhamra, 2006). Nowadays, these are more commonly used for hygiene and beauty products like in the form of razor blades, high-end aftershave, electric tooth- brush heads and wipes. Even though they are also used for stationery products such as pens, ink cartridges, toners, the most widely used, and in expansion, are household cleaners and laundry products (WRAP, 2008). Example of products, in the retail context, using these packaging systems are shown in Figure 3.

Figure 3: Example of self-contained refill sold in common large retail surfaces around the world

However, although these redesign approaches are meritorious and should be encouraged, they are not having a radical effect on the impact of packaging. Whilst the weight of packaging per unit of product has decreased, demographic and lifestyle changes such as a demand for greater convenience have led to a preference for conventional disposable packaging and an increase in the total amount of packaging used (Lofthouse and Bhamra, 2006).

Accordingly, in recent years, another approach to deal with this sustainable awareness has been the resurgence of farmer's markets and street markets which are increasingly visible and popular. In fact, the increased consumer awareness of the environmental and social externalities developed a new consumer segment, consumers who believe that local and fresh food is tastier and thus healthier, and there is no need for packaging (Brown, 2017). Besides the local markets, many food stores around the world have been adopting the concept of 1960s and ending the packaging concept. In these stores, consumers bring their own containers from home, weigh their weight, fill the container with the product and pay depending on the weight. As an alternative to conventional supermarkets, these stores offer a retail concept that includes organic food products and products from local manufacturers without any packaging (Beitzen-heineke, 2015; Van Herpen *et al.,* 2016). This retail concept has achieved great success around the world with the global bulk food market expected to attain a CAGR of 4.6% during the period between 2018 and 2023, majorly driven by evolving lifestyle factors (Mordor Intelligence, 2019). Today, there are more than 369 worldwide chains of packaging-free stores (plastic free shopping) scattered all over the world, from Cape Town to Hanoi, there is the shop "Zero Waste Hanoi" in Hanoi, Vietnam, the "Shop Zero" in Cape Town, South Africa, but the countries that prevail in terms of more stores across the country are US and the UK (Bepakt, 2019). Restricting to Portugal, consumer demand for this retail option is already high and is still increasing. The evidence is given by the indicators of the retail business' growth registered in the monthly bulletins of INE (2018), which refer to a variable percentage rate between 2% and 3% between 2017 and 2018. By consulting the online directory "A Granel", and although the numbers are not official, it is possible to get an overview of this growing market, with Portugal having already 179 bulk stores, with the largest concentration being located in Lisbon and Porto. The most famous and also the first organic bulk grocery store in Portugal is "Maria Granel", a 100% packaging-free store where nothing is previously packaged to promote sustainable consumption. Since opening its doors in late 2015, it has increased its product offering from 240 to 500, the products are placed in automatic dispensers or in transparent boxes with dosers, customers serve themselves on all products except honey (Expresso, 2018). The latest addition is the chain "Allegro Natura", which sells multi-purpose detergents by weight, a new concept, because it expands the market beyond food. Allegro Natura is a company dedicated to the manufacture of environmentally friendly detergents and cosmetics. All the detergents can be purchased in bulk, buying just what the customers want, avoiding plastic packaging (UniPlanet, 2018).

On account of their success and the continued growing consumer adhesion, some supermarkets have been introducing and testing this new concept of selling in five key categories of products: DIY and gardening products (e.g. grass seeds, compost and cement); dry non-food grocery products (e.g. washing powder); dry food (e.g. cereals, rice, grains, oats, flour and spices); non-food grocery liquids (e.g. fabric softener); and liquid health and beauty products (e.g. shampoo, skin care and moisturisers). However, passed the testing phase, only the dry food category has been adopted permanently in hypermarkets and supermarkets around the world (WRAP, 2010).

Focusing on Portugal, in terms of the largest supermarket chains, Jumbo, now Auchan, was the first to market a wide range of bulk goods, from gums to cereals. Then, in 2016, Jerónimos Martins in addition to the sale of nuts in bulk also launched a self-service water bottle refill service through a purified water dispenser, enabling customers to refill their bottles (Observador, 2018). However, success has been little, for example in Pingo Doce the sale of nuts in bulk only accounts for 3% of sales in the category of nuts (Ribeiro, 2018). In a survey of Pingo Doce consumers, it was found that the main reason why they do not opt for this approach is that environmental aspects such as 'product sustainability' play a secondary role when compared with price, product quality and convenience, and these proposals do not show sufficient incentives for change (Ribeiro, 2018).

Besides the low uptake, even though they are practices that help to reduce packaging, they turn out to be very ineffective since consumers do not use their reusable containers, as in zero packaging stores, but plastic bags available, the same as when buying fruit (Ribeiro, 2018). As such, the little success and ineffectiveness reveal that this approach can't be considered a definitive solution to the problem in the retail sector.

In terms regulation for bulk retail, there are some food policies in Portugal, however there is no register regulation for non-food products such as detergents and hygiene products. In accordance with current Portuguese legislation, some food products are prohibited or restricted to retail in bulk, namely: [1] the Decree Law No 78/2013, of 2013-06-11, Article No 6, restricts the bulk sale of non-prepacked coffee, chicory and barley, only to establishments complying with good hygiene conditions, which have adequate packaging, exposure and identification systems for the products to be marketed. It also states that the sale of ground coffee in bulk is only allowed at the buyer's request and only provided if milling takes place at the time of purchase; [2] the Decree Law No 290/2003, of 2003-11-15, Article No 3,prohibits the sale of unpacked sugar; [3] the Decree Law No 157/2017, of 2017-12-28, Article No 7, prohibits the sale of rice and rice crack (of the specie Oryza sativa L.) in bulk retail. Regarding plastic packaging, according to the EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE (UE) 2019/904 of 5 June 2019, the commercialization of plates, cutlery, straws, balloon sticks and cotton swabs made of single-use plastic will be prohibited until 2021. Furthermore, the Decree Law No 77/2019, of 2019-09-02, imposes the prohibition of distribution and the obligation to make available to consumers alternatives to ultralight plastic bags and plastic cuvettes at points of sale of bread, fruits and vegetables.

2.5 | Conclusions

A material created to make life easier and even to save lives is now creating a greatest threat to survival. Since then, driven by the packaging industry, the use of plastic has grown exponentially. However, the problem is not the plastic itself, but how it has been used. The main sources of the problem are the consumers, who consume packaging and plastic items indiscriminately and irresponsibly, the fragility of legislation and regulations, and the inadequate management of waste by companies. However, while it is an environmental menace and a major challenge to the market, the plastics issue is also an opportunity. There is room to create and think of something new, distinctive, and worthwhile, because leaving the solution in recycling alone is not enough, of all the plastic produced only 9% was recycled (UNEP, 2018). One trend that has been gaining strength worldwide is the reuse of packaging through reusable packing systems, but it is still a trend and a niche market, there is still a long way to go. With regard to large retail surfaces, sector accounting for two-thirds of the global total of packaging waste since is where the vast majority of purchases take place (Geyer et al., 2017), approaches to deal with this environmental problem have been very few and far between effective, and there is plenty of room for innovation and development of solutions that appeal to all stakeholders to make it a common practice enabling the reduction of plastic packaging waste.

3 | State of the art

This chapter provides the theoretical and scientific background that will serve to handle the problem identified in the previous chapter as well as the chosen approach for the research. Accordingly, in Section 3.1, ZWM is introduced, being described its concept and characteristics. Following in Section 3.2, the above concept is applied to packaging, reviewing the concept of Sustainable packaging with a focus on the four principles that distinguish it, and exposing the developments that have taken place over the years in sustainable packaging. At last, in Section 3.3 it is studied the several methodologies developed recently to solve sustainable problems by the creation of sustainable solutions.

3.1 | Zero Waste Concept

Waste has been troubling the world for a long time, it is considered a threat and there have been many attempts to solve the issue (Loiseau *et al.*, 2016). The first methods of dealing with waste began to be open dumping and open burning, and later the sophistication of these methods led to technological disposal solutions namely, landfills and incineration (Loiseau *et al.*, 2016). However, this improvement has not helped to solve the problem. These disposal solutions are highly wasteful (and costly) processes, destroy resources and, moreover, these technologies have also proved to be hazardous, emitting toxic compounds that contaminate not only soil but also water, affecting dangerously living bodies including human beings (Geissdoerfer *et al.*, 2017; Winans *et al.*, 2017). Besides the several attempts to get rid of it, there has been little success. The real problem is not the inefficiency of waste management processes, but the complexity of waste that makes it very difficult to create a sustainable process able to deal with it. The complexity can be directly attributed to the wrong and unsustainable material use, like plastics, bad and inefficient designs, increasing resource use, especially of non-replenishable type, and their combination use, since they came from mixed sources resulting in being very expensive to manage them sustainably (Ghisellini *et al.*, 2016). But it should be noted that the great cause is the thoughtless unethical practices of human society, today's take-make-dispose economy is one of the drivers for the accumulation of waste, as any material is seen to end up a waste after use (Sridhar, 2004). Thus, the concern about the hazards of waste disposal, the broader and globally recognized environmental concerns, the economic opportunities created by the new regulations and techno-innovations that resource recovery and better materials management offered combined with an unethical, inefficient, and uneconomical human lifestyle, became the main motivations behind the emergence of the Zero Waste (ZW) concept (Geissdoerfer *et al.*, 2017; Kirchherr *et al.*, 2017).

Driven by these, ZW is the most holistic innovation of the twenty-first century for achieving real sustainable waste management systems. This new paradigm turns waste into source of innovation and sets aside the idea of waste as a cost and economic drain on productive resources, instead of seeing used materials as garbage in need of disposal, discards are seen as valuable resources (Zaman and Lehmann, 2011). In terms of its origins, the concept was born in 1973 when Dr. Paul Palmer used the term ZW to recover resources from chemicals (Palmer, 2004). However, the concept has developed naturally as a need of survival in the late 1990s. Due to economic recession, communities learned that revitalizing the economy could very well start in the household dustbin, as discards also has value, and recovering and adding value to that was an economic activity in itself (Sridhar, 2004). The most recent and complete definition of ZW, according to the Zero Waste International Alliance (2018, p.1), is defined as "the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health".

3.1.1 | Circular economy

However, the goal of zero waste is frequently sought incrementally as no waste becomes less waste in practice. In fact, ZW is often misinterpreted as unrealistic since it cannot be achieved with today's economic signals (Greyson, 2007). Thus, for it to truly become a preventive approach, more than just a preventive objective, in 1986 the economist Kenneth Boulding described the proposed goal-set: a 'circular economy'.

The concept is a long-term aim compatible with economic growth, sustainability and ZW (Boulding,1986). In a circular economy, material flow is circular, which means the same materials are used several times until the optimum level of consumption. No materials are wasted or underused in circular system (Mason *et al*., 2003; Colon and Fawcett, 2006; Murphy and Pincetl, 2013). This closed-loop supply chain management (SCM) not only minimize waste, but also reduce raw material and energy inputs (European Environment Agency, 2016; Stahel, 2016). This happens because, the objective is for the products at their end life to be reused, repaired, sold, or redistributed within the system, and when this is not possible, they can be recycled or recovered and used as inputs, substituting the demand for the extraction of natural resources and, thus, reducing the raw material inputs.

The concept does not only pass by the production of the products and its end life, but in its best form, it encompasses a "cradle to grave" approach or a "life cycle" approach from material design, production, use and disposal, as shown in Figure 4 (Curran and Williams, 2012; Matete and Trois, 2008). It means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them (ZWIA, 2009). It goes beyond eliminating waste, but to eliminate inefficiency by way of total recovery of resources, from whatever is discarded throughout the supply chain (Greyson, 2007).

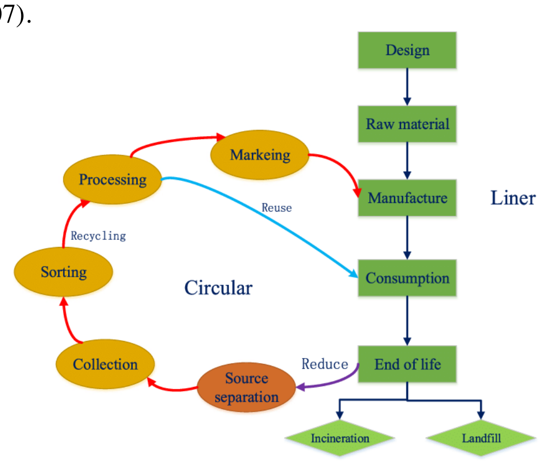


Figure 4:Linear and cyclical resource flow (Song et al., 2015)

A circular economy follows the 3R's rule (Reduction, Recycling and Reuse), being these three principles regarded as the founding principles of the sustainable waste management system (Mason *et al*., 2003; Colon and Fawcett, 2006; Murphy and Pincetl, 2013). From Figure 4, it is also possible to perceive how "3R rule" are present in ZW systems.

The reduction principle targets the minimization of raw material use, energy input, and waste production, while from a consumer perspective could be shopping products that will last, substituting quantity for quality. This is

the most effective of the three R's and should be always beginning. The reuse principle refers to the repeated use of products or components for their intended purpose or other, for example, a jam jar can store leftovers, an opened envelope can become a shopping list and a car resold. Reusing must also play a major role as it enables to keep new resources from being used for a while longer, and old resources from entering the waste stream (Ghisellini *et al*., 2016). Recycling aims to save energy, resources and emissions, however, although there are several recycling programs functioning nowadays, it remains a very inefficient and time-consuming process. Yet, regardless of reduction and reuse being "greener" options (Allwood, 2014), the use of recycled instead of original material is noted as a beneficial solution (Grosso *et al*., 2017). Thus, recycling is a good option, but it shouldn't be the first.
In 2008, the EC concluded that "preventing products and materials from becoming waste for as long as possible and turning waste that cannot be avoided into a resource are key steps to achieve a greener, more circular economy. This can boost growth, create jobs, help reduce greenhouse gas emissions and reduce the EU dependency on imported raw materials.". For this reason, the "3R" principles were extended to five, becoming the five steps in the waste hierarchy in the European Union Waste Framework Directive 2008. It was added Prevention (avoidance) and Disposal, with prevention becoming the first principle and the main strategy to be adopted in all cases (UNEP, 2010).

3.1.2 | Reverse logistics

The way to achieve this concept of circular economy in practice in supply chains is by implementing reverse logistics. Reverse logistics (RL) forms part of closed-loop supply chain management (SCM) and this field has gained increased importance as an environmental, profitable, and sustainable business strategy due to the importance of such operations for firms in every industrial sector. Consequently, the concept of RL has been subject to evolution over the years and various definitions can be found, including Stock (1992), Carter and Ellram (1998) and Rogers and Tibben-Lembke (1999) among others. Within this broad spectrum of definitions, the definition chosen for the purpose is the one proposed by the academy the European Working Group on Reverse Logistics (REVLOG), which defines RL as the: "process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal" (Brito & Dekker, 2004).
Accordingly, Thierry *et al*. (1995) conceptualised a model by distinguishing the three categories of activities in a reverse logistics supply chain: direct reuse or resale without any reprocessing, Product Recovery Management (PRM) activities, and waste management or disposal. These activities are presented in Appendix C.
Although direct reuse/resale and waste management are the already common destinations activities for products, Product Recovery Management is a new concept. Accordingly, Thierry *et al*. (1995) proposed PRM as "a mechanism to recover as much of the economic and ecological values as reasonably possible, thereby reducing quantities of waste to be disposed". This way, PRM focuses on recovery as opposed to disposal.
Each PRM option proposed is the same in the sense that involves the collection of used products or components and the subsequent reprocessing, and redistribution of them. Nevertheless, they differ in terms of the type of reprocessing involved. According to Thierry *et al*. (1995, p.118), the purpose of repair is to "bring used products up to working condition and usually only requires limited product disassembly and reassembly", whereas refurbishing "brings used products up to a specified quality, but quality standards are less precise than those of new products". In refurbishing, used products are disassembled, critical modules are separated and inspected, and

then fixed or replaced as required. In certain cases, this activity integrates the washing of the components until they approach their original quality. (Fleischmann *et al.,* 2000; Thierry *et al*., 1995).

Remanufacturing means "bringing used products up to the specified quality standard of new products and is thus more rigorous than refurbishing" (Thierry *et al*., 1995, p.119). In this process, used products are completely disassembled and are extensively inspected. Finally, cannibalization "involves selective disassembly of used products and inspection of potentially reusable parts" (Thierry *et al*., 1995, p.119). However, cannibalization reuses a smaller proportion of used modules in contrast to a large number of used products re-used during the repair, refurbishing, and re-manufacturing processes, which does not promote the concept of zero waste so much (*Thierry et al*., 1995).

Although the purpose of these four product recovery options is to retain the functionality of used products and parts as much as possible and practice zero waste, the cycle is not infinite. Depending on the life cycle of each part/material, it is possible to re-enter the process, but once the possible re-use cycles have been completed, the components go to the last product recovery option: Recycling.

Recycling is based on used products being disassembled into parts, divided into material groups, and the separated materials being re-used in the production of new parts (Kopicki *et al*., 1993; Pohlen and Farris, 1992). Yet, this option differs from the previous ones in that it aims at reusing materials from used products, and not at reusing the used products. Besides, much of the products' materials are lost in the recycling process. In practice, these materials can be re-used in the production as raw materials if materials quality is maintained (Thierry *et al*., 1995). However, contamination makes primary material impure and reduces its recycling value (Pohlen and Farris, 1992). For example, mixed resins introduced into a plastic recycling process can lead to bubbling, lack of coherence, or damage to the extruder. The ink and glue used on packaging labels also impaired the recycling of the plastic packaging. While contaminants such as oil or paper within the plastic recycling process can become hazardous flammable, resulting in fires and explosions (Koh and Aoshima, 2001).

Therefore, according to Koh and Aoshima (2001, p.150), "maintaining the purity of recyclable products considerably increases costs, therefore material standardization is crucial for manufacturers who recycle used plastic product parts themselves. Material standardization allows manufacturers to recycle plastic materials cheaply and easily over during the recycling process and this will result in the reduction of new resin use and its subsequent environmental impact".

3.2 | Sustainable Packaging

Packaging has long been regarded as a waste generator and the main reason why today many products are not designed to be used efficiently and then reused, repaired, or recycled. In this sense, packaging can play a key role in sustainable development (Lewis *et al*., 2005). The visibility it provides, coupled with its importance as a facilitator for distribution, marketing, and safe consumer use, creates significant challenges for advancing sustainable development in packaging. It goes beyond a hard challenge since current consumer behaviour and spending trends, as well as developments in distribution, are examples of drivers of new packaging formats and technologies, often contrary to the principles of sustainable development (James *et al*., 2005). The current packaging trend is more focused on convenience than sustainability since one of the most pressing and far-reaching challenges in advancing sustainable development in the packaging domain is the lack of a clear understanding of what constitutes sustainable packaging (James *et al*., 2005).

3.2.1 | Sustainable Packaging Definition

Acknowledged of the gap, in 2002, the Sustainable Packaging Alliance (SPA) was formed to provide a focal point for strategic research, technology transfer and education to sustain and facilitate the development and marketing of sustainable packaging systems. However, the SPA itself only has defined four principles for sustainable packaging (James *et al*., 2005; Lewis *et al*., 2007; Verghese, 2008):

- Effective, it needs to add real value to society, not only economic value but also social value, by effectively containing and protecting products as they move through the supply chain (which can improve people's lives, for example by providing products in a more convenient form), and performed in a cost-effective way for all of those involved by supported information and responsible consumption.
- Efficient, it should aim to minimise consumption of materials, energy and water throughout the life cycle, which allows to conserve resources and reduce waste, while reducing costs in the packaging supply chain.
- Cyclic, it should eliminate waste by cycling packaging materials continuously through natural or technical systems for optimal recovery, minimizing material degradation and/or the use of upgrading additives (as shown by the concept of ZW Systems).
- Safe, packaging components should avoid generating wastes or emissions that pose any risk to human health or ecosystems;

Then in 2005, based on these principles, James *et al*. (2005) began by devising a core definition, which over the years has been completed by other authors. James started by identifying three aspects that should be considered in any assessment of packaging sustainability, particularly in relation to scope: the entire life cycle of packaging, from raw material to final disposal, to avoid transferring problems along the life cycle; the interactions between the packaging and the product it contains, so that the environmental impacts of the product packaging system as a whole are minimized; the "triple" impacts of packaging: on business, people and the natural environment.

The core definition reached joins the four principles with the three fundamental aspects of packaging sustainability assessment as can be consulted in Appendix D.

The definition highlights the key role that packaging plays in our social and economic systems and its environmental impact. It is constructed to differentiate the macro levels of society associated with prosperity and welfare, the level of functional performance of the product/packaging system (efficiency and effectiveness) and the level of environmental performance of materials (impact and waste prevention), to the micro level of human and ecotoxicological soundness of the packaging components (James *et al*., 2005).

In 2007, Lewis *et al*. (2007) studied the advances to date, from the revised and updated National Packaging Covenant Mark II, a voluntary agreement between companies in the packaging supply chain and all levels of government, containing five performance goals and a series of more specific key performance indicators to measure them, to the new definition produced by the Sustainable Packaging Coalition (SPC) in the United States. Furthermore, by comparing SPA's principles with the principles, strategies and KPIs which have been proposed by others, it was possible to acknowledge the many synergies as well as gaps. A revised definition was developed in order to fill these gaps, with the four principles clarified and new strategies and KPIs added. The definition's objective is to maintain the principles fairly consistent over time, while the strategies and KPIs should be continuously improved to meet individual changes or circumstances, to highlight the fact that sustainability is a process of continuous improvement rather than a pre-determined endpoint. All the information collected can be seen in Appendix E, adapted from Lewis *et al*. (2007).

Later, based on the presented definition of sustainable packaging, Saghir (2012, p.37) defined the concept of sustainable packaging logistics as "the process of designing, implementing, and controlling the integrated packaging, product and supply chain systems in order to prepare goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption, recovery, reuse or disposal, and related information, with a view to maximizing social and consumer value, sales, and profit from a sustainable perspective, and on a continuous adaptation basis". The definition also covers all four pillars and is in line with the previously explored concept of a circular economy, considering elements that can reduce waste in a supply chain and limit consumption of raw materials and resources through the reuse of existing materials (Govindan and Hasanagic, 2018).

3.2.2 | Sustainable Packaging Principles

Acknowledging the 4 principles that define packaging as sustainable, and thus not harmful to the environment as the most used today, it is vital now to discover the studies and advances of recent years on packaging according to this perspective. Beyond providing information on the progress already studied in this area, this literature review will also make it possible to understand what has not yet been studied and which may be of interest for development. Therefore, given the different four pillars and the characteristics that define them, the following four sections provide a short-detailed summary of developments in the sustainable packaging literature under each pillar perspective.

3.2.2.1 | Effectiveness

According to the definition of sustainable packaging, one of the pillars is effectiveness which derives from the principle that sustainable packaging can not only provide environmental benefits but must also provide economic and social benefits (James *et al*., 2005).

By reviewing the literature on sustainable packaging, it is possible to see that while the environmental dimension remains the most addressed, not surprising as three of the four pillars of sustainable packaging focus on this dimension, the economic and social dimensions recently have been gaining interest.

The economic dimension emerges more in studies of down-stream logistics networks, where the traditional focus is on cost efficiency and productivity on reverse logistics and recovery processes. In most studies, this dimension is extensively studied along with the environmental dimension, considering the cost impacts of environmental management practices on packaging.

Studies under the economic dimension focus mainly on four subjects:

1) maximizing profits of the supply chain players by optimizing packaging collection routes (for e.g. Prive *et al*., 2006) etc.);
2) cost savings due to reduced use of virgin materials (for e.g. Ko *et al*., 2012 etc.);
3) cost savings due to product waste (for e.g. Accorsi *et al.,* 2014 etc.); and
4) cost savings due to better supply chain efficiencies (for e.g. Barrera *et al*., 2014 etc.).

A specific example of these themes is the analysis carried out by Hyde *et al.* (2001) suggesting that, in the food and drinks industry, waste reduction can make significant contributions to company profitability by improving yields per unit output and by reducing costs associated with waste disposal. Thus, the economic dimension focus on the profit and loss aspect of players along the supply chain (Beitzen-Heineke *et al.*, 2017).
In terms of the social dimension, it is the least addressed with fewer studies in the last decade (Meherishi *et al.*, 2019). In this regard, examples reflecting the issues addressed in this dimension are Vernuccio *et al.* (2010) and Azzi *et al.* (2012) with the analysis on what sustainable packaging can offer from a social point of view such as facilitating recycling or adapting product use to the needs of specific customers like the elderly or people with disabilities. Palombini *et al.* (2017) with the study on the impact of packaging on product, ethical trade and the workers involved, Geueke *et al.* (2018) on the impact of chemicals in packaging on consumer health and safety and Herbes *et al.* (2018) studying the influence of cultures in consumer attitudes towards eco-friendly packaging. Therefore, in brief the social impacts of packaging include product safety, ethical trade and impact on workers i.e. the society involved (Beitzen-Heineke et al., 2017). However, it is important to refer that the social aspect is possibly the least developed of the three pillars of sustainability.
About the environmental dimension, there are several studies identifying the negative impacts of packaging practices with focus on emissions, energy sources, non-renewable resources and water use, end-of-life treatment and packaging, as well as the benefits of sustainable packing adoption, which will be detailed in the literature review of the following sections on other three sustainable packaging principles. and the benefits of sustainable packing adoption (Beitzen-Heineke *et al.*, 2017). Still, there are many studies that present the three dimensions and how the three interact with each other like Verghese *et al.* (2012) that presents the new opportunities and challenges for business of adopting sustainable packaging.

3.2.2.2 | Efficiency

As far as efficiency is concerned, any sustainable packaging should continue to provide its function but with the least waste of resources, time and effort (James *et al.*, 2005). As in any product development, it is the product design that dictates everything that happens in the process. Thus, in the creation of sustainable packaging, eco-design is crucial to enable the desired efficiency (Williams *et al.*, 2008).
In terms of eco-design literature, Williams *et al.* (2008) studied how packaging design that focus on food waste reduction help to increase consumer satisfaction and, at the same time, reduce the environmental impact of the food-packaging system. Manfredi *et al.* (2015) presented the environmental savings from an eco-design for fresh milk packaging by applying an extra antimicrobial coating that enable to reduce milk waste and extend the shelf life, given the coating's life cycle. About stakeholder collaboration, Leppelt *et al.* (2013) found that the scope of corporate environmental strategies focused on packaging design not only achieves improved internal environmental performance but also reduces the environmental footprint of the product chain when in collaboration with all stakeholders along the supply chain. More specifically on the role of consumers, Wikström *et al.* (2016) shown how crucial this stakeholder is in the eco-design process by demonstrating that the consumer behaviour in households should be considered in the packaging design, since food waste caused by package size or attributes and the recyclability of the materials used bring indirect environmental impacts such as increased emissions and raw materials. Hanssen *et al.* (2017) also demonstrated that fact by showing that reducing the size of packages can reduce transport costs, energy consumption, and greenhouse gas emissions, while Obrecht and

Knez (2017) explained how eco-design principles can determine carbon emissions savings by dematerialisation (i.e. reducing material usage) in eco-friendly container designs.

Besides the packaging design process, many other authors examined how the adoption of sustainable packaging practices turned out to increase the efficiency of the processes along the supply chain. The studies are concentrated on examining the effect of introducing new packaging practices that are sustainable, the motivation and benefits of adopting sustainable packaging practices as well as the internal and external changes in perspectives and processes required by players and organizations along a supply chain.

Yang *et al*. (2013) studied the impact of internal and external green practices on the competitiveness of companies in the context of container transport, finding that internal green practices is an enabler for external green collaboration and green performance, and, internal green practices and external green collaboration positively influence firm competitiveness. García-Arca *et al*. (2014) concentrate on the internal and external transformations based on four cornerstones and three evolutionary stages under a continuous adaptation perspective that should take place along a supply chain to establish sustainable packaging logistics. In term of barriers, the main obstacles to be overcome for an effective implementation of Green Supply Chain Management (GSCM) have been identified by Wang *et al*. (2016) as poor training regarding environmental management concepts and lack of proper advertising and information on the benefits of GSCM in the packaging industry. While in more detailed scenarios, Yusuf *et al*. (2017) and Gustavo *et al*. (2018) analysed the motivations and benefits as well as the barriers and drivers for implementing sustainable packaging practices as returnable transport packaging in a supply chain and improved retail packaging in retail stores, respectively.

Some particular examples are, Hardy and Curran (2009) by a re-design of secondary packaging to eliminate the need for transit packaging with reusable secondary packaging or the total disposal of the secondary packaging layer to reduce associated waste streams in supermarket. Further, Torretta (2013) focused on the environmental benefits of incentivising sustainable behaviours in the supply chain by raising consumer awareness of uncapped water consumption, concluding that it enable to reduce to about one fifth of estimated CO_2 emissions as well as reduce of waste and the consumption of raw materials. Beitzen-Heineke *et al*. (2017) studied the concept of zero packaging grocery stores with the issue of food and packaging waste being able to be controlled in retail stores and the acceptance that has been gaining in practice. A simple praticle example is the approach of the the company Unilevar that explored product redesign by shifting to more concentrated liquid detergents requiring less packaging and being more efficient to transport (Unilever, 2019b).

3.2.2.3 | Cycling

The Cyclic Principle is aimed at ensuring that materials used in sustainable packaging should provide for waste reduction through natural or technical systems for optimum recovery by minimising material degradation and/or the use of improvement additives. In term of materials, there are eco-friendly packaging materials that by themselves make the forward processes of packaging competence more sustainable, whereas in term of systems, there are two possible cyclic loop systems available to collect and recover packaging: recycling or reusing (Meherishi *et al*., 2019).

Eco-friendly packaging materials

Starting with eco-friendly packaging materials, a range of packaging materials has been studied with regard to their environmental impacts, end of life treatment and ability to be re-used with effective performance of its core packaging functions. Simon *et al*. (2016) evaluated the environmental impacts of five different beverage packaging materials, of which glass bottles proved to be the best option due to their ability to be refilled and reused. The same result was obtained by Almeida *et al*. (2017) who compared three different packaging materials (glass, aluminium and plastic) for soft drinks. Bernstad Saraiva *et al*. (2016) compare three different packaging materials (cardboard, plastic packaging with and without natural fibbers) regarding their ability to reduce food losses and minimize the environmental impacts along the food supply chain, which turn out to reveal the importance of taking into account the frequency of reuse of plastic packaging as well as the assessment of environmental impacts depending on the different end-of-life treatment. Recently, Hahladakis and Iacovidou (2018) explored the functionality of materials, components and products, focusing on the influence of quality parameter on the recyclability of the plastic packaging materials.

In terms of recycled or non-recycled material, Toniolo *et al*. (2013) revealed the environmental preference of a recyclable plastic packaging tray to a non-recyclable plastic packaging tray, while Papong *et al*. (2014) demonstrated that the environmental performance of bottles made from a renewable thermoplastic is better than those made from non-renewable plastics.

Recycling

As far as cyclic loop systems for packaging are concerned, the best known is recycling, with hundreds of studies on the environmental benefits compared to other waste treatment systems such as incineration or landfill. However, in recent years, most studies have focused on the inefficiencies and barriers of this process as well as new improvement solutions. Meherishi *et al*. (2019, p.7) states that '…the recycling of packaging combines the domains of both packaging science and environmental management in that the recycling of packaging requires understanding the nature of the packaging material and its implications for the environment', which reveals the main topics explored in the packaging recycling practice literature.

Some studies around the world reflect the environmental advantages of this process like Ross and Evans (2003) which revealed the reduction of environmental burden by recyclable plastic packaging system as compared to a non-recyclable plastic packaging system. Or Mourad *et al*. (2008) demonstrated the environmental and economic benefits of increasing the recycling rates of different post-consumer packaging material as well as the replacement of the packaging contents by recycled material instead of virgin raw materials. Looking at different contexts, in the Italian context, Perugini *et al*. (2005) quantified the increased environmental performance of mechanical recycling of plastic containers compared to traditional options such as incineration or landfill, whereas Marques *et al*. (2014) compared institutional frameworks as well as financial costs in order to investigate the consequent viability of recycling systems of packaging waste in Belgium and Portugal, concluding that the theoretical system of recycling in Belgium is sustainable, unlike Portugal, which should invest more in raising citizens' awareness and creating incentives to increase participation in the recycling system.

In terms of adversities to the process, many authors studied the reasons behind the inefficiencies of the process and propose new solutions. Perrin and Barton (2001) investigated the reasons why many do not adopt the practice of recycling, finding as main results inconvenience, storage problems, and distance to recycling centres. Kuczenski and Geyer (2013) discover that the bottlenecks to improve recycling rate and material efficiency of post-consumer packaging materials are low collection rates and lack of reclamation infrastructure. Dahlbo *et al*. (2018) analysed the recycling potential of plastic packaging waste in the Finnish context, highlighting that even the plastic waste originating from the mixed municipal solid waste can be a valuable raw material, however the process is too inefficient to recover all the value.

In terms of proposals for improvement, Toniolo *et al*. (2013) showed that combining recycled packaging material with special additives can ensure the future recyclability of the packaging. Further, Barrera and Cruz-Mejia (2014) and Bortolini *et al*. (2018) demonstrate that routing and reconfiguration of supply chain networks is what is missing for optimal reverse logistics activities linked to collection of recyclable containers.

Reusable packaging systems

As far as reuse practices are concerned, considerable efforts have been made to reduce the environmental impacts of plastic packaging by focusing on issues such as material selection and recycling, however, while these are laudable and should be encouraged, there is still no radical effect on the impact of packaging (Lewis *et al*., 2001). Thus, in the past decade there has been a consistent focus on improving the reusability of packaging and the processes supporting it within the supply chain (Meherishi *et al*., 2019). Carrasco-Gallego *et al*. (2012) presented a definition of reusable items in closed loop supply chains accompanied by a typology that includes returnable transport items, returnable packaging material and reusable products. Kamarthi & Gupta (2011) demonstrated how reuse is a significant saving for materials and manufacturing, and for the collection and disposal operation since a multi-use product can compensate the cost with increased utilisation and an overall reduction in materials consumption.

A very detailed study was conducted by Lofthouse *et al*. (2009) in which reusable packaging systems were addressed on the possibilities they offer to the consumer and the environment by the analysis of several different types of refillable systems in terms of the success factors associated with each (from both a consumer and a business perspective) and the types of prejudices that these systems might have to face. Regarding Lofthouse *et al*. (2009), for the reusable packaging systems to be successful regardless of type, the attributes that lead consumers to a positive experience (e.g. good product quality, convenience, good value, easy and quick use, light to transport, clean and hygienic) need to be designed into the packaging system, just as the drivers of this change need to be recognized and built upon to stimulate companies in becoming part in the development of refills. Meanwhile, attributes associated with the negative consumer experience (e.g. inconvenience, cumbersome maintenance, poor quality packaging, incompatibility between systems, poor product quality) need to be actively removed from packaging, while barriers need to be acknowledged first and foremost minimized. The predominant and decisive issues raised have to do with (in) convenience and cost. When it comes to the cost of refills, the price incentive is expected and, therefore, the new solution has to be cost-efficient. However, this topic only becomes an issue if the quality endures, i.e., it may even be cheaper, but if the quality worsens, consumers will not want the refill option. As far as convenience is concerned, this attribute or the lack of it is the great barrier between choosing or not to use these types of systems, since not all consumers consider sustainable improvement convenience, rejecting this solution if it demands an extra organization or being more time-consuming. Therefore, the results reveal that incentive and the quality of packaging to be refilled are the main factors to enhance reuse behaviour and that as long as there is a proper reason behind the re-use approach, consumers will not hesitate to participate in the activity (Lofthouse *et al*., 2009).

Aaron *et al*. (2011) investigated the industries using reusable plastic packaging from the perspectives of green logistics, focusing on the processes of washing performed after their usage as per the customer requirements. Accorsi *et al*. (2014) carried out an environmental and economic evaluation of reusable containers made up of plastic in a fresh food packaging, revealing that for the case study in question, the adoption of a reusable system led to a reduced environmental impact in terms of CO2eq emissions, suppliers would likely achieve economic benefits however, the chain partner would bear most of the cost of adoption, due to increased management overhead, resulting in a high barrier to implementation. Yusuf et al. (2017) identified the drivers, barriers and benefits of reusable packaging while explaining its role for organizational competitiveness. Accordingly, reusable packaging enables firms to reduce their operational cost and lessening environmental impact in conformity with government regulations for sustainable supply chains. However, it also may increase operational cost, including for example, transportation, sophisticated equipment, and tracing and tracking. Furthermore, barriers to the usage of RTP could be maintenance, storage and cost of administration (Yusuf et al., 2017). Yusuf et al. (2017, p.639) argues that "the need to provide additional fund for supplementary logistics assets and sufficient workforce to manage them poses additional challenges to organisations that would have to manage reusable packaging both effectively and efficiently to avert potential negative consequences". Therefore, strict measures in the implementation and management of this kind of packaging are needed, such as tracking and tracing for high-level visibility, and quality control (Yusuf et al., 2017).

Finally, Gallego-Schmid *et al*. (2018) studied the environmental sustainability of reusable glass and plastic food savers in the European context, concluding that hand dishwashing industry was the most significant in reducing environmental impacts.

There are also many studies focused on comparing different systems or products to reusable ones. Ross and Evans (2003) and Bernstad Saraiva *et al*. (2016) show that reuse practices for plastic packaging system are environmentally preferable as compared non-reusable packaging systems. Menesatti *et al*. (2011) and Silva *et al*. (2013) explored the technical and environmental as well as economic benefits of returnable packaging over disposable packaging material. Accorsi *et al*. (2014) compared reusable plastic containers with single-use packaging in two supply chain configurations based on a conceptual framework for integrating packaging design as well as the distribution network. Torretta (2013) compared the economic and environmental costs of using plastic bottled water with those of water kiosks, also focusing on water quality in each system, concluding that the benefits of using water kiosks outweigh those of bottled water. In addition, Postacchini *et al*. (2018) demonstrated that re-use of glass jars is environmentally more beneficial than a recycle strategy, complementing with a new logistical solution to develop a sustainable honey supply chain. While a research conducted by the Foundation for Reusable Systems (2016) found that reusable packaging has an advantage in terms of reducing the amount of packaging going to waste schemes and recycling processes due to its strength, consistent size and compatibility compared to one-way packaging. Bortolini *et al*. (2018), on the other hand, argues that the packaging system that provides higher economic and environmental benefits is a mix of the reusable and disposable packaging containers for supply chain networks.

Although all these studies have demonstrated the potential of these systems, Lofthouse *et al*. (2009) highlights that these solutions might create even more waste if not well implemented. If packages, designed to be refilled, be discarded in the traditional way, followed by the collection of a new parent pack results in the loss of any potential sustainability benefit and may in fact contribute to an increased use of resources and energy compared to traditional packaging (Lofthouse *et al*., 2009). For example, Koskela *et al*. (2014) proved that the recyclable corrugated box delivery system for bread delivery is much more environmentally friendly as compared to the reusable plastic delivery system because of this reason. To prevent this from happening, some studies emphasised the importance of multiple actors in return and reuse practices, such as standardisation of packaging (Ko *et al*., 2012), collaboration between supply chain stakeholders in return packaging management (Li *et al*., 2014) and asset sharing (e.g. reusable packaging) between different actors across different supply chains (Zhang *et al*., 2015).

Return logistics systems

In terms of the logistical field, namely the reverse process for returning reusable packaging to its origin, logistics system design of reusable packaging has been addressed in a handful of studies. However, all instances found in the literature have focused on a tertiary packaging option.

In view of the various studies, return logistics systems are mainly characterized based on reusable containers' ownership and the responsibility of managing, cleaning, controlling, maintaining, and storing these containers. Kroon and Vrijens (1995) provided a comprehensive discussion about potential designs based on the study conducted by Lützebauer (1993). In this regard, Kroon and Vrijens (1995) categorizes return logistic systems as switch-pool systems and systems with return logistics.

According to Kroon and Vrijens (1995, p.58), "in a switch pool system every participant has his own allotment of containers, for which he is responsible. Thus cleaning, control, maintenance and storage of the containers are the responsibility of each pool-participant. Pool-participants may be the senders and recipients, or the senders, carriers, and recipients of the goods". There are two variants of this type of system, designed as a sender-recipient or sender-carrier-recipient system. In the former, only the senders and the recipients have an allotment of containers. A transfer of containers takes place when the goods are delivered to the recipient. The carrier either transports containers filled with goods from the sender to the recipient, or empty containers from the recipient to the sender. The sender is responsible for managing the return flow of containers and, thus, it has to guarantee that, in the long run, the number of returned containers equals the number of containers sent out.

In the latter, the carrier also has an allotment of containers and an ownership switch takes place at every ex- change of containers among participants. On picking up a containerized load from the sender, the carrier gives the sender a corresponding number of empty containers. Hence, in this case the sender bears no responsibility for administering the return flow of containers and it is the carrier who is responsible for managing the return flow of containers.

Regarding the systems with return logistics, Kroon and Vrijens (1995) defines them as the third-party's ownership in which the containers are owned by a central agency and this agency is also responsible for the return of the containers after they have been emptied by the recipient. The main prerequisite for such a system is that the recipient bundles the empty containers and stores them until a sufficient number of containers has accumulated for cost-effective collection.

Regarding the role of the central agency in this supply chain, Hellström and Johansson (2010) differentiates this type of systems in two new categories: transfer system or a depot system.

In the transfer system, the central agency is only responsible for return of containers from the recipient to the sender, and the sender is fully responsible for tracking, management, cleaning, maintenance, storage, as well as stock level of containers. In the depot system, the sender sends fully loaded containers to the recipient, and then, the idle containers are stored at depots by the central agency. The central agency cleans and inspects the containers and maintain them at the depot to be used for next shipments. This system can be coupled with deposits, the sender pays the agency a deposit for the number of containers delivered to his site. The deposit equals at least the value of the containers. The sender debits his recipient for this deposit, who does the same with his recipient, and so on. The moment the containers are delivered to the final destination, they are collected by the agency. Then, the agency refunds the deposit to the party from which the containers were collected. The deposit finances the shrinkage of the containers. The refundable deposit encourages quick return of empty containers and prevents the empty containers being stocked in one plant for a long period of time (Hellström and Johansson, 2010).
Table X summarizes the various logistics system designs of reusable packaging.

Table 1: Logistics system designs of reusable packaging (Mahmoudi et al., 2020)

Logistics system design	Participants	Ownership	Cleaning responsibility	Managing, maintaining, & storing responsibility	References
Switch-pool systems	Sender-recipient	All participants	All participants	Sender	Kroon and Vrijens (1995); Hellström and Johansson (2010)
Switch-pool systems	Sender-carrier-recipient	All participants	All participants	Carrier	Kroon and Vrijens (1995)
Systems with return logistics; transfer system	Sender-central agency-recipient	Central agency	Sender	Sender	Kroon and Vrijens (1995); Hellström and Johansson (2010)
Systems with return logistics; depot system	Sender-central agency-recipient	Central agency	Central agency	Central agency	Kroon and Vrijens (1995); Hellström and Johansson (2010)

3.2.2.4 | Safety

Besides the integrity of packaging for a safe disposal, storage and transport of products, the safety requirements in terms of confinement, containment, and radiation protection is crucial for any kind of packaging (Frano and Sanfiorenzo, 2016). Thus, one of the most addressed aspects in sustainable packaging literature goes according to the last principle, safety.
A decisive aspect since a proper and safe packaging protects the product and can even increase its shelf life, while improper packaging can lead to deterioration/destruction of the product and subsequently product waste with in some cases harmful effects to labor that handle it, end-consumers and the environment (Meherishi *et al*., 2019).
One of the issues of safety is the chemical interaction between packaging and the product it contains and its environmental implications, in the vast majority the pollution that generates, studied on several studies based on different products although all in the food and beverages industries (Burek *et al*., 2018; Geueke *et al*., 2018; Wikström *et al*., 2018). Likewise, Komolprasert and Lawson (1977) studied the hazards to health of the potential contamination of post-consumption polyethylene terephthalate (PETE) on the reuse of such material as food packaging, proposing an efficient approach to the cleaning process, whereas Darlow (2003) recognized a number of health and safety issues associated with different types of refillable packaging that appear to be one of the major barriers for the adoption of these type of systems. For last, Geueke *et al*. (2018) assessed the chemical safety aspects of recycled food packaging by providing details of the commonly used recycled materials, their recycling processes and decontamination options for removing chemicals which affect consumer health.
Moreover, with regard to integrity, there are many studies on the essential characteristics of packaging to facilitate transport, storage, handling, however, are not specifically dedicated to sustainable packaging. Nevertheless, some

studies have found some advantages in using reusable packaging relative to waste issues, such as high volume of solid waste, frequency of product damage, worker safety and hygiene demand, as for example the research conducted by the Foundation for Reusable Systems assessed how reusable packaging can save food from spoilage (Karst, 2013), while Langley *et al.* (2011) shown that reusable packaging is better in terms of confinement since reusable packaging might be twice as thick as a single-use packaging.
An overview of the literature discussed is presented in Appendix B.

3.3 | Sustainable Design Methodologies

When it comes to solving or finding solutions to sustainable problems, in recent times there has been great interest in studying frameworks for facilitating and guiding the process. Accordingly, several methodological frameworks have been developed and applied that have combined different methods so that actionable knowledge or, conversely, evidence-based solution options for sustainability challenges can be generated (Wiek and Lang, 2016). Sustainability research addresses problems that pose serious threats to the viability and integrity of societies around the world and has therefore been the main focus in recent times, being carried out mainly through two distinct streams (Jerneck et al. 2011; Wiek et al. 2012; Miller et al. 2014).
The first stream concerns to the identification of sustainability problems through the description and analysis of them centred on their complexity, dynamics and cause-effect relationships (Turner *et al.*, 2003; Ostrom, 2009; Collins *et al.*, 2011; De Vries, 2013). While the second strand approaches sustainability problems by developing evidence-based solution options to ongoing problems (Sarewitz *et al.*, 2012; Miller *et al.*, 2014). The dominant methodology to the first stream is systemic thinking and modelling, known as "analytic-descriptive", however, for the second, the methodology to be adopted is not of simple definition. Solutions to this kind of problems are typically not straightforward technical solutions or control procedures, they are in fact as complex as the problems themselves and requiring long-term processes involving real-world experimentation, collective learning and continuous adaptation (Wiek and Lang, 2016). Therefore, the second stream draws on the results of first stream analysis and adds to it an understanding undertaken pragmatically, without losing sight of the ultimate objective of developing evidence-based solution options (Sarewitz *et al.*, 2012). The combination of these streams gave rise to transformational sustainability research (Wiek, 2013).
For transformational sustainability research, it is important to develop clear methodological guidelines that provide researchers with instructions and quality criteria on how to conduct transformational sustainability research. In addition, they enable researchers to select, combine, and apply methods in pursuit of designing and testing solution options (Wiek and Lang, 2016). However, Miller et al. 2014 defends clearly that while such guidelines might be informed by existing methodologies, it is not enough to carry over established methodologies and hope to achieve transformational results with approaches that were not built for this purpose. Therefore, if transformational solutions are the ultimate goal, then it is essential to develop and adopt research methodologies that are capable of achieving this goal.
On this basis, Wiek and Lang (2016) differentiate three families of procedures and methods to approach sustainable problems that follows sequentially three families of procedures and methods. First, the descriptive-analytical family with procedures and methods that deliver descriptive-analytical or systemic knowledge by offering an insight into the past, present or future status of the problem under consideration. Examples of descriptive-analytical methods include methods for systems modelling and problem analysis (Ostrom, 2009). Second, the normative

family with procedures and methods that generate normative or targeted knowledge offering insights on the (un)sustainability of past, current, or future states of the problem. Examples of suitable methods for this stage are methods for visioning and scenario analysis (Swart *et al*., 2004; Wiek and Iwaniec, 2014). Third, the instructional family including procedures and methods that produce instructional or transformation knowledge by outline concrete transition and intervention strategies, i.e., action plans that detail how to resolve the problem and reach the sustainable vision. The most appropriate methods that really provide those insights are intervention research methods (Fraser *et al*., 2009).

An example of a framework created on the basis of these guidelines is the framework, called TRANSFORM, which integrates foresight, backcasting, and intervention research, as shown in Appendix F (Wiek and Lang, 2016).

The TRANSFORM framework was designed for developing solution options for sustainability problems and eventually to transform the status quo toward sustainability (Wiek and Lang, 2016).

The TRANSFORM framework entails two corresponding, yet reverse and complementary, research streams:

1. The first is foresight, in which researchers analyse and assess past and current states of the problem, as well as project the problem into the future to depict the diversity of plausible future states (I and IIa). These are called descriptive scenarios, i.e., scenarios describing possible developments starting from what is known about current conditions and trends (Swart et al., 2004).
2. The second stream is backcasting, in which researchers construct and assess sustainable future visions, as well as trace these visions back to the current state of the problem (pathways) (IIb and I). These are named normative scenarios, i.e., scenarios which are constructed to lead to a future that is afforded a specific subjective value by the scenario authors (Swart et al., 2004).

These two streams differ in terms of overall purpose. That is, the choice between descriptive or normative scenarios is dependent on the objectives of the scenario development exercise. Normative scenarios represent organized attempts at evaluating the feasibility and consequences of trying to achieve certain desired outcomes or avoid the risks of undesirable ones. Descriptive scenario analysis, on the other hand, tries to articulate different plausible future societal developments, and explore their consequences. For sustainability problems, a combination of backcasting from an array of possible end-states and forward-looking analysis from initial conditions and drivers of change is appropriate. The latter helps to identify long-term risks and to specify sustainability conditions, while the former identifies the bandwidth of initial trajectories and available actions to ‘‘bend the curve’’ (Raskin et al., 1998) toward long-term sustainability goals (Swart et al., 2004). Therefore, as indicated in the Appendix F, IIa and IIb inform and complement one another.

Finally, researchers design and test transition and intervention strategies (III) that contribute to mitigating the current state of the problem, achieving the sustainable visions, and actively avoiding undesirable scenarios. In order to use a broad evidence base, build capacity, and develop shared ownership for the intervention strategies, this framework calls for a close collaboration of researchers from different disciplines and stakeholders in government, businesses, and civil society (Wiek and Lang, 2016).

3.4 | Conclusions

From the review it is revealed that the literature on sustainable packaging based on the concept of ZW has been gathering pace since 2009 and is replete with such topics as return/reuse and recycling practices for post-consumer packaging, comparisons of sustainable alternatives in packaging, adoption of sustainable packaging solutions and packaging waste management. However, it is possible to identify where there is room for more research, with some gaps in the literature.

Accordingly, research on sustainable packaging is following the traditional paradigms of economy-environment trade and there is limited understanding of the social dimension. Thus, while the environmental and economic dimensions are fundamental and indispensable, in future research a focus on integrating all three dimensions of sustainability together rather than focusing on one or two dimensions is paramount. As the principle of effectiveness dictates, providing social value is just as important as economic and environmental value, and can therefore be exploited to a much greater extent in order to enforce the sustainability of packaging. Furthermore, the study of packaging alternatives has been addressed in different supply chain structures, indicating that these decisions occur at all stages of the supply chain. Likewise, other studies show the importance of collaboration between the different actors in the chain for economic and environmental sustainability, not only in the eco-design of packaging but also in the adoption of common practices (standardisation of packaging (Ko *et al*., 2012), return packaging management (Li *et al*., 2014), asset sharing(Zhang *et al*., 2015), etc.). However, although this valuable conclusion has been reached, cooperation and collaboration between all players along the supply chain is the recipe for making packaging processes more efficient, effective and thus sustainable for all, there are still no cases of packaging system alternatives designed and integrated in this way. Therefore, there is scope to address these concerns at a more integrated level, opening space for research to address further innovations in the adoption of sustainable supply chain practices concerning packaging throughout the chain and not just at some levels.

Another relevant aspect to mention is the fact that the vast majority of studies use the food and beverage industry and B2B processes (considering only secondary and not primary packaging) as the basis for the study. Consequently, there is an overriding need to consider more specific studies for other industries and especially regarding B2B processes, as concerns about sustainability and packaging needs vary between different industries and markets.

However, the main shortcoming stems from the fact that there are numerous studies proving that the practice of reuse provides the greatest sustainable character at all levels, specially research on reusable packaging, but the studies always focus on the same issue: demonstrating the benefits of this practice and how sustainable it is. In this sense, there are few studies that discuss and apply the practice in real scenarios. There is a lack of information as to different forms of implementation, which markets the adoption is most indicated, for which types of products the practice is most advantageous, among others. Although these systems already exist in some sectors, their predominance remains very little in relation to the benefits that they seem to provide, so it is necessary to understand why they are not succeeding or, on the other hand, gaining more relevance in terms of practicability to gain the interest of the markets. Some studies indicate that routing and reconfiguration of supply chain networks is what is needed to optimise reverse logistics activities, so once again rethinking packaging processes in an integrated way, now towards reusable packaging systems, should be the future focus. Indeed, reuse occupies the top position in the "waste hierarchy" that ranks waste management options according to what is best for the environmental, social as well as economic dimension (DEFRA, 2011). Therefore, it should be the priority theme in the waste management literature in the coming years.

Regarding methodologies for developing sustainable solutions, the scope of the studies is vast and complete, hence in the future dissertation some of those mentioned will be adapted and used.

4 | Research Methodology

This chapter presents the methodology, which will be followed during the development of the dissertation.
The research methodology employed is based on transformational sustainability research methodology studied in section 3.3. Based on the transformational sustainability methodology (Wiek and Lang, 2016), Figure 5 shows the proposed sustainable framework, following three main categories: the analysis of the problem that includes the definition of the scope and the analysis of the problem tree, then a market research where a benchmarking will be carried out, and finally a solution proposal analysis, addressing scenario building and scenario assessment.
Figure 5 illustrates the generic steps of the methodology and the methods to be applied in each. The following sections will describe in detail the different steps and methods that will be adopted.

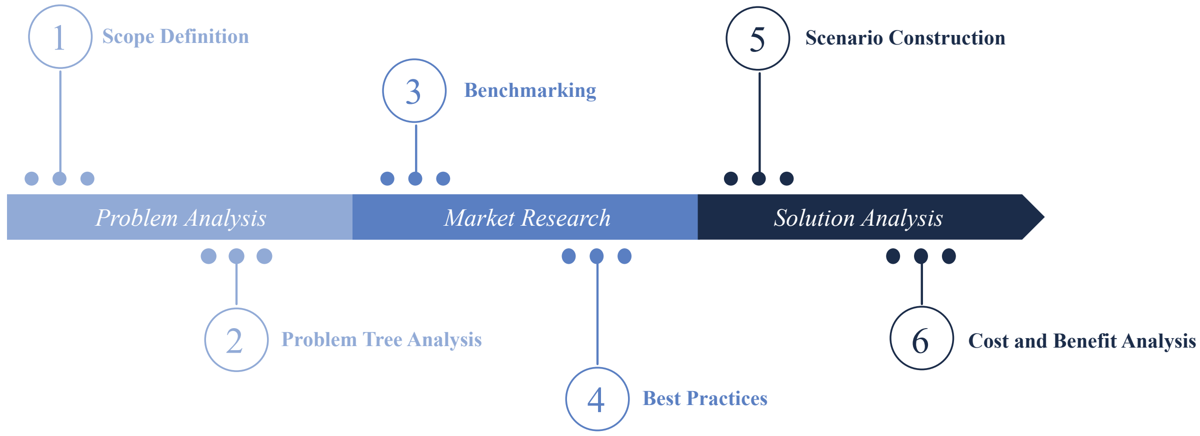


Figure 5: Methodology overview

4.1 | Problem Analysis

As the literature review has shown, reusable packaging systems appear to be the best solution for plastic packaging waste, yet they have not proven to be successful in large retail shops, revealing a new problem with unknown and unexplored causes. Thus, the starting point must be to address this gap and develop system knowledge so that the following research question can be answered: "Why have reusable packaging systems not yet been successful implemented in large retail surfaces?".
To develop this knowledge, an analysis using methods from the descriptive-analytical family will be employed in order to search and summarize insights from the past and present status of the problem and identify patterns to facilitate problem solving. The methods chosen for this stage were Scope definition and Problem Tree Analysis to first restrict the problem space and then focus on finding the causes of the problem (what needs to be solved) in that context.

4.1.1 | Scope Definition

In order to develop concrete knowledge on the field, the first step must be to define the boundaries of research to restrict the area under study.
As seen in the literature review, reusable packaging systems have already been studied in some, but not all contexts. Thus, in order to find new approaches to solve the problem of packaging waste, a good strategy will be

to focus the study on the areas that until now no one has studied. Hence, it makes sense to define the scope of the work on the basis of the gaps in the literature on reusable packaging found in the state-of-the-art chapter.
In addition, the scope must fall within the four characteristics that define a specific packaging, as shown in chapter 2. Those are: packaging level, packaging material, types of products that the packaging will contain, i.e. the industry, and finally the specific context of retail of such packaging. However, this last parameter is already established because it comes from the core question of the study. Thus, the large retail surfaces will be the starting point for the choice of the remaining parameters, since they are all interconnected and dependent on each other.
Finally, once these parameters are defined according to the gaps in the literature, it will be achieved a much restrict and concrete scope of study, making it much easier to carry out the investigation.
The following phases of the problem analysis will then focus on the possible causes for the non-adoption of reusable packaging systems in this chosen field.

4.1.2 | Problem Tree Analysis

Beneath every problem there is a cause for that problem (Doggett, 2005). Therefore, it is crucial to first identify what the root cause of the problem so that a solution can be proposed.
A popular tool to identify potential causes of problems is the Problem tree analysis technique (Guijt and Moiseev, 2001). This technique is based on constructing a diagram that allows to identify and visualize causes of the problem and their inter-relationships by showing the cause – effect relationships between problem conditions in a defined context. The analysis consists of three steps:

1. **Choice of problem**, which consists of identify major existing problems and select one for the analysis, based upon available information;
2. **Identification of causes** : Identification of important and direct causes of the focal problem and for each cause continue to identify its cause;
3. **Construction of tree**: Construction of the tree showing these relationships and analysis of it.

In the end there will be a multi-branch tree that demonstrates the various possible causes down to the smallest detail of the problem. However, beyond the exposure of all these, the great value of this type of diagram is the post analysis of the relationships found in the tree. That is, by broking down the problem into manageable and definable chunks, it enables a clearer prioritisation of factors, a more understanding of the problem and its often interconnected and even contradictory causes, which can be a first step in finding win-win solutions, while at the same time helping establish what actors and processes which will be essential to solve the problem.
The conclusions drawn will make it possible to identify the main factors and causes of the problem and hence what should be tackled, thereby having the core problem fully diagnosed.
The analysis that follows will then take these factors as performance measures and analyse current reusable packaging systems in other contexts other than the large retail surfaces. Before starting to build a possible solution, it is relevant to analyse reusable packaging systems currently in operation, even though in other contexts, to see if they also have these discovered problems or how have they solved them. In this way, it will be possible to learn successful practices and then apply and transform them for the context in question.

4.2 | Market Research

After problem characterization, it is time to evaluate the reusable packaging systems that are in place nowadays, even though in other contexts, to learn with successful practices and ascertain or find out new benefits that can be obtained from these systems.

4.2.1 | Benchmarking

Benchmarking method is frequently applied by companies to identify successful practices and incorporate them into the desired solutions. Many definitions have been proposed for Benchmarking, however, one of the most referenced is that of Keegan and O`Kelly (2006), which defines it as a way to help organizations compare with others in order to learn from them, providing a recognized and objective methodology to support the process of identifying and organizing priorities in those areas of the business that need improvement, as well as providing a simple way to evaluate progress over time. For these authors, Benchmarking allows organizations to objectively identify their key processes and associated issues, as well as identify and find ways to improve performance in key business areas by incorporating success findings, proven by others, into their strategic action plan, thereby increasing the chances of success. Benchmarking, therefore, allows managers to base their decisions on facts, learning from the positive and negative experiences of others, and not on opinions or intuitions (Keegan and O`Kelly, 2006).

There are various models describing the different steps that constitute a benchmarking study. One such model is the so-called benchmarking wheel, as portrayed in Figure 6 (Andersen, 1995). As can be seen, the process follows a basic five-step approach, each phase covering a natural part of the benchmarking study.

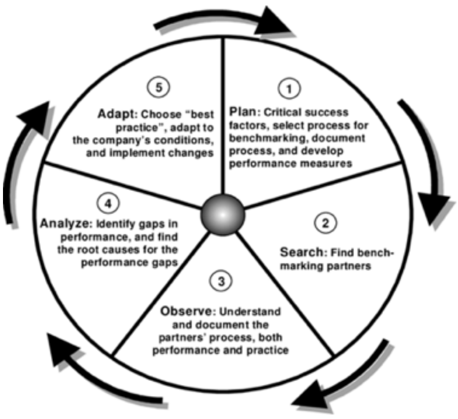


Figure 6: Benchmarking Wheel (Andersen, 1995)

In the first step, it is necessary to select and define what should be studied, identify the performance measures to be sought for characterisation. The performance measures will be based on those problems identified in the previous analysis to evaluate how these companies tackle these problems.

In the second step, it will be determined which cases will be studied. Companies/organisations using reusable packaging systems will be chosen on the basis of the criteria of similarity to the scope defined. In the third step, all available information will be collected to characterise what will be analysed and all the data regarding the chosen indicators from the cases will also be collected. The main objective will be to collect primary data and only supplement it with secondary data.

Moreover, the fourth step is the analysis of the data collected to determine the findings and recommendations for the next step, which in this case will have a whole section dedicated to it. From the analysis, it will be possible to identify new benefits of these systems and how they can be obtained, as well as learn successful practices for handling the problems identified in the Problem Tree Analysis.

The conclusions reached in this section will then be applied and transformed for the context in question. This will hopefully help to create a solution that solves all the small-scale barriers encountered and, consequently, solve the central problem of packaging waste in the mainstream.

4.2.2 | Best practices

Best practices are used to maintain quality as an alternative to mandatory legislated standards and can be based on the benchmarking results (Bogan *et al*., 1994). Moreover, Best practice is a feature of accredited management standards such as ISO 9000 and ISO 14001(Nash and Ehrenfeld, 2010).

Therefore, this section is only dedicated to adapting the results obtained in the benchmark to the context of the problem. In this way, it will be possible to identify which best practices need to be present when creating scenarios in order to ensure their success.

4.3 | Solution Proposal Analysis

Given the identified root causes of the problem, as well as some of the crucial practices for the success of these systems, it is time to start thinking about solutions. However, with this input alone, it is not yet possible to visualize an optimal solution but several solution options. Thus, the best method to be employed in this section is a Scenario Analysis as proposed by TRANSFORM framework studied in the literature review.

A Scenario Analysis is often performed to identify, compare, and assess viable alternatives to address a given business need or performance gap, determine and recommend the best alternative, and document the associated rationale (Gao,1994). However, following the idea of the TRANSFORM framework, the aim is to create scenarios that not only take into account realistic feasibility, but also achieve the desired sustainable vision. That is to say, in this case, various reusable packaging systems will be proposed and these will be evaluated not only in relation to the interests of the different stakeholders, but also in the fulfilment of the sustainable vision of plastic packaging waste reduction.

As such, the analysis goes through a first phase of creating different possible options for reusable packaging systems within the defined scope. And a second stage which is based on comparing the different scenarios through different factors, such as the benefits and trade-offs of the system.

4.3.1 | Scenario Construction

As mentioned, the first stage is the construction of different scenarios, so options for new reusable packaging systems to be implemented within the defined scope will be developed and proposed.

These options will be based on the different activities of reverse logistics and the three types of return logistics system design studied in the literature review.

To propose these scenarios, besides the knowledge found in the previous analysis, it is necessary to taking into account what was reviewed in the literature review, thus the scenarios will have to consider the following three decision levels:

1. Types of packaging return logistic systems (Kroon and Vrijens, 1995);
2. Reverse logistics activities (Thierry et al., 1995);
3. Stakeholders involved (Kroon and Vrijens, 1995).

As such, the baseline for the scenarios' construction are the types of systems already studied, the characteristics of the typical activities of the reverse process and the actors normally involved in this process. Then, the aim will be to adapt this work base according to scope defined.

4.3.2 | Cost and Benefit Analysis

At last, the second section of this analysis and final part of the dissertation, it is the comparison between the different scenarios created.

For this, a qualitative analysis of the benefits and trade-offs found in the system will first be performed for each of the players involved in the scenario.

A quantitative analysis will then be carried out for those scenarios for which the qualitative analysis was not decisive. For that, a cost-benefit model of reverse logistics constructed by Chen (2012) will be employed. This model enables precise computation of the costs and benefits of reverse logistics to facilitate enterprises implementing reverse logistics to better reduce their reverse logistics costs and enhance the overall operational efficiency of reverse logistics.

Therefore, in a first stage it will be identified the variables and its components for computing the model, then the characterisation and data collection process for each variable's component and, finally, the analysis of the data.

Finally, the results obtained will show whether any of the options are feasible, not only in terms of mitigating the root causes found in the analysis of the problem but also in quantifying the scale of additional cost and benefits for each of the players, according to each scenario evaluated.

5 | Results

As mentioned above, the aim of this dissertation is to decide, on the results obtained, the best way to implement packaging reuse systems, once it is proven to be the best approach to combat waste.

To this end, the first step is to define the scope of the study, since there are various types of packaging, products and sectors that could benefit from this analysis, and this will be the emphasis of chapter 5.1 Following this, an initial investigation, the focus of chapter 5.2, into why packaging reuse systems have not been adopted at the major retail surfaces is essential as the idea has not emerged today.

Then on section 5.3, a benchmarking analysis to the market, trying to collect all the information about these systems in order to identify the best practices to be later put into practice.

Subsequently in section 5.4, using the information collected, it becomes possible to construct different scenarios of reusable packaging systems. These scenarios will then be evaluated in order to find out whether any of the options created is feasible in the context of the problem and if it corresponds accordingly to the expectations of each player in order to convince them to implement the system.

5.1 | Scope Definition

Starting with defining the scope, the boundaries of the problem are established by defining the packaging level, packaging material, industry/sector, and the market.

The study will be focused on primary packaging, since it is the fastest disposable category because, once used the product it contains, generally ceases to function it is disposed, creating waste. The plastic has been selected as the packaging material to be studied. The choice of this material is due to plastic production and consumption growth in the past years, which has led to high environmental impacts.

In terms of industry, the industry chosen will be the beauty, personal care and cleaning products industry since it was a gap found in the literature review according to the industries predominantly studied. Additionally, 90% of the packaging used, in this industry, is plastic and, as they are not food products, all food hygiene issues can be removed from the study.

Finally, the chosen context will be retail stores as these are the places where the majority of the packaging with these products is available and bought by the consumers, and where very few, especially successful advances, have been achieved in combating packaging waste. The scope boundaries chosen are presented in Figure 7.

Level	Material	Industry	Market
Primary Packaging	Plastic Packaging	Beauty, Personal Care and Cleaning Products	Large Retail Surfaces (Mainstream)

Figure 7: Boundaries for the analysis

5.2 | Problem Tree Analysis

Already having the scope defined, it is then possible to initiate the attempt to discover the causes of the problem characterized in earlier chapters, since it is crucial to first identify what are the root causes of the problem so that a solution can be proposed. To do so, it is thus necessary to perform a Problem Tree Analysis, following four main steps: i) Choice and characterization of a concrete problem; (2) Data collection; (3) Construction of tree; and (4)Analysis of tree.

5.2.1 | Choice and characterization of a concrete problem

Through the literature review, it was possible to identify that the most sustainable solution to deal with packaging waste is the use of reusable packaging systems. However, although these systems are already implemented worldwide in the increasingly popular zero waste stores, their application in mainstream retail remains null and void.

In terms of the system currently used in these shops, it is a fairly simple and common system. It relies on customers taking reusable containers back to the store or using the ones empty sold in-store, refilling them with product via the store's product dispensers and paying only for the quantity purchased. Hence, suppliers provide not only the products in larger secondary packaging that are later poured into the store dispensers, but also reusable primary packaging is provided to enable consumption for consumers who do not bring or forget their packaging. While the primary packaging is in charge of cleaning and maintenance of consumers, the secondary packaging when empty are returned to suppliers to be washed and used again in the provision of products.

The only thing that may differ in the different zero waste shops, due to some progress in recent years, are the dispensers. For food and non-food products, as for solid and liquid products, the dispensers vary.

For **solid products** there are two options, the first is known as Bin and Scoop (Johnson et al., 1985), where customers use the spoon to collect the product. It has the advantage of being a simplified system of use, but the main disadvantage is the ease of contamination, which is not suitable for food products, although it is still often used for this purpose. As a result, a second system has been created where the feeding boxes are gravity supported, supporting larger sizes, containing more product and space for identification. It is also simple to use, and the risk of contamination is much lower as customers cannot actually touch the product before purchasing and need to use a hand crank, or other type of mechanism, for the food to be dispensed into a container.

For **liquid products**, the container from the dispenser is closed with a tap or a shut-off valve and the portion control system dispense a fixed portion of product which results in the dispensed volume being more equivalent to a standard weight of the chosen product, which simplifies the price for the consumer and enhanced quality control but limits the control of the desired portion (WRAP, 2007).

Although it seems to be a rather simple system in the end, there are many studies, as seen in the literature review, that show the economic and environmental benefits of these systems, since they can lead to higher profit margins derived from reduced material costs and distribution costs, as well as reduced waste and resource depletion.

In addition to the proven benefits, another fact that highlights the success of this system is the growing expansion of the zero-waste store market which, although it still a niche, is gaining exponential acceptance due to growing concern for the environment and sustainable consumption.

This should be another major driver for implementing this system in conventional retail markets, however, even with these strong incentives, no major change has yet taken place and its availability in the mainstream retail is rare.
Knowing that the retail sector is one of the most competitive sectors, always looking for new ways to win over its customers, the question remains as to why they are not exploiting this type of systems. With competition from niche shops growing every day and proven benefits from these systems, it is thus crucial to break the problem and try to find the root causes for this disinterest.
Accordingly, the choice of the problem and its translation into a question is: Why are the systems not adopted by the mainstream?

5.2.2 | Data collection

This second stage aims to collect important and direct causes of the focal problem by carrying out focus group discussions.
In order to conduct this qualitative approach to gain in-depth understanding of the problem, it is first necessary to identify the main actors with decision-making power over the problem to be the participants.
The retailers and suppliers are the main decision-makers with power to whether or not to implement the system. Nonetheless, consumers also have a key role in the systems' viability, since without their interest and consumption, the system fails. Hence, these three stakeholders should be analysed.
However, given the non-governmental stakeholders already identified, it is missing a governmental stakeholder to be taken into account. Although not an obvious actor at the outset, the possibility for the intervention of an external actor to the sector can help the analysis. This actor differs from the others in nature because, although he does not participate directly in the activity, he possesses a strong power that can influence it. Governments are entities that, through their legislative and executive powers, can greatly influence the market and economic activities, such as retail. In this context, through investment actions and/or tax benefits it would be possible to help encourage sustainable practices like the system in question.
Accordingly, group discussions were held with various types of consumers, however, for the other players it was only possible to collect passive information through interviews given on the subject. In discussions with consumers, they were asked whether they were familiar with these types of systems and whether they frequented shops that employ them. Ultimately, it was asked their view on if they were to be implemented in supermarkets and, at this stage, the big focus was to keep asking "why" until there was no more answer, so that it was possible to get to the bottom of the question.
For the remaining players, the aim was to gather information from interviews aimed at answering the question: Why don't suppliers/retailers/government opt for this system?
The results and the information collected that identify the reasons of the different actors, that are weighing on the other side of the balance and preventing the wide adoption of this system, will then be structured in the next step.

5.2.3 | Construction and analysis of tree

At this stage, the results of the previous stage will be presented and analysed. To facilitate the analysis, four trees will be constructed, one for each actor identified above. Then, the different reasons collected will be categorised into main causes and secondary causes, with the main causes being the first branch of the tree and the secondary the remaining branches of each main cause for the non-adoption of these systems by each of the actors.

Hence, the following tree diagrams present the possible causes for the nonadaptation of reusable packaging systems by suppliers, retailers, customers, and governments.

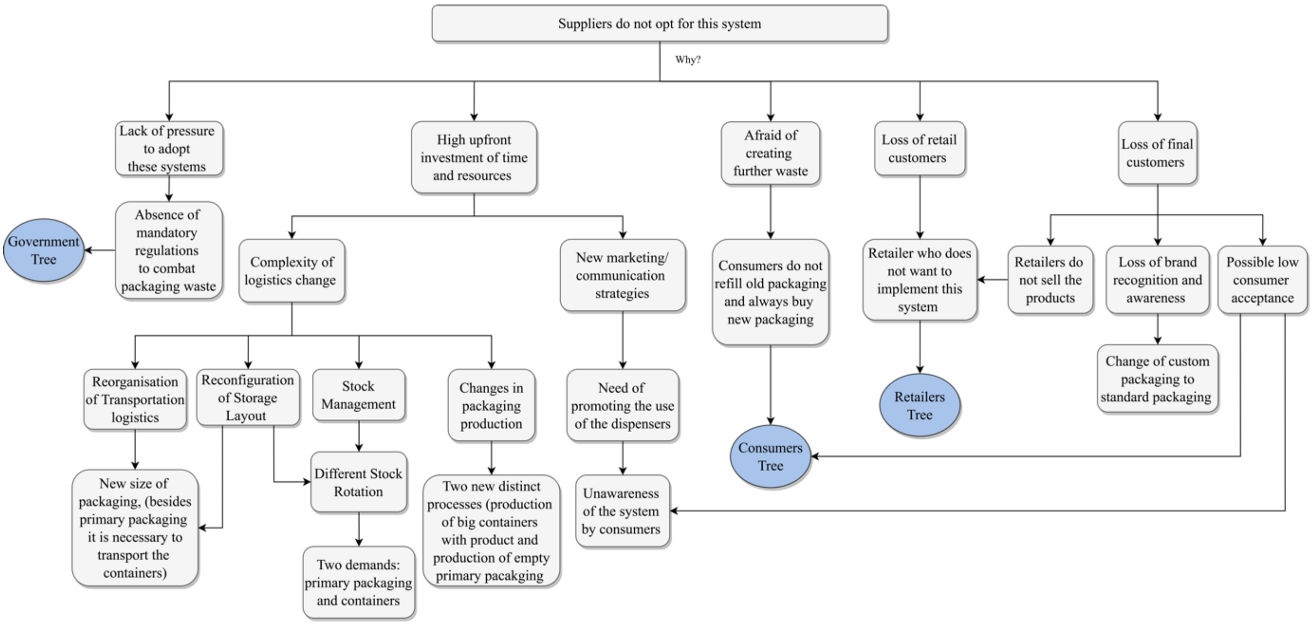


Figure 8: Problem tree diagram for suppliers

Starting with suppliers, Figure 8 illustrates with a tree of causes, the several reasons found for the problem of suppliers not wanting to adopt the reusable packaging system. As shown, five main causes were identified:

1. Lack of pressure to adopt these systems;
2. High upfront investment of time and resources;
3. Afraid of creating further waste;
4. Loss of retail customers;
5. Loss of final customers.

Having identified these causes, the next step was to continue asking "Why" until no further value was added for analysis. From the tree, it was possible to ascertain that for **cause 1, 3 and 4** the root causes depend on the reasons for the non-implementation of the systems by governments, consumers, and retailers respectively.

As regards **cause 2**, it has been identified that these systems require a major change and investment in operations, as production and logistics will be carried out using large secondary packaging, although primary packaging production and distribution will still be necessary for customer consumption. Therefore, this would require a major transformation of core activities, and time and resources would have to be invested in this structural change, making it impossible to change overnight. Moreover, this change would also have to be well publicised to customers, also requiring time and resources in new brand and communication strategies.

Finally, although **cause 5** also depends on the reasons of consumers and retailers, it reveals another critical root cause which consists on the loss of brand recognition and awareness by consumers. This stems from the fact that since the products are available in dispensers that are the same for all brands, it is more difficult to create a strong brand image that distinguishes itself from all the others on display.

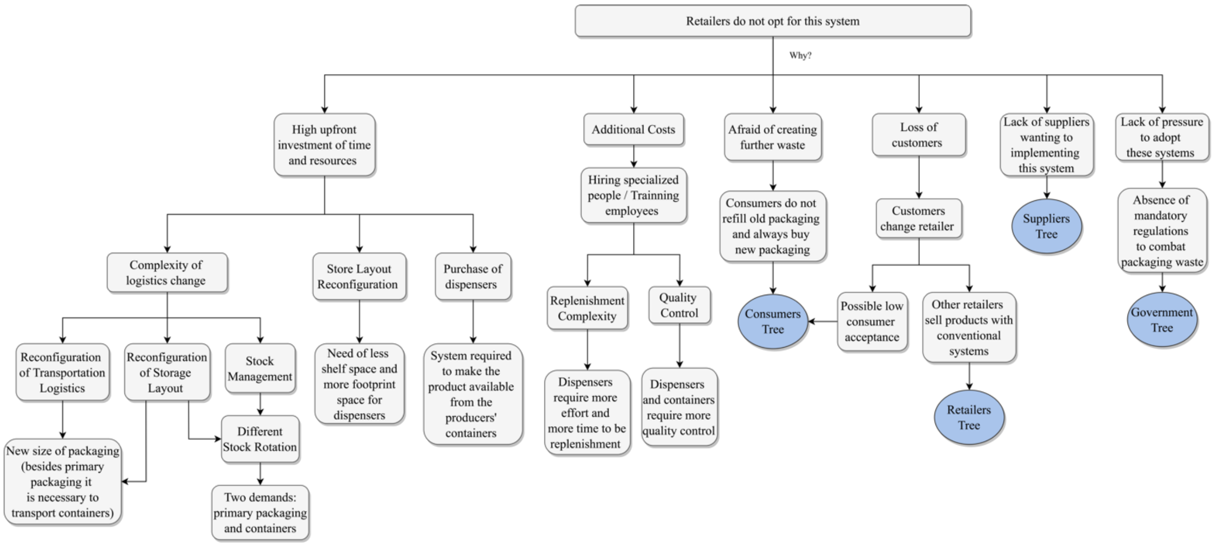


Figure 9: Problem tree diagram for retailers

For retailers, Figure 9 illustrates with a tree of causes, the several reasons found for the problem of retailers not wanting to adopt the reusable packaging system. As shown, six main causes were identified:

1. High upfront investment of time and resources;
2. Additional costs;
3. Afraid of creating further waste;
4. Loss of customers;
5. Lack of suppliers implementing this system;
6. Lack of pressure to adopt these systems.

Once again, for **cause 3, 5 and 6**, the root causes depend on the reasons for the non-implementation of the systems by governments, consumers and retailers respectively.

Moreover, **cause 1** reveals the same type of difficulty as suppliers: the investment of time and resources required to be able to implement these systems due to the major change required in operations and logistics.

Furthermore, another major constraint is the increased costs arising from this new system, highlighted by **cause 2**. As hygiene and safety must be a key focus, quality control is no longer just the responsibility of suppliers, but becomes mandatory and regular in retailer operations. Therefore, more staff are needed to take charge of the different product dispensers, not only for when they need to be replenished but also to ensure that all hygiene and safety conditions are ensured. An operation that was not necessary with conventional packaging.

Finally, **cause 4** demonstrates other relevant information, which is that if this change of systems is not generally implemented in retailers, there may be a loss of market share as customers, who do not like it or do not want to adapt, will eventually switch to those other competitors who do not have these systems in place. This cause becomes a dilemma because it creates a loop in the tree, i.e. retailers don't want to implement it because other retailers don't want to implement it and these other retailers don't want to implement it because others don't want to implement it.

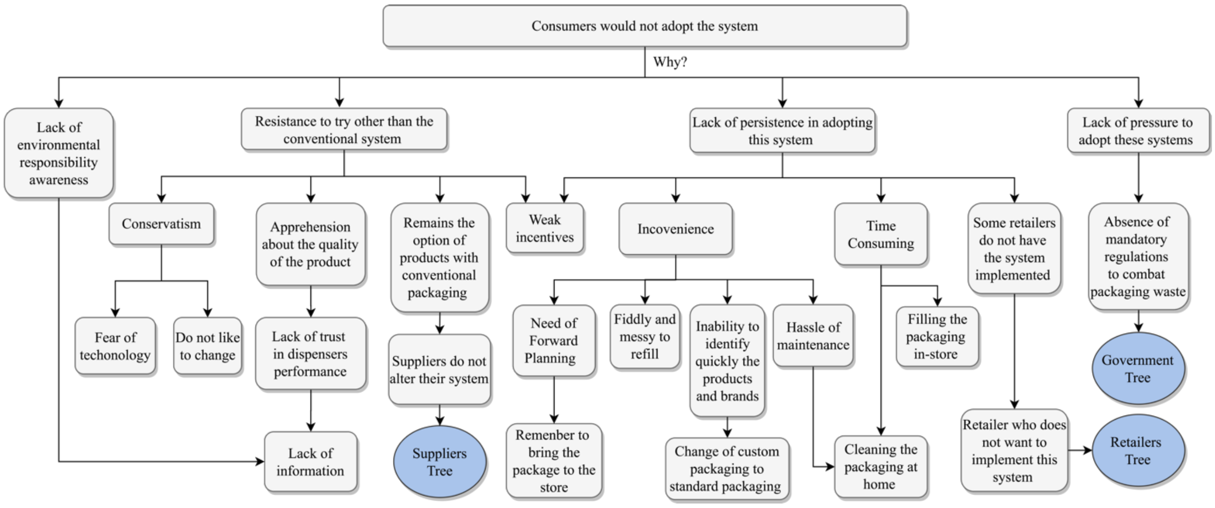


Figure 10: Problem tree for consumers

In terms of consumers, Figure 10 illustrates with a tree of causes, the several reasons found for the problem of consumers not wanting to adopt the system. As shown, four main causes were identified:

1. Lack of environmental responsibility awareness;
2. Resistance to try other than the conventional system;
3. Lack of persistence in adopting this system;
4. Lack of pressure to adopt these systems.

This time, while there are some root causes that depend on the reasons for non-implementation of systems by governments, suppliers and retailers, these are a minority and there are many other root causes.

The main causes arise from the fact that the system imposes the change of many habits and that there are not enough incentives to force and support this leap. In addition to the fear of change and the conservatism very present in society (**cause 2**), this system requires consumers to clean and bring to the shop their own packaging if they do not want to pay more, as well as spend more time in the supermarket to fill packaging for each product (**cause 3**). In this sense, strong incentives are needed to prevent the inconvenience of the system from prevailing. Thus, without the general adoption of this system by suppliers and retailers, or the legal imposition of government (**cause 4**), consumers will prefer convenience and not change their habits to a social environmental responsibility as much information is lacking on the visible consequences of this problem (**cause 1**).

Consequently, without incentives and external pressure, there are quite a few reasons to downgrade regular consumption with this system.

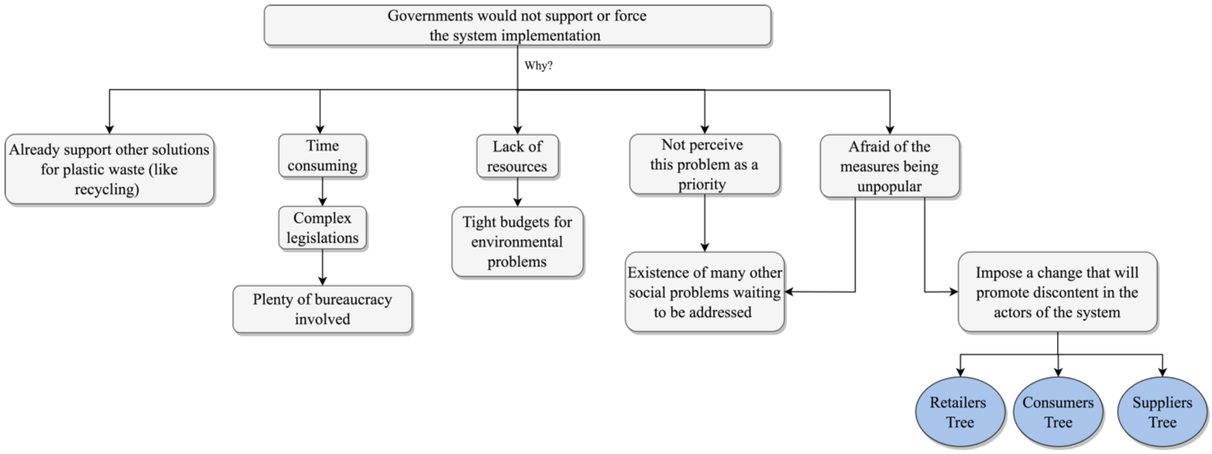


Figure 11: Problem tree for governments

As discussed above, analysing the possibility of government entities intervening and supporting this system enriches the analysis since it is one of the options to foster the general implementation of reusable packaging systems in the sector.

In matters of drivers, in addition to the objectives that several 150 countries, including Portugal, have committed themselves to meeting through the Sustainable Development Goals (SDGs) that include cultivating sustainable actions, the growing environmental awareness can offer a reason for popularity among voters. That being said, not everything is a bed of roses or otherwise these systems would already be in place since they were not invented yesterday. Therefore, it is fundamental to analyse the potential obstacles to this government support.

Figure 11 illustrates with a tree of causes, the several reasons found for the problem of retailers not wanting to adopt the reusable packaging system. As shown, five main causes were found to the detriment of government support:

1. Already support other solutions for plastic waste, like recycling;
2. Time consuming process;
3. Lack of resources;
4. Not perceive the problem as a priority;
5. Afraid of the measures being unpopular.

There are several reasons that make it difficult to motivate government stakeholders to commit to such initiatives, especially because of lack of time and resources, bureaucracy complexity and initiatives popularity.

Starting with the latter (**cause 5**), its root cause is all the reasons found in previous trees. Indeed, if the government imposes the implementation of these systems (with the characteristics defined in the problem), many of the causes of the problems will become a reality for the actors involved, meaning that this measure will not be received with open arms.

On the other hand, if the strategy is not to impose but to invest in these systems and support their implementation, the time it will take (**cause 2**) and the scarcity of budget due to bureaucracy involved (**causes 3**), makes this hypothesis very unlikely.

Moreover, given how much has already been invested in recycling as a solution to the plastic problem, this problem appears to be tackled rather than being a priority compared to the number of remaining problems waiting to be addressed (**causes 1 and 4**).

In view of this complicated scenario, it is still an option that must be considered, since investigating all possible options is a fundamental process in finding and developing an ideal solution.

5.2.4 | Analysis of Tree

At this stage, the aim is to analyse the four trees and to understand what conclusions can be drawn for the consequent phase of developing a solution.

Although the construction of the trees has provided crucial information in terms of the various causes that prevent the implementation of these systems for each actor, many of which are rather difficult to address, it was conceivable to find a vital common pattern in the causes among the four trees. This pattern is the result of the existence of a root cause, in all of them, which depends on implementation of the system by all other actors. Accordingly, even if it is possible to tackle all the other root causes of one of the actors, apart from dependence on the others, if there are still valid reasons for not being adopted by the others, the system will not work.

This dependence thus reveals the requirement for some kind of collaboration and commitment between the different actors for this type of solution to be viable. Consequently, every root cause of each player is equally important and must be solved within the new solution, so that there is even a chance of it to work. A conclusion which is consistent with the previous studies published about the need for collaboration (Ko *et al*., 2012; Li *et al*., 2014; Zhang *et al*., 2015).

Besides this finding, when examining all the different diagrams, it is also possible to conclude that some of the reasons outlined are common to all system participants (suppliers, retailers and consumers), highlighting some of the particularities and characteristics of this type of system:

- *Time constraints and inconvenience* – in all trees extra time is required from the actors, which for all purposes results in an inconvenience for their activities. For suppliers and retailers, time invested to reorganize operations and all the logistics of new operations, as well as more time wasted with quality control. The great inconvenience is that due to the size of the change, their activity will have to stop for some time, incurring additional costs and other consequences for the business;

  For customers, not only additional time is required in the purchasing process due to additional activities of bringing, filling and cleaning their packaging, but it is rather the additional inconvenience derived from customers having to clean the packages, unnecessary confusion when filling the packages or having to remember to transport the containers to the store;
- *High Upfront Investment –* both for suppliers and retailers, an extra effort is required to implement this system. The new system with their new activities, such as managing both secondary and primary packaging production, the new reverse logistics and cleaning process for secondary packaging, the need for more space and new equipment, among many other aspects makes the initial investment quite high for suppliers. Similarly, the new layout of the store, the additional space required, and the purchase of dispensers also makes the investment of retailers quite high.

  Therefore, the change may not be accessible to any company due to the size of the investment and time required;
- *Lack of incentives-* without government incentives and external pressure, the above reasons keep suppliers and retailers away from this change. For consumers, some kind of incentives are crucial in order to compensate for the change in common habits and the additional time wasted;

- *Logistics Complexity* - considering suppliers and retailers, due to the addition of the reverse process and the new stream of packaging, all the logistics involved becomes much more complex to manage, plan and execute than the conventional process. Thus, the Logistics complexity parameter serves to characterize all these difficulties added to the supply chain;
- *Safety and Hygiene-* this aspect arises in all trees since, once there are no more sealed packages, it becomes a concern of all. Both retailers and suppliers see this as a major obstacle, as the difficulty of providing the same level of quality as the conventional system becomes quite complicated and requires much more quality control processes. In the same way, as the washing and filling of the packaging are the responsibility of consumers, the probability of contamination of the product is quite high causing a feeling of insecurity in consumers;
- *Loss of brand recognition-* the loss of brand identity due to distribution being done through dispensers, creates impediments for all actors. For the suppliers, more than the quality of the products, it is through the packaging that they are distinguished from the rest of the competition, so the brand will lose a lot of value. Besides, the retailers won't have margin of differentiation of layout offer to the suppliers, making it much more difficult to charge more for products exhibition on strategic positions as the usual shelves at eye level. Finally, consumers raise a lot of concerns because without identification packaging, it will become much more difficult to distinguish products at home.

The other causes found are not shared by the different actors and are of less complexity to solve. Therefore, having these more crucial causes discovered, the next step is to first define the approach for their resolution, and only then adjust and make minor improvement changes to the less significant causes still present. This way, there is a greater likelihood of creating an effective and sustainable solution to the problem.

5.2 | Market Research

In this section the aim is to find and study other initiatives that promote reusable packaging systems other than the known and already studied zero waste stores. Thus, it will be analysed initiatives which, although not operating in the mainstream, have been developed in recent years to tackle the problem of packaging waste through reusable packaging.

This analysis will focus on characterising the context of each initiative, understanding whether the problems encountered in the previous section also remain and, finally, analysing what benefits each initiative offers. Finally, based on this assessment, it will be possible to identify which best practices must be a part of the reusable packaging system to be proposed, in order to ensure its success.

5.2.1 | Benchmarking

The Benchmark method allows to assess all these aspects in order to identify new benefits of these systems and how they can be obtained, as well as learn successful practices for the discovered causes of the problem. The analysis will follow the five steps mention in the methodology: Study Planning, Data Collection and Data Analysis.

5.2.1.1 | Study Planning

The first step, according to the Benchmarking wheel (Andersen, 1999), is to choose the critical success factors to evaluate the benchmarking partners.

The choice of these factors derived from the previous analysis, whereby the problematic aspects discovered in the previous analysis will be employed as parameters of the study. In this way, it will be possible to understand if these problems are also found among the benchmarking partners or why they are not, serving as a learning tool to solve them. However, before listing the previous parameters, another factor should be included in the list when analysing these initiatives. As the goal is to create a solution for mainstream retail, it is essential to be sensitive to the scale of the system proposed by the initiatives. Therefore, another decisive factor that makes a system viable or not, for the big context, is its capacity to be widespread and to be implemented in the mainstream retailers (the final objective in question). Accordingly, many systems operate perfectly on a small scale but are incompatible on a large scale due to the lack, mainly, of economies of scale, making this factor crucial for the analysis of initiatives.

Finally, the parameters to be considered for each of the initiatives are categorized in the nine following problematic aspects:

- Purchasing Habits Change Inconvenience
- Time Constraints
- High Upfront Investment
- Collaboration Need
- Lack of incentives
- Lack of Economies of Scale
- Logistics complexity
- Safety and Hygiene
- Brand recognition

Although analysing how other initiatives tackle these problems, or not, is of considerable importance, analysing only this type of parameter can provide a misleading view of reality. Simply because the system proposed by an initiative may even solve the problems, but at the expense of losing benefits that may be determinant for its success. Therefore, the analysis should also consider, as parameters, the benefits that the benchmarking partners' systems offer, in order to compare them also in terms of added value.

For this purpose, the advantages proposed in the literature review will be used as yardsticks. According to Lofthouse *et al*. (2009), Yusef *et al*. (2017), Coelho *et al*. (2020), among others, the main advantages and drivers for the implementation of reusable systems are:

- Customisation
- Operations Optimisation
- Brand Loyalty and Customer Retention
- Reduced Waste

Customisation is one of the advantages provided by reusable packaging systems since some systems accommodate individual needs by allow users mix and match flavours, personalise packaging or choose desired quantities. The optimization of operations is also a benefit of these systems derived from the common practices of standardisation of packaging or shared logistics and cleaning facilities across brands, sectors or wider networks, e.g. in combination with a third-party packaging/service provider. In addition, these shared activities enable to reduce on transportation and packaging costs. Besides, brand loyalty and customer retention are the main features of these systems because, through the usual deposit and reward schemes implemented with these systems, clients become easily attached to the system. Finally, the great advantage, and the one that is essential to solve the core problem of the issue, is that these systems make it possible to greatly reduce the waste of plastic.

It should be noted that although these authors have also focused on more concrete and quantitative economic and environmental advantages, such as cost and emission reductions, these advantages depend on numerous factors and will therefore not be considered in this comparative analysis. Moreover, if in the course of collecting information any other relevant advantage or problem are perceptible, they should be added to this list of success parameters.

To this end, these seven problems and four benefits are the parameters that will be used to analyse the benchmarking.

5.2.1.2 | Study Search

Moving on to the second step of the analysis, the benchmarking partners will now be defined.

First of all, the main characteristic of the benchmarking partners has to be that they must all have reusable packaging systems implemented. Then, since there are no companies with these systems in the big retail context, the remaining features for choice have to be common features among the companies that are in this context. This way, it will make it possible to reduce the gap between the context in which the chosen companies operate and where it is intended to implement these systems they practise, i.e. in the context of supermarkets.

Therefore, in order to compare with the context of supermarkets, the initiatives and organisations that should be studied should have, as their core products, products that are also sold in supermarkets and within the defined study scope. For example, to study a company employing a reusable packaging system for household appliances, although it is always possible to collect and learn valuable information, does not have the same valuable knowledge as studying a company reusing beverage packaging, since such products are common to both contexts.

In view of these conditions, the benchmarking partners chosen were: Loop, The Wally Shop, Hepi Circle, CoZie, Plaine Products and MIWA. These were chosen because, firstly, they all fall within the defined scope in terms of industry and, secondly, these are the initiatives with the largest size for each type of system currently on the market, thus serving to represent each, as well as being the initiatives with the closest scale to the supermarket dimension. And finally, they all sell products that are easily found in any supermarket.

In terms of similarities, they all rely on reusable packaging systems, albeit in different ways, and aim to promote the reduction of plastic packaging waste. On the other hand, in terms of differences, they can be distinguished on the basis of the business-to-consumer reuse model that each employ. These business models differ in terms of packaging ‘ownership’ and the requirement for the user to leave home to refill or return the packaging. According to Ellen Macarthur Foundation (2019), this type of systems are categorised as:

1. 'Return on the go', characterised by users returning the packaging at a store or drop-off point (e.g. in a deposit return machine or mailbox);
2. 'Return from home', since the packaging is collected at home by a collection service (e.g. a logistics company);
3. 'Refill on the go', where users refill their reusable container at stores;
4. 'Refill to Home', however this will not be represented by any initiative since, as previously studied, this type of system is quite common and therefore it is already possible to observe its results of how the system does not work in combating the problem to be solved, reducing the waste of plastic packaging.

The analysis of the six companies will allow to evaluate and learn which are the best practices available in the market.

5.2.1.3 | Data Collection

In this third step, all available information was collected to characterise each initiative according to the indicators mentioned above. Although several attempts have been made to contact the companies, in order to collect primary data, due to the pandemic situation no response could be obtained from any initiative. Therefore, it was only possible to collect secondary data. This data was thus collected through company publications and registers, articles, websites and news about them.

As the aim is also to analyse the different types of systems, the initiatives are then organised according to the categories of systems defined by Ellen Macarthur Foundation (2019). Starting with the first model category, 'Return on the go', Hepi Circle, Cozie and Plaine Products are the most predominant and largest scale initiatives using this model. Although each is based on this model, they all differ in some specifications and have therefore been chosen to serve as a good sample of the different strands of this type of model that exist in the market.

Hepi Circle

In 2017, Enviu started the initiative Hepi Circle, Indonesia's first refill delivery network that, with the aim of replacing hard-to-recycle sachets, allows users to purchase small quantities of household products in reusable bottles. The system consists of customers purchase a small refillable bottle with a household product (e.g. detergent) from Hepi Circle through a warung (local family-owned convenience store) and, once they have used the product, the empty bottle is exchanged at the warung for the purchase of a full bottle. Once returned, the empty bottle is shipped to a central location where it is cleaned and refilled, and then redistributed to the warungs through a delivery system powered by women on bikes.

Looking at the system according to the selected parameters:

- Time Constrains and Safety and Hygiene problems solved - as the company is responsible for cleaning and refilling the packaging, consumers no longer waste time and there is no longer a danger of contamination of the product. However, the initial investment problem prevails since new facilities and equipment are needed to carry out these operations, as well as the complexity in logistics because it is necessary to manage all the logistics of a new packaging cleaning process as well as all about the new reverse logistics;

- Lack of incentives problem solved - through its incentive policy that, above a certain number of returns, customers receive rewards, such as a free top-up or for return purchases, coupled with the fact that the price charged is equal to that of common sachets;
- Lack of economies of scale problem solved - due to only one standard packaging for all products, it is possible to benefit from growth with economies of scale. In addition, this standardization allows the desire advantage of optimizing operations in transportation and washing process;
- Brand Loyalty advantage achieved- the system offered incudes a deposit on each bottle purchased in order to promote the return of the empty packaging, which consequently ties consumers to this system;
- Reduced Waste advantage achieved - the start-up registered a reduction of 20 kg of plastic packaging from the results of the shopping since 02/2019 (Hepi Circle, 2020).

Nevertheless, Hepi Circle has been experiencing problems with returns with most people using the bottles to store spices and other products instead of returning them. Thus, the inconvenience problem, associated with the need to remember and bring the empty packaging to exchange for a new one, continues to be a major obstacle to this system. Moreover, since this system has been in operation for over 3 years and it can only be found in 3 warungs throughout Indonesia, one question that arises is whether the necessary collaboration shall be beneficial or not to both parties.

At last, even if the standard packaging for all products enables economies of scale and optimized operations, the brand recognition through packaging is lost. In this way, this so crucial problem for suppliers, when it comes to valuing their brand in the eye of the consumer, loses its strength with standard packaging.

CoZie

Also founded in 2017 by Emeric Baracat, Louise Salvati and Arnaud Lancelot, CoZie has developed a bulk dispensing machine for cosmetic liquid products that allows users to stock up to the nearest millilitre. All containers are glass, reusable and refillable, and these as well as the products are available in 335 points of sale in France, although none of them are supermarkets. Customers at store can buy CoZie products in already filled containers or in empty containers and fill them with the quantity of their choice thanks to the dispensing machine Dozeuse. The special design of the dispensing system created and patented by the company allows to stock the cosmetic products in airless bags to maintain the product shelf life and to prevent contact between the formulas and the machine, avoiding contamination. Once the product is finished, customers have to bring the empty containers back to the store where they are collected and then sent to an ESAT (establishment and service for work assistance) to be washed and then redistributed to vendors. However, the pumps offered cannot be washed and instead are only collected for recycling thanks to the partnership with Terracycle.

In terms of the selected parameters:

- Inconvenience problem solved – since it is not necessary to bring the empty packaging to buy another one and it is possible to bring all the empty packaging later when it is convenient to recover the deposits, the system does not become inconvenient;
- Time constraints problem solved - as the company offers the option of undertaking the cleaning and refilling process, consumers no longer waste time. Although there is also the possibility for consumers themselves to fill their packages, this is a choice for those who prioritise customisation over time, there being always the option of buying the packages already filled;

- Lack of economies of scale problem solved – as the company is responsible for reverse logistics and cleaning of packaging, the higher the volume of bottles sold, the easier it is to reduce the unit costs of transport and cleaning. However, the lack of standard packaging makes it impossible to optimise operations and take full advantage of growth;
- Brand recognition problem solved - as this system continues to sell individual and not standardised packaging, the communication of the brand does not require any major changes, being possible to continue to distinguish the brand and its products by the packaging;
- Brand Loyalty advantage achieved- the system offered is based on users paying EUR 1.5 per container in the first purchase and the same amount is deducted from the user's next purchase when bringing back empty containers to a store selling CoZie cosmetics. This deposit system not only promotes the return of the empty packaging but also tie consumers to this system;
- Reduced Waste advantage achieved - according to a study performed by the EVEA firm, CoZie system allows reducing carbon emissions by 79% compared to containers thrown in the trash, and the company claims to have already recovered over 50% % of CoZie containers on the market (CoZie, 2020);
- Customisation advantage achieved - this system allows consumers to customize their products as they can choose the quantity of product to buy.

However, due to this customised offer, a large initial investment is required, whereby the company balances by promoting its products as high-end and applying higher than normal values (e.g. CoZie toothpaste costs 11 euros). Due to these prices plus deposit, there are no incentives that make the vast majority of consumers prefer these products and consequently this system.

As in the previous initiative, the entire reverse logistics management and washing process makes this system quite complex in terms of logistics, requiring logistical changes by all stakeholders. Moreover, the fact that it is offered the option of buying products that are already full or filled at the dispensers in-store still adds a whole new difficulty and complexity in logistics, not only for suppliers but also for retailers. Thus, the system lives on collaboration and if it fails the system becomes impractical.

Finally, the problem of safety and hygiene is not completely overcome because, even though the company washes the packages and provides specialised dispensers for the purpose, some packages are filled in the store by consumers increasing the probability of product contamination.

Plaine Products

Launched in 2017, Plaine Products is a United States environmentally friendly company that provides custom, small batch and private label products through reusable aluminium cans. It is specialized in luxury all-natural and vegan products to nourish hair and body while promoting a circular economy business. The major difference to the previous initiatives is that the process of buying and returning products is all online and through the post office rather than at physical points of sale. It works with customers first ordering products online, receiving these products in reusable packaging in a cardboard box, that already contains the paid return label to future return of empty packaging for washing and refilling.

Assessing from a parameter perspective:

- Collaboration problem solved – since there are no intermediaries, the reverse logistics is paid to an external entity, in this case the post office, avoiding the sharing of tasks and the management of supplies;

- Safety and Hygiene problem solved - as the company is responsible for cleaning and refilling the packaging, consumers no longer waste time and there is no longer a danger of contamination of the product. However, the initial investment problem prevails since new facilities and equipment are needed to carry out these operations;
- Brand recognition problem solved - as this system continues to sell individual packaging, the communication of the brand does not require any major changes, being possible to continue to distinguish the brand and its products by the packaging;
- Reduced Waste advantage achieved - according to Plaine Products 2018 Sustainability Report, in 2018 the sale of these products prevented the creation of more than 11,670 kilograms of carbon dioxide, equivalent to the emissions generated from powering 1,397 homes in one year, and an additional 1,805 kg of carbon dioxide was prevented by replacing 39 000 plastic bottles that would have been sent to landfills. Furthermore, the use of aluminium instead of plastic allows bottles to be recycled without any quality loss, so that an infinite number of times can be processed into other aluminium products, unlike plastic which, when recycled, is downgraded and can only be recycled once or twice;

On the other hand, the fact that all logistics is carried out through the post office intensifies the problems of inconvenience, as consumers have to dislocate to the post office to return the packages, time wasted, in queues on the post office, complexity in logistics, since most of the process relies on an external entity and its independent management, and finally, it is not possible to take advantage of economies of scale because transport is outsourced. Moreover, depending on the quantity and the category of the product the prices vary but in general products of 500ml cost $30, a deposit fee is not required, but shipping costs are paid in addition. The shipping is via USPS to all fifty states in the U.S., Puerto Rico and APO addresses, which for these it is charged a flat $5 shipping fee for all orders under $100, over that amount the shipping is free. Due to these prices, there are no incentives that make the vast majority of consumers prefer these products and consequently this system. In addition, without a deposit policy, the opportunity to lock consumers into the system is lost.

For the second category, it is possible to study the Loop initiative, that is currently expanding and gaining great attention, and the Start-up 'The Wally Shop' in operation in NYC for the last 3 years, which in fact was the inspiration for the Loop initiative.

The Wally Shop and TerraCycle's Loop

The Wally Shop is a start-up founded in 2017 in Brooklyn offering a last-mile delivery infrastructure to online zero-waste shopping. The online store delivers bulk groceries (primarily pantry goods), home goods, and personal care items at fair prices in returnable containers made from durable, reusable plastic. The process starts with customers ordering local, organic groceries and products online through The Wally Shop. The service's shoppers/couriers visit farmers' markets and bulk shops to acquire fresh produce and other household essentials, which are delivered on the same day directly to the customer, all via bicycle.

There are no price mark-ups, so customers pay exactly the same price as in store, however service and delivery fees are added to underpin operations as well as deposit payment for the packaging, which they get back when the packaging is returned. Empty packaging is picked up on a subsequent delivery, and the Wally Shop cleans and reuses the packaging.

Later in 2019, with the aim of expanding this type of service to mainstream consumer products and thus attract more demand, the company Terracycle developed the Initiative 'Loop' following the similar "milkman" business model but customized to today's times. Currently available in the Mid-Atlantic United States and Paris, Loop is a global circular shopping platform designed to eliminate the idea of waste by transforming premium products and packaging of everyday items from single use to reusable. It offers about 300 items from Tide detergent, Pantene shampoo, Häagen-Dazs ice cream to Crest mouthwash.

In partnership with major brands such as P&G, Nestlé, PepsiCo, Unilever, etc., the platform streamlines return for the user by offering delivery and pickup of products and empty packaging, removing hassle for the brand owner by taking care of reverse logistics, cleaning, sanitation, and redistribution. When the packages are no longer suitable for use, the synergy of Terracycle's own recycling business is harnessed by recycling them. Nevertheless, to maximize the number of reuses, Loop packages are made out of durable materials like stainless steel, aluminium, glass and engineered plastic. Besides, only reusable and products that can be recycled into the same products at their end-of-life are accepted in the Loop platform. Appendix H demonstrates the system explained.

Looking at these 'return from home' systems according to the parameters:

- Lack of economies of scale problem solved – as the company is responsible for reverse logistics and cleaning of packaging, the higher the volume of bottles sold, the easier it is to reduce the unit costs of transport and cleaning. However, the lack of standard packaging makes it impossible to optimise operations and take full advantage of growth;
- Time constraints - although there is the inconvenience of having to be present to receive the products, keep them when they are finished and then return them to be washed, as the company travels to the customers' house extra travel or more work is avoided and no time is wasted;
- Safety and Hygiene problem solved - as the company is responsible for cleaning and refilling the packaging, there is no longer danger of contamination of the product. However, the initial investment problem prevails since new facilities and equipment are needed to carry out these operations;
- Brand recognition problem solved – it was solved by with the change of the system from Wally shop to Loop, since, with the partnership of the brands, the products are delivered to customers in branded packaging and not in standard packaging. Hence, the communication of the brand does not require any major changes, being possible to continue to distinguish the brand and its products by the packaging;
- Brand Loyalty advantage achieved - in addition to the regular cost of the item, customers must pay a refundable deposit for each package. Regarding Loop, the deposit varies from about 25 cents for a bottle of Coca-Cola to $47 for a Pampers diaper bin. This deposit system not only promotes the return of the empty packaging but also tie consumers to this system. Besides, one of things that only happens in this system is that even banged up packages earn back the deposit, clients therefore only lose it if they fail to make a return;
- Reduced Waste advantage achieved - it has been conducted life-cycle analyses to try to estimate the environmental impact in a variety of situations. The 3rd party Long Trail Sustainability revealed that Loop breaks even with traditional supply chains in as few as 3 use. By 10 use cycles, Loop has nearly 35% lower environmental impacts compared to regular eCommerce and approximately 20% lower environmental impacts than regular Retail. However, it was pointed out that carbon emissions from trucking could outweigh the environmental benefits of Loop if packages are only reused a few times, or

if the transportation system is too spread out. Overall, Loop has lower environmental impact than traditional in-store retail and eCommerce models with the environmental savings increasing per use of package (Loop, 2020).

On the contrary, since it is added a $20 flat rate shipping fee to all orders, even though the items' prices are comparable to what they would be at a nearby store, there is no incentive whatsoever to prefer this system. In addition, the possibility of customising orders provided by Wally Shop, i.e. customers could order the quantity they wanted of each product, was a way of incentive, however this option is no longer available with the Loop model.

Furthermore, not only is the logistics of home deliveries and collections more complicated than the common retail logistics, this system is also much more inconvenient for customers as they need to schedule visits with all this management of storing packages and calling the company to collect them. Finally, although one of the players, the retailer, is eliminated, collaboration on this system remains vital as the adaptation of suppliers' packaging and filling process are necessary in order for the closed packaging cycle to work.

Finally, in order to complete the characterisation of initiatives using reusable packaging systems, consideration must be given to the last category, which has been the biggest focus in recent years. This attention is due to the great expansion of the well-known and already analysed zero waste stores. As previously characterized, this 'Refill on the go' system, featured by its small local environment makes it work but only in a niche market, discouraging the bigger market players from adopting its system.

Therefore, in today's fast-paced, globalized world, only something a little more efficient could be adopted for the large retail surfaces. Accordingly, the company MIWA believes that engaging new technologies can be a first step to making reusable models work in today's retail reality.

MIWA

Since 2014, the Czech company MIWA has been developing smart solutions that help consumers, retailers and manufacturers overcome barriers in pre-cycling methods adoption. Accordingly, the company created an innovative, financially sustainable circular distribution and sale system for food and non-food products with reusable packaging. However, was only in September 2019 that the system was employed with the company opening the first store equipped with MIWA technology in collaboration with their development partner - Country Life. There it is possible to find eight MIWA modules with bio quality products.

In terms of the system, the concept is based on two reuse loops – delivery and consumer. Within the delivery loop, MIWA provides standardised, smart-powered reusable capsules to manufacturers who fill the capsules and send these through the supply chain for direct instalment at retailers. The reusable capsules are equipped with a hygienic insert pouch and are hygienically sealed after manufacturers have filled them, working in tandem with intelligent dispensing equipment, which ensures high product safety of in-store dispensing and facilitates the collection of product tracking information. After being transported into the store, they are then directly clicked into a smart modular shelf with smart valves, equipped with RFID/NFC tags enabling to send real-time stock data to the retailer monitoring system. These avoid the need to open the capsules, thus risking contamination or shortening the expiration.

The reverse process is based on shipping the empty capsules back to MIWA for cleaning, while the inner hygienic pouch goes for a controlled recycling. Finally, clean capsules with new pouches are redistributed to the manufacturers and the delivery loop repeats. The capsules are offered to the companies as a service and remain in the ownership of Miwa, enabling the company to keep the control over the materials.

Regarding the consumer loop, it is still under development and until now, for the shopping, consumers can use their own containers or the offered reusable ones in-store and there is no reverse process, leaving maintenance and cleaning of the containers to the consumers. The containers offered by MIWA are smart food containers that communicates with dispensers and the cash-desk system, avoiding the need to tare it or scan labels. Simultaneously, the company created a shopper app where consumers can view the information about the product bought, including expiration, instructions for cooking, allergens, etc, and at the same time pay for the purchases at the store. At the end of its life span consumers can return it to stores and MIWA takes care of the controlled recycling of the cup.

Therefore, the company argues that by creating a circular system of reusable capsules and containers, using smart technology, turns the system well adaptable for today's logistics and fit the logistic and hygienic standards of today's needs. The Appendix I illustrates the different components and actors of the system.

Assessing from a parameter perspective:

- Lack of incentives problem solved - through its incentive policy that, above a certain number of returns, customers receive rewards, such as a free top-up or for return purchases, coupled with the fact that the price charged is equal to that of conventional packaging products;
- Lack of economies of scale problem solved - due to standard packaging for all products, it is possible to benefit from growth with economies of scale. In addition, this standardization allows the desire advantage of optimizing operations in transportation and washing process;
- Reduced Waste advantage achieved - in 2018, an LCA was conducted by the University of Chemistry and Technology in Prague and it was concluded that in comparison to the normal distribution of food in disposable packaging, MIWA can reduce the overall negative environmental impact up to 71%. In the study, numerous factors were considered besides packaging waste reduction, such as eco-toxicity, fossil fuel consumption, influence on climate change, and water consumption (MIWA, 2020);
- Customisation advantage achieved - this system allows consumers to customize their products as they can choose the quantity of product to buy.

Although it has not been considered as a parameter, this model of system reveals a new advantage that can facilitate and contribute to the success of these systems and as such should also be considered as a parameter. That advantage is Smart systems. MIWA's new technology, with smart valves and smart containers connected to the consumer app, provides crucial and up-to-date information on the condition of the products. The smart valves equipped with RFID/NFC tags to send real-time stock data to the retailer monitoring system, facilitating the re-stocking process as dispensers warn when there is product shortage or when the product is not in good condition, either due to temperature or pressure.

In addition, the technology implemented in the smart containers for consumers allows to hold all the information necessary for the consumption of the product with even safer conditions than the common packaging, since the information is constantly updated in the application according to the state of the product.

On the other hand, in terms of the system's counterparts, as in this system there is not only one cycle but two and three in the future, the logistics triples in terms of complexity and management, and many adaptations are needed by all the parties involved, emphasizing the large initial investment required. Consequently, collaboration becomes again the essential success factor.

Furthermore, this system does not solve the problems of inconvenience and time wasted due to the tasks of cleaning and filling the packaging falling under the responsibility of consumers. Likewise, the problem of safety and hygiene is not completely overcome because, even though the company washes the suppliers' capsules and provides specialised dispensers for the purpose, the consumer packages are filled in the store and washed by consumers, increasing the likelihood of product contamination. Finally, just like in zero waste stores, with clients taking their own packaging to replenish products, brand recognition and communication on individual packaging ceases. This is a problem that gains greater proportion since it becomes impossible for brands to differentiate their products once outside the store.

5.2.1.4 | Data Analysis

Moving on to the fourth stage of this analysis, the aim here is to analyse the information gathered to draw useful conclusions about which operations have value added as well as those that should be avoided. The analysis will thus be performed on the basis of comparing the outcomes of the different systems used in each initiative.

Starting with the parameters regarding possible problems adjacent to reusable packaging systems, the aim is to understand whether or not these are present in these proposals. In cases where they are not, the point is to understand which conditions or characteristics of the system make it a non-issue.

In order to facilitate the comparative analysis, the results obtained for each initiative were aggregated into the following two tables, one for the problems and one for the benefits. In terms of evaluation, each initiative was classified according to the parameters analysed in the previous analysis, and the classification for each parameter was always given in comparison with the conventional system for disposable packaging in large retail surfaces, i.e., whether the proposed system is more or less inconvenient (for example) than the conventional system.

Hence, for Table 2, the classification is given by the blue check symbol, if the initiative does not aggravate the problem in question, and the black cross symbol, if it does. Taking the Hepi Circle initiative and the question of the need for collaboration as an example: the classification is black since the system requires an additional arrangement with retailers so that the service of returning empty packaging and delivering the deposit and the new packaging becomes possible. On the contrary, as regards the lack of incentives, the rating is blue, since the prices charged are the common ones and in addition there is a policy of incentives that, above a certain number of returns, customers receive rewards, such as a free refill or for return purchases.

Accordingly, the classification given to each initiative in terms of problems tackled can be consulted in Table 2 below:

Table 2: System's issues benchmark

		Purchasing Habits Change Inconvenience	Time Constraints	High Upfront Investment	Collaboration Need	Lack of Incentives	Lack of economies of scale	Logistics Complexity	Safety and Hygiene	Brand Recognition
Return on the go	**Hepi Circle**	✗	✓	✗	✗	✓	✓	✗	✓	✗
	CoZie	✓	✓	✗	✗	✗	✓	✗	✗	✓
	Plaine Products	✗	✗	✗	✓	✗	✗	✗	✓	✓
Return from home	**The Wally Shop**	✗	✓	✗	✓	✗	✓	✗	✓	✗
	Loop	✗	✓	✗	✗	✗	✓	✗	✓	✓
Refill on the go	**Zero Waste Stores**	✗	✗	✗	✓	✓	✓	✓	✗	✗
	MIWA	✗	✗	✗	✗	✓	✓	✗	✗	✗

✓ Problem tackled ✗ Problem not tackled

The same analysis was carried out, but for the possible advantages offered by reusable packaging systems. The classification was assigned exactly with the same criteria of the previous analysis changing only the blue colour to yellow, in order to facilitate the differentiation of the two analyses. Accordingly, the classification given to each initiative in terms of benefits achieved can be consulted in Table 3 below:

Table 3: System's Benefits Benchmark

		Customisation	Operations Optimisation	Brand Loyalty	Reduced Waste	Smart Systems
Return on the go	**Hepi Circle**	✗	✓	✓	✓	✗
	CoZie	✓	✗	✓	✓	✗
	Plaine Products	✗	✗	✗	✓	✗
Return from home	**The Wally Shop**	✓	✓	✓	✓	✗
	Loop	✗	✗	✓	✓	✗
Refill on the go	**Zero Waste Stores**	✓	✓	✗	✓	✗
	MIWA	✓	✓	✗	✓	✓

✓ Benefit achieved ✗ Benefit not achieved

Once the classification has been assigned, it is time to assess the findings of this analysis. First of all, the first conclusion, that can be drawn from Tables 2 and 3, is that none of these initiatives can solve all the problems or provide all the benefits encountered. The second is that in any initiative, with a focus on circular economy and thereby ensure the waste reduction benefit, a large initial investment is required because a reverse process is added and, even if it differs from system to system, it is necessary to invest in infrastructure and processes to enable the closing of the cycle. As there is no other direct and immediate perceptible conclusion from the tables, it is necessary to analyse each parameter individually and perceive, which initiatives have a favourable classification in order to discover the common characteristics of the systems that enable this outcome.

Inconvenience

The only initiative that manages to eliminate this problem is CoZie. Accordingly, the characteristic that only this one has, and that therefore allows the adaptation of the system not to be as inconvenience, is that there is no need to change or adapt the normal shopping routine for consumers. Consumers just have to go to the supermarket as usual and collect a full package, ready for the product to be consumed. In addition, the return process is also convenient because consumers only have to exchange empty packaging for a discount coupon at the store, where consumers would already have to go to repurchase the products or any other product they need, there being no need for appointments or extra travel.

On the other hand, although it is not inconvenient, it does not approach the ease of waste disposal in any dustbin or recycling bin.

Time Constraints and Customisation

In terms of time constraints, the initiatives that take away this problem are Hepi, Loop and again CoZie. The features, which the three have in common and which the rest do not, is that these systems do not require a greater effort from consumers. There is no need for extra travel or more work such as cleaning, transporting and filling the packaging.

On the other hand, the benefit of customization can be considered an added value for the products, since customers are given the opportunity to personalize it according to their preferences. However, any customization implies more lead time for the consumer, so it is only possible to offer this benefit in favour of giving up the problem of time restrictions.

It is therefore necessary to understand what consumers envisage and choose one of the hypotheses, or on the other hand, to provide both but entail a great deal of extra cost.

Incentives and Brand loyalty and Customer Retention

For the incentives, Hepi, Miwa and Zero Waste stores secure this feature through either lower prices or long-term incentive policies, such as discounts for future purchases. This last, besides being an incentive to purchase, guarantees the benefit of Customer Retention to these initiatives. On the other hand, the CoZie, Wally Shop and Loop initiatives, with their deposit policies, guarantee the benefit of retaining consumers after the first purchase, while for many consumers this same policy can be seen as a disincentive to purchase. Both long-term incentive and deposit policies aim to promote the return of packaging to ensure its re-introduction into the cycle.

Thus, it is possible to conclude that the best approach, for these parameters, is a long-term incentive policy, as it not only solves the problem of the lack of incentives, but also provides the benefit of customer retention and ensures the sustainability of the system.

Economies of Scale, Brand Recognition and Operations Optimisation

The initiatives that solve the problem of scale, a crucial aspect for large surfaces, are the initiatives using standard packaging across all products or systems that have integrated the processes of transport and cleaning of packaging. The characteristic of standard packaging is what enables Hepi Circle, Zero Waste stores, Wally Shop and MIWA not only to eliminate the problem of scale production, but to also benefit from the optimisation of operations compared to conventional retail. Although other initiatives will also reduce costs with growth due to optimisation of the transport and washing process of packaging, without this standardisation they will not be able to make the most of these operations. Plaine Products is the only that is prevented from enjoying economies of scale, since it does not use standard packaging and relies on out-sourced activities like the transportation, which is outsourced by the post office.

On the other hand, all these initiatives fail to address one of the root causes for suppliers not adopting these systems, the loss of brand recognition. Even if the standard packaging for all products enables economies of scale and optimized operations, the brand recognition through packaging is lost. In this way, this so crucial problem for suppliers, when it comes to valuing their brand in the eye of the consumer, loses its strength with standard packaging.

Therefore, it can be concluded that a system has yet to be found that allows the balance between achieving economies of scale and optimisation of operations through standard packaging and, at the same time, maintaining brand recognition.

Collaboration, Logistics Complexity, Safety and Hygiene

When it comes to the complexity of logistics, the results show that only the initiative that is not responsible for the reverse process, Zero Waste stores, has no additional complexity in its logistics. This result is easily perceptible since implementing and managing two opposite flows at the same time is much more complex than just one. However, it is crucial to implement the reverse process to ensure the hygienic and safe cleaning of the packaging. In fact, the initiatives that ensure safety and hygiene are those which take responsibility for activities where contamination is likely to occur, i.e. filling and cleaning the packaging. If these processes are not carried out by entities accredited for this purpose, the probability of product contamination is greatly increased and therefore harmful to the health of those who consume them.

5.2.2 | Best practices

This section intends to summarize the best approaches and practices to be pursued in a future solution to the problem of plastic packaging waste in the defined scope. Based on the previous analysis, it is time to outline and recommend the essential features of reusable packaging systems that must be part of the future proposal of their implementation in the defined context. There are six lessons learned that need to be implemented:

No.1 Incentives: Implement long term rather than short term incentives policy for consumers, which leads to solving the problem of incentives, while providing brand lock in. Of the initiatives studied, the best way to provide this incentives policy is to encourage the exchange of used packaging in good condition for discount vouchers in future purchases. This exchange does not even require human resources, as there are already deposits with a certain technology that allows for the inspection of packaging and printing vouchers (Zhou et al., 2019);

No.2 Consumption habits: Consumers want to go to the traditional stores and collect products already packed, instead of having to bring their own packages, fill the packages or replace them elsewhere out of hand. This type of solution will solve, on the one hand, the problems of inconvenience, waste of time and hygiene for consumers and, on the other hand, the complexity of logistics at some level for retailers and suppliers as the major changes to be made will be in the reverse process of the system rather than the conventional direct process;

No.3 Collection of used packaging: To avoid additional inconvenience and waste of time for consumers as well as to provide logistical ease for those responsible for the reverse process, the collection of used packaging has to take place at the retailer. If so, the collection becomes easier, since there is no need to create new channels as retailers already have direct access to consumers, while the whole return process is much more convenient for consumers, as they would already have to go there for their usual retail store;

No.4 Safety and hygiene: The washing and filling of reusable packaging must be the responsibility of entities accredited for this purpose and not the responsibility of consumers. This allows to solve the problem of safety and hygiene, as well as avoid problems of inconvenience and time for consumers, since they will not have to concern themselves with these tasks;

No.5 Type of packaging and brand recognition: The reusable packaging to be used in the system must be standardized, washable and easily transported. This way, it will be possible to ensure economies of scale and optimize operations, not only in the reverse process, but also in the direct process. However, suppliers and brands will have to explore the possible ways of washing packaging in order to differentiate packaging from different products but without hindering the optimization of washing different packaging. In this manner, it will be possible to prevail the recognition of brands with different packaging without being completely disparate in their standardisation;

No.6 Collaboration and logistics complexity: The complexity of logistics becomes somewhat immutable for this type of system owing to what must be accomplished according to lessons No. 2, 3 and 4. Accordingly, if consumer habits are to remain as normal as possible, the reverse process must be the most consumer-friendly achievable and therefore inevitably fall under the responsibility of accredited entities and not be left to consumers, as with typically zero waste shops. However, by doing so, the logistics involved becomes one of the main challenges of reusable packaging systems, since it is necessary to create a whole consumer-friendly reverse process, non-existent until now, for the collection of packaging, its inspection and washing, and its re-entry into the conventional direct process. Nonetheless, this logistics, if shared between the different players in the supply chain, can be streamlined;

On the one hand, with reverse logistics activities being shared, each player can adopt the activities that are most synergistic with its core activities, resulting in a lower logistical management requirement as well as wider cost dispersion and initial investment between the different supply chain players. However, as seen above, collaboration may be the key to the problem but also the most difficult to achieve because, while each actor has fewer activities and responsibilities, they will all become more dependent on each other and therefore only with more incentives (or suffering greater external pressure) will they enter this game of dependencies.

> Thus, when it comes to the complexity of logistics and collaboration, possible scenarios will have to be studied in order to find a balance that pleases all stakeholders.

Therefore, there are six important lessons but only four already defined characteristics that must be unquestionably present in the solution, which correspond to lessons No. 1, 2, 3, 4 and 5 above. Lesson 6 shows that it is still necessary to analyse different scenarios of collaboration until the ideal is established. Therefore, such analysis will then be carried out in the next section.

5.3 | Solution Analysis

Given the identified root causes of the problem, as well as some of the crucial practices for the success of these systems, it is time to start thinking about solutions. However, with this input alone, it is not yet possible to visualize an optimal solution but several solution options. This way, first several possible scenarios will be developed, which in a second instance will be analysed to check their viability.

5.3.1 | Scenario Construction

In this section, options for new reusable packaging systems to be implemented within the defined scope will be proposed.

To propose these scenarios, two aspects must be taken into consideration: i) the defined scope and all the characteristics and restrictions that it entails; ii) the six best practices identified above, knowing that the first five are a must have in all scenarios, while **No.6** is what this analysis aims to find, the positive balance between increased responsibilities and collaboration dependencies, and the gains and synergies that can be achieved from this cooperation. Additionally, lesson **No.2** must also be highlighted as it sets the focus for this scenario analysis. This lesson identifies as best practice not to change the conventional process of buying and consuming of packaging products, so the direct process of producing and selling products with packaging cannot change if it changes the way consumers are used to buying and consuming the products. Therefore, the focus will not be on the direct process of the logistic system, but on how to install a reverse process by changing the direct process as little as possible.

Accordingly, and regarding lesson **No.6**, scenarios will contemplate different options of collaboration and sharing of responsibilities on the reverse logistics process, that is, designate i) who are the actors operating the reverse logistics, ii) who will be responsible for each activity and iii) who will have the ownership and decision-making over the packaging and the process.

With this in mind, the first step is to define the concepts and principles that will be used as a basis for the construction of the different logistic scenarios for the reverse process of reusable packaging systems. Taking into account what was reviewed in the literature review, there are three decision levels that should be considered:

4. Types of packaging return logistic systems (Kroon and Vrijens, 1995);
5. Reverse logistics activities (Thierry et al., 1995);
6. Stakeholders involved (Kroon and Vrijens, 1995).

As such, the baseline are the types of systems already studied, the characteristics of the typical activities of the reverse process and the actors normally involved in this process. Consequently, the aim is to shape and adapt this work base according to the above considerations in order to find a realistically viable system.

Starting with the types of return logistic systems, according to Kroon and Vrijens (1995), a consequence of the use of returnable containers is that, after a container has been used for carrying products from a sender to a recipient, the container has to return to its original condition and transported from the recipient to the next sender, however, this does not have to not be the same as the first one. Hence, the authors distinguished three possible types of systems designs for tertiary packaging:

- Switch-pool systems, which consist of every supply chain participant having his own allotment of containers, for which it is responsible. Thus, all reverse activities are the responsibility of each pool participant. A transfer of containers takes place when the goods are delivered to the recipient. The carrier either transports containers filled with goods from the sender to the recipient, or empty containers from the recipient to the sender. However, it is the sender that has to guarantee that, in the long run, the number of returned containers equals the number of containers sent out.
- Depot systems, defined by the containers being owned by a central agency, which it is responsible for the return of the containers and all reverse activities after they have been emptied by the recipient. In this system the containers that are not in use are stored at container depots from the central agency.
- Transfer systems, where the essence of this system is that the sender always uses the same containers. In this, a central agency or the recipient is only responsible for return of containers from the recipient to the sender, and the sender is responsible for all remain reverse activities.

Although these concepts have been created on the basis of tertiary and not primary packaging, as the object of study, these different types of systems make it possible to identify and distinguish the different possibilities of allocation of responsibilities from the reverse process activities and packaging ownership.

Moving on to the reverse process activities, it is necessary to identify the activities that should be part of the reverse process with an understanding of their functionality and importance in the system. Accordingly, Thierry et al. (1995) distinguishes four product recovery options to retain the functionality of used products and two options of waste management when the possible re-use cycles have been completed.

Thereby, adopting for the context and scope of the problem, the reverse process activities should start with the collection of used packaging, then the inspection of the collected packaging that will dictate its destination, i.e., whether it is in good condition to be recovered or whether it is waste. Although the author offers four options, packaging can only be recovered in two ways. In cases where it is possible to recover the packaging to its origin condition, the only option is to refurbish packaging by removing old labels and washing them. Or, if it is not possible to restore to its initial state, the next recovering option is the recycling of these packaging.

Finally, in cases where, due to material mixtures and packaging contamination, recycling is not possible, there are two possible forms of waste management, incineration and landfilling.

In short, the reverse process activities necessary for the context and scope of the problem are: (1) Collection of used packaging; (2) Inspection of used packaging; (3) Washing of used packaging; (4) Recycling end-life packaging; (5) Incineration end-life packaging; and (6)Landfilling end-life packaging.

Having already established the activities, what is missing is identifying the potential players to be responsible for them. According to the logistic return systems analysed by Kroon and Vrijens (1995), the different types of systems studied were managed either by the sender, carrier or recipient. In an example of the study, Kroon and Vrijens (1995) identify as senders the manufacturers, retailers as recipients and the carrier a third-party logistics provider. Therefore, considering the context of the problem, packaging is produced and supplied by packaging suppliers, filled and supplied to retailers by manufacturers, sold and made available to consumers by retailers and consumed by consumers. In terms of transport, the most common, as in the example, is to be played by third-party logistics provider. Therefore, for this context, the potential players have been identified, which are packaging suppliers, manufacturers, retailers, third-party logistics provider (3PL) and consumers.

At this stage, the aim is to design the different scenarios, for which the three decision levels considered will be combined, assigning the different activities to the different actors identified on the basis of the guidelines of the three types of logistics system design (Kroon and Vrijens, 1995).

From this, three different scenarios can be created. The following table therefore reveals the three different systems that will be proposed below:

Table 4: Logistics' system scenarios

#	Logistics system design		Ownership	Collection responsibility	Inspection and Cleaning responsibility	End-of-life responsibility
1	Switch-pool System	Bulk packaging	Supplier	Supplier	Supplier	Supplier
		Individual packaging	Retailer	Retailer	Retailer	Retailer
2	Depot system		3PL	3PL	3PL	3PL
3	Transfer system		Suppliers	Retailer	Supplier	Supplier

Scenario 1: Switch-pool system

Based on Kroon and Vrijens (1995), switch-pool systems are based on every player having their own containers and therefore being responsible for them as well as for all activities related to their management, while the carrier is only responsible for the transportation of goods between players. Thus, the first scenario can already be assumed where packaging suppliers, retailers and manufacturers have to have their own packaging and be responsible for all the reverse process activities, while transport is carried out by a 3PL. However, as identified in lesson **No.4**, consumers cannot be left in charge of any activities related to packaging hygiene, so this player is excluded from taking responsibility over the reverse process activities.

Once these guidelines have been defined, it is time to design a concrete and realistic scenario for the actual retail context and taking into account the lessons **No.1**, **No.2**, **No.3**, **No.4** and **No.5** identified in the best practices' analysis.

Hence, in order for the retailers and manufacturers have their own packaging, the proposed system is based on the flow of two types of packaging, define by "bulk" packaging (BP) and "individual" packaging (IP). Thus, in this scenario, manufacturers will buy, from bulk packaging suppliers, large packaging to fill with their product in bulk. Then, they send these containers to retailers, where they will empty them into their individual packaging, which they bought from individual packaging suppliers, for sale to the public. Then, as soon as the manufacturers' containers are empty, they are sent to the manufacturers' facilities for inspection, washing and refilling.

In turn, consumers, after consuming the products, return the individual packaging to retailers, who inspect and wash them for reuse. Thus, manufacturers are only responsible for the management, maintenance and cleaning of bulk packaging and retailers are responsible for individual packaging.

However, as the cycle also has to be closed with the packaging suppliers, in case the packaging is not suitable for reuse, retailers and manufacturers will then sell it as scrap to the suppliers, who will recycle it and transform it into new packaging, thus closing the cycle.

To better understand the system, Figure 12 shows in more detail the activities and interactions of the system with the use of colour coding to distinguish the different actors, their responsibilities, and the different packaging processes as described in the legend.

Accordingly, a colour has been assigned to each activity (rectangles of the figure) to distinguish who is responsible for it, that is, the blue activities are those carried out by the manufacturers, the green by the retailers, the red by the consumers and the oranges by the packaging suppliers.

Besides identifying the different players and their responsibilities, it is necessary to understand the general flow of the system and the different process flows for each type of packaging. Therefore, the numbers of the activities show how to read the overall flow of the system, starting with the production of new packaging and ending with the sale of obsolete packaging, which cannot be reused, to suppliers.

Additionally, the arrows of different colours show how to follow the different logistical processes, the **black** arrows for the direct logistic process, the **green** and **blue** arrows for the reverse process of reusable BP and IP packaging, respectively, the **orange** arrows for the remaining packaging which cannot be reused but instead are sold as plastic scrap, and finally the grey arrows which are the remaining packaging which end up as waste in the various activities of the system.

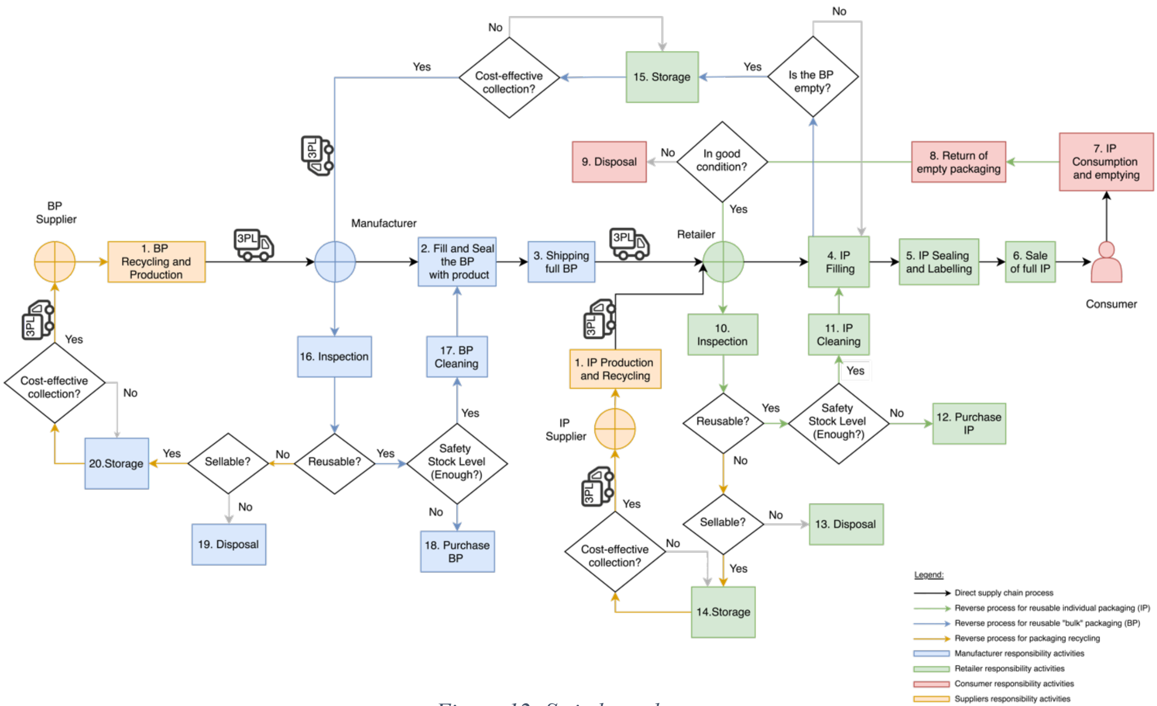


Figure 12: Switch-pool system

Once the figure has been elucidated, it becomes easier to detail the activities and processes. This way, to outline the system, the different activities will be described according to the five different processes identified by the different coloured arrows:

> **Direct logistics (identified by black arrows)** – This process characterises the conventional and current process of this sector, taking place in activities 1 to 7, where there is a packaging supplier, a manufacturer of the product who fills the packaging and a retailer who distributes the products in his shops, making

them available to consumers. Under this system, the direct process begins again with the packaging suppliers (activity 1), who are now two, one for large-scale packaging and the other for individual packaging. The former provides these containers to manufacturers so that they can send the product produced to retailers but now in larger quantities (activities 2 and 3). The second supplier in turn supplies individual packaging to retailers to proceed with their filling with the product supplied by the manufacturers (activities 4 and 5). The procedure then remains unchanged (activity 6 and 7). In this way, both manufacturers and retailers have their own packaging.

> **Reverse process for reusable IP (identified by green arrows)** – After the conventional consumption of the product by consumers (activity 7), in this system a reverse process is proposed for the IP by the activities 8 to 11. The process is based on consumers bringing their empty IP and exchanging them at the retailers' premises for discount vouchers for future purchases (activity 8). This exchange is done through deposits, equal to those used for recycling in the Nordic countries, which analyse the packaging. Only if there is no damage to its form and composition will consumers receive a voucher back, otherwise the packaging will not be accepted in the deposit and consumers will be responsible for its end of life (activity 9). The packaging stored in the depot is then inspected again, this time to see whether the packaging is still reusable or should be sold for suppliers' recycling (activity 10). If reusable, the packaging is cleaned and returned to the conventional process of filling and making it available to the public (activity11).
> One aspect that has to be taken into account is to understand the volume of reusable packaging recovered to see if it is sufficient to meet the demand or if new packaging has to be purchased (activity 12).

> **Reverse process for reusable BP (identified by blue arrows)** – The reverse process of BP packaging is very similar to the previous one but displayed by the activities 15 to 17. When BP becomes empty, it is stored by retailers to deliver to manufacturers when enough packaging is already available for cost-effective collection (activity 15). Thus, when manufacturers come to deliver full BP, they recover the same number of empty BP. The next procedure is the same as for IP, so the packaging is inspected, filtered, washed, and returned to the direct process (activities 16 and 17).

> **Process for packaging recycling (identified by orange arrows)** – When either BP or IP do not pass the inspection of manufacturers and retailers respectively, they can be sold to their own packaging suppliers as plastic scrap because, as it is possible to separate each kind of packaging of each supplier, there are no mixtures of plastics from different sources (unlike common recycling). Thus, after inspection, the packaging is kept until cost-effective collection is possible and then the exchange is made when delivery from the suppliers takes place (activities 14 and 20). Ending up at the packaging suppliers' premises to be recycled and integrating as raw material in the production of new packaging in the direct logistics and thus closing the cycle.

> **Process for packaging disposal (identified by grey arrows)** - Finally, activities 9, 13 and 19 represent packaging which, because it is not in good condition, ends up as waste in landfill or incineration. While in activities 13 and 19, retailers and manufacturers respectively are responsible for the end of life of packaging, activity 9 represents the time when consumers return packaging to the deposits and are not accepted, remaining to their responsibility their disposal.

With the system presented, all that remains to be confirmed is that all the best practices from the six lessons learned are in place.

No.1 Incentives and No.3 Collection of used packaging

In this scenario, the most problematic aspect of this system falls into lessons **No.1** and **No.3**, which is how to proceed in the collection of used packaging. This activity is vital for the success of the reverse process and for the sustainability of this system, so if it is not carried out successfully it puts the whole system at risk.

The collection of “bulk” packaging is unimpeded and even increases economies of scale, as trucks arrive with full packaging at retailers and they deliver exactly the same amount of empty packaging to be deliver in manufacturer’s premises. As for “individual” packaging, in order to ensure lesson **No.1**, the collection must be based on the exchange of used packaging in good condition for discounts on future purchases. Thus, there must be deposits with the necessary technology to inspect the packaging submitted and return a discount ticket to the customer. Yet, the collection in this system becomes easier, since there is no need to create new channels as retailers already have direct access to consumers. Thus, the deposits can be located at retailers, which makes the whole return process much more convenient for consumers as they would already have to go for their usual purchases (also ensuring lesson **No.3**).

No.2 Consumption habits and No.4 Safety and hygiene

In this scenario, manufacturers are responsible for collecting the used “bulk” packaging, inspecting it, cleaning it or re-selling it and re-entering the direct process, while retailers are responsible for all of this but regarding “individual packaging”. Therefore, the system guarantees lessons **No.2** and **No.4** of the key features identified to the success of these systems, since the inspection, washing and filling of the packaging is done at the and manufacturer’s and retailers' premises (and not by consumers), followed by the conventional process of selling and buying the products (not causing any additional inconvenience to consumers).

Furthermore, the most problematic point of this system, which falls into question lessons **No.1** and **No.3** is how to proceed in the collection of used packaging. This activity is vital for the success of the reverse process and for the sustainability of this system, so if it is not carried out successfully it puts the whole system at risk.

The collection of “bulk” packaging is unimpeded and even increases economies of scale, as trucks arrive with full packaging at retailers and they deliver exactly the same amount of empty packaging to be deliver in manufacturer’s premises. As for “individual” packaging, in order to ensure lesson **No.1**, the collection must be based on the exchange of used packaging in good condition for discounts on future purchases. Thus, there must be deposits with the necessary technology to inspect the packaging submitted and return a discount ticket to the customer. Yet, the collection in this system becomes easier, since there is no need to create new channels as retailers already have direct access to consumers. Thus, the deposits can be located at retailers, which makes the whole return process much more convenient for consumers as they would already have to go for their usual purchases (also ensuring lesson **No.3**).

No.5 Type of packaging and brand recognition

In terms of standard packaging, lesson **No.5**, this system does not impose difficulties either, as each player will have complete control over its packaging and will therefore design it to optimise its new operations to the maximum.

However, while it is possible to ensure optimal operations with standardised packaging for manufacturers and retailers, this is impossible when it comes to ensuring brand recognition through packaging. As those in charge of individual packaging are retailers, they will fight for having the most efficient process and that means using the same packaging for all the same type of products. Thus, in this system the power of the brands through the packaging becomes impossible, being a strong impediment to this system proposal.

In conclusion, this system ensures lessons **No.1**, **No.2**, **No.3** and **No.4**, while **No.5** becomes difficult to ensure and lesson **No.6**, on collaboration versus logistical complexity, remains to be assessed, with the analysis in the next section.

Scenario 2: Depot system

On the other hand, depot logistic systems consist of the reverse process being controlled by a central agency, as well as the ownership of the containers (Kroon and Vrijens, 1995). Thus, the central agency is responsible for the return of the containers and all reverse activities after they have been emptied by the recipient, whereas the other players do not need to make changes to their activities. In terms of who pays for this service, the system is coupled with deposits, thus the manufacturer pays the agency a deposit for the number of containers delivered to his site. Then, the manufacturer debits to his retailer for this deposit, who does the same in their products for also debit on consumers. At last, the moment the containers are returned, there is a refund of the deposit to the party from which the containers were collected, resulting in terms of vouchers for the consumers and a payment to retailers when they are collected by the central agency. Although the suppliers don't enter in this scheme because they supply new and not reused packaging, when the packaging is not suitable for reuse, the central agency will then sell it as scrap to the suppliers, who will recycle it and transform it into new packaging, thus closing the cycle.

With these guidelines, it is time to design a concrete and realistic second scenario for the actual retail context and taking into account the lessons **No.1**, **No.2**, **No.3**, **No.4** and **No.5** identified in the best practices' analysis.

Accordingly, Figure 13 displays the system created, showing in more detail the activities and interactions of the system with the use of the same colour coding, as in the above scenario, to distinguish the different actors, their responsibilities, and the different packaging processes as described in the legend.

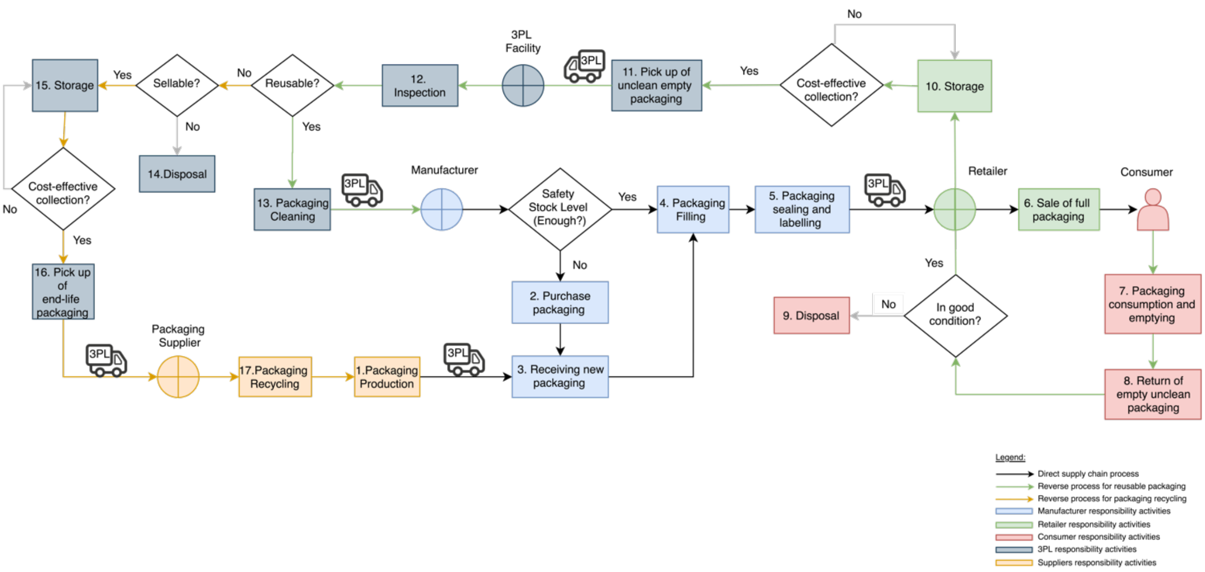


Figure 13: Depot system

Once the figure has been elucidated, it becomes easier to detail the activities and processes. This way, to outline the system, the different activities will be described according to the four different processes identified by the different coloured arrows:

> **Direct logistics (identified by black arrows) –** This process is the conventional and current process of this sector, taking place in activities 1 to 7, where there is a packaging supplier, a manufacturer of the product who fills the packaging and a retailer who distributes the products in his shops, making them available to consumers.

> **Reverse process for reusable packaging (identified by green arrows) –** The reverse process has a 3PL responsible for the main activities. This process starts with consumers bringing their empty packaging and exchanging them at the retailers' premises for discount vouchers for future purchases (activity 7 and 8). This exchange is done through deposits, same as the previous scenario, which analyse the packaging. Only if there is no damage to its form and composition will consumers receive a voucher back, otherwise the packaging will not be accepted in the deposit and consumers will be responsible for its end of life (activity 9). The packaging is then stored in the retailer's premises until cost-effective collection is possible (activity 10). After the collection, the 3PL will inspect again the packaging (activity 12), this time to see whether the packaging is still reusable or should be sold for packaging suppliers' recycling. If reusable, the packaging is cleaned and goes back into the direct process (activity 13).
However, the manufacturers continue to have the responsibility to order new packaging to meet demand according to the volume of reusable packaging recovered and delivered by the 3PL (activity 2).

> **Process for packaging recycling (identified by orange arrows) –** The only remaining process is that of packaging which does not pass the inspection of 3PL and which, as it is large volumes of the same plastic (unlike common recycling), can be sold to packaging suppliers. Thus, after inspection, the packaging is kept in the 3PL's premises until cost-effective collection is possible (activity 15). Ending up at the packaging suppliers' premises to be recycled and integrating as raw materials in the production of new packaging in the direct process and thus closing the cycle (activity 16 and 17).

> **Process for packaging disposal (identified by grey arrows)** - Finally, activities 9 and 14 represent packaging which, because it is not in good condition, ends up as waste in landfill or incineration. While in activitie 14, 3PL is responsible for the end of life of packaging, activity 9 represents the time when consumers return packaging to the deposits and are not accepted, remaining to their responsibility their disposal.

With the system presented, it is now necessary to confirm if all best practices from the six lessons learned have been met.

<u>No.2 Consumption habits</u>

First, there are no changes to the conventional process of buying and selling products, thus ensuring lesson **No.2** of the key features identified to the success of these systems.

<u>No.1 Incentives, No.3 Collection of used packaging and No.4 Safety and hygiene</u>

Again, the collection of the packaging used by consumers takes place at retailer's premises (ensuring lesson **No.3**), which keep the used packaging through inspection deposits to provide discounts to consumers if the packaging is in good condition (ensuring lesson **No.1**). These packages are then stored until cost-effective collection by the central agency is possible. After that, the central agency inspects, cleans, or resells the containers at its premises (ensuring lesson **No.4**), and then maintain them at the depot to be used for next shipments.

No.5 Type of packaging and brand recognition

In terms of standard packaging, lesson **No.5**, this system does not impose difficulties either, as the central agency has complete control over its packaging and will therefore design it to optimise its new operations to the maximum. However, while standard packaging is ensured, the packaging is owned by an external agency, making it more difficult to ensure brand recognition by distinguishing packaging. This is because, as manufacturers do not have full control over packaging design, it may be difficult to negotiate different and unique packaging for their products, becoming a problem in this system.

No.6 Collaboration and logistics complexity

Finally, in relation to lesson **No.6**, as in this system collaboration is not called into question, it is necessary to understand whether it is economically worthwhile for retailers and suppliers when contracting this external service.

Scenario 3: Transfer system

Regarding transfer systems from Kroon and Vrijens (1995), the sender is fully responsible for tracking, management, cleaning, maintenance, storage, as well as stock level of containers, that is all reverse activities, except for the transportation. Furthermore, in addition to most of the responsibilities being borne by the suppliers, they also hold the containers ownership.

Although the packaging suppliers and the manufacturers can be considered as senders from the 5 identified actors, for this scenario who will have all these responsibilities will be the manufacturers, since they will have easier and less costs in managing the reverse process because they are not at one end of the supply chain like the packaging suppliers.

Having these guidelines as a basis, it is time to design the final scenario for the actual retail context, keeping always in mind the lessons **No.1**, **No.2**, **No.3**, **No.4** and **No.5** identified in the best practices' analysis.

Accordingly, Figure 14 displays the system created, showing in more detail the activities and interactions of the system with the use of the same colour coding, as in the above scenarios, to distinguish the different actors, their responsibilities, and the different packaging processes as described in the legend.

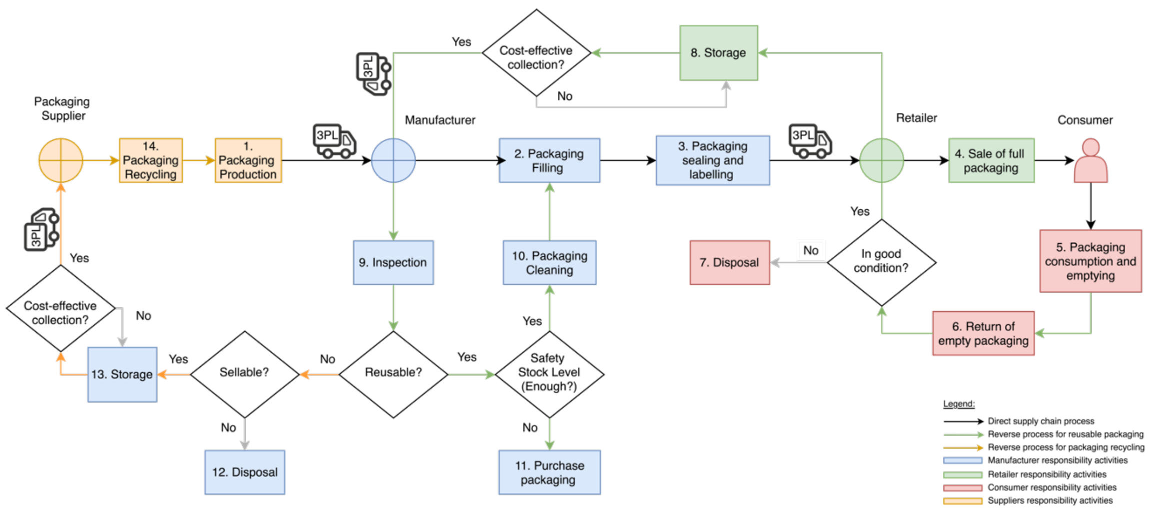


Figure 14: Transfer system

Once the figure has been elucidated, it becomes easier to detail the activities and processes. This way, to outline the system, the different activities will be described according to the four different processes identified by the different coloured arrows:

- **Direct logistics (identified by black arrows) –** Like in the previous scenario, in this system, the direct process does not undergo any change. Thus, this process is the conventional and current process of this sector, where there is a packaging supplier, a manufacturer of the product who fills the packaging and a retailer who distributes the products in his shops, making them available to consumers.
- **Reverse process for reusable packaging (identified by green arrows) –** This process only differs in one thing from the previous scenario, instead of an external player being the majority responsible for the reverse process, it is the manufacturer now. Accordingly, after the conventional consumption of the product by consumers, consumers bring their empty packaging and exchange them at the retailers' premises on the deposits for discount vouchers for future purchases. Again, only if there is no damage to its form and composition will consumers receive a voucher back, otherwise the packaging will not be accepted in the deposit and consumers will be responsible for its end of life. The packaging is then stored in the retailer's premises until cost-effective collection by the manufacturers is possible. After the collection, in the manufacturer's premises, the packaging is once again inspected to see whether the packaging is still reusable or if it should be sold for packaging suppliers' recycling. If reusable, the packaging is cleaned by the manufacturer's and goes directly back into the direct process.
  Once again, the manufacturers have the responsibility to order new packaging to meet demand according to the volume of reusable packaging recovered (activity 11).
- **Reverse process for packaging recycling (identified by orange arrows) –** Finally, the only remaining process is that of packaging which does not pass the inspection on the manufacturer's premises and which, as it is large volumes of the same plastic (unlike common recycling), can be sold to packaging suppliers. Thus, after inspection, the packaging is kept in the manufacturer's premises until cost-effective collection is possible. Ending up at the packaging suppliers' premises to be recycled and integrating as raw material in the production of new packaging in the direct process and thus closing the cycle.
- **Process for packaging disposal (identified by grey arrows)** - finally, activities 7 and 12 represent packaging which, because it is not in good condition, ends up as waste in landfill or incineration. While in activity 12, manufacturer is responsible for the end of life of packaging, activity 7 represents the time when consumers return packaging to the deposits and are not accepted, remaining to their responsibility their disposal.

Presented the system, what remains to be confirmed is whether all best practices from the six lessons learned have been met.

No.1 Incentives and No.3 Collection of used packaging

Once again, the collection of packaging in this system is still possible being performed in the retailer's premises through the deposits already described, making the whole return process much more convenient for consumers, and ensuring lessons **No.1** and **No.3**.

No.2 Consumption habits and No.4 Safety and hygiene

As described, the inspection and washing of the packaging is done at the premises of each manufacturer and then the packaging follows its normal route: filling, transport to retailers and sale to the consumer. Therefore, so far, it is already possible to secure lessons **No.2** and **No.4** of the key features.

No.5 Type of packaging and brand recognition

In terms of standard packaging, lesson **No.5**, this system does not impose difficulties either, as each supplier will have complete control over its packaging and will therefore design it to optimise its new operations to the maximum, while ensuring brand recognition.

No.6 Collaboration and logistics complexity

Finally, in relation to lesson **No.6**, as in this system collaboration is called more than ever into question, it is necessary to understand whether or not the collaboration and the large investment is worthwhile. In this system collaboration will be critical as both suppliers and retailers are completely dependent on each other.

In conclusion, this system ensures lessons **No.1**, **No.2**, **No.3**, **No.4** and **No.5**, while **No.6**, on collaboration versus logistical complexity, is still to be assessed, with the analysis in the next section.

In the following section it will then be possible to analyse this point for each system and really understand if any of the systems are feasible, and if so, which is best.

5.3.2 | Cost and Benefit Analysis

On the basis of the scenarios created, collaboration is crucial, so this section aims to assess the benefits and trade-offs of implementing the scenarios' systems for each of the stakeholders. First, a qualitative analysis and then a second, more in-depth quantitative analysis, in order to measure the burden and benefits of the system for each of the parties concerned. Based on the results, it will then be possible to assess, based on the benefits versus drawback, whether the players have more to gain or lose in implementing the system and thus assess its feasibility. The ultimate goal is to find a scenario that maximises the interests of each stakeholder.

5.3.2.1 | Qualitative Assessment

This analysis seeks to systematise the benefits and drawbacks of each system for each player. This first approach can be classified as qualitative, seeking perceptions and understanding of the general nature of an issue. According to Gil (2002), the assessment is qualitative when no statistical techniques are used to elucidate the problem.

In this way, each scenario will be analysed qualitatively in terms of benefits and drawbacks in view of each actor in the system.

Scenario 1: Switch-pool system

Starting with the first scenario, the analysis will be displayed in terms of the analysis to each of the players, with the summary of the overall benefits and disadvantages for the different actors of this system being available in the Appendix J.

Suppliers

Looking at suppliers, this system provides them with both benefits and drawbacks. For benefits, they mainly benefit from the increased bargaining power over manufacturers since they now depend even more on their suppliers to sell their obsolete packaging. In addition, due to the purchase of obsolete material for recycling into new packaging, there will be a reduction in raw material consumption and thus a reduction of the burden from environmental fees on plastic production. On the other hand, with a new activity of recycling obsolete plastic packaging, a large investment by suppliers will be necessary in terms of processes and logistics. Nevertheless, this investment may be worthwhile if the reduction in consumption of new raw materials, the savings on environmental taxes and the lower costs of recycled material reduce the total costs of packaging production.

Retailers

As far as retailers are concerned, they are the players who will have more to analyse in terms of gains and losses. In terms of benefits, this system offers them an opportunity for upstream vertical integration, which will give them extensive decision-making power over the supply chain, even greater bargaining power over manufacturers and the exploitation of economies of scale with greater efficiency and better results, as well as hindering the growth of competition. Furthermore, instead of brands enjoying the environmental visibility of these changes, as brands lose their strength due to retailers' control of packaging, it is retailers who will gain most from the environmental and social awareness visibility from the consumers' point of view. However, to achieve these benefits it will also require a large investment of resources and time as well as the need for more management due to the added complexity of the process. Unfortunately, these demands are part of the retailer’s root cause tree for which they do not want to adopt these systems, causing this system not to tackle all the issues raised in the problem analysis.

Manufacturers

With this vertical integration of retailers, it is the manufacturers and brands who have most to lose. Although economies of scale and cost savings can be achieved due to the new size of packaging (“bulk packaging”), the loss of decision-making power over the packaging, that will be made available to the final consumer, takes away one of the greatest strengths of these players, which is promoting brand recognition. Brands use the image of packaging to distinguish their products from others and thus win over consumers. This becomes now impossible as it will be the retailers who control the individual packaging, with the manufacturer’s companies becoming merely product suppliers rather than value-added brands, thus losing even more bargaining power over retailers. Moreover, as production costs decrease and the investment required is lower than in the conventional process, there are fewer barriers to entry, resulting in increased competition in the sector, making it even more difficult for manufacturers. In fact, in addition to having been identified as a root cause for the non-adoption of this system by this actor in the problem tree analysis, it has also been identified as one of the crucial points for the success in the benchmark analysis, making this system unworkable for manufacturers.

Consumers

Finally, for consumers, this system does not present any major impediments as they will gain from the discounts offered, balancing them against the possible price increases that would have to occur if the system were to become economically viable.

Overall view of Scenario 1

It follows that there is one possible beneficiary, the retailers, and one possible loser with this system, the manufacturers. However, as seen above, these systems only go forward with the willingness of all the actors involved as they are dependent on each other as found in the first analysis of this study. Thus, as retailers need products to sell, and as manufacturers do not want to lose their brand power, this scenario is hardly workable.

Scenario 2: Depot system

Regarding the second scenario, Appendix K summarises the overall benefits and disadvantages found for the different actors of this system. However, as this system is characterised by all new activities being the responsibility of an external entity, there are not as many discrepancies as in the previous scenario.

Suppliers and Consumers

In terms of suppliers and consumers, nothing changes in relation to the previous scenario with regard to benefits and disadvantages.

Retailers

As far as retailers are concerned, they are only responsible for the collection and storage of the packaging in good condition delivered by consumers until it is collected cost-effectively by the central agency. Thus, they enjoy the possibility of retaining customers due to the discount vouchers, as consumers can only discount them in the same retailer of the deposits. In addition, as this system works through depots, retailers will face increased costs as manufacturers will charge extra for packaging, just as the central agency did for them. As this deposit can only be retrieved at the final delivery of the collected packaging to the central agency, the retailer will lose out as it is not possible to guarantee that all packaging sold to consumers will be returned by them in order for retailers to be able to deliver it to the central agency and thus retrieve the deposit in full. Besides, they will have to incur an initial investment and further costs in terms of installing and maintaining the deposits for collecting packaging from consumers. Whereas, as result of these additional costs, they will have to increase prices and charge more to consumers. This may also result in a loss of consumers in case the implementation of the system is not general (as seen in the analysis of the problem).

Manufacturers

As for manufacturers, while they will be able to save on costs due to the reduction in the purchase of new packaging, there is a new cost associated with the deposit for the 3PL's packaging. However, this is not the biggest problem, since they will charge retailers the same amount, but again the problem of loss of brand recognition. As again in this system the control over the packaging ceases to be of the manufacturers, in this case being of an external entity, this great drawback of the system will again be a breaking point for brands, making this system not very feasible in terms of their acceptance.

Overall view of Scenario 2

This scenario, as before, presents a great disadvantage for manufacturers, the loss of brand recognition through packaging. Moreover, retailers do not have great advantages by adopting this type of systems, with the advantages remaining merely for the 3PL company, making the service more expensive. Thus, although the problem of logistics complexity is solved, leaving all reverse logistics' activities to an external company, the remaining players do not benefit greatly from the system, becoming a system unlikely to be implemented unless by the external pressure of mandatory regulations to reuse packaging.

Scenario 3: Transfer system

Finally, Appendix L summarises the overall benefits and disadvantages found for the different actors of this system.

This last scenario is characterized by the sharing of responsibilities of the reverse process between manufacturers and retailers, and hence again the decisive analysis will be based on the benefits and drawbacks for these two players.

Suppliers and Consumers

In this sense, regarding suppliers and consumers, nothing changes in relation to the previous scenarios with regard to benefits and disadvantages. Yet there are differences when it comes to manufacturers and retailers.

Manufacturers

As far as manufacturers are concerned, with the responsibility for several new activities, a large new investment as well as new costs will have to be incurred to make the system operational. However, the operations are set up to make the process more efficient allowing to benefit as much as possible from economies of scale and reduce costs in the direct logistics due to the reduction of new packaging. Nevertheless, new activities mean more logistics complexity and therefore the need for a better management to be assure that everything goes as planned. Still, the control and decision power of the products and packaging remains, without there being problems regarding brand recognition.

Retailers

As for retailers, they will operate the collection and storage of used packaging, demanding more resources and an additional management to deal with these new activities. However, although they operate these activites, the process is the responsibility of the manufacturers, so these tasks will be outsourced by the retailers. as they are responsible for the collection and storage of packaging in good condition delivered by consumers, they will have to adjust and incur new costs, as well as invest time and resources for the change. This way, the manufacturers incur all additional costs, while the retailers benefit from customer retention due to the strategy of long incentives, using the discount vouchers for the next purchases of consumers.

Overall view of Scenario 3

In short, this scenario offers good opportunities as well as less good aspects for all interested parties. However, there are no crucial features for the exclusion of this scenario since it guarantees all five factors of success studied and no further major drawback for any of the players has been encountered.

Nonetheless, it is not yet possible to classify this scenario as viable since it has not been assessed whether the benefits outweigh the risks.

Accordingly, in this analysis it was possible to conclude that neither scenario 1 nor scenario 2 present considerable benefits to the different stakeholders and thus promote its implementation, mainly because several of the problems identified in the problem tree analysis remain to be solved. This leaves only scenario 3, which although it presents advantages to the various stakeholders, the question of whether it is economically feasible remains to be analysed. Therefore, the next section will present a quantitative analysis in terms of gains and costs in order to evaluate the economic feasibility of the system.

5.3.2.2 | Quantitative Assessment

Based on the previous analysis, this section will serve to further analyse the feasibility of Scenario 3, since it is the only one that does not compromise the root causes identified in the problem analysis, as scenario 1 and 2 do and thus making them unfeasible.

Accordingly, the aim of this analysis is to assess if scenario 3 is economically viable by quantifying the additional variable costs and revenues from the addition of the reverse logistics, which will enable to understand their dimension and therefore whether it is an impediment to the implementation of the system. For that, a cost-benefit model of reverse logistics constructed by Chen (2012) will be employed. This model enables precise computation of the costs and benefits of reverse logistics to facilitate enterprises implementing reverse logistics to better reduce their reverse logistics costs and enhance the overall operational efficiency of reverse logistics.

Therefore, in a first stage it will be identified the variables and its components for computing the model. Hence, in a first stage it will be defined the variables and cost and revenues components for computing the model, then the characterisation and data collection process for each variable's component and, finally, the analysis of this data based on the proposed scenario.

Variables

As stated by Chen (2012, p.75), " reverse logistics refers to the process to regain the value of or properly deal with the waste raw material generated during the production process and the packaging material, reject product, flawed product and return product to reduce environment pollution and move them from ending place to the origin place". Although the model focuses mainly on reverse logistics of products (such as clothing and toys), the variables will be adapted for an analysis focused only on reverse logistics of packaging, more specifically of plastic, as well as for the scenario in question.

In this sense, the author distinguishes between cost and benefit variables. In terms of costs, the reverse logistical costs refer to the expenses and material consumption incurred in the process of circulation or value recovery, so the adapted variables that will be used to measure these processes monetarily are the following:

> **Collection Costs (CC)** – the reverse logistics starts with collection work, which results in transportation costs (C_L). However, due to the characteristics of the proposed scenario, there is an additional collection cost that should also be taken into account, the cost of the return fee (C_F) given to consumers depending on the good condition of the returned packaging, which corresponds which corresponds to the component of payment for residue value proposed by the author for this variable.
>
> Thus, C_C is used to refer to the collection costs, which consists of transportation expenses and payment for residue value of the collected items, calculated as follows:
>
> $$C_C = C_R + C_F \quad (1)$$
>
> $$C_R = \sum (C_{1i} * Q_{Ci}) \quad (2)$$
>
> $$C_F = \sum (C_{2i} * Q_{Ci}) \quad (3)$$
>
> Where, C_{1i} refers to the unit transportation charge for item i;
>
> Q_{Ci} refers to the quantity of item i collected;
>
> C_{2i} refers to the residue expenses paid for acquiring each unit of item i, i.e, the unit fee cost given to consumers.

> **Testing and Classification Costs (C_T)** – testing and classification is an essential procedure in implementing reverse logistics, since it dictates the next stages of the items according to their classification. The more detailed the testing and classification work is, the easier the following processing can be while the higher the testing and classification costs can occur. The collected items can usually be classified into reconditionable

(reusable in this case) items, renewable materials, and waste material. Thus, the testing and classification costs (C_T) can be calculated as follows:

$$C_T = C_{T1} + C_{T2} \quad (4)$$

$$C_{T1} = \sum(C_{3i} * Q_{Ci}) \quad (5)$$

$$C_{T1} = \sum(C_{4i} * Q_{Ci}) \quad (6)$$

Where, C_{3i} refers to the unit testing costs for first inspection of item i;

Q_{Ci} refers to the quantity of item i collected;

C_{4i} refers to the unit testing costs for second inspection of item i.

> **Washing Costs (C_W)** – collection and testing in reverse logistics belong to the investment portion with no benefit reflected, but it is the preparatory work for the following remanufacturing and material recycle where benefit of reverse logistics is realized. Remanufacturing costs mainly include refurbishing costs, which, in this case, corresponds to the washing process of the packaging collected and tested as reusable. Thus, the washing costs (C_W) can be calculated as follows:

$$C_W = \sum(C_{5i} * Q_{Wi}) \quad (7)$$

Where, C_{5i} refers to the unit cost for washing item i;

Q_{Wi} refers to the quantity of item i washed.

> **Environmental Protection Costs (C_E)** – due to technological and economic reasons, non-recyclable waste will exist in the reverse logistic process, ending up in two disposal mode of the wastes: landfill or incineration. The cost of incineration (C_I) refers to depreciation of fixed assets and manpower costs during the incineration, and landfill costs (C_L) refers to the manpower costs and environmental penalties, etc., which vary with the grade of the wastes. Thus, the environmental protection costs (C_E) can be calculated as follows:

$$C_E = C_I + C_L \quad (8)$$

$$C_I = \sum(C_{6i} * W_i * Q_{Ii}) \quad (9)$$

$$C_L = \sum(C_{7i} * W_i * Q_{Li}) \quad (10)$$

Where, C_{6i} refers to the costs for incinerating unit weight of waste;

Q_{Ii} refers to the quantity of item i incinerated;

W_i refers to the weight of the waste of item i;

C_{7i} refers to the costs for landfilling unit weight of waste;

Q_{Li} refers to the quantity of item i landfilled.

> **New Packaging Acquisition Costs (C_P)** – although not included in the list proposed by Chen (2012), in the scenario constructed, it will be necessary to change not only the composition of the packaging used but also the quantity purchased for the direct process. Thus, although it is not a direct cost of the reverse process, it depends on the reverse process as the amount of new packaging purchased will depend on the amount of packaging collected and able to reuse. So, the cost of acquisition of new packaging will also be included in the analysis. Thus, the new packaging acquisition costs (C_P) can be calculated as follows:

$$C_P = \sum(C_{8i} * W_i * Q_{Ai}) \quad (11)$$

Where, C_{8i} refers to the unit cost for purchasing a new item i;

Q_{Ai} refers to the quantity of item i acquired.

- **Holding Costs (C_H) –** With the reverse process, retailers now have to store the collected packaging until it can be cost-effective transported to the manufacturers' premises. This storage requires space and management, so it also has to be contemplated and calculated as a cost**.** Additionally, although this analysis focuses only on the additional costs to the direct process, with the holding costs of the conventional packaging in the direct process being already considered for manufacturers and thus not an additional cost, it was decided to also consider this holding cost for manufacturers since the packaging value differs from the conventional ones. Nevertheless, it should be noted that the analysis may be more conservative than reality. Thus, the holding costs (C_H) can be calculated as follows:

$$C_H = C_{HM} + C_{HR} \quad (12)$$

$$C_{HM} = \sum(C_{9i} * Q_{Ai}) \quad (13)$$

$$C_{HR} = \sum(C_{10i} * Q_{Ci}) \quad (14)$$

Where, C_{9i} refers to the unit of holding costs for item i on manufacturer's facilities;

Q_{Ai} refers to the quantity of item i acquired;

C_{10i} refers to the unit of holding costs for item i on retailer's facilities;

Q_{Ci} refers to the quantity of item i collected.

In terms of benefits, according to Cheng (2012), the direct reason behind the implementation of reverse logistics in the corporate world is not only because of environmental protection and legal and energy-saving constraints, but also because of the drive of economic benefit. Thus, considerable economic benefit can be realized in the enterprise with the implementation of reverse logistics as by implementing reverse logistics, the purchase of items and materials can be less, manufacturing costs can be reduced, more sales revenue can be realized by resale of remanufactured parts and materials, and environmental protection expenses can be reduced resulting in less pollution penalties and less environmental protection expenses.

Therefore, there are three categories of quantifiable benefits of reverse logistics:

- **Packaging Purchasing Savings (R_P)** – this revenue includes the saved costs from reuse of items in production, in this case reusable packaging. This revenue (RP) can be calculated as follows:

$$R_P = \sum(C_{8i} * Q_{Ri}) \quad (15)$$

Where, C_{8i} refers to the unit cost for purchasing a new item i;

Q_{Ri} refers to the quantity of item i reusable.

- **Material Reproduction Revenue (R_M)** – As not all packaging is suitable for reuse, some according to certain criteria may be sold as plastic scrap. Since in this case there isn't a mixture of plastics, the plastic scrap can be directly sold to plastic packaging suppliers and achieve sales revenue. This revenue (R_M) can be calculated as follows:

$$R_M = \sum(C_{11i} * Q_{Si}) \quad (16)$$

Where, C_{11i} refers to the market selling price for selling an obsolete item i;

Q_{Si} refers to the quantity of item i sellable.

- **Environmental Protection Benefit (R_E)** – One of the most important drivers for the implementation of reverse logistics is environmental protection. The environmental protection benefit of reverse logistics is shown in the decrease of waste and the recycle of resources. In fact, the utilization of the parts and items acquired through reverse logistics can reduce the amount of landfill and incineration, which results in less environmental protection penalties. This revenue (R_E) can be calculated as follows:

$$R_M = \sum(C_{12i} * W_i * Q_{Ai}) \quad (17)$$

Where, C_{12i} refers to the environmental protection penalty expenses saved for unit weight of waste of item i;

Q_{Ai} refers to the quantity of item i acquired;

W_i refers to the weight of the waste of item i;

With these parameters it will be possible to analyse the quantifiable benefits and costs of the reverse process added to the conventional retail process by scenario 3.

Data collection:

For data collection procedures, the research of the parameters for the analysis is classified as documental according to the author Gil (2002), consisting of research being based on material already elaborated, consisting mainly of books, scientific articles, and case studies of this field area.

This analysis will not allow a 100% assessment of the feasibility of the system under analysis, but it will allow an approximation of the dimension of quantifiable costs and benefits for each of the actor responsible for the reverse process.

In order to collect the previous data and to be possible an analysis, a set of assumptions were established to define the study in question and to make data collection possible. The taken-up assumptions were:

- It was considered that the reusable packaging of the analysis would have the same dimensions as a H&S shampoo packaging, as shown in Appendix M. However, this conventional packaging weighs around 70g when empty, so it was assumed the weight of 100g for a reusable packaging since the plastic used will to be more resistant and therefore possible to be washed several times.
- In terms of players to analyse, only costs and benefits for suppliers and retailers will be analysed. This is because as seen in the previous analysis, these two players will assume the responsibility, and consequently the costs, of the reverse process activities.
- The analysis will only be centred on the reverse process and the collection and analysis will be focused on one batch of packaging. As a presupposition, this batch will be dictated by the quantity of a full truck load (FTL), for the collection of empty packaging, and the average inspection results of the study of reusable beer bottles, as will be elaborated further below.
- Additionally, in the last year of 2019, the Portuguese government created the pilot project "Quando do velho se faz novo, todos ganham!". This pilot project for the return of non-reusable PET plastic beverage bottles aims to encourage citizens to adopt sustainable behaviours, so that the collected material is recycled and incorporated as raw material in the production of new beverage bottles (Dovelhosefaznovo, 2020). The project covers a set of 23 automatic collection machines installed in large commercial areas, supplied by the government. In these deposits, consumers can deliver used bottles and receive in return, in the form of a discount coupon, the amount corresponding to the unit(s) delivered. In terms of who manages the project, the pilot project is managed by a consortium composed of Associação Águas Minerais e de Nascente de Portugal, Associação Portuguesa das Bebidas Refrescantes Não Alcoólicas (PROBEB) and Associação Portuguesa de Empresas de Distribuição (APED), within the scope of the

application of Law no. 69/2018, of 26 December, which amended Decree-Law no. 152-D/2017, of 11 December, and regulated through Ordinance no. 202/2019, of 3 July. The Environmental Fund of the Ministry of Environment and Climate Action, through Notice No. 12599/2019 of 23 July, provides 100% financing for this pilot project, amounting to 1 665 000 euros. The government will thus finance the installation and the deposits but, according to Law no. 69/2018, the large retailers selling packaged drinks are obliged to make space available on the premises free of charge for the installation of the equipment, while their maintenance must be of the consortium entities responsibility. As in scenario 3 this deposit mechanism is also used for the purpose of reusing packaging rather than recycling, it will be assumed, for the analysis, that this support to finance and maintain the deposits would be left to the government and not to retailers or suppliers. Moreover, with this assumption of the possibility of the pilot project being extended to this proposed system, one of the root causes discovered, the lack of pressure to adopt these systems, is solved. With a government project, a law, and a funding proposal to reduce plastic waste, the government's problem tree created no longer makes sense, as do all the root causes found on the other player's trees about inexistence of external incentives and pressure. For example, there is now a law obliging retailers to provide space for these deposits.

Based on these assumptions, the various data were collected for analysis for each of the cost categories:

Collection Costs (C_C)

> Transportation Costs (C_R): to determine the parameters of transport costs, it was assumed that all pick-ups would be cost-effective, so the truck would be full. After some research, company X (2020) was found and contacted (which requested data confidentiality), which provided the price of a 20-ton capacity truck route at FTL. The price indicated was given in terms of weight transported and not km travelled, so no assumptions were made in terms of km. As the empty packaging weighs 100g, FTL corresponds 200000 packaging. Thus, the quantity collected for the analysis is 200000 packaging.

> Consumers Fee Costs (C_F): for the rate given to consumers, the government's pilot project referred above gave rise to the Despacho nº6534/2019 (Diário da República, 2019), where a table of values of the premium to be awarded to the final consumer for the act of returning packaging has been fixed. In the case of packaging with a capacity greater than 0.5 litres, the rate of 5 cents for packaging returned in good conditions was determined(Diário da República, 2019). This being the value that will be adopted for the analysis.

Testing and Classification Costs (C_T)

> The data for unit inspection costs were assumed to be the same as for the study by Barbosa (2010) on inspection of reusable beer bottles. The inspection data counts for a first and second inspection. A first to decide which are apparently reusable and can be directed to washing and a second to decide the final destination for each, i.e., which are reusable after washing, which are sellable and which are disposable. The cost of the first inspection is 0.000338€ per packaging tested, while the cost of the second inspection is 0.0002258€ per packaging tested.

> To discover the quantities tested in the first and second inspection, there is a need to estimate the percentage of items produced, collected, reusable, sellable and disposable. To estimate this percentage of collected packaging, it will be used as assumption the statistics of plastic packaging collection rate for

recycling. In several countries, other than Portugal, there is an incentive system for the recycling of plastic packaging, where a discount rate is granted if the plastic packaging returned is in good condition.

> According to the different discount rates offered, there are different collection rates around the world, as is perceptible by Figure 15.

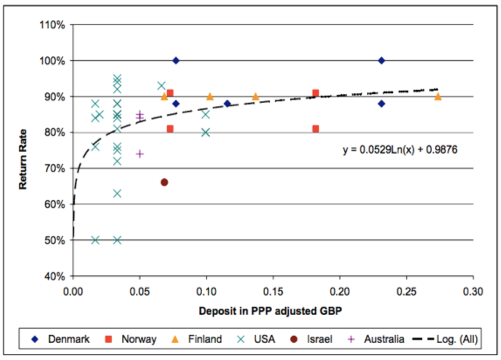


Figure 15: Return Rates as a Function of Deposits in PPP-Adjusted GB Pounds (Eunomia, 2010)

As the collection rate has been set at 5 cents (corresponding to 0.045 pounds in 2020), using the linear function identified in the Annex, it is possible to estimate the percentage of packaging returned (in good condition) in relation to packaging purchased and put up for sale by manufacturers. This percentage is estimated at 82%, corresponding to the 20000 packages collected for FTL in one packaging reuse cycle. For the remaining percentages, the study of beer bottles Barbosa (2010) was used as basis, where it was experienced that average in the first inspection 63% of the packaging collected is reusable, passing to the washing process and that by the second inspection, only 70% of those are really reusable and re-enters the direct process. Thus, the remaining 30% are considered in good condition for sale for recycling, added to the remaining 20% of packaging already considered non-reusable, at the first inspection, which are also fit for sale. The rest reach their end-life and are sent for incineration or landfill. The following Figure 16 schematically shows these percentages and destinations:

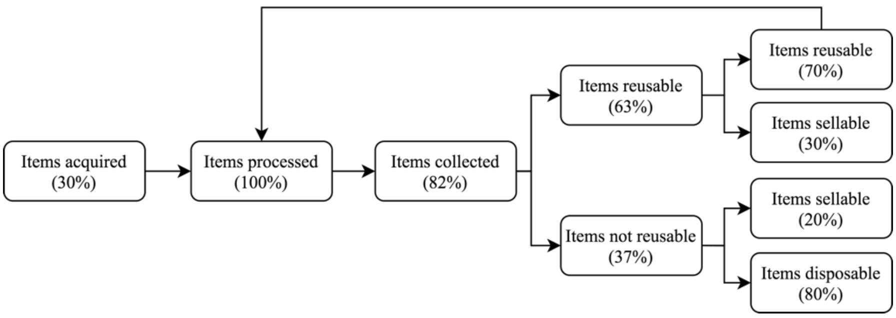


Figure 16: Percentages of packaging acquired, collected, reusable, sellable and disposal during the reverse process

Therefore, since all items are tested two times, the quantity of items tested are the double of the items collected, amounting for 200000 items tested two times or 400000 tests.

Washing Costs (C_W)

> A cycle of 100 washes to the end of life, such as the study of beer bottles, was taken as an assumption. Once again, the data for unit washing costs were assumed to be the same as for the study by Barbosa

(2010) on washing of reusable beer bottles, considering an assumption because the weight is the same, considered an assumption since the weight is the same but not the same material. So, the cost assumed for washing is 0,26€ per packaging washed.

> Regarding the quantity of washed packages, since the collected items are 200000 and the packaging that will undergo the washing process are 63% of the packages collected and inspected as reusable, there is a quantity of 126000 packaging to be washed.

Environmental Protection Costs (C_E)

> Firstly, a 50/50 ratio in the end-of-life distribution between incineration and landfill was assumed arbitrarily. Thus, according to the percentages of Figure 16, 29,6% of the items collected (37% of the first inspection and 80% of the second inspection) are disposable.

> As regards data, all cost data were taken from the European data on incineration and landfill of PET packaging. Therefore, the costs of incineration are 98€ per tonne of waste and 140€ per tonne of waste for landfill (RDC-Environment & Pira International, 2013).

New Packaging Acquisition Costs (C_P)

> To determine the acquisition cost of new reusable packaging, it was researched suppliers of reusable plastic packaging, which sell packaging with the dimensions and weight of the base packaging chosen, and additionally that use recycled plastic in the composition of packaging. This last factor is due to the fact that in scenario 3, the manufacturers sell the packaging that are not reused to their suppliers and they recycle this plastic in new packaging. Thus, the new packaging must contain recycled plastic. Additionally, it was considered that the packaging must be made of resistant PET material and could not contain BPA in their composition, since it was proven to be harmful to health. Based on these criteria, the average value found was 0,168 euros per package, based on the price per ton of some suppliers of reusable plastic packaging in the Indian supplier market (Indiamar, 2020).

> In terms of quantities to be purchased, 242850 packages have to be sent to the market so that 82% of these are returned making up the 200000 packages (FTP). However, this quantity contemplates not only new but also reused packaging, as well as the reusable ones are 44.1% of the collected packaging (63% of the first inspection and 70% of the second inspection), amounting to 88200 packaging, the quantity of new packaging to be acquired is 154650.

Holding Costs (C_H)

> For the holding costs, 10% of the value of the packaging was assumed as a valid assumption indicated in the book "Operations and Supply Chain Management" (Jacobs and R. B. Chase 2012).

> For the value of the packaging, the cost of its acquisition was considered.

> Finally, in terms of quantities, these differ for retailers and manufacturers. Retailers only have to store the collected packaging, i.e., 20000, while manufacturers have to store new and collected packaging in a total of 242850 packaging (154650 + 242850).

Packaging Purchasing Savings (R_P)

> For the savings in the purchase of packaging, it was considered the price at which new packaging would be purchased if there was no reusable packaging to replace it, and the amount of packaging that would have to be purchased, which results in the number of packages that will be reusable (and therefore not

purchased). These values are the same as the components of the variable for purchase of new packaging, i.e., 0,168€ per unit and 88200 reusable packaging.

Material Reproduction Revenue (RM)

> For the sale of end-of-life packaging for recycling plastic, the market for PET packaging scrap was analysed and the price per kg at which the remaining packaging could be sold for recycling was assumed to be an average of 0,36€/kg (Indiamar, 2020). It should be noted that this scrap is not composed of a mixture of plastics and its price was also found to be in line with this particularity.

Environmental Protection Benefit (R_E)

> According to ICIS (2020), EU leaders agreed on a new EU tax on plastic packaging wastes. The tax, to be introduced as of 1 January 2021 on plastic packaging suppliers, will be calculated on the weight of plastic packaging waste with a rate of €0.80/kilogramme. Hence, it was assumed for the future this fee as a saving on the purchased packaging in relation to the conventional packaging.

Data Analysis

Moving on to the final stage of this analysis, the aim is to calculate and analyse the data collected and draw useful conclusions on how this system scenario can prejudice or benefit its players. To this end, this stage will also simulate possible different cost and revenue allocations between retailers and manufacturers.

As outlined by what characterises a transfer system, Scenario 3, identified in Table 4, manufacturers have ownership over the system and thus responsibility for managing all system activities. However, what if there were another scenario, apart from those discriminated by Kroon and Vrijens (1995), in which retailers were not outsourced but were fully responsible for the activities they operate, assuming all costs?

Hence, a possible scenario is that all activities, even if carried out by retailers, are covered by the manufacturers, incurring all costs and profiting from the additional revenues. This can be defined as a new scenario A.

On the other hand, as retailers will operate some of the activities, in particular the collection of packaging and its storage until its transport to the manufacturers' premises, in view of optimizing the activities and ensuring that they are being conducted as efficiently as possible, a way of creating this pressure is for the costs to be borne by the entity that is operating the activity, i.e., the retailers. In return, since no direct revenues can be earned from these activities, retailers can gain some bargaining power over the manufacturers to better negotiate the product prices. However, once again it is necessary to estimate the scale of the costs to be incurred in order to understand whether this bargaining power is really worth the cost. Therefore, this scenario of cost-sharing can be identified as scenario B of this analysis.

Considering all the data collected and these two scenarios, the results obtained can be consulted in Figure 17, and in more detail in Appendix N.

	Scenario A		Scenario B		
	Supplier	Retailer	Supplier	Retailer	
Total Costs per item processed	0.348	0	0.275	0.074	€/item processed
Total Revenues per item processed	-0.120	0	-0.120	0	€/item processed
Total	0.229	0	0.1547	0.074	€/item processed

Figure 17: Total additional variable costs per item processed

For Scenario A, it was considered that all costs were incurred by the manufacturers and the cost of the reverse process activities, already accounted with the revenues benefited, is 0.22 cents additional per processed package, i.e., entering the direct process. On the other hand, for Scenario B, it was assumed that the collection activities, with the transport charge plus the discount rates offered to the customer, as well as the holding costs at the retailers' premises, would be undertaken by the retailers. In this cost-sharing scenario, manufacturers would incur an additional cost of 15 cents per packaging processed and retailers an additional cost of 7 cents per packaging purchased from manufacturers.

In addition, in order to understand the impact of the cost sharing of the activities operated by retailers, a sensitivity analysis was carried out where only the percentage of the costs incurred by manufacturers and retailers of the same activities changed. The following Figure 18 shows the results obtained:

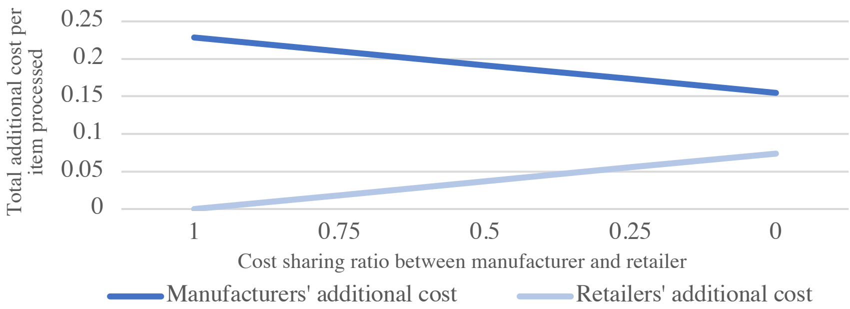


Figure 18: Sensitivity Analysis to cost sharing ratio

As can be seen from Figure 18, the greater the cost sharing ratio, the lower the costs incurred by manufacturers and the higher the costs incurred by manufacturers, as is to be expected. Thus, where the collection and storage of packaging is the full responsibility of retailers, the cost to this player is 7 cents per packaging, while it is 15 cents for all other activities to the manufacturer. Therefore, it shows that there is room to dissolve the costs between the two players.

Although not accounted by this model, retailers will have the opportunity to increase customer retention due to this proposal of discounts on packaging collection. Additionally, if these discounts have an end-date they could also boost consumer consumption, as usual marketing strategy. Therefore, although it is difficult to account for these possible additional revenues, these additional 7 cents per package does not present a figure that prevents the system from being viable, but rather a door to test it. Nonetheless the more tangible costs taken on by retailers, the more power they will have to negotiate over manufacturers, especially now that they will be even more dependent on retailers, because without them it will not be possible to collect the packaging and this system only works if a considerable amount of packaging can be reused.

In terms of manufacturers, in order to understand better these 15 additional cents per packaging that they would have to incur, and to see if there is room for improvement, the different types of costs have been analysed. Accordingly, Figures 19 shows the scale of the different costs in terms of percentages and according to a Pareto analysis.

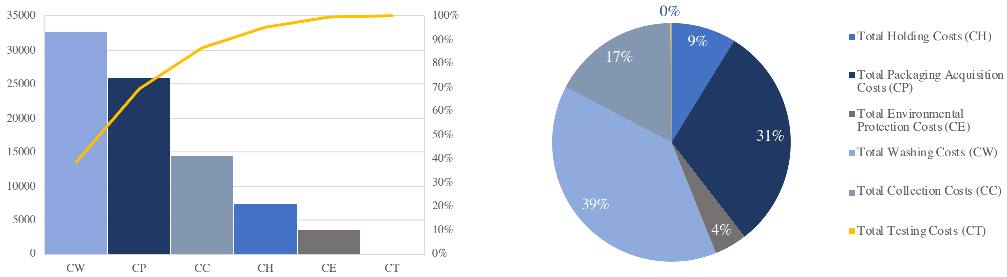


Figure 19: Pareto Analysis

The graph highlights that not all the types of costs are equally balanced. In particular the washing and packaging acquisition costs are those processes, which entails the highest contribution for the total cost of reverse process carried by manufactures. So, if there is room for improvement, the focus has to be on these two as, like the Pareto rule, 80% of the problems are usually caused by 20% of the factors, in this case almost 80% of the costs are generated by these two processes.

As far as the washing process is concerned, there is room to make the process more efficient. As all the packaging that has passed only the first inspection is washed, 30% of the washed packaging is still not reused after washing and therefore would not need to go through this process. Therefore, if the inspections could be adjusted so that only the packaging that will be reused is washed, the costs would be lower as there would be less packaging to be washed and a second inspection would no longer be necessary.

In terms of purchasing new reusable packaging, this component of the process will always be one of the most burdensome as without packaging the process will not work. And since manufacturers do not produce their own packaging, they are at the mercy of the market and can only try to find the most competitive price in the market.

In this analysis, however, use has already been made of the Indian market, which is already one of the most competitive markets, so the improvement is unlikely to be this. However, something that has already been mentioned, but still has a major impact on the analysis, is that this cost, while becoming part of the reverse process, replaces a direct logistics cost, the purchase of new disposable packaging. Therefore, performing a simplistic analysis, assuming that the price of disposable packaging is 30% cheaper than reusable, then costing 11 cents per package, and the total amount of packaging to be purchased (disregarding the reusable ones), regarded in the analysis as 242850 packages, the saving would be 28559 euros, surpassing the cost of purchasing reusable packaging. Hence, Table 5 therefore presents a sensitivity analysis which varies the percentage of the price of disposable packaging from that of reusable packaging, revealing the total additional cost per package for manufacturers.

Table 5: Sensitivity analysis to cost of disposable and reusable packaging

Disposable/Reusable packaging	0	15%	30%	45%	60%	75%	90%	93%	95%	%
Total Cost per item processed	0.154746716	0.129546716	0.104346716	0.079146716	0.053946716	0.028746716	0.003546716	-0.001493284	-0.004853284	€/item processed

As it is perceptible by the results, according to the price difference between reusable and disposable packaging, it is possible to reduce costs considerably and even reach a level where there is no additional cost.

In short, this analysis shows that Scenario B is the ideal one, since the costs can be dissolved by the two players, but neither of them will lose with this collaboration. While retailers will gain even more negotiating power and a new marketing strategy to retain and attract customers, producers have maneuverer for improvement and that according to the negotiation of good prices for reusable packaging, it is manageable to eliminate almost entirely the additional costs due to savings from the purchase of disposable packaging. Additionally, this shampoo is sold at retailers at around 5,79€ (Continente, 2020), so the overall additional cost of 0,22€ represents an increase of 3,8% in the cost of the product.

Therefore, the main conclusion of this last analysis is that the results obtained demonstrate that the magnitude of the additional variable costs for this proposed system are not a hindrance to starting to develop the system and to carrying out a proper case study in the future.

6. | Limitations, Conclusions and Future Work

Massive consumption of plastic is one of the most serious problems the world is facing today, threatening all ecosystems, with more than 300 million tonnes of plastic being produced worldwide each year (Geyer et al., 2017). Although there is still production of durable and reusable plastics, most production is for disposable and single-use products, and so if the goal is to save ecosystems, the era of disposability must end with innovative business approaches.

One of these approaches, and already proven by several scientific studies, is reusable packaging systems, recognised as a great solution to tackle this problem, not only for its environmental benefits but also from an economic point of view. According to Ellen MacArthur Foundation (2017), replacing 20% of plastic packaging into reuse models is a USD 10 billion business opportunity that benefits customers while representing a crucial element for eliminating plastic waste and pollution. However, these systems, although already popular in a niche market like zero waste stores, have not yet flourished in mainstream retail.

Looking at the literature review on sustainable options for packaging, research demonstrated how the concept of ZW has been gathering pace since 2009 and is replete with such topics as return/reuse and recycling practices for post-consumer packaging, comparisons of sustainable alternatives in packaging, adoption of sustainable packaging solutions and packaging waste management. However, it was possible to identify where there is room for more research, with some gaps in the literature. In particular, to adapt scientific studies and models to the real contexts and with an integral supply chain approach and not only at some levels. Moreover, the focus of packaging reuse has remained only on the food and beverage industry and for tertiary packaging. Therefore, there is a pressing need to consider more specific studies for other industries and especially in relation to primary packaging, which is where the greatest waste occurs.

Hence, although reusing packaging seems to offer many advantages, the lack of proven results and real case studies of success in mainstream retail, the sector remains hesitant to explore this alternative. To bridge this gap, it was decided to study this problem, understanding why it is not put into practice and developing an innovative system for the reuse of primary packaging that mitigates all possible obstacles for its non-adoption, so that retail stakeholders have no reason not to adopt it and thus help reduce the waste of plastic packaging.

First, an analysis of the problem was carried out and it was perceived that the majority of the reasons outlined for each actor not wanting to adopt these systems are common to all system participants. Moreover, a pattern was found in all of them, revealing the dependence between the players, i.e. each actor depends on the implementation of the system by all the other stakeholders. This dependence thus reveals the requirement for some kind of collaboration and commitment between the different actors for this type of solution to be viable.

Based on the general root causes for the various actors, the market was analysed for other initiatives which in some way practise packaging reuse systems. From this reference, it was possible to conclude which best practices should be present for a successful system, in terms of addressing the root causes identified. The main lesson learned was that the new system cannot require a change in consumption habits as society does not yet give primacy and recognises sustainability to lifestyle inconvenience. The system has to please everyone and not only those who prevail more sustainable options, because for that there is already the market of zero waste shops.

Accordingly, several scenarios of reusable packaging systems were constructed adapting the reverse logistic designs studied in the literature review according to the best practices identified and the actual context of the problem. After three scenarios were created, the three were evaluated qualitatively and it was perceived that the first two did only benefit some of the players in the system, being impossible to convince the others to collaborate in a system that does not benefit them and on the contrary makes their business weaker.

However, system 3 has proven to be beneficial for all stakeholders crucial to its implementation, and thus a final quantitative analysis has been carried out to analyse the economic viability of the system. From this analysis, the results obtained demonstrate that the magnitude of the additional variable costs of this proposed system are not a hindrance to starting to develop the system and to carrying out a case study in practice. Moreover, it has been realised that with greater collaboration, it is possible to dissolve the costs between the actors and, in an attempt to make the reverse process' activities more efficient, it even becomes possible to almost eradicate the manufacturer's, which is the player that holds the greatest responsibility of the process.

Nonetheless, although the results present good news for combating plastic waste, they were obtained based on many different assumptions. Due to the current state of the pandemic, it became impossible to conduct detailed interviews and a proper case study for the analysis and validation of the proposed scenario. Thus, both the root causes of the problem and the feasibility analysis of the scenario are underlying a collection of secondary and not primary data, so it will not be possible to assume the result obtained as conclusive but rather in a macro level. Accordingly, three main areas for future research are suggested. First, it should be sought to work on agile methodology and design this system together with the main stakeholders, retailers and manufacturers. In this way, it would be possible to obtain throughout the process, and not only at the beginning, the obstacles and their opinion regarding the system that is being created. With their continuous input, besides being possible to create an improved system, it makes them part of the process and this involvement will make it easier to accept and implement the system created, since it was also created by them and with their perspective.

In addition, the validation process of the constructed scenarios should be extended to a real case study. By replacing secondary data with primary data from a real case study, it would increase the reliability of the results and allow the generalization of better-founded hypotheses.

Finally, ideally the last step in order to achieve the most evidence-based results possible would be to implement the system in a real retail context for a trial period and analyse the results obtained, in terms of the opinion of all intervening players, i.e., packaging suppliers, manufacturers, retailers and consumers. According to the feedback, there would be a need to adjust the system to the best possible performance and possibly make the system designs accessible to those who want to implement it. Only in this way would it really be possible to achieve the goal of reducing plastic packaging waste.

References

Aaron D., Castillejo T., & Stensson, F. (2011). Returnable plastic packaging flow in the automotive industry: An evaluation of the washing from a green logistics ' perspective. Chalmers University of Technology.

Accorsi, R., Cascini, A., Cholette, S., Manzini, R., Mora, C. (2014). Economic and environmental assessment of reusable plastic containers: a food catering supply chain case study. Int. J. Prod. Econ. 152, 88-101.

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., Overy, P. (2015). Sustainability- oriented innovation: a systematic review. Int. J. Manag. Rev. 18 (2), 180-205.

All4Pack. (2018). Packaging: Market and Challenges in 2018, Available at: https://www.all4pack.com/Archives/Packaging-market-challenges-2018

Almeida, C.M.V.B., Rodrigues, A.J.M., Agostinho, F., Giannetti, B.F. (2017). Material selection for environmental responsibility: the case of soft drinks packaging in Brazil. J. Clean. Prod. 142, 173-179.

Andersen, B. (1995). The results of benchmarking and a benchmarking process model, PhD dissertation, Norwegian Institute of Technology, Trondheim, Norway.

Andersen, B., Fagerhaug, T., Randmæl, S., Schuldmaier, J., & Prenninger, J. (1999). Benchmarking supply chain management: finding best practices. Journal of Business & Industrial Marketing, 14(5/6), 378–389.

Azzi, A., Battini, D., Persona, A., Sgarbossa, F. (2012). Packaging design: general framework and research agenda. Packaging Technology and Science, 25(8), 435-456.

Bapakt (2019). Open Knowledge Base on Zero-Waste Supermarkets. Available at: https://www.bepakt.com/

Barbosa, T. (2010). Mestrado Integrado em Engenharia Química Optimização de Sistemas CIP Tese de Mestrado.

Barrera, M.M.M., Cruz-Mejia, O. (2014). Reverse logistics of recovery and recycling of non-returnable beverage containers in the brewery industry: a "profitable visit" algorithm. Int. J. Phys. Distrib. Logist. Manag. 44 (7), 577-596.

Beitzen-heineke, E. F. (2015). The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain, 140(September), 2014–2015.

Beitzen-Heineke, E. F., Balta-Ozkan, N., & Reefke, H. (2017). The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain. Journal of Cleaner Production, 140, 1528–1541.

Benoît-Norris, C., Vickery-Niederman, G., Valdivia, S., Franze, J., Traverso, M., Ciroth, A., Mazijn, B. 2011. Introducing the UNEP/SETAC methodological sheets for subcategories of social LCA. Int. J. Life Cycle Assess. 16 (7), 682-690.

Bernstad Saraiva, A., Pacheco, E.B.A.V., Gomes, G.M., Visconte, L.L.Y., Bernardo, C.A., Simo~es, C.L., Soares, A.G. (2016). Comparative lifecycle assessment of mango packaging made from a polyethylene/natural fiber-composite and from card- board material. J. Clean. Prod. 139, 1168-1180.

Bittencourt Marconatto, D. A., Barin-Cruz, L., Pozzebon, M., & Poitras, J. E. (2015). Developing sustainable business models within BOP contexts: Mobilizing native capability to cope with government programs. Journal of Cleaner Production, 129, 735-748.

Bogan, C.E. & English, M.J. (1994). Bench marking for Best Practices: Winning Through Innovative Adaptation. New York: McGraw-Hill.

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. Journal Clean Production, 45, 8-19.

Bortolini, M., Galizia, F.G., Mora, C., Botti, L., Rosano, M. (2018). Bi-objective design of fresh food supply chain networks with reusable and disposable packaging containers. J. Clean. Prod. 184, 375-388.

Boulding K. (1966).The economics of the coming spaceship Earth. In: Jarrett H, editor. Environmental quality in a growing economy,resources for the future. Baltimore, MD: Johns Hopkins University Press, 3-14.

Brown, T. A., Friedman, D. C., & Taran, Z. (2017). Showrooming and the small retailer. Qualitative Consumer Research, 14, 79-94.

Burek, J., Kim, D., Nutter, D., Selke, S., Auras, R., Cashman, S., et al. (2018). Environmental sustainability of fluid milk delivery systems in the United States. J. Ind. Ecol. 22 (1), 180-195.

Bylinsky, G. (1995). Manufacturing for reuse, Fortune, February 6, 60-5.

Carrasco-Gallego, R., Ponce-Cueto, E., Dekker, R. (2012). Closed-loop supply chains of reusable articles: a typology grounded on case studies. Int. J. Prod. Res. 50 (19), 5582-5596.

Casadesus-Masanell, R., & Ricart, J. (2010). From Strategy to Business Models and onto Tactics. Long Range Planning, 43(2-3), 195-215.

Chen, Y. P. (2012). Cost and benefit analysis of reverse logistics. Proceedings of the 2012 2nd International Conference on Business Computing and Global Informatization, BCGIN 2012, (3), 75–77.

Collins SL, Carpenter SR, Swinton SM, Orenstein DE, Childers DL et al. (2011). An integrated conceptual framework for long-term social-ecological research. Front Ecol Environ 9:351–357

Collins, J.C., Porras, J.I. (1996). Building your company's vision. Harv. Bus. Rev. 74 (5), 65-76.

Colon, M., Fawcett, B. (2006). Community-based household waste management: lessons learnt from EXNORA's 'zero waste management' scheme in two South Indian cities. Habitat Int. 30, 916-931

Continente. (2020). Available at: https://www.continente.pt/pt-pt/public/Pages/searchresults.aspx?k=h%26S

Curran, T., Williams, I.D.(2012). A zero waste vision for industrial networks in Europe. J. Hazard. Mater. 207e208, 3-7.

Dahlbo, H., Poliakova, V., Mylläri, V., Sahimaa, O., & Anderson, R. (2018). Recycling potential of post-consumer plastic packaging waste in Finland. Waste Management, 71, 52–61.

Darlow T. (2003). Waste Plans: Report on Categorisation and Pilot Studies. Scottish Institute of Sustainable Technology: Edinburgh

De Benedetto, L., Klemes, J. (2009). The Environmental Performance Strategy Map.

De Vries B. (2013. Sustainability science. Cambridge University Press, New York

Dede, B., Sarı, M., Gürsul, A., Hanedar, A., Gadis, A., Görgülü, B., … Eser, E. (2016). Variables affecting quality of care of the outpatients having a chronic condition. TAF Preventive Medicine Bulletin, 15(3), 238–247.

Diário da República n. º 167/2019, Série I.(2019). Available at: https://dre.pt/home/-/dre/124346828/details/maximized

Diário da República n.º 137/2019, Série II. (2019). Available at: https://dre.pt/home//dre/123326823/details/3/maximized?serie=II&dreId=123326776

Dovelhosefaznovo. (2020). Available at: https://dovelhosefaznovo.pt/projeto

Ellen MacArthur Foundation. (2017). The New Plastics Economy: catalysing action

Emblem, A., & Emblem, H. (2012). Packaging technology: Fundamentals,materials and processes.

Encyclopædia Britannica, inc. (2011). Packaging. Available at: https://www.britannica.com/technology/packaging

Environment Agency. (2012). Waste Electrical and Electronic Equipment (WEEE). Available at: http://www.environment-agency.gov.uk/business/topics/waste/32084.aspx

European Commission (EC). (2017). Moving towards a circular economy with EMAS. In Circular Economy Strategy. Roadmap.

European Commission (EC). (2018). A European strategy for plastics in a circular economy. Available at: http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy.pdf

European Environment Agency. (2016). Circular Economy in Europe - Developing the Knowledge Base. EEA Report 2/2016

European Parliament. (2018). Plastic waste and recycling in the EU: facts and figures, Available at: https://www.europarl.europa.eu/news/en/headlines/society/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

European Union. (1994). European Parliament and Council Directive 94/62/EC on Packaging and Packaging Waste. Official Journal of the European Communities No L 365/10, 1993(L), 10–23.

Eurostat. (2019). Development of all packaging waste generated, recovered and recycled, EU, 2007-2016. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Packaging_waste_statistics

F. R. Jacobs, R. B. Chase (2012). Operations and Supply Chain Management 14th Global Edition, 2011, McGrawHill Education

Fischer, S. (2012). Personal Business Model Evolution: How Individuals Change Their Business Model Over Time. Master Thesis. Twente University.

Fleischmann, M., Krikke, H.R., Dekker, R. and Flapper, S.D.P. (2000). A characterisation of logistics networks for product recovery, Omega, Vol. 28, pp. 653-66.

Frano, R. L., & Sanfiorenzo, A. (2016). Demonstration of structural performance of IP-2 package by simulation and full-scale horizontal free drop test. Progress in Nuclear Energy, 86, 40-49.

Fraser MW, Richman JM, Galinsky MJ, Day SH. (2009). Intervention research: developing social programs. Oxford University Press, New York

Gallego-Schmid, A., Mendoza, J. M. F., & Azapagic, A. (2018). Improving the environmental sustainability of reusable food containers in Europe. Science of The Total Environment, 628, 979-989.

García-Arca, J., Prado-Prado, J. C., & Gonzalez-Portela Garrido, A. T. (2014). "Packaging logistics": promoting sustainable efficiency in supply chains. International Journal of Physical Distribution & Logistics Management, 44(4), 325–346.

Geueke, B., Groh, K., Muncke, J. (2018). Food packaging in the circular economy: overview of chemical safety aspects for commonly used materials. J. Clean. Prod. 193, 491-505.

Geyer, R., Jambeck, J. R. and Law, K. L. (2017). 'Production, use, and fate of all plastics ever made'. Available at: http://advances.sciencemag.org/

Gil, A. C. (2002). Como elaborar projetos de pesquisa (Vol. 4, p. 175). São Paulo: Atlas.

Gregor-Svetec, D. (2018). Chapter 8 - Intelligent Packaging. In Nanomaterials for Food Packaging.

Greyson, J. (2007). An economic instrument for zero waste, economic growth and sustainability. J. Clean. Prod. 15, 1382-1390

Haddock-Fraser, J. E., , Tourelle, M. (2010). Corporate motivations for environmental sustainable development: Exploring the role of consumers in stakeholder engagement. Business Strategy and the Environment, 19(8), 527–542.

Hahladakis, J. N., & Iacovidou, E. (2018). Closing the loop on plastic packaging materials: What is quality and how does it affect their circularity? Science of The Total Environment, 630, 1394–1400.

Hannay, F. (2002). Rigid plastics packaging: materials, processes and applications (Vol. 151). iSmithers Rapra Publishing.

Hanssen, O. J., Vold, M., Schakenda, V., Tufte, P.-A., Møller, H., Olsen, N. V., & Skaret, J. (2017). Environmental profile, packaging intensity and food waste generation for three types of dinner meals. Journal of Cleaner Production, 142, 395–402.

Hardy, D. W., & Curran, B. A. (2009). Types of packaging waste from secondary sources (supermarkets) - The situation in the UK. Waste Management, 29(3), 1198–1207.

Hellström, D., Johansson, O., 2010. The impact of control strategies on the management of returnable transport items. Transport. Res. E Logist. Transport. Rev. 46 (6), 1128–1139.

Herbes, C., Beuthner, C., Ramme, I. (2018). Consumer attitudes towards biobased packaging e a cross-cultural comparative study. J. Clean. Prod. 194, 203-218.

Hyde, K., Smith, A., Smith, M., & Henningsson, S. (2001). Challenge of waste minimization in the food and drink industry: A demonstration project in East Anglia, UK. Journal of Cleaner Production, 9(1), 57–64.

ICIS (2020). Available at: https://www.icis.com/explore/resources/news/2020/07/21/10532318/eu-agrees-tax-on-plastic-packaging-waste

INCPEN. (2007). Packaging in the Sustainability Agenda-A Guide for Corporate Decision Makers

Iwaniec, D. (2013). Crafting Sustainability Visions–Integrating VisioningPractice, Research, and Education. Arizona State University.

J. Kirchherr, D. Reike, M. Hekkert. (2017). Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conserv. Recycl., 127, pp. 221-232

J.M. Allwood. (2014). Chapter 30-Squaring the circular economy: the role of recycling within a hierarchy of material management strategies, E. Worrell, M. Reuter (Eds.), Handbook of Recycling, Elsevier, Boston, pp. 445-477

Jacobs, F. R., Chase, R. B., & Lummus, R. R. (2011). Operations and supply chain management (Vol. 567). New York: McGraw-Hill Irwin.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... Law, K. L. (2015). the Ocean. Science Magazine, 347(February), 768–771.

James, K., Fitzpatrick, L., Lewis, H., and Sonneveld, K. (2005) Sustainable Packaging System Development. In Leal Filho, W. (ed) Handbook of Sustainability Research. Peter Lang Scientific Publishing, Frankfurt.

Janjarasskul, T., , Suppakul, P. (2018). Active and intelligent packaging: The indication of quality and safety. Critical Reviews in Food Science and Nutrition, 58(5), 808–831

Janssen, H. G., Davies, I. G., Richardson, L. D., , Stevenson, L. (2017). Determinants of takeaway and fast food consumption : a narrative review Nutrition Research Reviews.

Jarupan, L., Kamarthi, V., & Gupta, S. (2011). Evaluation of trade-offs in costs and environmental impact for returnable packaging implementation. Environmental Conscious Manufacturing III, 6-14.

Jerneck A, Olsson L, Ness B, Anderberg S, Baier M et al. (2011). Structuring sustainability science. Sustain Sci 6:69–82

Joyce, A.; Paquin, R. and Pigneur, Y. (2015): The triple layered business model canvas: a tool to design more sustainable business models, ARTEM Organizational Creativity International Conference, 26-27 March 2015, Nancy, France.

K. Winans, A. Kendall, H. Deng. (2017).The history and current applications of the circular economy concept. Renew. Sustain. Energy Rev., 68, pp. 825-833

Kannan Govindan & Mia Hasanagic. (2018). A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective, International Journal of Production Research, 56:1-2, 278-311

Karst, T. (2013). German study looks at spoilage by packaging type.

Kirchgeorg, M., Jung, K., & Klante, O. (2010). The future of trade shows: insights from a scenario analysis. Journal of Business & Industrial Marketing, 25(4), 301–312

Ko, Y.D., Noh, I., Hwang, H. (2012). Cost benefits from standardization of the packaging glass bottles. Comput. Ind. Eng. 62 (3), 693-702.

Koh, Y. and Aoshima, Y. (2001). Recycle and reuse, Hitotsubashi Business Review, Vol. 49 No. 3, 144-58.

Komolprasert, V., & Lawson, A. R. (1997). Considerations for reuse of poly (ethylene terephthalate) bottles in food packaging: migration study. Journal of agricultural and food chemistry, 45(2), 444-448.

Kopicki, R., Berg, M., Legg, L., Dasappa, V. and Maggioni, C. (1993). Reuse and Recycling – Reverse Logistics Opportunities, Council of Logistics Management, Oak Brook, IL.

Koskela, S., Dahlbo, H., Judl, J., Korhonen, M.-R., Niininen, M. (2014). Reusable plastic crate or recyclable cardboard box? A comparison of two delivery systems. J. Clean. Prod. 69, 83-90.

Kroon, L., Vrijens, G. (1995). Returnable containers: an example of reverse logistics. Int. J. Phys. Distrib. Logist. Manag. 25 (2), 56–68.

Kuczenski, B., Geyer, R. (2010). Material flow analysis of polyethylene terephthalate in the US, 1996-2007. Resour. Conserv. Recycl. 54 (12), 1161-1169.

L. Lu, W. Zheng, Z. Lv, Y. Tang. (2013). Development and application of time-temperature indicators used on food during the cold chain logistics, Packag. Technol. Sci. 26, 80–90.

Landier, A., Nair, V.B., Wulf, J. (2009). Trade-offs in staying close: corporate decision making and geographic dispersion. Rev. Financial Stud. 22 (3), 1119-1148.

Langley, J., Turner, N., & Yoxall, A. (2011). Attributes of packaging and Influences on waste. Packaging Technology and Science, 24(3), 161-175.

Laszlo, C. (2008). Sustainable Value: How the World's Leading Companies Are Doing Well by Doing Good. Stanford University Press.

Leppelt, T., Foerstl, K., Reuter, C., & Hartmann, E. (2013). Sustainability management beyond organizational boundaries–sustainable supplier relationship management in the chemical industry. Journal of Cleaner Production, 56, 94-102.

Lewis H, Gertsakis J, Grant T, Morelli N, Sweatman A. (2001). Design + Environment, a Global Guide to Designing Greener Goods. Greenleaf Publishing: Sheffield.

Lewis, H. (2005). "Defining product stewardship and sustainability in the Australian packaging industry." Environmental Science and Policy 8: 45- 55.

Lewis, H., L. Fitzpatrick, K. Verghese, K. Sonneveld and R. Jordan (2007). Sustainable packaging redefined (draft). Melbourne, Sustainable Packaging Alliance

Li, L., Wang, B., Cook, D.P. (2014). Enhancing green supply chain initiatives via empty container reuse. Transp. Res. Part E 70, 190-204.

Licciardello, F. (2017). Packaging, blessing in disguise. Review on its diverse contribution to food sustainability. Trends in Food Science and Technology, 65, 32–39.

Lofthouse, V. A., & Bhamra, T. A. (2006). Refillable packaging systems: Design considerations. 9th International Design Conference, DESIGN 2006, 1391–1398.

Lofthouse, V. A., Bhamra, T. A., & Trimingham, R. L. (2009). Investigating customer perceptions of refillable packaging and assessing business drivers and barriers to their use. Packaging Technology and Science, 22(6), 335–348

Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., ... & Thomsen, M. (2016). Green economy and related concepts: An overview. Journal of cleaner production, 139, 361-371.

Lützebauer, M. (1993). Systems for Returnable Transport Packaging, Frankfurt am Main.

M. Geissdoerfer, P. Savaget, N.M.P. Bocken, E.J. Hultink. (2017). The Circular Economy – a new sustainability paradigm? J. Clean. Prod., 143, pp. 757-768

M. Grosso, M. Niero, L. Rigamonti. (2017). Circular economy, permanent materials and limitations to recycling: where do we stand and what is the way forward? Waste Manag. Res., 35 (8), pp. 793-794

Magretta, J. (2002). Why business models matter. Harvard Business Review, 80(5), 86-92.

Mahmoudi, M., & Parviziomran, I. (2020). Reusable packaging in supply chains: A review of environmental and economic impacts, logistics system designs, and operations management. International Journal of Production Economics, 107730.

Marques, R. C., da Cruz, N. F., Simões, P., Faria Ferreira, S., Pereira, M. C., & De Jaeger, S. (2014). Economic viability of packaging waste recycling systems: A comparison between Belgium and Portugal. Resources, Conservation and Recycling, 85

Mary Meeker. (2019). BOND Internet Trends 2019. 2019-06-11, 161. Retrieved from https://www.bondcap.com/report/itr19/#view/1

Mason, I.G., Brooking, A.K., Oberender, A., Harford, J.M., Horsley, P.G. (2003). Implementation of a zero waste program at a university campus. Resour. Conserv. Recycl. 38, 257-269.

Matete, N., Trois, C. (2008). Towards zero waste in emerging countries e a South African experience. Waste Manag. 28, 1480-1492.

Meadows D. (1999). Leverage points: places to intervene in a system. Vermont: Sustainability Institute, http://www.sustainabilityinstitute.org.

Meherishi, L., Narayana, S. A., & Ranjani, K. S. (2019). Sustainable packaging for supply chain management in the circular economy: A review. Journal of Cleaner Production, 237, 117582.

Menesatti, B.P., Canali, E., Sperandio, G., Burchi, G., Devlin, G., Costa, C. (2011). Cost and waste comparison of reusable and disposable shipping containers for cut flowers. Packag. Technol. Sci. 25 (4), 203-215.

Miller TR, Wiek A, Sarewitz D, Robinson J, Olsson L, Kriebel D, Loorbach D. (2014). The future of sustainability science: a solutions-oriented research agenda. Sustain Sci 9:239–246

Mittchell, R., Agle, B. & Wood, D. (1997). Toward a Theory of Stakeholder Identification and Salience : Defining the Principle of Who and What Really Counts. Academy of Management Review, 22(4), 853–886.

Mordor Intelligence. (2019). Plastic Packaging Market - Growth, Trends, and Forecast (2020 - 2025) Available at: https://www.mordorintelligence.com/industry-reports/plastic-packaging-market

Mourad, A.L.L.L., Garcia, E.E.C., Vilela, G.B., Von Zuben, F. (2008). Influence of recy- cling rate increase of aseptic carton for long-life milk on GWP reduction. Resour. Conserv. Recycl. 52 (4), 678.

Mrkajić, V., Stanisavljevic, N., Wang, X., Tomas, L., , Haro, P. (2018). Efficiency of packaging waste management in a European Union candidate country. Resources, Conservation and Recycling, 136(January), 130–141.

Murphy, S., Pincetl, S. (2013). Zero waste in Los Angeles: Is the emperor wearing any clothes? Resour. Conserv. Recycl. 81, 40-51.

Nash, Jennifer; Ehrenfeld, John (2010). "Code Green: Business Adopts Voluntary Environmental Standards". Environment: Science and Policy for Sustainable Development. 38, 16–45.

Nastasi, B. K., & Schensul, S. L. (2005). Contributions of qualitative research to the validity of intervention research. Journal of School Psychology, 43(3), 177–195.

Nastasi, B. K., & Schensul, S. L. (2005). Contributions of qualitative research to the validity of intervention research. Journal of School Psychology, 43(3), 177-195.

Natarajan, S., Govindarajan, M., & Kumar, B. (2014). Fundamentals of packaging technology. PHI Learning Pvt. Ltd.

Needleman, C., & Needleman, M. L. (1996). Qualitative methods for intervention research. American Journal of Industrial Medicine, 29(4), 329–337.

Nidumolu, R., Prahalad, C., Rangaswami, M. (2009). Why Sustainability is now the key driver of innovation. Harv. Bus. Rev. 87 (9), 56-64.

Obrecht, M., Knez, M. (2017). Carbon and resource savings of different cargo container designs. J. Clean. Prod. 155, 151-156.

OCC: Third-Party Relationships: Risk Management Guidance". occ.gov.

Osterwalder, A. (2004). The Business Model Ontology e a Proposition in a Design Science Approach available at: http://www.hec.unil.ch/aosterwa/PhD/

Osterwalder, A., & Pigneur, Y. (2010). Business model canvas. Self published. Last.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science, 325(5939), 419–422.

P. Ghisellini, C. Cialani, S. Ulgiati. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod., 114, pp. 11-32

P. Hsia, J. Samuel, J. Gao, D. Kung, Y. Toyoshima and C. Chen. (1994). Formal approach to scenario analysis, *IEEE Software*, vol. 11, no. 2, pp. 33-41

Paine FA. (1991). The packaging user's handbook. New York: AVI, Van Nostrand Reinhold. 158 p.

Palmer, P., (2004). Getting to Zero Waste. Purple Sky Press, Sebastopol, CA, USA.

Palombini, F.L., Cidade, M.K., de Jacques, J.J. (2017). How sustainable is organic packaging? A design method for recyclability assessment via a social perspective: a case study of Porto Alegre city (Brazil). J. Clean. Prod. 142, 2593-2605.

Pålsson, H., Finnsgård, C., Wanstrom, C. (2013). Selection of packaging systems in supply chains from a sustainability perspective e the case of Volvo. Packag. Technol. Sci. 26, 289-310.

Papaj, K. A. (2016). Katarzyna Anna Papaj Food waste - Policies , initiatives and consumer behaviour . Case study : Poland and Portugal.

Papong, S., Malakul, P., Trungkavashirakun, R., Wenunun, P., Chom-In, T., Nithitanakul, M., Sarobol, E. (2014). Comparative assessment of the environ- mental profile of PLA and PET drinking water bottles from a life cycle perspective. J. Clean. Prod. 65, 539-550.

Perrin, D., & Barton, J. (2001). Issues associated with transforming household attitudes and opinions into materials recovery: a review of two kerbside recycling schemes. Resources, Conservation and Recycling, 33(1), 61–74.

Perugini, F., Mastellone, M. L., & Arena, U. (2005). A life cycle assessment of mechanical and feedstock recycling options for management of plastic packaging wastes. Environmental Progress, 24(2), 137–154.

Pfeffer, J., Salancik, G.R. (1978). The External Control of Organizations: a Resource Dependence Approach. Harper and Row Publishers, NY.

Plastics Europe. (2017). Plastics-the facts 2017: an analysis of European plastics production, demand and waste data. Available at: https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL _for_website_one_page.pdf

Plastics Europe. (2018). Plastics-the facts 2018: an analysis of European plastics production, demand and waste data. Available at: https://www.plasticseurope.org/application/files/6315/4510/9658/Plastics_the_facts_2018_AF_we b.pdf.

Pohlen, T.L. and Farris, M.T. (1992). Reverse logistics in plastic recycling, International Journal of Physical Distribution and Logistics Management, Vol. 22 No. 7, 35-47.

Postacchini, L., Mazzuto, G., Paciarotti, C., Ciarapica, F.E. (2018). Reuse of honey jars for healthier bees: developing a sustainable honey jars supply chain through the use of LCA. J. Clean. Prod. 177, 573-588.

Powell, B. J. (2010). Book Review: Fraser, M.W., Richman, J.M., Galinsky, M. J. & Day, S. H. Intervention Research: Developing Social Programs. New York: Oxford, 2009. 224 pp. $24.95 paperback, ISBN 978-0-19-532549-2). Research on Social Work Practice, 20(3), 325–327.

Prive , J., Renaud, J., Boctor, F., Laporte, G. (2006). Solving a vehicle-routing problem arising in soft-drink distribution. J. Oper. Res. Soc. 57 (9), 1045-1052.

Rajeev, A., Pati, R. K., Padhi, S. S., , Govindan, K. (2017). Evolution of sustainability in supply chain management: A literature review. Journal of Cleaner Production, 162, 299–314.

RDC-Environment and Pira International. (2003). Evaluation of costs and benefits for the achievement of reuse and recycling targets for the different packaging materials in the frame of the packaging and packaging waste directive 94/62/EC. Final consolidated report.

RDC. (2013). International, R.-E. & P., & RDC-Environment & Pira International, Process trees and system descriptions. Evaluation of Costs and Benefits for the Achievement of Reuse and Recycling Targets for the Different Packaging Materials in the Frame of the Packaging and Packaging Waste Directive 94/62/EC, (March), 75–213.

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W.-P. (2004). Life cycle assessment: Part 1: framework, goal and scope definition, inventory analysis, and applications. Environ. Int. 30 (5), 701-720.

República, D. (2019). AMBIENTE E TRANSIÇÃO ENERGÉTICA Gabinete do Ministro. 2019.

Restuccia, D., Spizzirri, U. G., Parisi, O. I., Cirillo, G., Curcio, M., Iemma, F., Puoci, F., Vinci, G. and Picci, N. (2010). New EU regulation aspects and global market of active and intelligent packaging for food industry applications. Food Control 21:1425–1435.

Ribeiro, D. F. (2018). Avaliação da venda de produtos a granel em supermercados – Caso de estudo Supermercado Pingo Doce.

Richardson, J. (2008). The business model: an integrative framework for strategy execution. Strategic Change, 17(5 - 6), 133-144.

Ritchie, H. and Roser, M. (2018), Plastic pollution. Available at: https://ourworldindata.org/plastic- pollution.

Robertson GL. (1993). Food packaging: principles and practice. Marcel Dekker, New York. 686 p.

Robinson JB.(1990). Future under glassda recipe for people who hate to predict.

Rocca, F. C. (2016). Supply Chain Management for Frugal Innovation Products. (June).

Rogers, D.S. and Tibben-Lembke, R. (2001). An examination of reverse logistics practices, Journal of Business Logistics, Vol. 22 No. 2, 129-48.

Ross, S., Evans, D. (2003). The environmental effect of reusing and recycling a plastic-based packaging system. J. Clean. Prod. 11 (5), 561-571.

Sacharow, S. & Griffin, R.C. (1980) Principles of food packaging. In Food Packaging – Its Background, Basic Food Processes. Food Packaging – Its Background, pp. 1– 71. AVI Publishing Company, Westport, CT

Saghir, M. (2012), Packaging Logistics Evaluation in the Swedish Retail Supply Chain, Lund University, Lund.

Sarewitz D, Kriebel D, Clapp R, Crumbley C, Hoppin P, Jacobs M, Tickner J. (2012). The sustainability solutions agenda. New Solut 22(2):139–151

Schaefer, D., , Cheung, W. M. (2018). Smart Packaging: Opportunities and Challenges. Procedia CIRP, 72, 1022–1027.

Schaltegger, S., Hansen, E. G., & Lüdeke-Freund, F. (2015). Business Models for Sustainability. Organization & Environment, 29(1), 3–10.

Schaltegger, S., Hansen, E. G., & Lüdeke-freund, F. (2016). Business Models for Sustainability : Origins , Present Research , and Future Avenues. Organizational and Environment, 29(1), 3- 10.

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models . Business Horizons, 48(3), 199-207.

Sherrington, C., Darrah, C., Hann, S., Cole, G., & Corbin, M. (2016). Study to support the development of measures to combat a range of marine litter sources.

Silva, D.A.L., Reno , G.W.S., Sevegnani, G., Sevegnani, T.B., Truzzi, O.M.S. (2013). Comparison of disposable and returnable packaging: a case study of reverse logistics in Brazil. J. Clean. Prod. 47, 377-387.

Simms, C., & Trott, P. (2010). Packaging development: A conceptual framework for identifying new product opportunities. Marketing Theory, 10(4), 397–415.

Simon, B., Amor, M. Ben, Foldenyi, R. (2016). Life cycle impact assessment of beverage packaging systems: focus on the collection of post-consumer bottles. J. Clean. Prod. 112, 238-248.

Smithers. (2019). Four key trends that will shape the future of packaging to 2028, Available at: https://www.smithers.com/resources/2019/feb/future-packaging-trends-2018-to-2028

Song, Q., Li, J., & Zeng, X. (2015). Minimizing the increasing solid waste through zero waste strategy. Journal of Cleaner Production, 104, 199-210.

Stock, J.R. (1992). Reverse Logistics Programs, Council of Logistics Management, Oak Brook, IL.

Stubbs, W., & Cocklin, C. (2008). Conceptualizing a “sustainability business model". Organization and Environment, 21(2), 103-127.

Swart RJ, Raskin P, Robinson J. (2004). The problem of the future: sustainability science and scenario analysis. Glob Environ Chang 14(2):137–146

Swart, R. ., Raskin, P., & Robinson, J. (2004). The problem of the future: sustainability science and scenario analysis. Global Environmental Change, 14(2), 137–146

Thierry, M., Salomon, M., Van Nunen, J. and Van Wassenhove, L. (1995). Strategic issues in product recovery management, California Management Review, Vol. 37 No. 2, 114-35.

Timmers, P. (1998). Business models for electronic markets. Journal on Electronic Markets, 8(2), 3-8.
Timmers, P. (1998). Business models for electronic markets. Journal on Electronic Markets, 8(2), 3-8.
Toniolo, S., Mazzi, A., Niero, M., Zuliani, F., Scipioni, A. (2013). Comparative LCA to evaluate how much recycling is environmentally favourable for food packaging. Resour. Conserv. Recycl. 77, 61e68.

Torretta, V. (2013). Environmental and economic aspects of water kiosks: Case study of a medium-sized Italian town. Waste Management, 33(5), 1057–1063.

Turner BL, Kasperson RE, Matson PA, McCarthy JJ, Corell RW et al. (2003). A framework for vulnerability analysis in sustainability science.

UNEP. (2010). Waste and Climate Change.

UNEP. (2018). Single-use plastics | a roadmap for sustainability. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pd f?isAllowed=y&sequence=1

Unilever. (2019). Omo-Unilever. Retrieved from. https://www.unilever.com/brands/home-care/omo.html.

United Nations. (2019). World Population Prospects 2019, Available at: https://population.un.org/wpp/Graphs/900

Van Herpen, E., Immink, V., & van den Puttelaar, J. (2016). Organics unpacked: The influence of packaging on the choice for organic fruits and vegetables. Food Quality and Preference, 53, 90–96.

Verghese, K., Lewis, H., & Burritt, R. (2008). Sustainable packaging and sustainability accounting: Exploring links and synergies. Journal of the Asia Pacific Centre for Environmental Accountability, 14(3), 18–33.

Verghese, K., Lewis, H., Fitzpatrick, L. (2012). Packaging for Sustainability. Springer, London.

Verghese, K., Lewis, H., Lockrey, S., & Williams, H. (2015). Packaging’s Role in Minimizing Food Loss and Waste Across the Supply Chain. Packaging and Technology and Science, 28(April).

Vernuccio, M., Cozzolino, A., & Michelini, L. (2010). An exploratory study of marketing, logistics, and ethics in packaging innovation. European Journal of Innovation Management.

W.R. Stahel. Circular economy. (2016). Nature, 531, pp. 435-438

Wang, Z., Mathiyazhagan, K., Xu, L., & Diabat, A. (2016). A decision making trial and evaluation laboratory approach to analyze the barriers to Green Supply Chain Management adoption in a food packaging company. Journal of Cleaner Production, 117, 19–28.

West, M., , Norris, C. (2000). G o o d f o o d.

Wiek A, Ness B, Brand FS, Schweizer-Ries P, Farioli F. (2012). From complex systems analysis to transformational change: a comparative appraisal of sustainability science projects. Sustain Sci 7(Supplement 1):5–24

Wiek A. (2014). Transform – a framework for transformational sustainability research. Working paper. Sustainability Transition and Intervention Research Lab, School of Sustainability, Arizona State University, Tempe, AZ

Wiek, A., & Iwaniec, D. (2014). Quality criteria for visions and visioning in sustainability science. Sustainability Science, 9(4), 497–512.

Wiek, A., & Lang, D. J. (2016). Sustainability Science. Sustainability Science, 31–41.

Wikström, F., Verghese, K., Auras, R., Olsson, A., Williams, H., Wever, R., et al. (2018). Packaging strategies that save food: a research agenda for 2030. J. Ind. Ecol. 00 (0).

Wikström, F., Verghese, K., Auras, R., Olsson, A., Williams, H., Wever, R., Soukka, R. (2019). Packaging Strategies That Save Food: A Research Agenda for 2030. Journal of Industrial Ecology, 23(3), 532–540.

Wikström, F., Williams, H., & Venkatesh, G. (2016). The influence of packaging attributes on recycling and food waste behaviour – An environmental comparison of two packaging alternatives. Journal of Cleaner Production, 137, 895–902.

Williams H, Wikström F, Löfgren M. (2008). A life cycle perspective on environmental effects of customer focused packaging development. Journal of Cleaner Production; 16(7): 853–859.

Wróblewska-Krepsztul, J., Rydzkowski, T., Borowski, G., Szczypiński, M., Klepka, T., , Thakur, V. K. (2018). Recent progress in biodegradable polymers and nanocomposite-based packaging materials for sustainable environment. International Journal of Polymer Analysis and Characterization, 23(4), 383–395.

Yam, K. L., Takhistov, P. T., & Miltz, J. (2005). Intelligent packaging: Concepts and applications. Journal of Food Science, 70, 1–10.

Yusuf, Y.Y., Olaberinjo, A.E., Papadopoulos, T., Gunasekaran, A., Subramanian, N., Sharifi, H. (2017). Returnable transport packaging in developing countries: drivers, barriers and business performance. Prod. Plan. Control 28 (6e8), 629-658.

Zaman, A. U., & Lehmann, S. (2011). Challenges and Opportunities in Transforming a City into a “Zero Waste City.” Challenges, 2(4), 73–93.

Zhang, Q., Segerstedt, A., Tsao, Y.C., Liu, B. (2015). Returnable packaging management in automotive parts logistics: dedicated mode and shared mode. Int. J. Prod. Econ. 168, 234-244.

Zhou, G., Gu, Y., Wu, Y., Gong, Y., Mu, X., Han, H., & Chang, T. (2019). A Systematic Review of the Deposit-Refund System for Beverage Packaging: Operating Mode, Key Parameter and Development Trend. Journal of Cleaner Production, 119660.

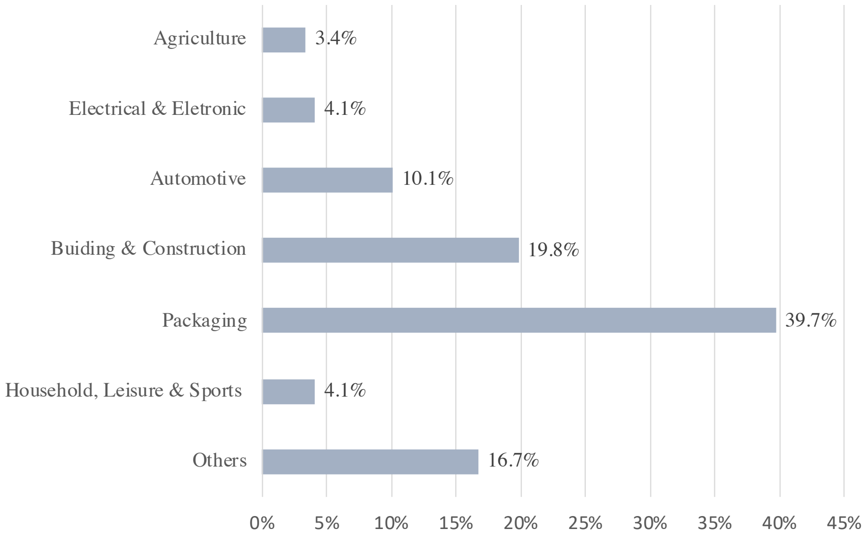
Zion Market Research. (2018). Global Rigid Packaging Market Will Reach USD 802.43 Billion By 2024.

ZWIA. (2013). ZW Business Principles. Available. http://zwia.org/standards/zw-business-principles/.

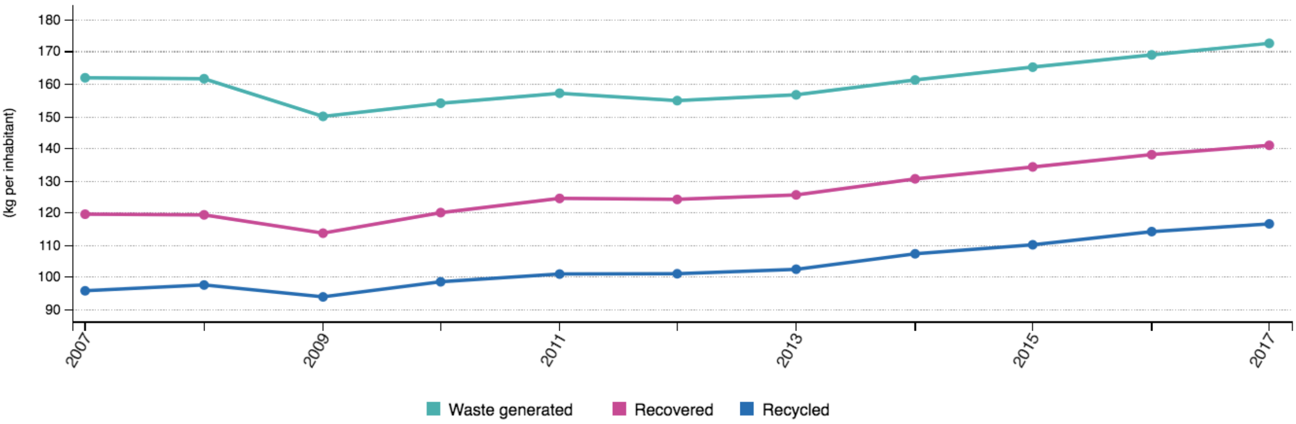
ZWIA. (2018). Zero Waste Definition. Zero Waste International Alliance. Available from: http://zwia.org/standards/zw-definition/

Appendix

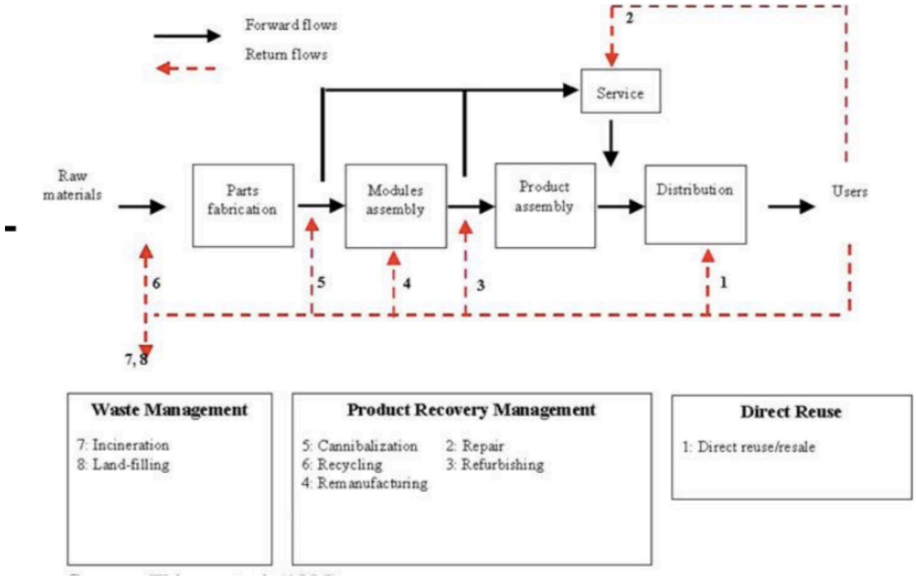
Appendix A: Distribution of European plastics demand by segment in 2017 (Adapted from Plastics Europe, 2018)



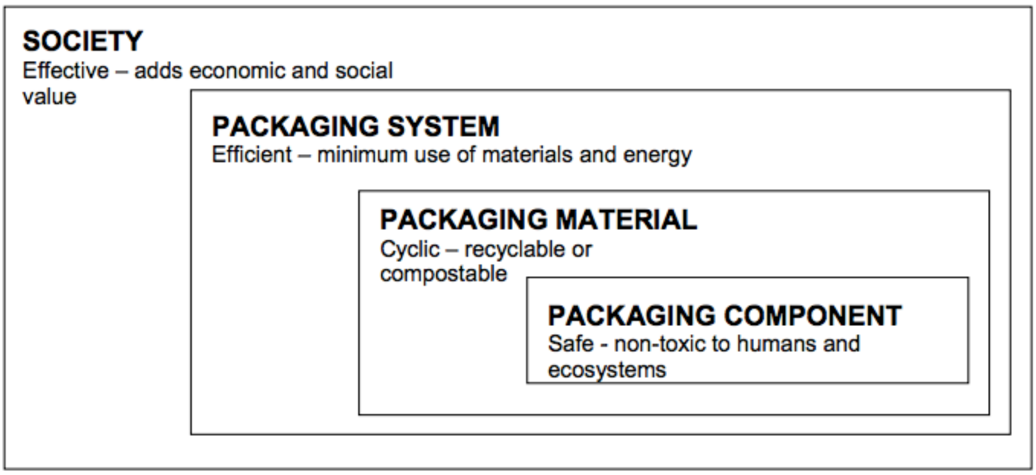
Appendix B: Development of all packaging waste generated, recovered, and recycled, EU, 2007-2016 (Eurostat, 2019)



Appendix C: A model for reverse logistics (Thierry et al., 1995)



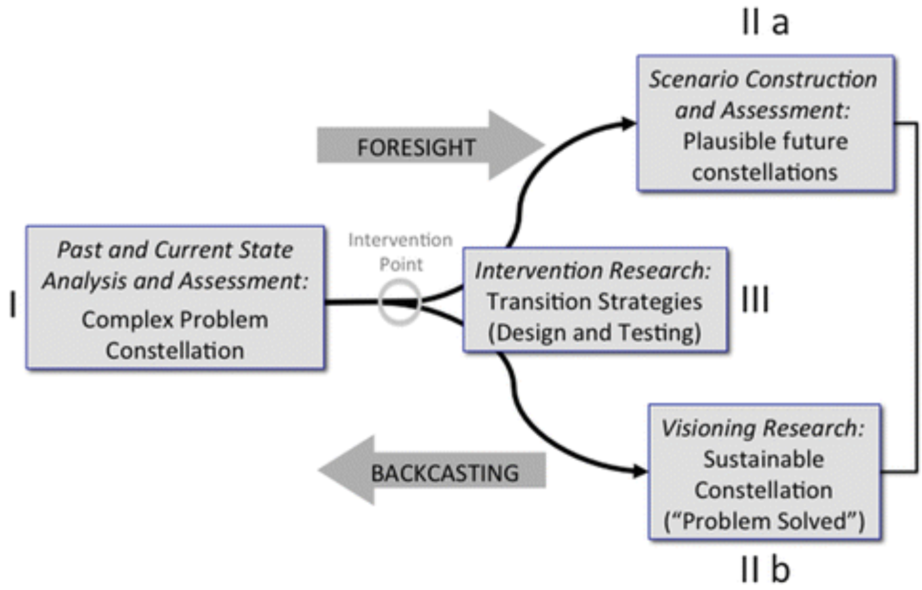
Appendix D: The four levels and principles of SPA's sustainable packaging definition (James et al., 2005)



Appendix E: Revised SPA sustainable packaging definition, strategies and key performances (adapted from Lewis et al., 2007)

Principles	Strategies	KPIs
Effective	Eliminate any packaging that is not necessary	Product-packaging ratio by weight
	Ensure that the packaging fulfils supply chain requirements for product protection, containment, distribution, retailing and use	Functionality of each component of the packaging system
	Design the product-packaging system to minimise total life cycle environmental impact	Social and economic benefits of the packaging system as a whole
	Provide information to consumers on environmental attributes of the packaging.	Specific, relevant, accurate and verifiable environmental claims consistent with ISO 14021.
	Provide advice to the consumer on correct disposal of the packaging.	Recycling logos and advice on recyclable packaging Plastics identification code correctly used on plastics packaging (PACIA guidelines) Instructions NOT to recycle on containers used for hazardous products
Efficient	Reduce packaging volume and weight to the minimum required for product protection, safety, hygiene and acceptability to the consumer.	Total weight of material used in the packaging system
	Increase the efficiency of the product-packaging system by changing the product, e.g. use of concentrates.	Product-packaging ratio by weight
	Minimise product waste	Percentage of product which becomes waste before it reaches the consumer Percentage of product remaining in retail unit packaging (once consumer has dispensed product)
	Maximise energy and water efficiency during manufacturing and recovery systems.	Energy and water consumed over the packaging lifecycle
	Improve transport efficiency	Pallet configuration and efficiency - cube utilisation (%)
Cyclic	Identify the cyclic loops which are available to recover the packaging and ensure that the packaging can be collected and processed within them.	Reusability (national recovery rate for the product through company / industry schemes) Recyclability (national recovery rate for the material through recycling systems) Percentage of the packaging Average % of recycled material (post consumer). Average % of recycled material (total).
	Degradable packaging: specify compostable rather than oxo- degradable materials and ensure that a system is available for collection and processing	Compostability (national recovery rate for the product through composting systems)
	Specify renewable materials where it is demonstrated they provide the lowest environmental impact.	Percentage of packaging material which is from a renewable source.
	Use renewable stationary and transport energy	Percentage of stationary and transport energy use which is from a renewable source.
Safe	Manufacture packaging using cleaner production techniques and using best practice materials and energy consumption technologies.	Cleaner product policies and procedures
	Avoid or minimise the use of materials or additives which may pose risks to humans or ecosystems during recovery or disposal.	Health or environmental risks associated with the package
	Minimise the environmental impacts of transport (considering distance, mode of transport and fuel type	Transport distances at each stage of the packaging life cycle (km). Mode of transport used for each stage of the packaging life cycle (km)

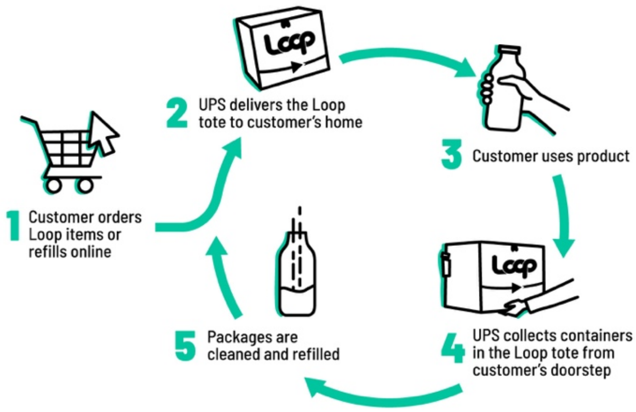
Appendix F: Basic structure of TRANSFORM framework (Wiek and Lang., 2016)



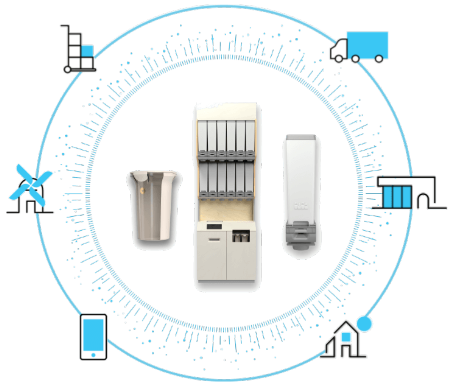
Appendix G: Literature Overview on Sustainable Packaging

Principle	Theme	Authors	Summary
Efficacy	Economic Benefits	Hyde et al. (2001)	Higher profitability and reduced costs in the food and drinks industry
		Prive et al. (2006)	Maximization of profits by optimizing packaging collection routes
		Ko et al. (2012)	Cost savings due to reduced use of virgin materials
		Accorsi et al. (2014)	Cost savings due to product waste
		Barrera et al. (2014)	Cost savings due to better supply chain efficiencies
	Social Benefits	Vernuccio et al. (2010)	Benefits of sustainable packaging from a social point of view
		Azzi et al. (2012)	
		Palombini et al. (2017)	Impact of packaging on product, ethical trade and the workers involve
		Geueke et al. (2018)	Impact of chemicals in packaging on consumer health and safety
		Herbes et al. (2018)	Influence of cultures in consumer attitudes towards eco-friendly packaging.
Efficiency	Eco-Design	Williams et al. (2008)	Reduced environmental impacts and increased customer satisfaction with eco design
		Leppelt et al. (2013)	Better environmental performance when with all stakeholders collaboration.
		Manfredi et al. (2015)	Environmental savings from an eco-design for fresh milk packaging
		Wikstro¨m et al. (2016)	Importance of consumer behaviour to be considered in packaging design
		Hanssen et al. (2017)	Environmental benefits of re-desgining the size of packages
		Obrecht and Knez (2017)	How eco-design principles can determine carbon emissions savings
	Sustainable packaging practices	Hardy & Curran (2009)	Reusable seconday packing to reduc waste strems in supermarkets
		Torretta (2013)	Environmental benefits of incentivising sustainable behaviours in the supply chain
		Yang et al. (2013)	Impact of internal and external green practices on the competitiveness of companies
		Garci´a-Arca et al. (2014)	Transformations needed to establish sustainable packaging logistics
		Wang et al. (2016)	Obstacles of implementating GSCM in the food packaging industry
		Besch & Palsson (2016)	Internal and external barriers of green packaging development in a firm
		Beitzen-Heineke et al. (2017)	Concept of zero packaging grocery stores
		Yusuf et al. (2017)	Motivations, benefits, barriers and drivers for implementing sustainable packaging practices
		Gustavo et al. (2018)	
Cyclic	Eco-friendly packaging materials	Toniolo et al. (2013)	Environmental evaluation between a recyclable plastic packaging tray and a non- recyclable
		Papong et al. (2014)	Better environmental performance of bottles made from renewable thermoplastic
		Bernstad Saraiva et al. (2016)	Comparation of different packaging materials inrelation to environmental impacts
		Simon et al. (2016)	Analysis of the environmental impacts of five different beverage packaging materials
		Almeida et al. (2017)	Comparation three different packaging materials for soft drinks
		Hahladakis and Iacovidou (2018)	Influence of quality parameter on the recyclability of the plastic packaging materials.
	Recycling	Perrin and Barton (2001)	Main reasons why many people do not recycling
		Ross and Evans (2003)	Environmental evaluation between a recyclable packaging system and a non-recyclable
		Perugini et al. (2005)	Environmental performance of recycling of plastic containers in the Italian context
		Mourad et al. (2008)	Environmental and economic benefits of increasing the recycling rates of packaging material
		Kuczenski and Geyer (2013)	Bottlenecks to improve recycling rate and material efficiency of packaging materials
		Toniolo et al. (2013)	A solution based on additives to ensure the future recyclability of packaging
		Marques et al. (2014)	Viability of recycling systems of packaging waste in Belgium and Portugal.
		Kang et al. (2017)	Environmental effect of increasing bottle collection through management intervention
		Barrera and Cruz-Mejia (2014)	Need of routing and reconfiguration of supply chain networks for optimal reverse logistics activities linked to collection of recyclable containers
		Bortolini et al. (2018)	
	Reusable packaging systems	Ross and Evans (2003)	Reusable plastic packaging system over non-reusable packaging system
		Lofthouse et al. (2009)	Analysis on different types of refillable systems
		Aaron et al. (2011)	Industries using reusable plastic packaging from the perspectives of green logistics
		Kamarthi & Gupta (2011)	Reuse as a save for materials, manufacturing, the collection and disposal operation
		Ko et al., (2012)	Importance of multiple actors in return and reuse practices such as standardisation of packaging
		Carrasco-Gallego et al. (2013)	Definition of reusable items in closed loop supply chains
		Silva et al. (2013)	Benefits of returnable packaging over disposal packaging
		Torretta (2013)	Environmental comparation between plastic bottled water and water kiosks
		Pålsson et al. (2013)	Case where one-way packaging systems result in fewer economic and environmental impacts
		Accorsi et al. (2014)	Environmental and economic evaluation of reusable plastic containers in a fresh a food packaging
		Li et al. (2014)	Collaboration between supply chain stakeholders in return packaging management
		Koskela et al. (2014)	A case of bread delivery packaging system
		Zhang et al. (2015)	Reusable packaging sharing between different actors across different supply chains
		Bernstad Saraiva et al. (2016)	Reusable packaging system over non-reusable packaging systems
		Yusuf et al. (2017)	Drivers, barriers and benefits of reusable packaging
		Postacchini et al. (2018)	Re-use of glass jars is environmentally more beneficial than a recycle strategy
		Bortolini et al. (2018)	Mix of the reusable and disposable packaging containers for supply chain networks
		Gallego-Schmid et al. (2018)	Environmental sustainability of reusable glass and plastic food savers in the European context
	Return logistic systems	Lu¨ tzebauer (1993)	Return logistic systems identification
		Kroon and Vrijens (1995)	Return logistic systems categorization
		Hellström and Johansson (2010)	Return logistic systems categorization improvement
Safety	Contamination	Komolprasert & Lawson (1977)	Contamination of PETE on the reuse of food packaging
		Darlow (2003)	Health and safety issues associated with different types of refillable packaging
		Geueke et al. (2018)	Chemical safety aspects of recycled food packaging
		Burek et al. (2018)	Environmental implications of chemical interaction between packaging and product
	Confinement	Karst (2013)	Reusable packaging saves food from spoilage
		Langley et al. (2011)	Better confinement in reusable packaging

Appendix H: Loop's system (Loop, 2020)



Appendix I: MIWA's system components (MIWA, 2020)



Appendix J: Qualitative Analysis of Switch-pool system

	Suppliers	Manufacturers	Retailers	Consumers
Benefits	• Reduction of raw material costs due to purchase of obsolete plastic at a lower cost • Reduction in consumption of new raw materials and thus less burden from environmental fees on plastic production • Increased bargaining power over manufacturers	• Reduction on activities to manage and take responsibility • Reduction on fixed and variable costs • Increased economies of scale	• Increased decision-making power over the supply chain • Increased bargaining power over manufacturers • Increased economies of scale • Reduction of growth in competition • Increased environmental and social awareness visibility • Increased customer retention due to the discount vouchers offered	• Obtention of discounts on future purchases in exchange for the return of packages
Drawbacks	• Large initial investment for a new plastic recycling process • New fixed and variable costs to be incurred with the recycling process	• Lost of decision-making power over the packaging and thus loss of branding power • Reduction of bargaining power over retailers • Reduction of barriers to entry, resulting in greater competition	• New activities to manage and take responsibility • Large initial investment • Increased fixed and variable costs • Increased logistics complexity	• Potential price increase of products to overcome cost increase with the new system

Appendix K: Qualitative Analysis of depot system

	Suppliers	Manufacturers	Retailers	Consumers
Benefits	• Reduction of raw material costs due to purchase of obsolete plastic at a lower cost • Reduction in consumption of new raw materials and thus less burden from environmental fees on plastic production • Increased bargaining power over manufacturers	• Reduction on variable costs due to reduced purchase of new packaging	• Increased environmental and social awareness visibility • Increased customer retention due to the discount vouchers offered	• Obtention of discounts on future purchases in exchange for the return of packages
Drawbacks	• Large initial investment for a new plastic recycling process • New fixed and variable costs to be incurred with the recycling process	• Lost of decision-making power over the packaging and thus loss of branding power • Increased costs of outsourcing the reverse process	• Increased costs of outsourcing the reverse process • Initial investment for packaging deposits • Possible loss of customers	• Potential price increase of products to overcome cost increase with the new system

Appendix L: Qualitative Analysis of transfer system

	Suppliers	Manufacturers	Retailers	Consumers
Benefits	• Reduction of raw material costs due to purchase of obsolete plastic at a lower cost • Reduction in consumption of new raw materials and thus less burden from environmental fees on plastic production • Increased bargaining power over manufacturers	• Increased economies of scale • Increased decision-making power over the supply chain • Reduction of growth in competition • Increased environmental and social awareness visibility	• Increased customer retention due to the discount vouchers offered • Increased environmental and social awareness visibility	• Obtention of discounts on future purchases in exchange for the return of packages
Drawbacks	• Large initial investment for a new plastic recycling process • New fixed and variable costs to be incurred with the recycling process	• New activities to manage and take responsibility • Large initial investment • Increased logistics complexity • Increased fixed and variable costs	• Increased logistics complexity	• Potential price increase of products to overcome cost increase with the new system

Appendix M: H&S packaging

Appendix N: Cost and Benefit quantitively analysis' calculations and results

	Scenario A		Scenario B		
Costs	Supplier	Retailer	Supplier	Retailer	
Collection Costs (C_C)					
Unit transportation charge	0.022796	0	0.022796	0.022796	€/unit
Unit fee cost given to consumers	0.05	0	0.05	0.05	€/unit
Cost sharing ratio	1	0	0	1	%
Quantity of items collected	200000	0	200000	200000	unit
Total Transportation Costs (C_R)	4559.2	0	0	4559.2	€
Total Consumers Fee Costs (C_F)	10000	0	0	10000	€
Total Collection Costs (C_C)	14559.2	0	0	14559.2	€
Testing and Classification Costs (C_T)					
Unit testing costs for first inspection	0.000338	0	0.000338	0	€/unit
Unit testing costs for second inspection	0.0002258	0	0.0002258	0	€/unit
Quantity of items collected	200000	0	200000	0	unit
Quantity of items washed	200000	0	200000	0	unit
Total First Inspection Costs (C_{T1})	67.60	0	67.60	0	€
Total Second Inspection Costs (C_{T2})	45.16	0	45.16	0	€
Total Testing Costs (C_T)	112.76	0	112.76	0	€
Washing Costs (C_W)					
Unit washing cost	0.26	0	0.26	0	€/unit
Quantity of items washed	126000	0	126000	0	unit
Total Washing Costs (C_W)	32760	0	32760	0	€
Environmental Protection Costs (C_E)					
Unit weight incinerating costs	98	0	98	0	€/ton
Incineration and Landfill Ratio	0.5	0	0.5	0	%
Unit weight landfill costs	140	0	140	0	€/ton
Item weight	0.1	0	0.1	0	kg
Quantity of items disposable	59200	0	59200	0	unit
Total Incineration Costs (C_I)	2900.80	0	2900.80	0	€
Total Landfill Costs (C_L)	828.80	0	828.80	0	€
Total Environmental Protection Costs (C_E)	3729.60	0	3729.60	0	€
New Packaging Acquisition Costs (C_P)					
Unit packaging cost	0.168	0	0.168	0	€/unit
Quantity of items acquired	154650	0	154650	0	unit
Total Packaging Acquisition Costs (C_P)	25981.2	0	25981.2	0	€
Holding Costs (C_H)					
Percentage on packaging value	0.1	0	0.1	0.1	%
Packaging value	0.168	0	0.168	0.168	€/unit
Quantity of items acquired	242850	0	242850	242850	unit
Quantity of items collected	200000	0	200000	200000	unit
Cost sharing ratio			0	1	%
Total Manufacturer's Holding Costs (C_{HM})	4079.88	0	4079.88	0	€
Total Retailer's Holding Costs (C_{HR})	3360	0	0	3360	€
Total Holding Costs (C_H)	7439.88	0	4079.88	3360	€
Total Costs	84582.64	0	66663.44	17919.2	€
Total Costs per item processed	0.3482917	0	0.27450459	0.07378711	€/item processed
Revenues					
Packaging Purchasing Savings (R_P)					
Unit packaging cost	0.168	0	0.168	0	€
Quantity of items reusable	88200	0	88200	0	unit
Total Packaging Purchasing Savings (R_P)	-14818	0	-14818	0	€
Material Reproduction Revenue (R_M)					
Market selling price	0.36	0	0.36	0	€/kg
Quantity of items sellable	52600	0	52600	0	unit
Item weight	0.1	0	0.1	0	kg
Total Material Reproduction Revenue (R_M)	-1893.6	0	-1893.6	0	€
Environmental Protection Benefit (R_E)					
Environmental protection penalty	0.8	0	0.8	0	€/kg
Item weight	0.1	0	0.1	0	kg
Quantity of items acquired	154650	0	154650	0	unit
Total Environmental Protection Benefit (R_E)	-12372	0	-12372	0	€
Total Revenues	-29083	0	-29083	0	€
Total Revenues per item processed	-0.1197579	0	-0.1197579	0	€
Total	0.22853383	0	0.15474672	0.07378711	€/item processed