Food Packaging and Circular Economy in the Netherlands:

Challenges and Policy Solutions

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Abstract

As highlighted by the Sustainable Development Goal 12 “Responsible consumption and production”, reducing food waste, and enhancing resource efficiency have become primary goals worldwide. Yet, the take-make-waste culture and the rapid growth of disposable food packaging are not satisfying the sustainability context. Packaging adds to the amount of total waste, but at the same time protects food from spoilage and enhances its shelf life, thus functions against food waste. The function of packaging is hindered by the waste and the subsequent pollution of its use. Circular Economy and its principles are highly promoted by the European Commission’s Green Deal and the Dutch national plan for Circular Economy as a holistic solution to reduce the environmental footprint of packaging.

This thesis examines how circular economy can be integrated into food packaging practices. Moreover, it studies the challenges of such an integration focusing on the Dutch context of food packaging. It also analyses the relevant policy frameworks suggested by the European and Dutch policymakers that aim to overcome the identified challenges and enable and/or accelerate the Circular transition of the sector. The aforementioned research objectives are studied through desk research and semi-structured interviews with food packaging experts. The most predominant challenges in the Dutch context are categorized into informational, technological, behavioural, regulatory, and societal challenges. Next to this, relevant policy solutions provided by the European Commission and the Dutch government to address these challenges are illustrated. The results of these findings are further discussed and interpreted before conclusions are drawn. Lastly, recommendations regarding the inadequately addressed challenges are presented along with directions for future research.

Keywords: circular economy, food packaging, sustainable packaging

Acknowledgments

The topic of this thesis was created out of my genuine interest in sustainable food packaging and especially, the challenges related to its adoption. I hope this thesis would be informative and helpful to those who are interested in transforming the food chain into a circular one.

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List of Abbreviations

CE	Circular Economy
EU	European Union
PACE	Platform for Accelerating the Circular Economy
R&D	Research and Design
TRECS	Tradable renewable allowances
WFD	European Waste Framework Directive

Table of Contents

List of Figures

List of Tables

1. Introduction

This chapter includes background information on food packaging, with a focus on the Netherlands. The problem statement, the research objective, and the research questions that are used as a baseline of this research are also included. A brief illustration of the outline of the thesis is presented.

1.1 Background

Food packaging is a combination of art, science, and technology towards the quality and safety of a product. It involves the transportation, distribution, storage, retailing, and end-use of the products. After the start of globalization and urbanization, consumers value safety and food quality more, and therefore, the demand for proper packaging is more than ever at stake (Kalpana et al., 2019).

Nevertheless, food packaging is a major contributor to environmental and social challenges across Europe. According to J.-P. Schweitzer et al. (2018), Europeans dispose of more than 30kg of plastic packaging per person per year. Packaging represents one of the largest environmental impacts in the food production system. The predominant trend of today's society is take-make-dispose, a trend that has led to a global environmental change. This practice does not comply with the European guidelines concerning Circular Economy, especially since a significant amount of the waste is coming from single-used materials (Licciardello, 2017). The challenges that food packaging manufacturing should overcome to reach circularity and comply with the European and Dutch goals are further illustrated in chapter 4.

Even though food safety is an important factor, current packaging practises are imposing an environmental threat. The on-the-go culture is based on the convenience of consumers by extending the shelf-life of products and providing ready-made packaged meals (J.-P. Schweitzer et al, 2018). Concerning food safety, the reliability of a food producer is highly correlated to his packaging practises among other factors (Kalpana et al., 2019). Not only the consumers but also governments are putting companies under pressure to opt for eco-friendly packaging (Nguyen et al., 2020).

Transportation of food is also affecting dramatically the dependence of packaging. Vast distances and supply chains require intermediate processing of packaging (J.-P. Schweitzer et al., 2018). Packaging serves as a shield against contamination, various environmental factors, and mechanical damage that occurs at the transportation stage. The end-user can be reassured that there was no defect when he receives the goods (Kalpana et al., 2019).

Although food packaging has many benefits, it has a high production volume, usually short usage time, and interferes with waste management and littering. Reducing, reusing, recycling, and even redesigning food packaging can reinforce Circular Economy and thus, limit the footprint of food packaging (Geueke et al., 2018). According to Ellen Macarthur Foundation(n.d.), Circular Economy encloses maintenance of

material at their highest value and utility through a systematic approach and differentiating between technical and biological cycles. Furthermore, the need for a transition from linear to circular economy is justified by the urgency of resource efficiency. Waste management is closely related to resource efficiency, which is an increasing challenge in the 21st century due to population growth, increase the use of materials, and therefore, increased waste generation. On the other hand, resources are becoming scarce, more expensive and their environmental impact is rising (Cramer, 2015). For this reason, Waste Hierarchy is explained in this thesis along with the principles of Circular Economy. Both concepts display different pathways to become more resource-efficient while at the same time, preventing waste generation.

The Netherlands, as a member of the European Union, has made circular economy a top priority of its agenda. According to the report for "A Circular Economy in the Netherlands by 2050", the Dutch government's ambition is to reach circularity by 2050 and cut in half the usage of primary resources in 10 years. Zero waste economy as a goal entails circular design (suitable for re-use products) and a reduction of 1Mtonnes CO2 achieved by sustainable procurement practises (Government of the Netherlands, 2016).

Plastics are predominant in the food packaging sector, as the use of this material has improved hygiene and prolonged shelf life. However, plastic packaging ends up as litter, and it takes a long time to degrade if it does so. Plastic Pact, an initiative of the Netherlands and France, marks the end of single-use plastic products, such as straws and plates, among others(The European Plastics Pact, 2020). Moreover, the European Strategy for Plastics in a Circular Economy was introduced to reshape the design, usage, production, and recycling of plastics (European Commission, 2018). European and Dutch policies on Circular Economy and food packaging are further elaborated on chapter 5 of this thesis.

1.2 Problem Statement

The modern society is based on fast-paced lifestyles and prioritizes convenience and affordability over environmental protection. For this reason, disposable packaging has become increasingly popular. This thesis acknowledges the essential role of packaging to sustainable production and consumption since it contributes to the reduction of food waste and the preservation of resources. Although packaging has many benefits, it boosts littering and waste streams in the food production system and therefore puts stress on the environment. The reason is that food packaging practises are often not sustainable. However, the principles of Circular Economy, if integrated into food packaging practises, can reduce significantly the environmental impact of packaging. Circular food packaging can generate benefits for the economy and the environment but is facing various challenges.

1.3 Research Objective

The objective of this research is to identify the main challenges inhibiting Circular food packaging practises in the Netherlands and the policy enablers offered by the Dutch government to overcome these challenges. The following research questions are used as the tool to attain the objective of this research.

1.4 Research Questions

The objective of this thesis is achieved by answering the following main research question:

> **"**What are the challenges and policy enablers of integrating Circular Economy in food packaging in the Dutch context?"

To be able to an answer to this question, two sub-questions were formulated:

a) What are the major challenges that the food packaging industry in the Netherlands should tackle to achieve circularity?

b) Which policy instruments were introduced by the Dutch government to enable the circular transition of food packaging by overcoming the identified challenges?

1.5 Thesis Outline

The research uses the questions set by the researcher as general guidance in composing this thesis. The organization of the thesis is as follows: Chapter 2 elaborates on the theories used as a basis to analyze the results of this research, Chapter 3 illustrates the methodology of this research, including the research framework, research strategy, methods of collecting data and data analysis, Chapters 4 and 5 present the results from the analysis of data collected in terms of challenges and policy solutions, respectively, Chapter 6 discusses the importance, relevance and meaning of the results, and finally, Chapter 7 summarizes the results, draws conclusions and offers recommendations.

2. Literature Review

This chapter introduces briefly the function of food packaging, its current practises and their impact in the European Union and the Netherlands. The concepts of Sustainable Food packaging, Waste Hierarchy, and Circular Economy are selected as the most relevant to this research. The idea of Circular food packaging that is the baseline of this research, is based on the integration of the three aforementioned principles. All three of them are defined and used to explain how the current conventional food packaging design can become circular. A short illustration of the main challenges of this Circular transition is also included.

2.1 Functions of food packaging

Food packaging has evolved in a parallel line with the development of lifestyles. Initially, people consumed the food on point and fed on whatever was available in proximity. Communities were self-sufficient; almost zero need for transportation or storage, and thus packaging (Berger & B. Welt, 2002).

The innovative manufacturing processes and the introduction of new materials took place after the Industrial Revolution. Glass bottles with corks and metal cans enhanced the shelf-life of products by preventing deterioration, while paperboard was turned into folding cartons. The main source of packaging, plastic was only used after the 20th century, roughly around World War II. In recent years, polyethylene naphthalene (PEN) was a new form of plastic introduced and approved by the FDA (Risch, 2009).

Initially, packaging was a simple container to store food whereas it evolved to a necessary tool of food quality and preservation; it acts as a barrier to oxygen, moisture, and keeps the flavours. It could also be microwave-safe packaging or enhances the shelf-life of food by adding antimicrobials to its surface. Seasonal food is now offered all year round. Moreover, packaging gave birth to the introduction of different types of food as well, such as microwave popcorn (Risch, 2009).

Food and food quality gain attention after World War II. Materials and their qualities were utilized during the war for other purposes ending up in the food sector (Risch, 2009). The roles of food packaging have also evolved. The primary ones are the protection of food from external influences, preservation, information about nutritional content while traceability, convenience, and tamper-proof are of lesser importance. The objective of food packaging is to provide a cost-effective solution to the industry and the consumers, reassure food safety, and limit environmental footprint (Marsh & Bugusu, 2007).

By proper packaging, food is preserved for an extended period while retaining its quality and safety levels. For instance, the film used for fresh-cut vegetables, a film that blocks moisture while being open to both carbon dioxide and oxygen(FoodPrint, 2019). This protection lies in the chemical, biological, and

physical aspects. Chemical protection reduces the alterations in the composition affected by environmental factors, such as overexposure to moisture or light. The second type of protection is biological; packaging functions as a shield against microorganisms, insects, rodents, and other animals and flattens the ripening process. The last one, physical protection, refers to providing barriers for vibrations and shocks during the distribution stage, especially for fragile products, such as fresh fruit (Marsh & Bugusu, 2007).

Another substantial function of food packaging includes food losses and waste. Food loss can take place during any stage of the food supply chain. If a loss occurs, all the resources that were exploited are also lost; land use, nutrients, (synthetic) fertilizers, water, and energy. Therefore, packaging plays a substantial role in controlling the environmental impacts of possible food waste by protecting the products along the cycle. Innovative solutions also enhance the effectiveness of packaging materials, while design and labelling offer extra competences (Verghese et al., 2013).

The trade-off between packaging and marketing and customer information is also essential. Utilizing innovative solutions can enhance sales in the food sector, since packaging may act as a distinctive characteristic. Moreover, labelling and traceability ensure a high level of customer information. In today's take-make-waste society, convenience is an important aspect. Some examples of contribution to it are resealability and microwave ability. Food preparation and serving are minimized. Apart from that, the customer can be reassured that the products in his shopping cart are unopened and safe to consume thanks to tamper indication (Marsh & Bugusu, 2007).

The four main types of food packaging are plastic, metal, paper/fibre, and glass. The material chosen defines the environmental impact, the recycling possibilities, and pollution created. The concern about packaging pollution is a global concern since it generates waste and affects human health (FoodPrint, 2019). Therefore, choosing the most suitable material is crucial to ensure sustainable packaging. As Marsh et al. (2007) mentioned in their work, design of packaging is a rather complex matter, since packaging needs to satisfy competing needs concerning product qualities, marketing matters and thus, consumer demands, environmental and waste management factors and cost. The food packaging designers decide based on the features of packaging materials (such as recyclability), the food type to be packaged, potential interactions between packaging and food, the target group or market for the product and the potential shelf life of the product (Marsh et al., 2007). Balancing all the factors is a current challenge for food packaging designers who strive to increase the sustainability of their products, as it is further elaborated in chapter 4. Table 1 illustrates the materials used for food packaging and the relevant product characteristics/ food compatibility, consumer/marketing issues, environmental issues, and cost.

Table 1 *Packaging material properties, consumer and environmental issues, and cost (Marsh et al., 2007)*

Material	Product characteristics/food compatibility		Consumer/marketing issues		Environmental issues		Cost
	Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages	
Glass	• Impermeable to moisture and gases • Nonreactive (inert) • Withstands heat processing	•Brittle and breakable • Needs a separate closure	• Transparent: allows consumer to see product • Can be colored for light-sensitive products	• Poor portability: heavy and breakable • Relatively difficult to decorate	• Reusable • Recyclable • Often contains recycled content	• Heavy and bulky to transport	• Low-cost material, but somewhat costly to transport
Aluminum	• Impermeable to moisture and gases • Resistant to corrosion • Withstands heat processing	• Cannot be welded • Limited structural strength	• Easy to decorate • Lightweight • Good portability • Not breakable	• Limited shapes	• Recyclable • Lightweight • Economic incentive to recycle	• No disadvantages in rigid form • Separation difficulties in laminated form	• Relatively expensive, but value encourages recycling
Tinplate	• Impermeable • Strong and formable • Resistant to corrosion • Withstands heat processing	• Can react with foods; coating required	• Easy to decorate	• Typically requires a can opener to access product	• Recyclable • Magnetic, thus easily separated	• Heavier than aluminum	• Cheaper than aluminum
Tin-free steel	• Strong • Good resistance to corrosion • Withstands heat processing	• Difficult to weld, requires removal of coating • Less resistant to corrosion	• Easy to decorate	• Typically requires a can opener to access product	• Recyclable • Magnetic, thus easily separated	• Heavier than aluminum	• Cheaper than tinplate
Polyolefins	• Good moisture barrier • Strong • Resistant to chemicals	• Poor gas barrier	• Lightweight	• Slight haze or translucency	• Recyclable[a] • High-energy source for incineration	Easily recycled in semi-rigid form, but identification and separation more difficult for films	• Low cost
Polyester	• Strong • Withstands hot filling • Good barrier properties		• High clarity • Shatter resistant		• Recyclable[a,b]	• Easily recycled in rigid form, but identification and separation more difficult for films	• Inexpensive, but higher cost among plastics
Polyvinyl chloride	• Moldable • Resistant to chemicals		• High clarity		• Recyclable[a]	• Contains chlorine • Requires separating from other waste	• Inexpensive
Polyvinylidene chloride	• High barrier to moisture and gases • Heat sealable • Withstands hot filling		• Maintains product quality		• Recyclable[a]	• Contains chlorine • Requires separating from other waste	• Inexpensive, but higher cost among plastics
Polystyrene	• Available in rigid, film, and foamed form	• Poor barrier properties	• Good clarity		• Recyclable[a]	• Requires separating from other waste	• Inexpensive
Polyamide	• Strong • Good barrier properties				• Recyclable[a]	• Requires separating from other waste	• Inexpensive, but higher cost among plastics
Ethylene vinyl alcohol	• High barrier to gases and oils/fat	• Low moisture barrier, moisture sensitive	• Maintains product quality for oxygen-sensitive products		• Recyclable[a]	• Requires separating from other waste	• Inexpensive when used as thin film
Polylactic acid	• Biodegradable • Hydrolyzable				• Recyclable[a,c]	• Requires separating from other waste	• Relatively expensive
Paper & paperboard	• Very good strength-to-weight characteristics	• Poor barrier to light • Recycled content makes it unsuitable for food contact material	• Low-density materials • Easily decorated • Efficient, low-cost protection	• Moisture sensitive, loses strength with increasing humidity • Tears easily	• Made from renewable resources • Recyclable[b]		• Low cost
Laminates/ coextrusions	• Properties can be tailored for product needs		• Flexibility in design and characteristics		• Often allows for source reduction	• Layer separation is required	• Relatively expensive, but cost-effective for purpose

In Table 1, both the advantages and disadvantages per type of packaging material concerning the environmental footprint are presented. Another key point of the table is that the potential to reuse a product thanks to its packaging recyclability can reduce waste, but yet in the best-case scenario, the current packaging trends affect the environment. One example of that is the consumer's favourability towards single-used plastic, which has contributed to clogged landfills and waterways. In the meantime, the additives used for the production of packaging, such as perfluorinated chemicals, pose a threat to the

consumer's health (FoodPrint, 2019). Figure 1 shows the primary types of food packaging and the chemicals associated with them.

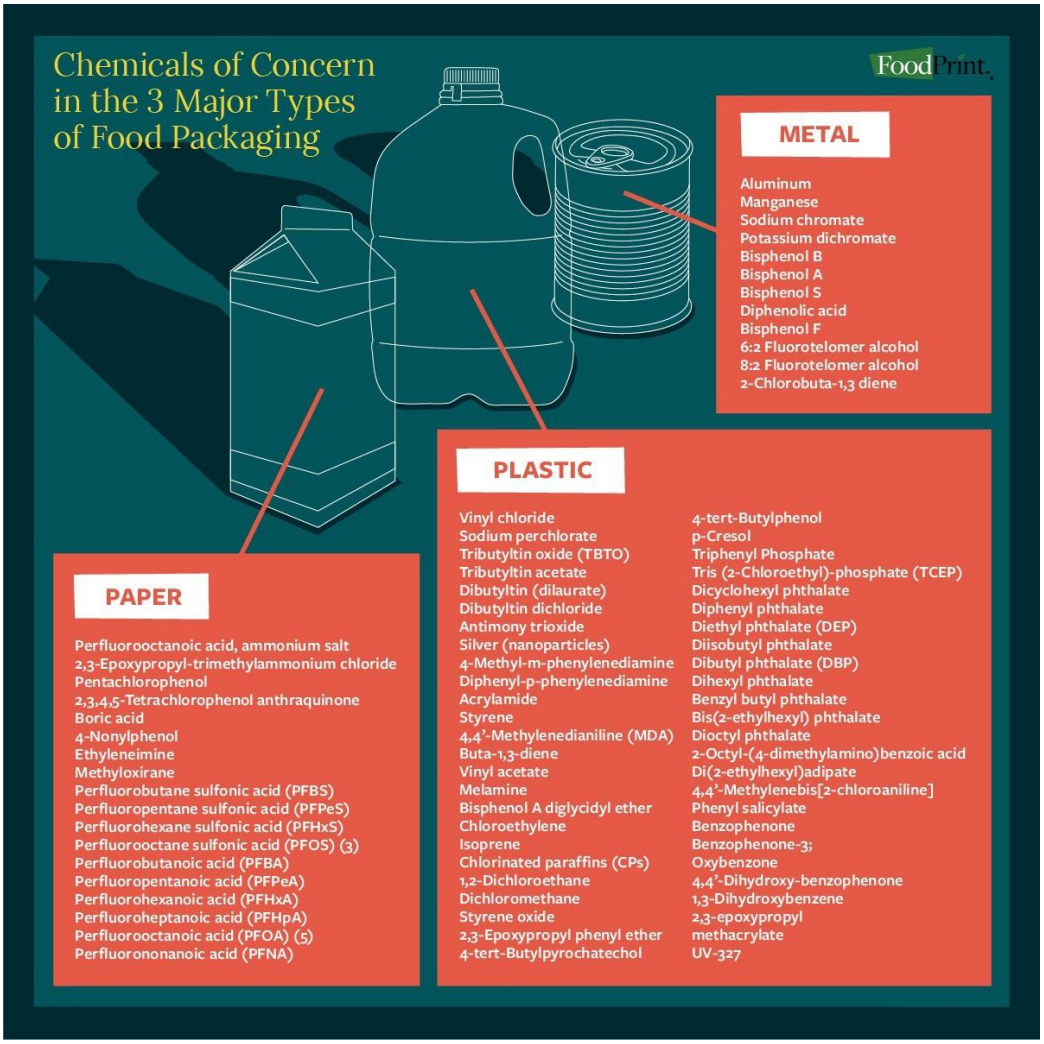


Figure 1 *Chemicals of Concern in the 3 major types of Food Packaging (FOODPRINT, 2019)*

Food consumption is not anymore based on local production but a greater geographical area. As food became more processed, packaging technology followed its lead. Disposable plastics became predominant in increasing pollution by contributing to the gas emission levels from production to consumption to waste disposal. Fossil fuel extraction intensified carbon life cycles adding to the global climate crisis. The fracking industry is booming since it introduced plastic solutions that are energy-intensive, but cheap. These cheap options pollute the air, soil, and water with the marine environment affected the most. Microplastics end in the soil thanks to flooding, littering, through the atmosphere, or even via composting and sewage sludge (FoodPrint, 2019).

2.2. Food packaging in the European and Dutch context

Approximately 20 billion kilos of the total demand for plastic is used for packaging in Europe. Of this amount, around 8.2 billion kilos are used for food products, a number that equals the weight of more

than 8 million cars. Figure 2 shows the plastic demand by segment, estimated by ING based on the assumption that 40% of all plastic packaging is used for food and drink packaging (Geijer, 2019).

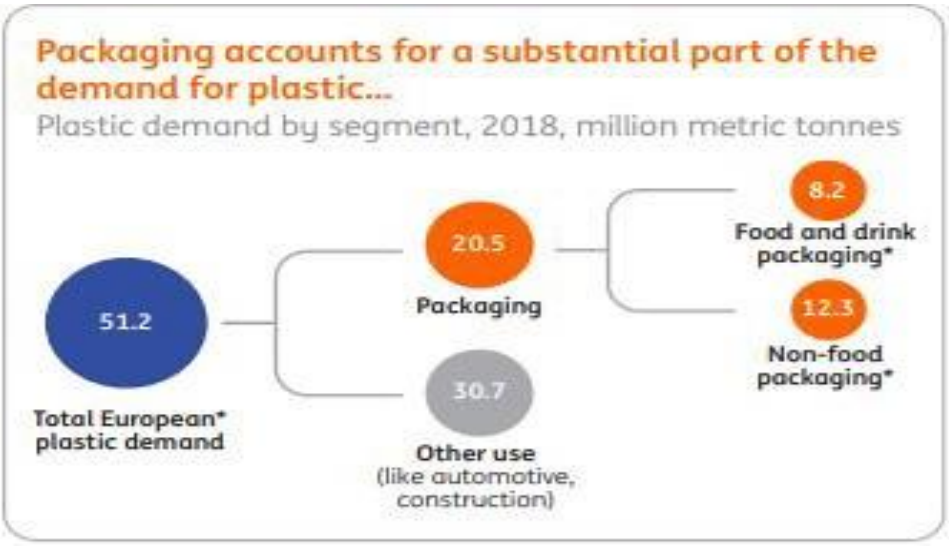


Figure 2 *Plastic Demand by segment in million metric tonnes in Europe, estimation by ING (2018)*

Food producers are in favour of plastic packaging since it is light, flexible, and affordable (Geijer, 2019). For this reason, plastic production in Europe is increasing by 2% every year, as it is illustrated in figure 3.

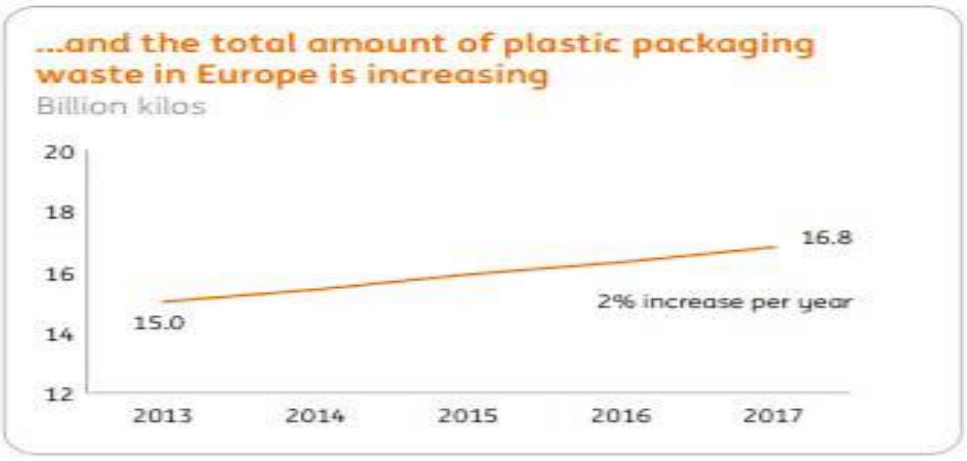


Figure 3 *Total amount of Plastic Packaging in Europe (Van Bruggen et al., 2019)*

Due to population growth, modern consumer behaviour, and current trends, the use of packaging per person is rising. The demand for convenience and on-the-go consumption is accelerating (Geijer, 2019). Plastic is preferred instead of glass, can or cardboard, and is the most popular material for fruit and vegetables, as shown in figure 4.

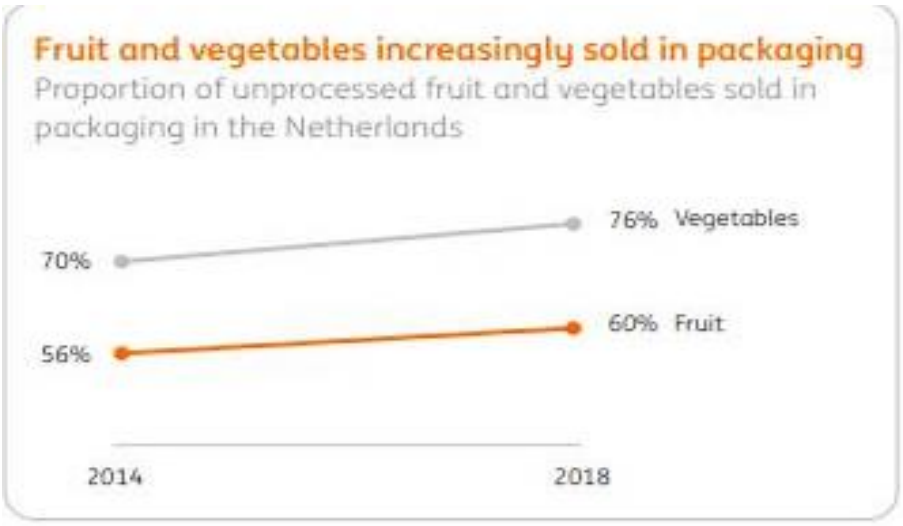


Figure 4 *Proportion of Unprocessed Fruit and Vegetables sold in Packaging in the Netherlands (Geijer, 2019)*

In February 2019, the Dutch government initiated the Dutch Plastic Pact (Plastic Pact NL) along with 97 other parties, such as producers, retailers, and the Ministry of Infrastructure and Water Management (IenW). There are four objectives for 2025: achieving 100% recyclability of single-use plastic products and packaging, lowering to 20% the volume of packaging and promoting reuse, recycling a minimum of 70% of single-use products and packaging and these products will consist of a minimum of 35% recycled plastic (Van Bruggen et al., 2019). The Pact among other Dutch policies is further discussed in chapter 5.

It is important to mention the current sustainability trends in the field of packaging. JASA Packaging Solutions identified four of these trends in the Dutch context. Firstly, The Dutch Plastic Pact has led to a decrease in plastic as a resource of packaging, while recycling is gaining popularity since recycled plastic keeps food fresh and protects it during transportation. Recycling assists Circular goals of less energy since the material already exists and is reused (Geus, 2019). Furthermore, paper packaging is another solution chosen by packaging designers as it is easily recyclable. Papier Recycling Nederland mentions that in 2017, 1262 kton of paper as a source of packaging was utilized in the Netherlands. Moreover, “Fruit Logistica 2019” introduced a cardboard sleeve to keep apples, fresh fruit, and vegetables. Smaller packages and therefore, smaller portions have also assisted in the reduction of food waste. On that matter, The Dutch Government initiated the TaskForce Circular Economy in Food in 2018. According to this initiative, food waste must be shrunk by 50% in 2030. (Geus, 2019).

Even though there is a trend of using alternative materials to plastics, switching to these solutions is shown to have both advantages and disadvantages. ING’s report shows that reaching out to substitutes will limit the volume of plastic packaging and eventually, plastic waste, while it will improve recycling rates since other materials have higher recyclability. However, not many producers are willing to switch to other materials than plastic. On that basis, the environmental footprint of packaging is not reduced with alternative options but rather transformed. Another obstacle to this change is the long-term

commitment to investments on new machinery by the producers, while some fresh products cannot be preserved differently than in plastic (Geijer, 2019).

Guillard et al. (2018) add that the lack of motivation and commitment of packaging designers, which are a result of the limited collaboration and communication of stakeholders across the food chain, namely Research & Design centres, food and packaging developers, lawmakers, and consumers. Similarly, the food industry and consumers tend to be sceptical to adopt alternative packaging solutions. The cost of applying the new technologies, the absence of strong competitors in these new markets, and the existence of regulatory barriers delay or prohibit the market entry of sustainable packaging options (Guillard et al., 2018). The challenges of the Circular integration in food packaging mainly focused in the Netherlands are further developed in chapter 4. Before investigating the challenges of the Circular Food Packaging model, the next sections of this chapter present the theories of Circular Economy, sustainable packaging, and Waste Hierarchy, which are then combined into one model that serves as the analytical framework for this research.

2.3 Circular Economy

This section introduces Circular Economy and its principles, which is the main concept of this research. Circular Economy (CE) is defined by Ellen Macarthur Foundation as follows;

Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles: Design out waste and pollution, keep products and materials in use and regenerate natural systems (Ellen Macarthur Foundation, n.d., concept section).

The concept is highly relevant to the Dutch policies. The government of the Netherlands in its report "A Circular Economy in the Netherlands by 2050" points out the urgency to deal with the increasing plastic soup in the country. The food packaging sector faces the challenge of limiting the use of fossil fuels and improving the recyclability of materials used for packaging, especially the multilayer ones (Government of the Netherlands, 2016). The country's vision is a sustainable future for future generations and Circular Economy is the core of its agenda to achieve that.

The core of circularity is the restoration of capital (financial, manufactured, human, social, or natural) which results in a continuous flow of goods and services. The concept illustrates a systemic shift that creates long-lasting resilience, builds business and economic opportunities, and provides environmental and societal benefits (Ellen Macarthur Foundation, n.d.). About plastics, the predominant material of food packaging, the practices of reuse, repair, remanufacture, and recycle across the technical cycles

enable the recovery and restoration of products, components, and materials. Food packaging can be also created by eco-friendly materials at the manufacturing stage. Likewise, it can be reused, remanufactured, or recycled by composting or anaerobic digestion (Ellen Macarthur Foundation, 2017). The following diagram illustrates the unstoppable flow of technical and biological elements along the “value cycle":

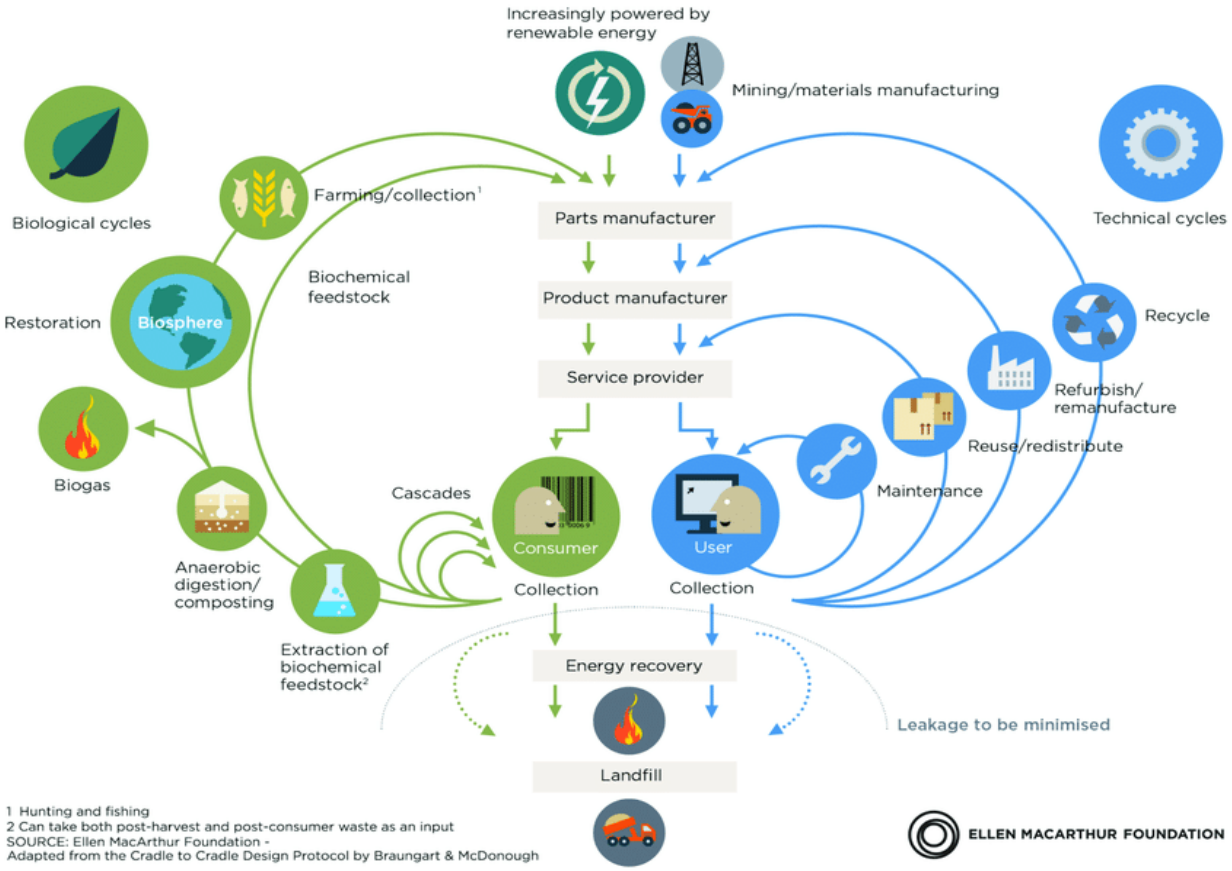


Figure 5 *The Circular Economy model (Ellen Macarthur Foundation,n.d.)*

According to the concept of CE, waste must be designed out from the economic system. This requires a distinction between biological and technical materials. As shown in the diagram, the biological materials must be returned to the biosphere safely, whereas the technical ones, must be reserved by employing maintenance, reuse, refurbish and recycle (Ellen Macarthur Foundation, 2017). A more detailed illustration of waste management in the CE is included in section 2.5.

The butterfly diagram of Circular Economy represents two sides of the cycle; the biosphere and the Technosphere. The left part, thus the biosphere is the cycle with a natural flow, while the right one Technosphere is the man-made cycle. Hence, the cycles are part of the same system and not completely autonomous (Ibowdish, 2017). Sustainable packaging is the other side of the coin (biosphere) when it comes to Circularity, and therefore, its concept is explained in the next sub-chapter.

2.4 Sustainable Food packaging

Sustainability is based on the concept of sustainable development as defined in the Brundtland report:

"Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). A packaging design that meets this vision can be considered sustainable.

The criteria of sustainable packaging that this research uses are based upon three schools; the European Organization for Packaging and the Environment (EUROPEN), the sustainable packaging coalition (SPC), whose criteria were utilized during the preliminary research of the report and the sustainable packaging Alliance (SPA). These criteria are illustrated in Table 2.

Table 2 *Existing Sustainable Packaging Criteria (Rezaei et al., 2019*

Existing sustainable packaging criteria		
According to European Organization for Packaging and the environment (EUROPEN)	According to sustainable packaging coalition (SPC)	According to sustainable packaging Alliance (SPA)
1. Packaging should be designed holistically with the product in order to optimize overall environmental performance	1. Packaging should be beneficial, safe, and healthy for individuals and communities throughout its life cycle	1. Effective: packaging should have social and economic benefit
2. Packaging should be made from responsibly sourced materials	2. Packaging should meet market criteria for performance and cost	2. Efficient: packaging should be based on "doing more with less"
3. Packaging should be designed to be effective and safe throughout its life cycle, to protect the product	3. Packaging should be sourced, manufactured, transported, and recycled using renewable energy	3. Cyclic: packaging should optimize recovery
4. Packaging should meet market criteria for performance and cost	4. Packaging should optimize the use of renewable or recycled source materials	4. Clean/safe: packaging should contain nonpolluting and nontoxic materials
5. Packaging should meet consumer choice and expectations	5. Packaging should be manufactured using clean production technologies and best practices	
6. Packaging should be recycled or recovered efficiently after use.	6. Packaging should be made from materials healthy throughout the life cycle	
	7. Packaging should be physically designed to optimize materials and energy	
	8. Packaging should be effectively recovered and utilized in biological and/or industrial closed loop cycles	

Among the different reviewed sources, the definition of sustainable packaging given by GreenBlue (2011), which was part of the outcome of the project of "Sustainable Packaging Coalition (SPC)", is selected. The definition covers diverse criteria which define sustainable packaging as a packaging system that;

A. Is beneficial, safe & healthy for individuals and communities throughout its life cycle

B. Meets market criteria for performance and cost

C. Is sourced, manufactured, transported, and recycled using renewable energy

D. Optimizes the use of renewable or recycled source materials

E. Is manufactured using clean production technologies and best practices

F. Is made from materials healthy throughout the life cycle

G. Is physically designed to optimize materials and energy

H. Is effectively recovered and utilized in biological and/or industrial closed loop cycles (GreenBlue, 2011,

p. 1)

GreenBlue (2011)'s criteria are further described here:

a) ***"Is beneficial, safe & healthy for individuals and communities throughout its life cycle";*** According to GreenBlue's (2011) definition, packaging is a tool that preserves the environmental and economic value of products, while it facilitates the distribution and delivery of products. However, it adds to municipal solid waste and necessitates proper management as it poses a threat to the environment. Sustainable materials management entails the creation of closing the loop of recovering packaging material by designing out the negative impact of packaging on the environment the society. This is also beneficial for the community, since it generates jobs, recovers infrastructure, preserves resources, and improves the environmental situation of the area. Social equity and the environment should be in line with profitability by achieving holistic sustainability measures.

b) ***"Meets market criteria for performance and cost";*** Population growth and therefore, the increasing demand for goods and resources necessitates a more effective implementation of sustainable practices. Profitability cannot be excluded from the equation of sustainable business practice. Legislation and stricter concurrence regulations have transferred the true cost of packaging from the society and the environment to the producers. Handling the cost of packaging, the production and the product delivery go along with acquiring the needed functionality and appearance of the product (GreenBlue, 2011).

   In practice, more efficient package design, optimization of recourses, knowledgeable material options, design for recovery, and limitation of sources are the key to meet market criteria for performance and cost. Along with the education of all the actors involved collaboration across the packaging supply chain will generate opportunities to achieve optimum performance by enabling sustainable alternatives with reduced cost.

c) ***"Is sourced, manufactured, transported, and recycled using renewable energy";*** Renewable energy provides alternatives that solve environmental, social, and economic issues. Predominantly, renewable energy includes solar energy, wind power, hydroelectric, biomass, tidal energy, and geothermal. Currently, packaging materials and processes are based on fossil fuel energy. However, ensuring a sufficient supply of renewable energy at a local level and introducing national energy policies could accommodate a better transition to renewable options. Product distribution is an area that can benefit the most from this transition since it bears the direct cost-benefit from a more efficient fuel use (GreenBlue, 2011).

d) ***"Optimizes the use of renewable or recycled source materials";*** Sustainable material flows that are based on bio-based and renewable sources enhance the perseverance of materials for future

generations. Moreover, the utilization of recycled materials contributes to waste reduction, the development of markets for these materials, and closing the loop systems. Optimization of the use of bio-based and recycled materials boosts the sustainability of packaging by enhancing its environmental footprint. The recyclability of these materials must be ensured (GreenBlue, 2011).

e) ***"Is manufactured using clean production technologies and best practices";*** Clean production entails the protection and management of natural resources according to inclusive and equitable economic growth while supporting the ecosystems. Any toxins that are released during the manufacturing and product packaging process must be limited as well as the emissions, energy use, and waste. To achieve this a producer can adopt an eco-efficiency strategy, such as voluntary emission reduction practises (GreenBlue, 2011).

f) ***"Made from Materials Healthy Throughout the Life Cycle";*** Dealing with harmful substances that are transferred to the environment must be a key point to sustainable production. These substances must be identified and reduced or eliminated throughout the life cycle of packaging. Packaging design must also utilize additives, inks, adhesives, and coating that are eco-friendly according to relevant legislation, material bans, and issues identified. This process shall be transparent as well.

g) ***"Physically Designed to Optimize Materials and Energy";*** It is feasible to design-out in advance issues and waste if the complete life cycle of products is examined. This cycle includes material selection and performance requirements and specifically; energy use, the environmental footprint of materials, and the possible recovery of material after the end-use.

h) ***"Effectively Recovered and Utilized in Biological and/or Industrial Closed-Loop Cycles":*** Minimization of waste and limitation on usage of non-renewable resources is possible under sustainable cycles of materials. Recovery of materials for future production entails enough collection and recycling infrastructure, which shall be economically feasible and effective (recovery at the highest value possible). Namely, recovery methods are biological (composting), technical (recycling), and energy (waste to energy). Figure 6 represents the idea of closing the loop of material flows for packaging (GreenBlue, 2011).

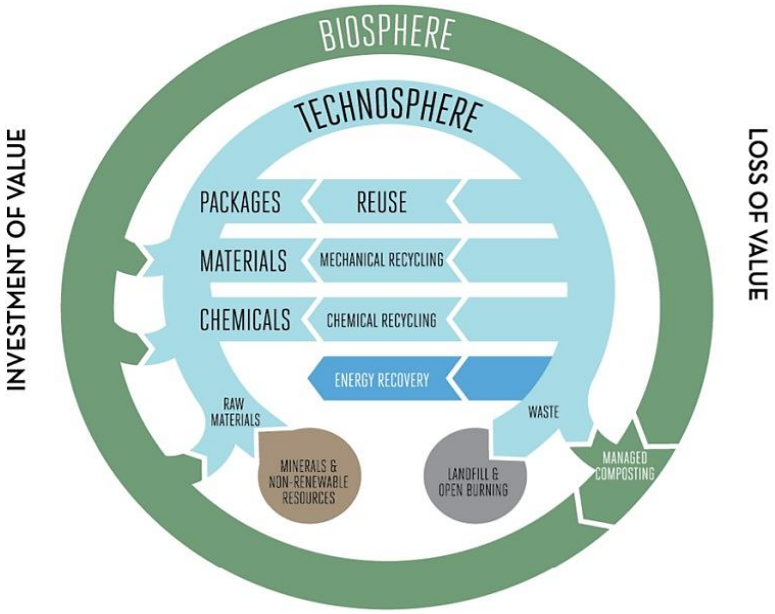


Figure 6 *Closing the Loop on recovering Material Value (GreenBlue, 2011)*

A more recent study of Rezaei et al. (2019) found that the criteria of Table 2 are mainly product-specific and are not closely related to every part of the supply chain to ensure sustainability as a whole. The objective of this research is to utilize the most recent and updated theories of, in this case, sustainability and Circular Economy as a whole. Therefore, Table 3 includes the criteria that define sustainable food packaging in this thesis.

Table 3 *Selected Sustainable Packaging Criteria (Rezaei et al., 2019)*

Selected sustainable packaging criteria		
Environmental performance	**Economic performance**	**Social performance**
1. Transported in an environmentally friendly way	1. Performance meets market needs	1. Beneficial for individuals and the community
2. Manufactured in an environmentally friendly way	2. Sourcing, manufacturing, distribution, and recycling costs	2. Healthy and safe for individuals and the community
3. Recycled, reused, and disposed in an environmentally friendly way	3. Physically designed to optimize materials and energy	3. Manages reputational risk
4. Uses recycled, renewable, reused sourced materials	4. Continuity	4. In accordance with governmental policies and regulations
5. Recovered and utilized in industrial closed loop cycles	5. Cooperation with supply chain members	5. Employee's quality of life
6. Avoids packaging and raw material waste	6. Profitability	6. Suppliers and carriers are certified
	7. Package functionality	

These specific criteria are chosen based on the recent date of the study (Rezaei et al., 2019), the fact that they are graded by academic experts, are based on food products produced in Europe and are chosen to take into account surveys with respondents from the whole supply chain (the raw material suppliers, the packaging material suppliers, the product-package manufacturer (namely, the Kraft Heinz Company), the retailers, the consumers, and the end-of-life companies) (Rezaei et al., 2019).

In detail, the environmental performance is defined by the way that packaging is manufactured, transported, recycled, reused, and disposed. Packaging must be handled using renewable energy, reducing the dependence on fossil fuels, and achieving optimal energy efficiency. GreenBlue (2011) suggests that reducing non-renewable material use can be achieved by using directly or investing indirectly in renewable energy, carbon credits, and tradable renewable allowances (TRECS) (GreenBlue, 2011).

Notably, Ellen MacArthur Foundation defines a "circular economy" as an industrial economy meant to be restorative in which products are meant for reuse, disassembly, refurbishment, or recycling (Ellen Macarthur Foundation, 2013). These operations are linked to and support the close looped cycles. Closing the industrial loop cycles entails sufficient recovery and utilization of packaging, which can be accomplished by collaboration across the whole value chain, by the creation of "healthy and recyclable materials" (GreenBlue, 2011, p. 7), by designing packaging suitable for recovery and by assuring sufficient collection and recovery infrastructure. The recovery methods mentioned as opportunities overlap with the ones mentioned in the waste hierarchy section, in which waste is turned into resources.

Moreover, the equal importance given to the three dimensions of sustainability is also in line with the holistic approach of Circular Economy, the main compass of this thesis. The Sustainable Packaging Coalition definition illustrates that there must be a holistic solution to shrink the plastic soup of food packaging, which, according to Geijer (2019), entails the equal involvement of the various levels and actors of a food company. A recycling system within the plastic chain needs to be introduced and the producers should be accountable for their choice of packaging towards the customers. In the "Plastic Packaging in the Food sector" report, six practices are suggested to enhance sustainability; "*1. Lighter packaging 2. More recycled plastic in packaging 3. Improve recyclability 4. Bio-based and/or biodegradable plastic 5. From non-reusable to reusable packaging 6. From plastic to other materials"* (Geijer, 2019, p. 3). Considering the environmental performance criteria of table 4, the next section elaborates their relation to resource management in which waste can be a valuable resource for food packaging design.

2.5 Waste Hierarchy

Waste management is an essential part of food packaging design. The Netherlands is a frontrunner in waste management at the EU level to sustainably utilize raw materials according to its green program "From Waste to Resources"(Van Afval Naar Grondstof-VANG) (Government of the Netherlands, 2016). According to the Ministry of Infrastructure and Water Management, 78% of the country's waste is recycled while the rest is mainly used to produce energy. According to Cramer (2014), an improved resource efficiency necessitates a circular transition to avoid resource scarcity and achieve sustainable long-term profits. It is believed that considering waste to be a potential resource will enhance the

economy and secure the supply of resources and thus, assist the transition to a circular economy in the Netherlands (Rijkswaterstaat Environment, n.d.). Such an explanation serves to introduce the principles of Waste Hierarchy, which were proposed by Lansink, a former Dutch politician. Those WH principles are for some of the baseline of the actual CE frameworks and hence considered a relevant component of the CE integration in food packaging. Further details in the construction of the CE integration in food packaging are described in the following paragraphs.

The waste hierarchy guides consumers and businesses to minimize the waste of products, and thus supports circular economy and sustainability. In specific, the waste hierarchy idea entails the sustainable packaging criteria of "Recycled, reused and disposed of in an environmentally friendly way", "Recovered and utilized in industrial closed loops", while it also promotes a better economic and social performance. Consequently, the concept addresses the three dimensions of sustainability as they are defined in section 2.4.

Waste hierarchy suggests adopting a preventive policy regarding managing waste, which is perceived as waste from the standpoint of this research. Moreover, it encompasses reusing raw materials generated from waste either after separating them at the source or processing them in designated plants (Lansink et al., 2019). t does not exclude the production of energy from waste processing and the controlling of landfilling or the discharge of useless waste. The sequence of these practices shows a strong preference for environmentally friendly ones (Lansink et al., 2019).

The "Waste Hierarchy" was proposed in 1979, way before the concept of Circular Economy was introduced by Mac Arthur Foundation in 2010. Lansink suggested the prioritization of reduction, recycling, and reuse of waste over treatment or disposal. One of the main principles of Lansink's hierarchy is "From waste to Resource Hierarchy", which among others, functions as a roadmap to circular economy since it defines resource management (Lansink et al., 2019). In particular, the European Waste Framework Directive 2008/98/EC (WFD) incorporated the waste hierarchy principle, which hence was integrated into the national law of the European Union Member States. The European WFD denotes the waste hierarchy principle as the leading factor in waste management (Pires & Martinho, 2019). The principle was also included in the first European report of Circular Economy Strategy in 2015, in which waste management that is based on the waste hierarchy is crucial to restore materials in the economy and enhance the overall environmental performance (European Commission, 2015). Another key point is that several waste hierarchy operations support CE: designing for reuse, up-cycling, re-recycling, down-cycling, composting/anaerobic digestion after separating collection at source, the biological process from mixed collection, waste-to-energy (WtE), incineration without energy recovery, and landfill (Pires & Martinho, 2019). The correlation of Circular Economy and the waste hierarchy is shown in the following graph:

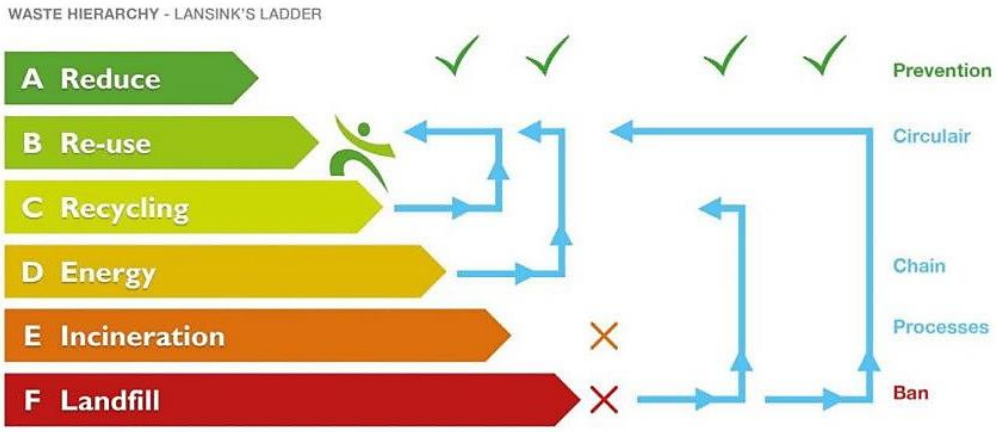


Figure 7 *Waste Hierarchy- Lansink's Ladder (Lansink et al., 2019)*

The prevention of waste, thus the reduction of resources used is on the top of the hierarchy as it is illustrated in Figure 7. The next levels of reuse and recycle promote a transition to more circular systems, in which **waste is turned into a resource**. Reuse refers to discovering new ways of product use, while recycling is about reusing the raw materials of the product (Cramer, 2015). Nevertheless, valuable resources or secondary raw materials are yet restricted due to their performance, availability, and cost. The EU aims to address this issue by setting requirements for the recycled content in products so that the supply and demand of them will reach an equilibrium. In that way, the recycling sector can flourish as an internal market of materials (Deselnicu et al., 2018).

The next level of the hierarchy includes energy recovery from waste or incineration of energy, whereas the last resort of resource management is disposing of the materials and products in the landfill (Cramer, 2015). Avoidance of landfilling at all costs is the EU's main message since the accumulated waste in landfills must then be incinerated (Lee et al., 2017). Incineration contributes substantially to C02 emissions. The Circular model can assist in better resource management reducing greenhouse emissions and assisting in fighting climate change (Ellen MacArthur Foundation, 2019). The aforementioned principles of Waste Hierarchy have been adopted by the EU and are part of the "Circular Economy Action Plan", one pillar of the European Green Deal. This the second action plan proposed by the European policymakers since 2015. Waste policy sets as top priority waste prevention and circularity along with waste reduction targets (European Commission, 2020).

However, this transition requires alternative consumer behaviour. Figure 8 illustrates what efficient communications stand for in creating support at a societal level. The levels of communication, starting from inner to outer levels, are: internal community (employees), extra community (suppliers), external community (customers), managed social media (managed community), and social media (participating community (Lansink et al., 2019). During the session of "From waste to Resource-moving towards a Circular Economy" (2019), the meaning of efficient communication between the different levels in a

Circular Economy system was further explained. The recommended actions to ensure support in the society include setting realistic expectations, acknowledging natural laws, simplifying terminology, and altering CE perception as a marketing tool. Notably, the importance of increasing consumer awareness is identified as a challenge of the Circular food packaging model in chapter 4.

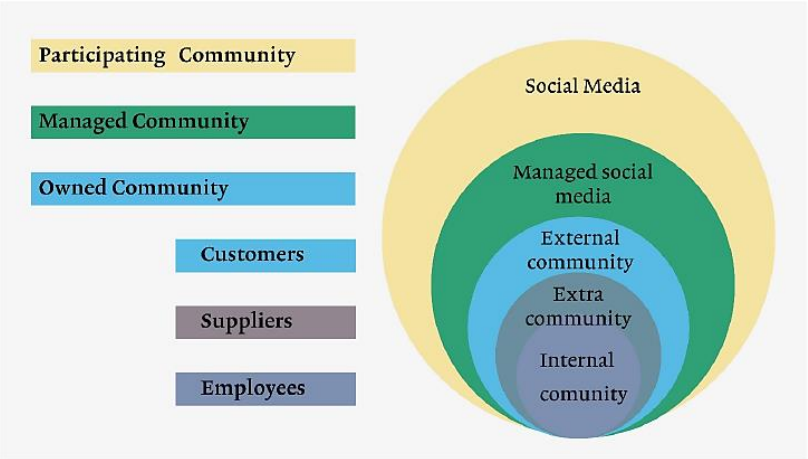


Figure 8 *Creating Support in society (Lansink et al., 2019)*

Apart from consumer behaviour and communication of actors, closing the loop at different levels of the value chain necessitates a business model, as it is illustrated in Figure 9 (Lansink et al., 2019). The industrial economy with a restorative identity, as defined by Ellen MacArthur Foundation, entails that reusing materials instead of extracting resources is the foundation of economic growth. A new circular business model is believed to enhance economic growth and profitability since it deals with the resource scarcity of a linear model (Ellen Macarthur Foundation, 2013).

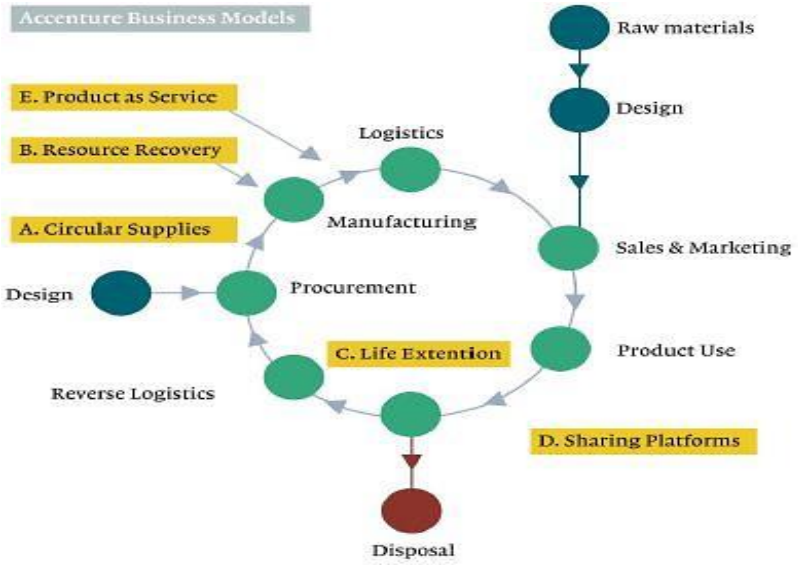


Figure 9 *Circular Business Model (Lansink et al., 2019)*

One of the main principles of the circular business model is the resource hierarchy, as previously explained. The materials entering the cycle are designed for recycling in the first place. The marketing of the product aims at a higher consumer awareness, which is followed by the actual product use. The utilization of circular supplies is the result of recycling and inclusive resource policy to recover materials which were introduced in the system at an earlier stage. In that case, there is an extended life of materials after design and product use. Products can function as a service for the manufacturing stage. Furthermore, The Circular business model promotes "sharing platforms", as a result of a well-performed chain management considering climate policy (Lansink et al., 2019).

Likewise, a Circular food packaging model adopts a similar cycle from the moment that packaging materials enter the design phase. The concept of the Circular business model with regards to food packaging design is further developed in the following section.

2.6 Circular Food Packaging Model

This section illustrates how the previously explained concepts of sustainable food packaging, waste hierarchy, and Circular Economy are combined into one model. The Sustainable Food packaging concept and framework as it is elaborated in 2.4 is used as a conceptual baseline of the integration of Circular Economy in Food packaging design.

The left part of the butterfly diagram of Circular Economy as presented in figure 5 is focused on the biosphere. The biosphere includes materials that will cycle without the intervention of the human hand. It has evolved from ecology and environmental science making sustainability a holistic system. On the other hand, Circularity is mostly linked to the Technosphere, the human-made system that supports the transformation of raw materials for consumption. The Technosphere is different than the biosphere since cycling materials is part of the design that requires intervention. However, the concepts are part of the same system and are not fully independent (Ibowdish, 2017). Circular Economy can be perceived as a condition for sustainability, an advantageous relation, or a trade-off (Geissdoerfer et al., 2017).

In a Circular system products and materials are ideally continuously reused in a closed-loop (Ellen Macarthur Foundation, 2013). The materials that have been altered are recycled using chemical, mechanical, or even biological processes, as shown in figure 10 (Circule, n.d.), which shows the application of the Circular model to food packaging. The Circular food packaging model is the product of the Circular Economy principles and framework, as explained in the second chapter of this document, in the food packaging sector. The diagram entails the linear model of production; raw material extraction, product manufacturing, marketing/service, products/packaging design, product use, and disposal. However, disposal is not the end, but the start of the chemical and mechanical reuse with recycling and reusing of materials along the production cycle. It is also the starting point of the biological reuse, which

encompasses composting, then either carbon release or appliance to sustainable agriculture and bio feedstocks (Circule, n.d.).

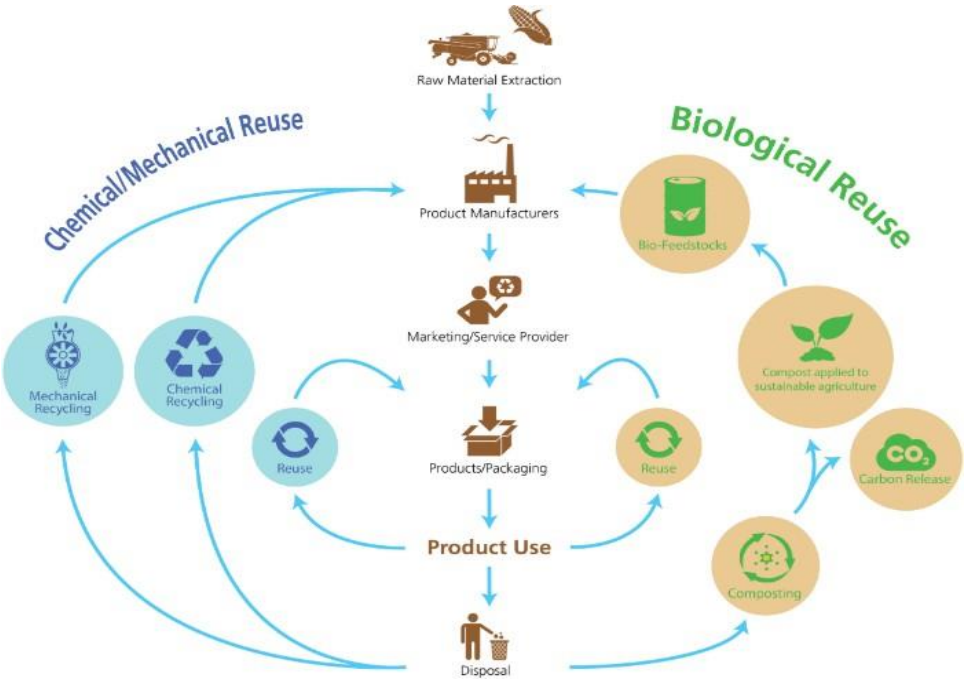


Figure 10 *Circular Food Packaging Model (Circule, n.d.)*

According to Circule's calculations adapted to the company's packaging, the benefits of circular packaging include a 73% drop in carbon footprint, a 68% limitation in feedstocks that are fossil-fuel based and a 30% biobased feedstock (Circule, n.d.).

A Circular Food packaging model could look like Circule's diagram. The model represents the biosphere and the Technosphere of the "butterfly" diagram of Ellen Mac Arthur Foundation and thus includes, the sustainability criteria selected for this research. It also illustrates that, after the end-product use, disposal is not the end of the cycle, but the re-start of it, since waste is a valuable resource for biological or chemical/mechanical reuse. In other words, the principles of waste (or resource) hierarchy are integrated into this model. This is the idea of the so-called "second-sourcing" that facilitates closed loops of resources by ensuring the recyclability of products at the design phase (Lee et al., 2017). "Second sourcing" can be further supported by ensuring the conservation of value of materials at the design phase to ensure a less difficult and faster mechanical recycling (Gabriel & AninditYo, 2017). A similar paradigm can be followed for the other types of recycling as well.

However, there is a possibility that only a small number of materials are utilized in top quality secondary markets and the rest is considered residue for disposal lowering the environmental benefits of the total waste stream (Lee et al., 2017). For the secondary markets to flourish, a post-consumption sorting of the

packaging materials should be adopted by the various stakeholders. Gabriel & Anindityo (2017) examined the efficient strategic roles that the actors can play to increase the quality and value of post-consumption resources. The European "Circular Economy Action Plan" also acknowledges the need for strategic roles in key-value chains and the subsequent broadening of the market for circular products (European Commission, 2020b). Consequently, the Circular food packaging model can be defined as a holistic solution to deal with the increasing pollution from packaging that includes all the various levels and actors of the food chain (Geijer, 2019).

European Commissions' ambition to move faster towards regenerative economic models is justified by the advances these models can provide in the society, economy, and the environment. As it is stated in the new Circular Economy Action plan (2020), part of the European Green Deal, CE will enhance the functionality, quality, and safety of products while offering sustainable services. A climate-neutral with higher resource efficiency and a growing economy is the expected benefit of the action plan (European Commission, 2020b). Nevertheless, the envisioned advancements of a CE integration in the food packaging industry are hindered by various hurdles. Chapter 4 highlights the most prominent challenges of such integration at the Dutch level.

3. Research Design

Designing research consists of determining the objective of the research (conceptual design) and examining the concepts identified as a part of the research strategy (technical design) (Verschuren et al., 2010). This chapter describes the steps followed to provide answers to the research questions of this thesis report. Desk research and semi-structured interviews were the methods used for data gathering. The content of this chapter is structured by the research framework, research questions, concepts definition, the research strategy, research materials, and methods of accessing and analysing the data.

3.1 Research Framework

The research framework represents visually the research project. For this reason, Verschuren et al. (2010) created a step-by-step approach that has been followed to develop the framework of this research. The steps followed are explained below.

Step 1: Characterizing briefly the objective of the research project

The main goal of this research is to identify the challenges and the policy solutions of integrating the Circular Economy principles in food packaging practises in the Netherlands. For this purpose, this report analyses the policies regarding food packaging, the integration of Circular Economy, and current practises.

Step 2: Determining the object of the research project

The main object in this research is the Circular Food Packaging Model in the Dutch context.

Step 3: Establish the nature of the research perspective

The research provides insights into the challenges of introducing circular food packaging in the Netherlands. The research perspective is problem-analysis research and intervention research. The research perspective is a conceptual model to identify the challenges and policy solutions of integrating Circular Economy in food packaging in the Netherlands.

Step 4: Determining the sources of the research perspective

The conceptual model of this research is derived from the scientific literature. The concepts that were used in this research are summarised in Table 4:

Table 4 *Sources of the Research Perspective*

Key concepts	Concepts and documentation
Circular Food Packaging model	Sustainable food packaging
	Waste hierarchy

	Circular Economy Concept and Framework
	Dutch (EU-level) Policies on food packaging
	Preliminary Research on current practices

Step 5: Make a schematic presentation of the research framework

The research framework followed for this thesis is illustrated in figure 11:

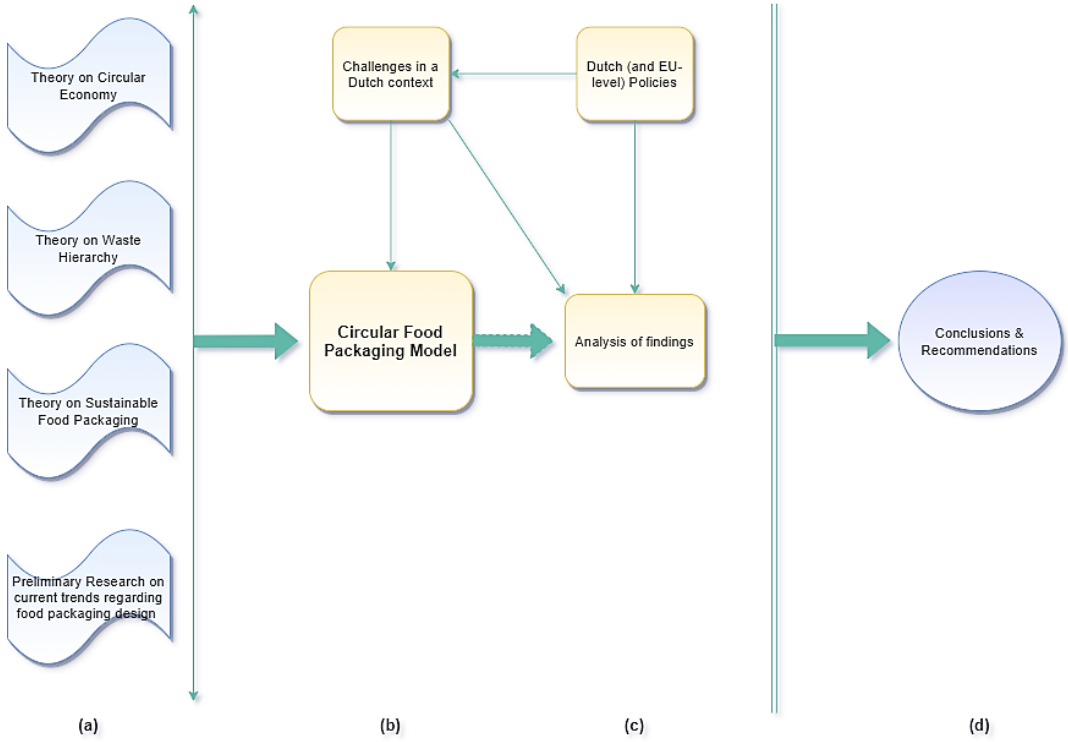


Figure 11 *Schematic presentation of the Research Framework*

Step 6: Formulating the research framework in the form of arguments which are elaborated;

a) An analysis of the theories of sustainable packaging, Waste Hierarchy, the Circular Economy Concept and Framework, and preliminary research on the current food packaging trends in the European and Dutch level,

b) Identification of the research object; the Circular Food Packaging Model and its main environmental benefits, the challenges of a CE integration in food packaging and the Dutch (European) policies assisting this integration,

c) Analysis of the results as the basis for recommendations,

d) Conclusion and Recommendations to address the problem statement.

Step 7: Checking whether the model requires any change

At the current point, there is no indication that any change is required.

3.2 Research Strategy

This research uses a selection of research methods to answer the research questions.

3.2.1 Research Unit

The selected unit of this research is the Dutch food packaging sector and its practises. Due to time restrictions, the location of the university, and the availability of interviewees, The Netherlands was selected as a reference point to analyse the challenges that the food packaging sector faces in order to become circular. Similarly, policy solutions are analysed only at a Dutch and EU level.

3.2.2 Research Boundaries

At an early stage of this research, research boundaries were set in order to achieve certain goals in the given timeframe of the thesis period. Due to time constraints and the location of the university, the researcher chose the Netherlands as a geographical scale for this research. The country will be the reference point of this report.

3.2.3 Research Limitations

This research includes the following limitations; a) time constraint; due to the time restriction set by the University guidelines, the research focuses on the main factors that influence food packaging and its integration in Circular Economy framework, while the enablers of this integration are only at a Dutch policy level, b) on-line interviews; the interviews are held exclusively online through conference tools and the communication with the informants and supervisors is also held online due to the social distancing rules set by the Dutch government concerning Covid-19.

3.3 Research Material and Accessing methods

Research materials are characterized as the way of defining and operationalizing the key concepts of the research objective along with the research questions (Verschuren et al., 2010). Data and information required were collected via document analysis, literature review, and semi-structured interviews. The document analysis was conducted regarding EU and Dutch policy documents on Circular Economy. Semi-structured interviews were held with experts in the field of sustainable food packaging, Circular packaging and current practises in the Netherlands. Table 5 provides the names and affiliations of the interviewees. The data and information required, and its accessing method was identified through a set of sub- research questions which are shown in table 6.

Table 5 *Participants of the research and their affiliation*

Name of Participant	Affiliation	Interview Method
Jean-Paul Lange	Principal research chemist at Shell Technology and Professor in Chemical biorefining at the University of Twente.	Online interview
Bjorn de Koeijer	Postdoctoral researcher of University of Twente	Online interview
Roland ten Klooster	Professor of packaging design and management at the University of Twente	Personal Communication via email

Table 6 *Data and Information required for the research and the Accessing Methods*

Research Question	Required Information	Research Method	Accessing Data
What are the major challenges that food packaging must tackle to enter the loop of Circular Economy?	Main challenges that prohibit or delay the transition to a more circular food packaging model, focused on the Netherlands	Desk Research Primary Data: Interviews	Content Analysis and semi-structured interviews
What are the policy instruments that are introduced by the Dutch government to overcome the challenges to adopt Circular sustainable food packaging?	Relevant policies introduced by the EU and the Dutch government aiming to address the identified challenges	Desk Research	Content Analysis

The interview guide upon which the interviews were conducted is included in Appendix A. To clarify, the interview questions presented in Appendix A are only a mere indicator of the themes discussed and not a rigid guide that the researcher followed in every interview.

In particular, the interviewees were asked about their view on the most important challenges the food packaging sector faces to become Circular. The fact that the respondents are involved in research projects implemented in the Netherlands ensures the relevance of the results. This also served the cross-analysis of challenges identified through literature and interviews in order to present and conclude on the most prominent ones for the Dutch food packaging sector as an answer to the first sub-question. After categorizing and presenting the challenges that the sector faces, relevant EU and Dutch policies were identified to answer the second sub-question. The concluding section 5.3 presents a table, which summarizes and links categories of challenges with the policies that are introduced to address them.

Finally, the main research question was answered based on the synthesis of the answers given to the two sub-questions.

3.4 Ethical Aspects

The research includes interviews and therefore, ethical issues might arise. Therefore, a consent form was set up by the researcher which includes prior consent for the recording and the transcription of the recorded data. The interviewees also had the option to stay anonymous but chose not to do so. Interviewees who did not wish to sign the form gave their consent via email or during the interview itself. The consent form also included other ethical considerations, such as the interviewee's privacy and confidentiality of data collection.

3.5 Data analysis

As previously explained, data collecting was carried out by desk research and semi-structured interviews. The questionnaire used is included in Appendix A. The method used for the content analysis is described below.

3.5.1 Methods of Analysing data

This research uses the qualitative method as a content analysis. In specific, the research questions were the guide of the data approach in a deductive way. Table 7 illustrates the data and methods of data analysis in detail.

Table 7 *Data required and Method of Analysis*

Required information	Method of Analysis
Main challenges that prohibit or delay the transition to a more circular food packaging model, focused on the Netherlands	Qualitative: Identified the major inhibitors of a Circular transition of the current food packaging model and categorized them in different sections
Relevant policies introduced by the EU and the Dutch government aiming to address the identified challenges	Qualitative: Identified and analysed the actions followed by the Dutch policymakers to address the inhibitors

The acquired data concerning the Circular Economy and food packaging in the Netherlands was confronted with the information illustrated in section 2.6. During the semi-structured interviews, the experts shared their insights on the challenges of a Circular integration in the food packaging sector in

the Dutch context. The researcher also utilized, whenever possible, the interviews as a cross-verification method to explore which of the identified challenges of the food packaging sector according to the literature are indeed predominant in the Netherlands. To enhance the narrative and the structure of the analysis of challenges, 4 categories are used. Likewise, in chapter 5, after presenting the relevant Dutch and EU-level policies, a table in which selected challenges are linked to the policies that are introduced to address them, is presented.

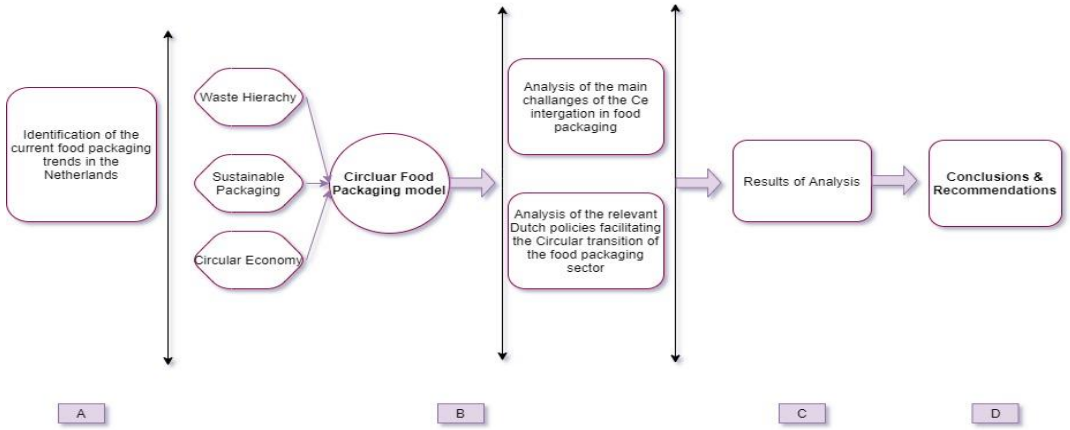
3.5.2 Validation of Data Analysis

The validity of the research report is analysed based on the research methods and information gathered to provide answers to the research questions. The information presented is also multi-dimensional; addressing different dimensions (social, economic, and environmental) of the same phenomenon, thus the Circular integration in food packaging.

3.5.3 Analytical Framework

The first stage **(A)** of data gathering included the identification of current food packaging trends in the EU. From the preliminary literature review, it was found that the concepts of Sustainable food packaging and Waste hierarchy are closely related to the Circular Economy Principles. Therefore, the concepts of sustainable packaging, waste hierarchy, and Circular Economy framework, which is also the core of this research, were analysed and contributed to the Circular Food Packaging model. During the stage (**B)**, the researcher identified the challenges of the integration of such a model into the Dutch food packaging industry and the Dutch and EU policies addressing these challenges. The third step **(C)** included the analysis of these findings that are used as a basis for the conclusions and recommendations of the final stage **(D)** of this research.

Figure 12 *Schematic Presentation of the Analytical Framework*



4. Challenges of a CE integration in food packaging practices

As explained in the previous chapter, from a circular economy perspective waste management is turned into resource management (Lansink et al., 2019). The main function of food packaging is the contribution to food loss reduction, which entails the preservation of food quality and safety, prevention of food-borne diseases, and handling the impact that the production and distribution of uneaten or inedible food can cause on the environment and the economy. Consequently, food requirements should be aligned with the functional characteristics of packaging materials (Guillard et al., 2018). A transition to a higher level of sustainability for packaging requires attention since packaging is a substantial component of the entire value chain and thus, strongly affects it (Vella, 2018).

In order to achieve resource efficiency and overall circularity, while preserving the main functions of packaging, the food packaging sector must overcome certain obstacles. During the desk research, the general challenges of the sector were identified, while the interviews conducted were utilized to distinguish the most trending challenges in the Dutch context. By analysing the content of the interviews, the researcher was able to organise in categories the major challenges identified. The challenges that are elaborated concern the food producers and their choices of packaging practises. Hence, the most recent and up-to-date challenges concerning the transition of conventional food packaging to a circular model can be classified as 1. Informational and Technological, 2. Behavioural, 3. Regulatory and, 4. Societal. In the following sections, each of those challenges is further described.

4.1 Informational and technological challenges

The first category refers to informational and technological challenges. Informational refers to the knowledge of food packaging designers about Circular Economy and its principles and the available sustainable options including the lack of awareness or limited focus on sustainability. As for the technological factors, these are linked to inadequate innovations and available technology as a result, but not exclusively, of a lack of investment by the decision-makers of a company. The two factors, informational and technological, seem to overlap since knowledge can be the main driver of technological innovations.

The practicality and convenience are top priorities for the fast-paced lifestyle of modern society. Innovative solutions are needed and although the Netherlands enjoys the privilege of numerous patents, the successful implementation of technology is lacking (Bastein et al., 2013). Sustainable resources, such as bio-based and/or biodegradable exist but, in many cases, their environmental footprint is yet to be discovered (Guillard et al., 2018). Licciardello (2017) explains further the ambiguity regarding eco-friendly materials. Biopolymers are produced using renewable materials and bioplastics are plastics made by renewable materials (biobased) or plastics that are biodegradable and/or compostable. For instance,

polyethylene (“green-PE”) or polyethylene terephthalate (“bio-PET”) are biopolymers that do not biodegrade. However, numerous polymers do biodegrade, such as cellulose, soy protein isolate, gluten, etc. (Licciardello, 2017). As priorly mentioned in the introduction section, packaging plays a fundamental role in food security which in turn contributes to food loss reduction. Therefore, bio-sourced plastic, which might use also food resources such as corn and cane sugar must overcome the security issues related to them (Putri, 2018).

Similarly, Vella (2018) points out that manufacturers seem to struggle to choose materials due to their complex nature and the continuously changing public opinion towards them, as both elements are explained further in this chapter. Specifically, the sustainable options illustrated in the previous paragraph (biobased and/or biodegradable), are linked to a limited level of recycling and are usually mixed with general waste, which makes the separation and recycling process difficult (Vella, 2018). More often than not packaging is multi-material and there is a lack of adequate recycling systems that can ensure the packaging potential recyclability (Berg et al., 2020). To enumerate, the European rate of packaging recycling is around 40 percent, paperboard around 80 percent, and 75-80 percent concerning metal and glass (Eurostat, 2020). Similarly, the non-biodegradable bio-sourced plastics or the non-compostable at home are affecting negatively the waste management, since collecting separately and sorting these materials is necessary (Guillard et al., 2018).

Even though the plastic packaging rates are low, oil-based materials are mainly chosen over bio-based ones due to their design flexibility and low cost, which allows wide options for processing (Licciardello, 2017). An interviewee argued that plastic is often cheaper than other packaging materials as it requires less energy and transport time. There appears to be a correlation between the cost and Co2 emissions per material weight (R. Ten Klooster, personal communication, July 8, 2020). For that matter, Berg et al. (2020) state that sustainable alternatives should be more affordable to have the opportunity of an upscale at a market level.

At the moment, the Research & Design sector does not provide sufficiently the necessary packaging technologies to increase packed food sustainability. In other words, packaging designers lack tools to customize packaging to food needs, e.g. in order to enhance perseverance and retain the sustainable features of bio-packaging options and packaging itself, especially regarding limiting food loss. Therefore, stakeholders of the food packaging sector are unable to fully attain the economic, societal, and environmental benefits of these solutions (Guillard et al., 2018). Hence, the management team does not prioritize the allocated funds for research on sustainable alternatives. To sum up, the suggestions for alternative resources exist, but the market entry, especially at a large level, of these bio-based and/or biodegradable materials is hindered by technical issues (Licciardello, 2017).

The idea of “overpackaging” is an opportunity for development in the field of sustainable food

packaging. Decreasing the materials used for package production is not yet tackled. Licciardello (2017) claims the absence of knowledge on packaging by the responsible actors in the food companies and their unwillingness to adapt to new ways to be a possible reason for this issue. It is not surprising that small and medium-sized companies are perceiving packaging as not an important element of production and as a result, their packaging systems are not up to date with the most recent innovations (Licciardello, 2017). Hence, there is room for integrating the viewpoints of food value stakeholders and the food packaging producers. Likewise, R. Ten Klooster indicates that, although packaging can be considered a separate role, few companies have invested in training their employees in the field. According to the expert, the responsible person for the packaging is usually the buyer of the product or a person from the operational level. Research done by the University of Twente showed that the marketing team is usually the one to decide on the materials depending mostly on its colour, transparency, etc., and less on its sustainability features, such as recyclability (R. Ten Klooster, personal communication, July 8, 2020).

Not only the lack of knowledge but also the inflexibility in terms of financing innovative technologies is hindering Circular Economy integration (Guillard et al., 2018). The production side is in line with the consumer one. In other words, the company will proceed with certain investments, only if the management is convinced that it could charge more for sustainable packaging. There needs to be a certainty that a rise in the product price will be acceptable. This thinking pattern becomes more complex considering the retail, which, for instance, influences the costs of fast-moving consumer goods (B. de Koeijer, online interview, July 13, 2020). An article written by Jillian Ambrose (2019) shows that the cost of recycled plastic flakes is higher than virgin plastic. The higher cost is a result of increased demand for the secondary materials in new products. This fact also hinders the flexibility of manufactures that strive to keep the cost down, especially the smaller ones (Ambrose, 2019). Consequently, the packaging industry seems to lack the flexibility and freedom to change and adopt a circular approach.

Overcoming these challenges requires investments. Financing the transition to Circular packaging is a substantial hurdle. During the interviews, it was discussed that the reason behind the lack of financing is that the packaging itself is not the one under scope, but the end-product. The role of packaging is mainly to give additional benefits to the product meaning that its cost must remain low. It is believed that consumers are unwilling to pay extra, even though packaging provides added value, as it is further explained later in this chapter (J. Lange, online interview, July 3, 2020). Therefore, packaging must be cheap, which creates complexity in its development especially under a limited development scope regarding financial aspects (B. de Koeijer, online interview, July 13, 2020).

4.2 Behavioural challenges

The actual behaviour of the various stakeholders involved in either the decision-making process or the development of packaging is crucial when it comes to generating or adopting new developments. This

fact is supported by the “Stakeholder theory”, which refers to the need for alignment between the strategic and operational levels in a company (Bjorn de Koeijer et al., 2019; Parmar et al., 2010). Negative behaviour refers to externalizing costs or failing to incorporate sustainable practises (Guillard et al., 2018). These behaviours hinder the transition towards Circular Economy.

Specifically, B. de Koeijer mentioned that there are various perspectives of different stakeholders regarding the type and the process of packaging development. Among them are the material knowledge, marking of the product, and the product lines on which the packaging is created. The combination of these various variables creates a certain ambiguity, which makes the development process more complex. He also pointed out that there are many factors and, in many cases, developing a circular product is not the leading one (B. de Koeijer, online interview, July 13, 2020). According to the interviewee’s opinion, the balance of these different views of stakeholders is a major challenge that the packaging industry faces. In many cases, brand identity or other factors play a more important role. The motivation to produce a sustainable product exists, but the ability to do so is hindered by the misalignment in decision making. This upstream movement in the chain forces the suppliers to explore new solutions (Bjorn de Koeijer et al., 2019).

There is a gap between the strategic and the operational level within companies. The strategic part is concerned with the conservation of the planet and the lives of future generations, while at an operational level, integrating sustainability in the product development appears to be delayed (Bjorn de Koeijer et al., 2019). For instance, there might be strategic targets for reducing CO_2 emissions or even achieving full circularity (B. de Koeijer, online interview, July 13, 2020). However, on the operational level, the daily processes to develop packaging combinations are the main focus, as the actors involved in this level are fixated on the day to day actions. There are different goals between these levels of management and finding the right balance to gain the most trade-offs is challenging. The management might have the motivation to adopt Circular practises, but the involvement of various stakeholders defines its real actions (B. de Koeijer, online interview, July 13, 2020).

A transition to CE is, in principle, technically feasible, but it requires a close collaboration of all actors across the value chain. Koeijer et al. (2019) clarify the importance of inclusiveness and decision making by internal and external stakeholders along with setting sustainability targets in order to produce results on both strategic and operational levels of packaging design.

4.3 Regulatory challenges

Existing laws regarding food contact materials function as a protective shield for consumers. However, regulations could also hinder the Circular transition as highlighted by B. de Koijer. Law does not always follow up innovations resulting in delays between the development of, for example, post-consumer

recycled food contact materials, and the actual implementation stage. New technology might take years to become officially allowed, but the innovative solutions themselves are not hindered, but rather delayed (B. de Koeijer, online interview, July 13, 2020). Simultaneously, the preconditions towards food contact packaging are increasing in number due to the fear of negative effects that material might cause in the quality of products and subsequently, human health (Wyrwa & Barska, 2017). A possible justification for this delay is another misalignment between the lawmakers and the developers in companies. The innovators are keen on pushing new developments to the market as fast as possible, while the lawmakers require time to evaluate the safety of a new technology concerning the environment and the consumers. If these two actors were in close contact, the transparency of the developments would be reassured, and the process of their implementation would be expected to happen faster (B. de Koeijer, online interview, July 13, 2020).

The identified solutions by packaging companies must always comply with the relevant regulations set by the Dutch government and subsequently, by the EU. Innovative technologies must follow food and packaging regulations before they enter the market. This can generate additional costs and time to restrict the market entry of the technology (Guillard et al., 2018).

Cramer (2015) also illustrates the possible hindering nature of legislation in technological advancements and generally, in the circular transition. The author claims that, in some cases, waste is prohibited to be used as a resource to avoid the abuse of waste and thus, restricts the secondary market of resources and a production facility for new products and materials (Cramer, 2015).

4.4 Societal challenges

The challenge that a holistic model of Circular food packaging faces demands the awareness of all actors of the value chain, including end-consumers. According to the research of Boz et. Al (2020), unfavourable consumer attitudes can restrain companies from adopting more sustainable packaging solutions. The consumer's behaviour and willingness to change are important factors that could assist or hinder the successful implementation of sustainable practises. For such a circular model to flourish, the consumers should acknowledge the environmental stress that food packaging poses and be committed to adopting the disposal guidelines suggested by the product designer and the general instructions of waste disposal at a national level (B. de Koeijer, online interview, July 13, 2020). Public perception is influenced by the societal norms, thus the preference for convenience and by the cost of a product, as Prof. Lange mentions. Companies might bear the cost of eco-friendly solutions at the production stage, but this cost will be translated in a higher price at the supermarket's shelves. Consumers are not aware that opting for a cheaper less sustainable option, the end cost is externalized (B. de Koeijer, online interview, July 13, 2020).

Identical to the lack of knowledge of the decision-makers of packaging, the lack of information also results in incomplete knowledge of the public. An important reason for that lacking is the misconception that packaging is exclusively a source of pollution (Licciardello, 2017).In fact, the functional role of packaging as a food protection shield and enhancing food safety and hygiene is not the main known characteristic (Licciardello,2017; B. de Koeijer, online interview, July 13, 2020). Even though consumers are becoming more aware of whether the packaging is sustainable, the image of ocean plastics and the general environmental pollution curtain the food waste reduction thanks to packaging (Boz et al., 2020). This is the case especially for plastics, which are perceived as not sustainable. Plastic is a packaging material that is well-developed and a rather easy solution. It is also the solution that facilitates the most options regarding freshness, hygiene, quality, etc. (R. Ten Klooster, personal communication, July 8, 2020). Alternative solutions, such as glass paper-based materials are perceived as more sustainable (Geijer, 2019; Lindh et al., 2016).

A study on how Swedish consumers perceive food packaging confirmed this. Paper-based materials are considered more environmentally friendly than plastics or metal. Consumers believe that the environmental footprint of a product is mostly related to the choice of material, as they overestimate the actual impact of it (Lindh et al., 2016). However, according to B. de Koeijer's opinion the sustainability of a material is a complex matter and using plastics does not cancel by definition the circularity of a system. Likewise, R. Ten Klooster illustrates the complexity of a sustainable product chain, since based on his insights, to ensure the sustainability of the chain, a combined analysis of the product and the packaging is necessary. The product usually is responsible for a higher carbon footprint than the packaging (R. Ten Klooster, personal communication, July 8, 2020).

The public opinion could be influenced by the positive effects and potential that packaging must prolong the quality of the fresh food products and the avoidance of food losses. Therefore, the challenge of informing citizens is posed. Increased need for food safety and hygiene reinforce "overpackaging" (Packaging Europe, 2020). The current pandemic is affecting the decisions of people as a result of a higher need for safety. The consumers require these needs to be met. The packaging companies follow this lead and strive to enhance their packaging by adding more layers to ensure higher protection of food (J. Lange, online interview, July 3, 2020) This could be considered as "overpackaging", but not definitely. The difference between over and under packaging is not clear (B. de Koeijer, online interview, July 13, 2020). Comparatively, Packaging Europe(2020), acknowledges the influence of Covid-19 on consumer behaviour. This shift might last longer than expected, since there appears to be a preference towards pre-packaged food, such as fruit and vegetables by consumers and retailers. These types of packaging might be perceived as safer, as the need for safety and hygiene is rising (Packaging Europe, 2020).

After identifying the most prominent challenges of the Circular Economy integration in food packaging

focused in the Netherlands, which is based on the insights explored through interviews and desk research, an analysis of the enablers offered by the Dutch policymakers is held. The policies included are predominantly Dutch and relevant EU-level, which are set to accommodate the Circular transition in the food packaging sector. The next chapter illustrates the actions of the EU and the Dutch policy context.

5. Policy Solutions to Integrate Circular Economy and Food Packaging

The challenges of a circular transition for the food packaging sector require sufficient solutions in order to accelerate the process. In the previous chapter, it became clear that the food packaging sector faces specific inhibitors to implement the circular model, as it was defined in chapter 2. The European Union and the Dutch government as a part of it, strive to address them with a multi-level approach utilizing their policy tools and legislation. The most relevant policies are presented in this chapter. Although the various levels often overlap, the categories of chapter 4 are used to ensure the cohesion of the interpretation of the results.

5.1 Relevant Dutch Policies

In September 2016, the Dutch government released its plan to achieve Circular Economy by 2050. The plan acknowledges the need for technical, social, and system innovations, and points out the economic opportunities of a circular transition. The Dutch policymakers are engaged in creating a circular food system by transforming the food chain. An integrated approach is believed to be the enabler of this. The plan also aims to integrate policy paths, such as the Biomass Vision for 2030, and commits to accommodate a faster circular transition (Government of the Netherlands, 2016).

Informational and Technological level

The lack of knowledge, one of the main challenges of Circular food packaging, is considered to be solved by educating employees and customers in waste prevention and waste separation. Emphasis is given to improving the waste collection and return systems, with initiatives such as reverse collection[1], in order to increase the waste that is recycled. This gives an incentive for companies to educate their employees and customers. The ambiguity of whether a product is sustainable is meant to be resolved by ensuring that the products offered are sustainable by definition, thus made by recycled materials of high quality (Government of the Netherlands, 2016).

As for biodegradable plastics, which are increasingly used by packaging developers, there should be transparency towards consumers, municipalities, and the waste and recycling sector to increase their social acceptance and thus, use. The action plan considers consumer perspective and the complexity of proper waste disposal highly related to reduce littering. Moreover, boosting the production of bioplastics is supported by innovation programmes such as the Biobased Performance Materials programme (Government of the Netherlands, 2016).

The importance of knowledge of actors was presented in chapter 4. In 2018, the country became a

[1] Reverse collection is a collection system based on collecting materials that can be reused door-to-door, while residual waste must be transferred to a central location

member of the Platform for Accelerating the Circular Economy (PACE) in order to share knowledge and plans at a global level. The Dutch government's goal for a zero-waste economy by 2050 will be assisted by this initiative. The platform was created in 2017 by the World Economic Forum (WEF), UN environment, and Ellen Mac Arthur Foundation. It is intended to bridge the gap between organisations, and companies and boost public-private cooperation by sharing best practises and policies. It promotes cross-learning that is believed to accelerate the circular transition. The areas of plastics and, food and bio-economy are two of the priorities of this initiation (Waterstaat, 2018).

More efficient use of materials and limitations of packaging is required for a Circular transition. In this line, the Packaging Management Decree (Besluit Beheer Verpakkingen) was launched in 2014 to regulate the use of packaging. The producer is obligated to finance and handle the collection and recycling of packaging, while there are restrictions in the number of materials used for packaging, litter produced, and maximisation of recycled materials used in new packaging. The percentage of packaging materials that must be recycled is accelerating, namely plastic must be 52% in 2022(Netherlands Enterprise Agency, n.d.).

Behavioural level

Plastic Pact, an initiative of the Netherlands and France, marks the end of single-use plastic products, such as straws and plates, on the way to drop plastic consumption by 20% by 2025, while enhancing plastic recycling and establishing 100 recyclable new plastic products. The pact is designed to ensure the commitment of companies to less plastic and more plastic recycling and is signed by 75 companies (in February 2019), the environment ministry, and environmental organisations (Government of the Netherlands, 2019). The pact's targets entail making single-use plastic products and packaging more sustainable and suited for reuse. The first baseline data useful for evaluation were collected and shared by the Dutch National Institute for Public Health and the Environment (RIVM) from the parties involved in plastic use in 2017 and 2018. The monitoring of the Pact's progress will be ongoing(Van Bruggen et al., 2019).

The Dutch targets for recycling are higher than the EU ones with a 70% recycling of all packaging combined achieved by 2021 instead of 2030 at the EU level. The Director of the Packaging Waste Fund, Cees de Mol van Otterloo, states that the country is set to achieve its targets and become closer to a circular economic packaging model (Waterstaat, 2020). However, re-use is generally preferred and at the Dutch level, 74% of packaging materials must be recycled and/or re-used by 2025. There are assigned PMD (Plastics, Metal, and Drink Cartons) bins for all packaging except for glass and wastepaper. The policymakers of the country go one step further by including the Dutch circular targets and the European recycling targets in law in effect from 2021 (Waterstaat, 2020). The most prominent European regulations adopted by the Dutch government are included in the next section.

According to TNO's view (2019) "Plastic Pact leads to more circular plastics". TNO, the Netherlands Organisation for applied scientific research espouses Plastic Pact's objectives and contributes by creating tools that aim to assess material use, develop and extended the use of circular plastics, and lastly, introduce a new way of designing plastics based on Circular Economy. The circular plastics are made through chemical recycling, which deals with the challenge of various polymers of plastic packaging. By applying high pressure, heat is being released that separates successfully plastic polymers from other additives, such as flame retardants. This process also reassures the high quality of recycled plastic, since polymers are not composted while it can be used as a "pre-process" for already existing refining processes (TNO, 2019).

A new research program regarding circular plastics packaging, which can be seen as a result of the Dutch Plastic Pact, has been launched by TNO with collaboration with Brightlands Materials Center. The program aims to further stimulate the advancement of circular packaging options by selecting certain polymer materials that ensure plastic packaging with higher recyclability (TNO, 2020b). Therefore, food producers who worry about low-quality secondary materials, as it was explained in the previous chapter, are offered an alternative that possibly meets their standards.

Regulatory level

Restrictive regulations delay the innovative solutions from entering the market, as it was explained in the previous chapter. As a response to promote a faster introduction of new technologies, the "Smart Regulation Programme" (Ruimte in Regels) was created and will last till the end of this year (Government of the Netherlands, 2016). The programme aims to fill in the gap of communication between the lawmakers and the entrepreneurs, who previously had to adhere to regulations that restrict their innovative plans. The two parties are able to work in collaboration and this has resulted in lifting more than 80 barriers, a fact that assisted the initiation of circular businesses (Government of the Netherlands, 2016).

Food contact materials and the rules that accompany them are included in the Packaging and Materials (Commodities Act) Decree (Warenwetbesluit verpakking en gebruiksartikelen). The act entails the allowed materials and the prerequisite condition of the packaging itself (Netherlands Enterprise Agency, n.d.). On the other hand, the European Plastics Pact acknowledges the difficulty of ensuring food safety of post-consumer recycled (PCR) plastics, even though the Packaging Management Decree promotes the use of them. For this reason, in the report of 2020, the collaboration of all participants in the value chain is considered essential. In particular, there must be a plan and a regulatory framework regarding food safety and the members of the Pact will strive for this (The European Plastics Pact, 2020). The goal is to boost the use of PCR plastics to at a minimum of 30% in new products. However, technologies for food products are a challenge as it was stated in the previous chapter, since their implementation and their

availability are narrow, and the relevant regulations may need revision. Moreover, the report illustrates the need to promote PCR plastics by raising the demand for them and ensuring the quality of their supply to limit the use of fossil-fuel based plastics (The European Plastics Pact, 2020).

Societal level

An initiative for a shift in consumer behaviour, especially regarding waste prevention as a part of more sustainable consumption, is also included in the action plan. The consumer behaviour is a result of the opinion on consumer goods, such as packed food, the personal situation, and the personal beliefs of the consumer (Government of the Netherlands, 2016; Martínez-Ruiz & Gómez-Cantó, 2016). The policymakers acknowledge the importance of this challenge towards circular transition and the need for continuous monitoring, analysis, and interventions. Societal factors, such as education and culture are considered as significant as technological innovations. For this reason, under the program "From Waste to Resources" an "Approach to promote sustainable consumer behaviour" was created to gain behavioural insights and propose amendments to policies based on the results (Government of the Netherlands, 2016,p.65).

5.2 Relevant EU policies

Apart from the Dutch Plastic Pact, the European Plastic Pact, which includes all EU member states and the whole value chain of plastics, aims to limit plastic waste (The European Plastics Pact, 2020). TNO collaborates with stakeholders in order to enhance depolymerization and dissolution technologies at the Dutch level, as it was mentioned before. The research institute wishes to develop also technologies on thermochemical recycling, which deal with mixed, highly contaminated waste streams. Simplification of packaging and plastic products is also an objective regarding designing for circularity. Life Cycle Assessment and Life Cycle Costs assessment for recycling options are also developed by TNO (TNO, 2020a). Moreover, the European Strategy for Plastics in a Circular Economy was introduced in 2018. This strategy aims to reshape the design, usage, production, and recycling of plastics in the EU as a step towards circular economy (EUROPEAN COMMISSION, 2018).

As part of the European Green Deal, a new Circular Economy action plan was released by the European Commission in 2020. Eco-design is one of the most significant pillars of the plan since the policymakers acknowledge the absence of incentives for circular products and of a detailed set of prerequisites to certify the sustainability of products in the European market (European Commission, 2020b). To safeguard the action's targets, a "sustainable product policy legislative initiative" will be suggested (EUROPEAN COMMISSION, 2020,p.6).

One of the predominant product value chains of the 2020 plan is the packaging. Specifically, the review of EU Packaging Waste Directive 94/62/EC that was introduced in 1994 regarding packaging and

packaging waste includes the necessary preconditions for packaging to enter the EU market. Namely, the preconditions are curtailing the amount of (over)packaging and its waste, designing in the purpose of re-use and increased recyclability of packaging (limiting the use of certain materials for specific purposes that allow the use of reusable sources or eliminating packaging when safety is not jeopardized), and lastly, addressing the complicated nature of packaging sources concerning the amount of them and the polymers needed (European Commission, 2020b). The last element of the set preconditions is an attempt to develop a waste policy that enhances waste prevention and circularity. The waste policy consists of introducing designated collection models while enhancing the effectiveness of collection points and the set standards concerning the quality of products that are meant for reuse as food contact materials (European Commission, 2020b).

The new CEAP is designed to scale-up and advocate for sustainable production practises in a socially responsible manner, especially for SMEs. To improve the sustainability of food packaging, there will be support for relevant innovations that use eco-friendly and suitable for reuse and recycle materials to provide substitutes to single-use packaging in the long run (European Commission, 2020a).

Besides, the Commission acknowledges the need for investments in Research and Innovation (R&I) in order to transform the food system and overcome the obstacles of developing new solutions and market entries. There will be a call for proposals based on the targets set in the Green Deal in 2020, under Horizon 2020, for a sum of 1 billion euros. Horizon 2020 allocates 10 billion euro on R&I on food and relevant areas, while the European Institute of Innovation and Technology will be the guide with innovations in the field of Circular Economy. Moreover, the European Regional Development Fund, LIFE, and the aforementioned Horizon Europe are designed to support innovation funding and the innovation cycle at a private level (European Commission, 2020a). Another area of improvement is knowledge sharing among the actors of the food system with the SMEs being the central focus, as there will be relieved of administrative cost with additional guidance on best practises concerning sustainability. An advisory tool of Enterprise Europe Network is also supposed to support the small food operators (European Commission, 2020a). A global transition towards circularity is at stake according to the European Commission. Therefore, the European policymakers support international collaboration on food research and innovation.

The promotion of sustainable food packaging is considered vital, since the EU is the largest food importer and exporter at a global level and thus, has a large environmental and social footprint. Food safety is the main compass of the European plan “From Farm to Fork”, another part of the European Green Deal. (European Commission, 2020a). To ensure the reduction of European footprint, the Commission decided on creating along with all the stakeholders a new EU Code of “conduct for responsible business and market practises” with a relevant framework for monitoring (European Commission, 2020,p.12).

The successful implementation of the plan entails the commitment of food companies and organisations on scaling packaging down to the new Circular Economy Action Plan (CEAP), with continuous monitoring and legislative measures. A corporate governance framework will ensure the inclusion of sustainability, which according to B. de Koijer is not always the leading factor of the company's strategies (European Commission, 2020a); B. de Koeijer, online interview, July 13, 2020).

Future policy frameworks by the EU include: "review to reinforce the essential requirements for packaging and reduce (over) packaging and packaging waste " 2021, "mandatory requirements on recycled plastic content and plastic waste reduction measures for key products such as packaging," 2021/20222, a policy framework for "bio-based plastics and biodegradable or compostable plastics" 2021, an initiative to substitute single-use packaging by reusable products in food services 2021, (European Commission, 2020b).

After illustrating the most relevant European and Dutch policies that aim to accommodate a faster Circular transition of food packaging in the Netherlands, Table 8 summarizes which challenges are addressed by these policies.

5.3 Policy solutions linked to the identified challenges

Table 8 presents the identified challenges of the Circular integration in food packaging in the Netherlands and the policy solutions that are designed to address them. To emphasize, the challenges presented either hinder or delay the adoption of circular food packaging options. To a large extent, the table is based on the analysis carried out in this research project and offers an overview of the findings.

Table 8 *Identified challenges and the relevant EU and Dutch policies that address them*

Challenges	Policy Solutions At a Dutch level	Policy solutions at an EU-level
Limited scope on the environmental footprint of bio-based solutions	Packaging and Materials (Commodities Act) Decree/ Biobased Performance Materials programme	"Green Deal" & "From Farm to Fork"
Lack of knowledge and different perspectives of the various stakeholders involved in the food packaging process	Platform for Accelerating the Circular Economy (PACE)	Enterprise Europe Network & European Plastics Pact
Lack of design flexibility of eco-friendly options	Dutch Plastic Pact and TNO's research on improving circular design of recycled plastics	European Plastic pact
Inadequate packaging recycling systems/Packaging Recyclability	Packaging Management Decree/Dutch Plastic Pact	"Green Deal" & Packaging Waste Directive
Lack of innovative technologies (or the adoption of them) due to lack	Horizon 2020 under the Green Deal	Under Horizon 2020 under the Green Deal

of financing and investments		
Regulatory constraints of new sustainable options regarding food contact material	"Smart Regulation Programme"/European Plastics Pact	"From Farm to Fork"
Societal challenges	"From Waste to Resources"	"Green Deal"

The table is used as a reference point for the discussion part of this thesis that is presented in chapter 6.

6. Discussion

As it is already illustrated in Table 8, the EU and the Dutch government have utilized their policy tools and legislation to address the Circular challenges identified, but a point that cannot be overlooked is the implementation and the actual results of these initiatives. Hence, this section illustrates the gaps regarding the successful implementation of these policies. The different views presented are not evaluating the implementation of any policy per se, but rather shed light where there is possibly room for improvement. To support these claims, interviews' data and findings of additional research are included when appropriate.

Informational & Technological challenges

Although the Dutch government introduced better sorting and collecting waste systems, recycling is still not at a desirable rate. Disposal behavior is not optimal, waste processors are not operating effectively regarding composting as well as recycling (Geijer, 2019). According to Ten Wolde (2019), EPR initiated an "eco-modulated fee" concerning recyclability by proposing a low tariff for plastic packaging that can be effectively sorted and recycled. However, an equivalent low tariff on biodegradable plastics was canceled due to the remains left in composting plants (Ten Wolde, 2019). This might justify the reluctance of manufactures and consumers to opt for biodegradable materials, since the recycling of them appears to be more complex and thus, costly. The leakages from their recycling process is another factor that could be considered an unresolved technological challenge. The recycling system requires more innovations to facilitate better results.

Moreover, the EU packaging waste directive might be a solution that enhances the circularity of a product, but it perceives packaging and product as two separate systems, and not as an integrated system regarding its environmental footprint. Lindh et al. (2016) criticizes the directive as it disregards the function of packaging as a protector of food loss or waste, which provides a higher environmental benefit than altering the packaging material. The interviewees also pointed out the complex nature of a sustainable product chain and the requirement of an analysis of both the product and its packaging to estimate the sustainability level.

On the positive side, there is a promising initiative named "Netherlands as Circular Hotspot", which aspires to turn the Netherlands into a model for circular business and assist the circular transition in the country by 2050. The campaign was developed in 2016 and was funded by Dutch companies aiming to accelerate circular transition of the plastic sector among others. The objective is to use only renewable plastics, thus recycled or biobased, by 2050. The initiative has motivated Dutch companies and public authorities to adopt a circular approach with, in 2018, ING releasing a 100 million fund for investments concerning sustainable concepts (McCarville, 2019).

Based on the global Circularity Gap Report, the Circularity metric of the Netherlands is considered to be at a rate of 24,5% and higher than the global circular rate of 8,6%. Circle justifies this achievement with regards to Dutch policies, technical innovations that aim to boost effective and extended use of materials, and an end-of-life recovery. It also praises the function of the recycling system and the reuse of waste (De Wit et al., 2020).

Plastics are in the main scope of the Dutch policies and specifically, reduction of them as fossil-fuel based materials stress the environment while microplastics contribute to water and soil pollution. However, the "Transition Agenda Circular Economy-Plastics" is not specific regarding the practicality of the policies introduced and the intended reduction of greenhouse gases is not yet clear (Urgenda, n.d.).

Behavioral challenges

Adding to the legislation the Dutch recycling targets are meant to ensure the commitment to recycling of packaging at a national level. According to a report published as part of PACE and released by Circle, the Extended Producer Responsibility (EPR) scheme designates packaging suppliers as responsible for waste produced while it promotes circular design innovations suitable for reuse and recycling. A circular design entails mono-materials design as well, which compared to multi-layer or multi-material, are easier sorted and processed (De Wit et al., 2020). Along with policies, TNO research aims to ensure a high quality of recycled plastic and therefore, provide an incentive for sustainable packaging.

Contrary to the EPR's promising results, the misalignments observed between the operational and strategic levels in the food packaging sector cannot be adequately addressed by policies. A systemic change within the companies responsible for food packaging would be a more effective solution, as the different views of the various stakeholders are a matter of communication and sharing of knowledge and information.

Regulatory challenges

"Smart Regulation programme" has resulted in the removal of 80 barriers that were delaying the introduction of circular businesses. B. de Koijer questioned the acceleration of regulatory constraints, as lawmakers and packaging developers seem to be in misalignment when it comes to innovations. The transparency of innovations could justify the delay that a new technology faces before entering the market and especially, before upscaling. The additional costs and time restrictions can discourage packaging developers from investing in new technologies, as the benefits are only evident in the long run. Guillard et al. (2018) supports this claim and adds the absence of competitors in these new markets as another hurdle for breakthroughs.

Societal challenges

Consumer behavior as a part of societal challenge regarding the knowledge, information, and behavior

of consumers is included in both the Dutch and EU circular action plans. However, it seems that there are not enough incentives given to enhance the awareness of the end consumers. According to the data presented in section 2.2, consumers do realize the problem of plastic waste caused by food packaging among others, but the total amount of plastic packaging across Europe is rising. Geijer (2019) suggests that food producers and retailers should reconsider their choice of packaging per product to be able to advocate for it to their customers. Communication between the two actors could be beneficial, especially since retailers and consumers should firstly identify the added value of sustainable packaging. This could justify any extra cost of an eco-friendly package offered by the producer.

7. Conclusions and Recommendations

In this chapter, the answers to the research questions as they are presented in chapters 4 and 5 are summarized. The intended recommendations are based on the challenges that are not (adequately) addressed in the Dutch context. Directions for further research are also drawn.

7.1 Conclusions

The main research question of this research is **"**What are the challenges and policy enablers of integrating Circular Economy in food packaging in the Dutch context?". To begin with, the Circular Food packaging model used in this research is a combination of principles for sustainable food packaging, waste hierarchy, and circular economy. The challenges identified are strictly linked to the principles embedded in this model.

In particular, the challenges are mainly linked to informational, technological, behavioural, regulatory, and societal factors. Despite the increasing awareness of stakeholders and consumers regarding sustainability and sustainable packaging, the ambiguous environmental footprint of sustainable options hinders their market entry at a large level. On the same basis, the regulations regarding food contact materials also seem to a large extent restrict the packaging manufacturers. Plastics remain the most popular packaging material since compared to bio-based solutions, are cheap, highly customizable, and ensures food security. The unwillingness of bearing the extra cost of sustainable packaging by consumers contributes to the selection of cheap materials by the companies' decision-makers. Another important challenge that should be tackled is the lack of financing of innovative technologies.

Moreover, sustainability is not always the main aspect of packaging design, since sometimes the actors involved are not knowledgeable enough or share different views. This can result in misalignments of operational and strategic practises in companies. A possible cause of the lack of knowledge and information between the stakeholders across every level is lacking communication and sharing of knowledge schemes. The negative public perception of packaging as a cause of pollution disregarding all of its positive functions is also a substantial hurdle. Another factor that cannot be overlooked is the increasing need for food safety and hygiene, especially in pandemic circumstances as those of the current Covid-19, which often results in extra layers of packaging being added to a product. The pandemic is shown to have affected consumer behaviour.

Scientific literature and primary data collected during this research showed that, even though there are many policies introduced by the Dutch government to accommodate the circular transition of food packaging, they are often not sufficient. The overall food chain, including the packaging design of food, often follows the linear paradigm of modern society.

7.2 Recommendations

This section illustrates the gaps found during this research, which require further actions. After exploring the current policy solutions offered by the Dutch government in chapter 5, recommendations concerning the major challenges that the food packaging sector faces to become circular, are outlined in the following paragraphs.

Additional research and financing of new packaging and recycling of packaging technologies

Eliminating packaging will compromise our food safety and hygiene and might even have the opposite effects than expected since packaging limits food waste. The solution lies somewhere in the middle, and the policymakers of the Netherlands should discover it by investing more in research, especially for biobased materials (KIDV, 2019). Furthermore, even though thermo-mechanical recycling is being currently deployed, recycled plastics for food contact are yet not fully developed or publicly accepted. Alternative packaging options should be explored to ensure food safety and hygiene and overall, satisfy the consumers' high demand for quality and safe products, especially during these times of a pandemic. As Circle recommends, taxes can be reformed in line with the Sustainable Development Goals and climate mitigation with investment funds to be allocated for sustainable projects.

Moreover, based on the practicalities of sustainable food packaging, a comparative analysis of countries that strive to incorporate Circular Economy in their agenda could be useful. Insights on how policy instruments facilitate the Circular transition at a national level can be explored and shared between the lawmakers of the different countries to accelerate the transition.

Addressing the lack of knowledge of actors

The insufficient knowledge of stakeholders is a result of a lack of information. For this reason, the benefits of sustainable packaging solutions (usage, decrease in food waste) should be quantified and communicated with all the stakeholders in a simple and informative way, especially with consumers. This could be a way to increase the consumers' awareness and preference towards eco-friendly solutions. (Guillard et al., 2018). Bio-based alternatives might be the solution, but as it is explained, stakeholders of the food packaging chain and the public are still not persuaded.

Integrating sustainability at a company level

Not only establishing sustainability policies within companies but also translating them into realistic goals and executing them is essential for a Circular transition. Koeijer et al. (2019) clarify the importance of inclusiveness and decision making by internal and external stakeholders along with setting sustainability targets in order to produce results on both strategic and operational levels of packaging design. To emphasize, the existence of a "sustainability guardian" as part of the development team, can ensure the

integration of sustainability in packaging development processes (B. de Koeijer, 2018). The research also recommends a transition of focus from the traditional sustainability goals of achieving a balance in economic, social, and environmental dimensions to the strategic and operational levels of sustainability in design processes (Bjorn de Koeijer et al., 2019). According to Cramer (2015), there should be a limited number of actors leading the change towards circular economy. This practise can ensure cohesion between the various strategies of a company.

To conclude, reusing and recycling are not the only factors that can contribute to Circular food packaging. The proactive nature of the design of products and the selection of materials that ensure recyclability, especially of multi-layer and multi-material packaging and the overall sustainability of the product is key. As Cramer (2015) suggests a redesign of the product chain can be a significant factor that contributes to Circular Economy.

7.3 Directions for future research

As with all research, there are limitations that require reflection. According to Flick et al. (2004), content analysis as a part of qualitative research appears to be restrictive regarding the amount of data that can be possibly analysed. Likewise, Payne and Payne (2004) claim that, although qualitative interviewing offers flexibility and room for the elaboration of answering, there might be bias from the perspective of the interviewee. As the interviews can be lengthier, this fact restricts the researcher from approaching a larger sample of experts due to time constraints (Payne & Payne, 2004). On that basis, interviewing a larger number of experts on the sustainable food packaging field is recommended. Even though the data gathered during the interviews contributed to a better understanding of the practicalities of the circular transition, different and possibly contracting ideas can present a more holistic answer to the research question. Furthermore, the questionnaires used are semi-structured, which offered flexibility to customize the questions and the time spent on each topic depending on the knowledge or time availability of the interviewee. However, this did not always allow an explorative nature of the interview.

Secondly, more empirical data from the stakeholders involved in packaging production are also advised. Due to time constraints and period of the research (COVID-19, summer holidays), the researcher was not able to reach the actors involved in the production chain of food packaging. The decision-makers at a strategic or operational level in the food industry can provide their opinion on the implementation of the policy solutions introduced at a national level by the Dutch government. A combined, simultaneous analysis of the product and packaging should be further investigated to discover its practicalities and possible limitations.

Thirdly, during the initial structuring stage of the research, the topic had to be demarcated to adapt to the time constraints set by the University guidelines. To achieve the practical goals of the thesis, the

researcher reduced the extent of the research objective to ensure valid and reliable answers to the research questions (Verschuren et al., 2010). Even though there is a larger number of barriers or challenges that hinders the Circular transition of food packaging in the Netherlands, the challenges presented are the most trending ones based on the scientific literature studied and the interviews conducted.

Lastly, as for the solutions illustrated, the researcher adjusted her scope at a policy level. Further research would provide insights into other types of existing or possible solutions. For instance, instruments or measures introduced at a private (company or organizational) level that offer solutions at a regional level might exist.

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Appendix A

Interview Guide

i. Introduction of myself, the project and explanation of the research Ethics, if not already received the signed consent form.

ii. Start of recording.

General Questions: In your opinion, what are the most prominent challenges that food packaging design must overcome to become circular in the Dutch scenario?

Specific Research Questions:

- According to the literature, there are many innovative solutions (bio-based and/or biodegradable) that are not adopted due to technical issues that restrict the materials from scaling up. Why do you think this is happening?
- What is your view on public opinion? Are the consumers aware of their choices?
- In what way has Covid-19 influenced packaging of food in the NL?
- In your opinion, the decision-makers of food companies and packing designers collaborate sufficiently? Are they knowledgeable and supported enough to choose innovative solutions? What is lacking?
- Regulations regarding food contact materials are strict in the EU and in the NL. Do you think that this prohibits or assists the transition to Circular economy?
- Do you think that the Dutch Plastic pact will further contribute to CE model and eventually assist in reducing plastic waste?

Concluding Section: Clarification or additional questions that arise during the interview

Nota bene: the interview with R. Ten Klooster did not follow the above guide. The professor shared information with the research via email and made suggestions for further research.