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Development of Sustainable Supply Chain Management through Green Manufacturing Practices

The case of food sector in Belgium

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Acknowledgements and Declaration

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I hereby declare that this work is my own work, that all references used are accurately reported, and that the work has not been submitted for any other degree or professional qualification.

Table of Contents

Table of Figures

Abbreviations and Acronyms

AI	Artificial Intelligence
CDP	Carbon Disclosure Project
CIP	Clean-in-Place
CO2e	Carbon Dioxide Equivalent
CPS	Consumer Products & Services
CSR	Corporate Social Responsibility
DPI	Dairy Product & Ingredients
EMS	Environmental Management System
GM	Green Manufacturing
GMP	Green Manufacturing Practice
GSCM	Green Supply Chain Management
ISO	International Organization for Standardization
Kg	Kilogram
KPI	Key Performance Indicator
NGO	Non-Governmental Organization
SCM	Supply Chain Management
SC	Supply Chain
SDGs	Sustainable Development Goals

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1. Introduction

1.1.Research Motivations

In the period that we are in today, we face important problems such as global warming, loss of biodiversity, fast consumption and pollution of resources, hunger, poverty, discrimination, human rights violations, the ever-increasing world population, and the increase in need for new resources (Nations, 2020). Although the rapid growth of consumption and production contributes to the economy, the unconscious and constantly increasing use of natural resources impacts the environment very negatively (Nations, 2020). Therefore, consumption and production models should be changed urgently to reduce these threats.

On the other hand, consumers are now more conscious and conscientious than before when purchasing products. They expect the products to be produced and distributed by meeting ethical standards without adversely affecting the environment and using fewer natural resources (SCCG, 2018). According to the research by Deloitte on sustainability and health in food and our shopping behaviors, shoppers more and more expect grocers to play a powerful role in impacting healthy and sustainable behaviors and facilitate good consumer behaviors that have a positive effect on health and the environment. They also observed that "*more than 70% of consumers are ready to pay 5% more for organic, sustainable, and locally sourced food and fair trade*" (Hop & Jagt, 2021, p. 2). To meet these expectations, companies need to use more sustainable resources than ever, apply green, ethical, and environmentally friendly methods, and supply chains must be transparent (Johar, 2019). With these businesses and customers' expectations, the development desire of the companies brought the concept of sustainability to the agenda which has also led businesses to search for a new system, increase efficiency and cut costs.

According to European Commission, "*Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, Europe needs a new growth strategy that will transform the Union into a modern, resource-efficient, and competitive economy*" (Commission, 2019). Implementation of sustainable supply chain management systems is a crucial element for companies to reduce environmental problems and provide economic and social benefits. As a result, such problems encourage firms to seriously consider environmental impacts while doing their business. Sustainability considers the way that we can live in conformity with the natural environment, protecting it from harm and devastation (Mason, 2020). However, many manufacturing companies compose waste and pollution and threaten the existence of life in the world. As the world population grows and

resource availability decreases (Gurzawska, 2019), companies are increasingly interested in sustainable supply chain management and sustainable production systems. There is a growing awareness of supply chain vulnerabilities in this industry. Therefore, this thesis investigated how companies are involved in sustainability, what their sustainability goals and strategies are, and how they adopt green supply chain practices.

Another reason for the research is that, according to Fevia's annual economic report (2017-2018), the food industry represents the most important and largest sector in the Belgian market compared to the other sectors (Fevia, s.d.). The food industry is the leading sector that strengthens Belgium's economy (Preillon & Decoster, 2015). According to statistics in 2020, there were approximately 8,500 food manufacturing companies in Belgium (Gelder, 2021). The largest sub-sector was bakery and dough products, produced by 4,619 manufacturing companies, and the second sub-sector was meat products, by 1,000 companies (appendix E) (Gelder, 2021). However, this overgrowth will cause scarcity of natural sources and increase pollution and negative impact on the environment (FEVIA, 2015). For instance, if we consider carbon emissions in Belgium, according to the statistics in 2020, Belgium produced 88.7 million metric tons of carbon dioxide (MtCO2) emissions (Tiseo L. , 2021) (appendix F). Even though Belgium is the smallest country in Europe, is the sixth-largest carbon polluter in the EU, producing approximately 10.8 metric tons of CO2 per capita (Tiseo L. , 2021). These statistics mean that while Belgium's economy is getting stronger, at the same time it causes serious problems. Therefore, if food companies do not take concrete actions to reduce the negative impact of production, also the risk of access to raw materials will increase (FEVIA, 2015), and it will cause considerable problems. The fact that food companies are in a leading position in the market plays a major role in the implementation and adoption of green supply chain practices. For this reason, this study examined whether food companies, especially dairy, bakery, and pastry, implement green practices and their implementation barriers.

1.2.Research Question

In the light of the theme above, the aim of this thesis is to analyze the following questions: First, how do food companies in Belgium implement green practices in their manufacturing? Second, if they do not what are the implementation barriers? Third, how do they cope with these barriers and successfully integrate green practices into their manufacturing?

The purpose of this study is to conduct a research based on a multiple case study of food manufacturing companies in Belgium. In particular, the case studies can show how companies integrated green practices into their manufacturing process to minimize their negative

environmental impact, reduce production waste. Therefore, through case studies of selected food companies this thesis seeks to analyze their similar and different green practices, and challenges that they are facing. Besides, it aims to gain concrete, in-depth knowledge about the subject, and understand different aspects of a research problem. In this way, it allowed to compare their practical approaches with the theoretical concepts examined in the literature.

For this purpose, this study carried out a literature review which includes two chapters, also cross-case analysis of green manufacturing practices in food companies. In this direction, in order to be suitable to the research questions and to find answers, SSCM has been broadly examined in the first part of the literature, and then the role of GSCM in the SSCM has been examined more in-depth. Because green supply chain management is the subset of sustainable supply chain management, and the aim was to focus on the environmental aspects. However, his role in sustainability was also examined in the study. In addition, in the part of the analysis, green manufacturing practices of food companies were examined more specifically to compare theoretical foundations with practical findings, also to understand the facts of the specific subject. Therefore, in the literature review, the aim was first to provide novel insight and view about the phenomenon, and then gather the most relevant and particular information possible. For instance, all aspects of green manufacturing practices such as food waste, water waste, wastewater treatment, resource management, green supplier selection were explored in the literature review, and their applicability was examined in the analysis. Thus, the literature review explained that how food companies can effectively apply, what activities or methods they can carry out, and the benefits of these methods.

1.3.Thesis Structure

This thesis is divided into three main parts: literature review, research methodology, and analysis of food companies in Belgium. The other sections consist of the introduction, conclusion, and limitations. After explaining the research motivations, research questions, and the purpose of the study, the first part consists of a literature review which is the most important part of the thesis and reveals the theoretical foundations. The literature review contains two main chapters.

The first chapter broadly describes sustainability and sustainability development, then the definition, network structure, and the evolution of SCM, finally the definition of SSCM, and fundamental challenges of SSCM. The main goal of this chapter is to provide a general statement related to the topic. However, in the second chapter, the topic was narrowed down and focused on the main direction of the study. The second chapter describes the definition of

Green Supply Chain Management and its role in the SSCM, then specifically examines Green Manufacturing practices such as waste management (food waste, water waste in manufacturing), and resource management. At the end of the second chapter, the study focuses on the integration of suppliers into GSC practices such as green supplier selection, evaluation and monitoring of suppliers, then certifications of suppliers. This part is also important for this thesis, as suppliers are the main actors of the supply chain. In fact, in the study, it is explained according to which criteria the companies choose their suppliers to adopt green applications and how they integrate their suppliers into these applications to implement green practices more easily. Because these applications are hard to implement and require collaboration between partners and suppliers.

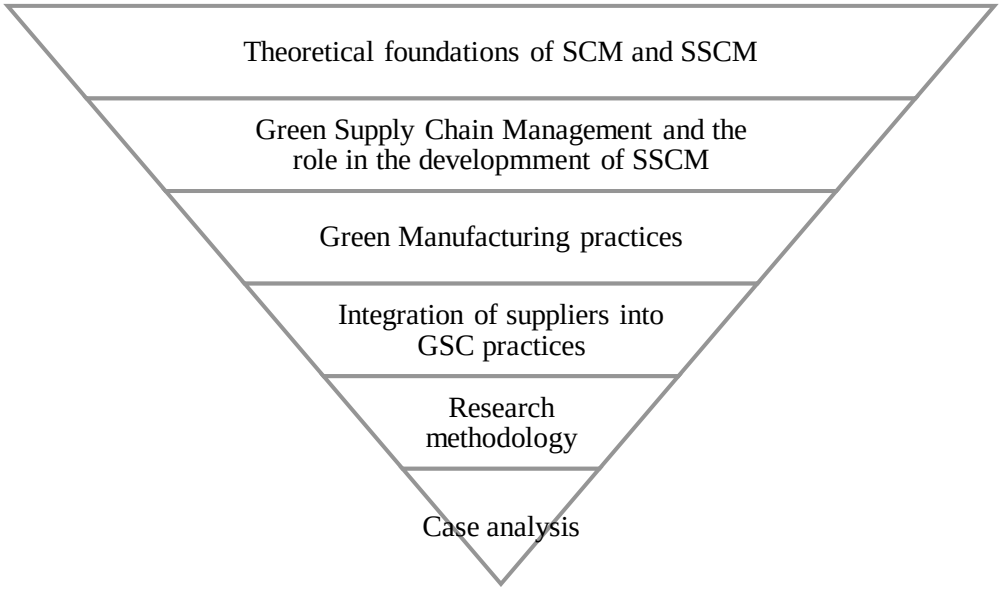
After studying the literature review, the methodology of the case study was explained in detail before carrying out the cross-case analysis. The methodology part is divided into five sub-sections. The first part consists of a research design that clarifies specific research questions, and research methods, the second part explains the reasons for selecting cases, criteria, as well as demographics of interviewed companies. Afterward, the problem statement was built to clarify the problems of supply chains, on the other hand, the common barriers that companies face when implementing green manufacturing practices. The fourth section explains the data collection method of the study. In fact, this section describes what types of sources were used to gather data and which databases were used to collect them. On the other hand, the interviewed companies and participants were expressed as confidential. In the last part of the methodology, the data analysis technique was defined.

After explaining the methodology in detail, the cross-case analysis of green manufacturing practices in food companies is presented. The analysis was examined in four sections. In the first part, the background, findings, and sustainability vision and strategies of the cases were explained. In the second part, each green manufacturing practice of the companies was analysed, such as waste management, resource management, supplier evaluation, certifications. Consequently, similarities, differences between companies, and common difficulties were described. Their results, implementations barriers, achievements were also presented. Analysing their problems and barriers of implementation, the thesis aimed to address the gaps between theory and practical implications, in other words, the reality of the literature review. In the third part, the significant benefits gained by the companies through green manufacturing practices, the numbers they have accomplished, or the results were defined. At the same time, it was explained which objectives they had achieved. The fourth part focuses on the potential

solutions which are found for the cases according to the findings gathered from the analysis and their problems to overcome their barriers related to the topic.

At last, the study finishes with the conclusion and limitation of the work. The conclusion describes all outcomes of the related topic and analysis. It provides an answer to the research questions, includes managerial implications and practical implications. On the other hand, it explains how food companies in Belgium can achieve their environmental sustainability goals, how they overcome their barriers, also describes the role of green manufacturing practices in the SSCM. Finally, the limitations encountered in the study were explained, and recommendations were provided for further research to develop the phenomenon and subject. A structure of the process followed in this study was illustrated on figure 1.

Figure 1*:* Process of the study



Source: developed by the author

2. CHAPTER 1: Conceptual and Theoretical Foundations of Sustainability in the SCM

2.1.What is "Sustainability"?

Sustainability today is a prime topic on the agenda of many businesses, governments, and NGOs. The ever-increasing world population, urbanization and the need for new resources cause climate changes caused by the effect of increasing greenhouse gases, rising energy prices, deterioration of natural resources, insufficient water, agricultural land, and rural workforce to

feed more people. In addition, people are nowadays consuming more resources than before, and the current patterns of development in the entire world are not sustainable (Akenji, et al., 2015). To meet these resources, it is necessary to adopt a more sustainable production and consumption approach (FAO, Ensure sustainable consumption and production patterns, s.d.). Therefore, companies, private sectors, governments also consumers have an important role in this transition toward sustainability. The concept of sustainability has emerged to provide solutions to the current global problems that we are living in socially, economically, and ecologically. Besides, due to the "profit-oriented" perspective of companies today, the frequent conflicts of corporate interests with social interests have led companies to sustainability.

Sustainability theory put forward by Weele (2010) focuses on to develop business solutions that meet the needs of the current world population without harming the needs of future generations (Weele, 2010). It is a holistic approach that combines environmental, social, and economic factors together, that is, sustainability emerges at the intersection point. According to Elkington (1997), the three-pillar concept of sustainability, in other term triple bottom line or "TBL" which is the "planet, profit, and people", as well as concerns working to protect the environment while keeping the business financially steady also dealing with the people and society in which it operates (SCCG, 2018) (Figure 2). Many businesses have already started integrating sustainability principles into their strategic planning, innovative actions, and as part of the corporate culture, as well as implement sustainability activities (Lynch, 2016). Similarly, Peters & Simaens state that almost half of the companies already had the policy to integrate sustainability and set measurable targets for integration (Peters & Simaens, 2020). However, while trying for this transition, many businesses are having great complexity in applying the three dimensions together or integrating them into the culture of the business. Therefore, companies need to find the balance between dimensions and make situational decisions (Brandenburg, Oelze, & Gruchmann, 2019).

***Figure 2*:** The Three Circles of Sustainability - TBL

Source: (Usta, 2021, p. 12)

The environmental dimension focuses on environmental protection such as efficient use of natural resources, water use, energy use, raw material use, waste disposal and reuse of wastes, climate change, reverse logistics, etc. The economic dimension focuses on increase human welfare while the consumption of goods and services increases, it aims for economic growth, cost savings, and profit also ensures the sustainable financial development of the company. The social dimension focuses on social development such as social justice, human rights, good working standards, child labor, good quality of life, fair wages, also safety and health including companies and suppliers.

It is not possible to separate the dimensions of sustainability from each other. All of them are interrelated, therefore their sustainability also connected. That is, if we consume natural resources non-renewable way, or not protect them, we cannot achieve a sustainable economy, because our natural resources to sustain the economic system will be depleted. Or, if we consider the social dimension of sustainability, it will not be possible to achieve environmental sustainability unless the required political regulations are made, and our lifestyle and consumption habits do not change. Although sustainability is not only the conservation of natural resources, and implement green activities, this is of course one of the most fundamental pillars of sustainability. Krisnaiah argued that if the economic system cannot be transformed into a suitable structure for environmental values, that is unless people adopt a new philosophy of life, the target for sustainable development will be unsuccessful (Usta, 2021).

2.2.Sustainability Development

Sustainable development, as mentioned before, is the intersection of the economy, society, and environment pillars. Therefore, all three are interconnected. In line with this, Weele argued that "*sustainable development focuses on creating economic growth while respecting local laws, environmental regulations and labor conditions*" (Weele, 2010, p. 397).

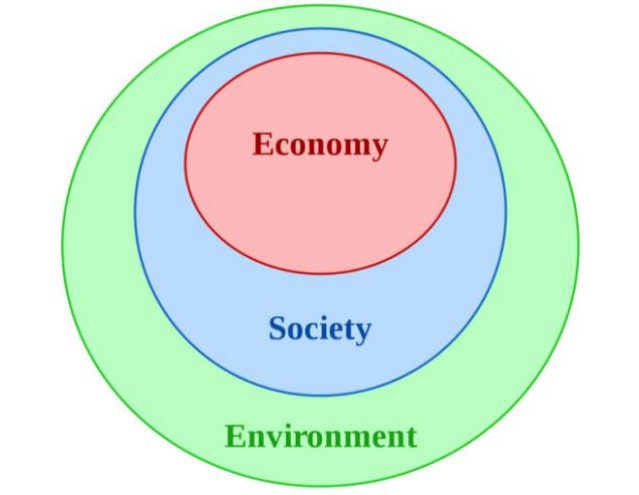
The concept of the sustainable development was first mentioned and defined in the report of "Our Common Future" also referred to as the Brundtland Report by the United Nations World Environment and Development Organization in 1987. In this report, the concept of sustainable development has been defined for the first time as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). In addition, it focused on the links between environmental degradation, social equality, poverty, economic growth, and environmental problems and policy solutions which combined all three areas are investigated and developed (Jarvie, 2016). According to this, the rapidly growing world population can lead to increased consumption of resources and slowing down the development of living standards, and therefore sustainable development can only be sustained if population size and growth are compatible with ecosystem balance (WCED, 1987).

Furthermore, poverty and environmental degradation result from the waste of resources, unnecessary consumption habits. Therefore, the adoption of sustainable production and consumption habits is essential for economic and environmental development and a sustainable future. The environment is where we all live, and it is impossible to aim for sustainable development without the protection of the environment and balancing the ecosystem with population growth. In line with this, sustainable development is the meeting of human needs by increasing the productivity of societies also providing equal opportunities for all (WCED, 1987). Although the environment is the most important dimension for sustainable development, it is not possible to think about sustainable development without considering social and economic dimensions. Accordingly, the concept of sustainable development is illustrated in figure 3 which is called "Nested" model. There are a several models that illustrate sustainable development and explain the relationship of the three dimensions. The most well-known are "Three Pillars" model, the "Three Overlapping-Circles" model, and "Nested Circles" model.

Sustainability and sustainable development are solutions to prevent the problems of our world (Usta, 2021), such as reducing negative environmental impact, emissions, eliminating waste, poverty, and hunger, they also lead to many opportunities and become a source of income growth (Lynch, 2016). In addition, the environment can affect society and the economy, that is

the environment encompasses society and economy. Sustainability development can be represented as the area where three dimensions overlap, as shown in the figure 3. Farley & Smith (2013) in their alternative approach to sustainability, which they propose as this "Nested" model of sustainability, show that the environmental circle encompasses both the social and the economic circles inside and that the environmental circle cannot get bigger (Farley & Smith, 2013). Similar findings were obtained by IUCN, UNEP and WWF (1991) suggests that the Nested circles of sustainability which is also known as the egg of wellbeing model for explanation of sustainable development, demonstrate the links between different dimensions as concentric circles with one circle fully cover the other circle (IUCN,UNEP,WWF, 1991). To better understand the relationships, Thi Minh et al. (2020) argued that "*the largest circle is the natural environment which encapsulates the subsystem of human society, which in turn encapsulates the subsystem of the economy"* (Thi Minh, Thi Thu, & Thi Mai, 2020) Consequently, the disruption of the environment, that is, the biggest circle, may have destructive effects on society and the economy, because human society cannot live without food, clean water, clean air, fertile soil, and other natural resources. Therefore, if the environment deteriorates, the society and economy will be naturally damaged (Willard, 2010; Usta, 2021).

Figure 3: Nested Sustainable Development Model - Concentric Circle Model



Source: (Farley & Smith, 2013)

To ensure sustainable life, economic sustainability, human welfare, and meeting the needs of future generations, we need to switch to sustainable production and consumption methods, which are one of the most important factors (Seidel & Shahbazpour, 2006). Unfortunately, natural resources are not shared fairly among people, and the unequal distribution of resources also causes serious health problems for poor people. In addition, less use and protection of natural resources such as energy, clean air, water, fertile soil, and forests, less pollution, reduction of harmful substances such as waste and toxic chemicals, are essential for having a safe and comfortable shelter, safe working conditions, green economy, low carbon, improvement of environmental health, and create a sustainable environment (Akenji, et al., 2015). Therefore, sustainable development requires the improvement of these conditions, the implementation of the necessary policies by the states, also the adoption by companies.

2.3.Sustainable Development Goals

Sustainable Development Goals have been determined by the United Nations in 2015 to find solutions to problems that we are facing today, also for sustainable development and sustainable life. These targets consist of 17 goals planned to be implemented by 2030 (Usta, 2021). The Sustainable Development Goals aim to end poverty, protect the environment, take measures against climate change, fair distribution of wealth and peace. Usta (2021) suggests that sustainable development goals include problems concerned with sustainable consumption and production, climate change, poverty reduction, economic inequality and injustice, innovation, economic growth and prosperity, peace, energy resources, industrialization (Usta, 2021). To leave a better planet and life to future generations, governments, private sectors, civil societies, and citizens need to act together to achieve Sustainable Development Goals. They provide guidance to companies on the sustainable development path they will adopt and implement in line with the problems they face. In addition, these goals encourage companies and governments to implement sustainable practices and principles, in this way it helps them achieve sustainability. The 17 Sustainable Development Goals (SDGs) of the UN, which are designed to be implemented by 2030, are as follows.

1. **No poverty:** Ending poverty in all its forms everywhere
2. **Zero Hunger:** Ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture
3. **Good Health and Well-Being:** Ensuring healthy lives and promoting well-being for all at all ages

4. **Quality Education:** Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all
5. **Gender Equality:** Achieving gender equality and empowering all women and girls
6. **Clean Water and Sanitation:** Ensuring availability and sustainable management of water and sanitation for all
7. **Affordable and Clean Energy:** Ensuring access to affordable, reliable, sustainable, and modern energy for all
8. **Decent Work and Economic Growth:** Promoting sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all
9. **Industry, Innovation, and Infrastructure:** Building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation
10. **Reduced Inequalities:** Reducing inequality within and among countries
11. **Sustainable Cities and Communities:** Making cities and human settlements inclusive, safe, resilient, and sustainable
12. **Responsible Consumption and Production:** Ensuring sustainable consumption and production patterns
13. **Climate Action:** Taking urgent action to combat climate change and its impacts
14. **Life Below Water:** Conserving and sustainably using the oceans, sea, and marine resources for sustainable development
15. **Life on Land:** Protecting, restoring, and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. **Peace, Justice and Strong Institutions:** Promoting peaceful and inclusive societies for sustainable development, providing access to justice for all and building effective, accountable, and inclusive institutions at all levels
17. **Partnerships for the Goals:** Strengthening the means of implementation and revitalizing the Global Partnership for Sustainable Development (Usta, 2021; UN, 2020).

According to the International Resource Panel (2021), natural resources are the assets that keep us alive and are the basis of human consumption and production systems. However, the way we extract, process, use, and waste natural resources are harming biodiversity, nature, climate also our health (IRP, 2021). These issues are the primary topics for the Sustainable Development Goals, also necessitates us to switch to some urgent practices. Furthermore,

natural resources should be protected, and efficiency should be improved, wastes must be reduced, and more sustainable practices should be implemented immediately in all sectors of the economy (UNEP, Belgium, on its way towards a circular economy, 2020). Besides, the pandemic (Covid-19) we have been combating recently weakening the global economy and the health, as well as the economic and social crisis threatens lives and livelihoods, also making the achievement of the 2030 Sustainable Development Goals even more difficult than before (UN, 2020). Therefore, the Sustainable Development Goals are very essential for an improvement that provides to be greener, stronger economies, more resilient, and stronger, healthy societies (UN, 2020).

2.4.Supply Chain Management

2.4.1. Definition and Concepts

The supply chain and the sustainable supply chain have become to the fore in recent times due to the increase in consumption and production, as well as the more conscious consumers. In addition, the literature on supply chain management and its significance is increasing. Supply chains are expressed as vertical series of interconnected transactions that add value to the end consumer (Silvestre, 2016). Supply chain definitions differ in the literature. However, the common point of these definitions is that the processes which are start with the production of the raw materials required to produce a product and include the flow of goods and information until the product is produced, processed, and completed its life cycle. In other words, it is the activities from ordering and obtaining the raw materials to the production of the final product, distribution, and delivery to the customer. The supply chain is concerned with the processes involved in the flow of materials, data, money, and expertise to delivers goods and services from suppliers to consumers. On the other hand, it consists of product design, purchasing, manufacturing, and distribution activities that work in coordination to deliver products to final consumers in a profitable and timely (Semso, 2020). Reducing the cycle time for manufacturers can realize this practice by composing less inventories with better service from both the supplier and the end user, and can also respond quickly to customer demand, thereby increase customer value and satisfaction (Semso, 2020).

Supply chain management handles all processes up to consumers, including all individuals in the chain like manufacturers, distributors, vendors, and end-users (Semso, 2020). Similarly, (Gurzawska, 2019) argues that the supply chain is a complex network of businesses, thus supply

chain management helps to build this flow of goods and services, also overcome complex relationships between producers, intermediaries, and end-users. Accordingly, supply chain management ensures the excellence of the overall business process and is also a way to best manage the business and relationships among members of this chain (Lambert, Cooper, & Pagh, Supply Chain Management: Implementation Issues and Research Opportunities, 1998). Since the supply chain is a chain of activities that are interconnected and affects each other, the perfect functioning of the supply chain requires the cooperation of all members. Bourdeaux (2020) claims that achieving this cooperation requires organizations to work together to achieve common goals and solve common problems (Bourdeaux, 2020).

The concept of SCM has been reformed in 1998 by members of the Global Supply Chain Forum as "*supply chain management is the integration of key business processes from end-user through original suppliers that provides products, services, and information that add value for customers and other stakeholders*" (Lambert, Cooper, & Pagh, Supply Chain Management: Implementation Issues and Research Opportunities, 1998, p. 1). In parallel, Morehouse (1998) defines SCM in a broad sense as "*for companies to survive and succeed, they will need to operate their supply chains as extended businesses with relationships spanning business processes from material extraction to consumption*" (Lambert, Cooper, & Pagh, 1998, p. 2). Furthermore, Lambert et al. (1998) believe that the combination of elements of the SCM framework which are supply chain structure, supply chain business processes, and supply chain management components are the core of SCM (Lambert, Cooper, & Pagh, 1998).

Today, since industrialization, urbanization, and population increase, the demands and needs of consumers increase, and the fact that they are more conscious and willing, hence the production increases. Therefore, the supply chains of companies have become even more challenging and complex. Because it is very important and requires meeting the wishes and needs of the customers in the best and fastest way to increase customer satisfaction and competition. Accordingly, the competition between companies and suppliers has increased. However, it necessitates supply chains to implement newer technologies, systems, and more effective practices to provide services and goods more efficiently, with better quality, and with more cost-effectively in the shortest time. While doing these, they also need to consider their impacts on nature, use, and management of natural resources. This not only increases their competitive advantage and reputation, at the same time helps them succeed and be sustainable. Since each problem or disruption in the supply chain will affect other chains, namely the next

process, the supply chain needs to be well managed. The complexity of the supply chain can be solved with collaboration, partnership, and good communication of each member, and it is essential that they integrate into the whole process at this point. Similarly, a supply chain is a network of interconnected organizations through upstream and downstream relationships in different processes and activities. This definition underlines that the supply chain is formed of cross-firm as well as cross-functional activities (Winter & Knemeyer, 2013). In other words, it is not only the network between companies but also between suppliers, stakeholders, and other members of the chain.

The supply chain is at the heart of a company, at the same time the biggest problems occur in the supply chain, thus managing the supply chains in the best and effective way helps them succeed. In line with this, Zvezdov & Akhavan (2018) argue that supply chain management is one of the crucial resources to obtain and secure a competitive advantage in the global race (Zvezdov & Akhavan, 2018). While managing complex supply chains significantly increases a company's competitiveness, however, uncertainty and risk arise, such as too many deliberate opportunistic behaviors or unintentional poor working conditions and adverse environmental impact (Zvezdov & Akhavan, 2018). Furthermore, manage the supply chain has now become even more difficult than before, as technologies have evolved and more sustainable, ethical, responsible, and green practices have developed. Alongside the economic objectives for efficient supply chain processes and resulting performance, the necessities for the sustainable management of supply chains are becoming increasingly important (Zvezdov & Akhavan, 2018). While the production and consumption of goods increases by globalization in parallel, thus the environmental and social impacts of the supply chain increase. Therefore, supply chain management has a major impact on social and environmental problems (Thorlakson, Zegher, & Lambin, 2008). Ultimately, this means that the supply chain is crucial in determining a company's social, economic, and environmental impacts, which means it is affecting more stakeholders and shareholders (Cetinkaya, et al., 2011).

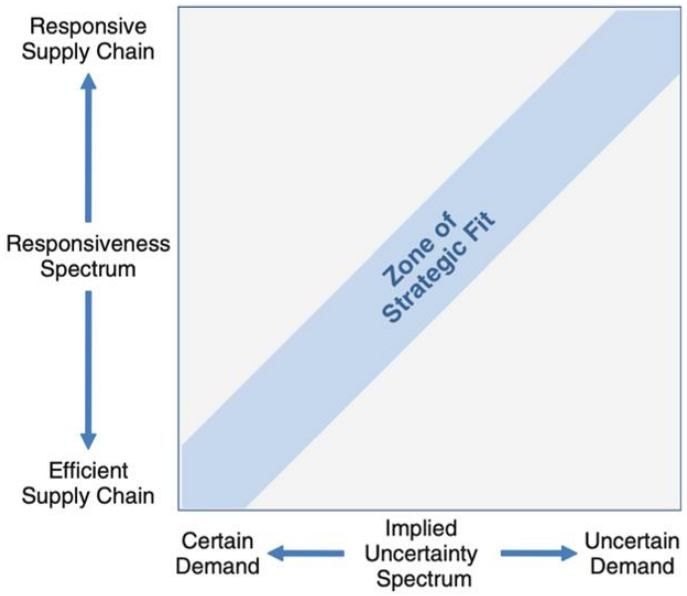
2.4.2. The Supply Chain Strategy

Today's complex supply chains need strategic management to achieve their goals. Supply chain strategy identifies the objectives and configuration of the supply chain in relation to supply chain partners, structures, processes, and systems, as well as the supply chain has an important place in these three determining factors. Thus, it's an important strategic resource in achieving strategic goals (Cetinkaya, et al., 2011). Supply chain strategies focus on "supply"

and "demand" aspects. However, customers don't know what to choose, and customers' need is always changing over time, thus, it creates demand uncertainty. The firms need to adapt to the innovations, and they should answer their needs, suppliers are the big players to provide what they need and create new demands. Therefore, having the supply chain strategies are hugely important to figure out those challenges. Fisher (1997) suggests that supply chain strategies are to match the product's right level of demand uncertainties (Cetinkaya, et al., 2011). The match here signifies fulfilling customer demand while minimizing supply chain cost. According to him, to form an effective supply chain, it is first necessary to consider the essence of the demand for the products supplied by the company. That is, we can determine how we will supply and what kind of supply chain structure we will have by understanding the demands and needs of customers and their level of desire. In addition, he expresses supply and demand characteristics in terms of product factors such as product life cycle, predictability of demand, product diversity and market standards for service and lead times (Cetinkaya, et al., 2011). In line with this, products might be two categories that are mainly functional or mainly innovative, so these categories need a different type of supply chain (Cetinkaya, et al., 2011). Different supply chains meaning here is that the firm chooses either cost-effectiveness (lower cost) or differentiation. In other words, the supply chain can be either efficient or responsive. The challenge here is the fit between a product type and the supply chain type. Therefore, the one of most fundamental problems of supply chains occurs in this incompatibility (Cetinkaya, et al., 2011).

For supply chains to be successful and to overcome these challenges, they need to achieve the point of strategic fit or find the balance between the two categories, as shown in the figure 4. The concept of strategic fit means the alignment of the customer's demand with supply chain capacity. In other words, products need to be appropriate with the supply chain process also supply chain strategy. In this strategic fit matrix, we consider the term "supply", and the uncertainty level of "demand" characteristics (Cetinkaya, et al., 2011). The level of "supply chain fit" with firm strategy will establish financial performance of the firm (Bourdeaux, 2020). According to Agrell (2019), the firms can achieve strategic fit by three steps; first, by understanding their customers and supply chain uncertainty, that is, determine the customers' demand, second, by understanding the supply chain, last, by aligning supply chain responsiveness with implied uncertainty (Bourdeaux, 2020) (figure 4).

Figure 4 : The Supply Chain Strategy – The Zone of Strategic Fit



Source: (Cetinkaya, et al., 2011; Bourdeaux, 2020)

To manage the supply chain well and effectively, the relations of the supply chain members must be good, also there should be a linkage between supplier tiers.

2.4.3. Supply Chain Network Structure

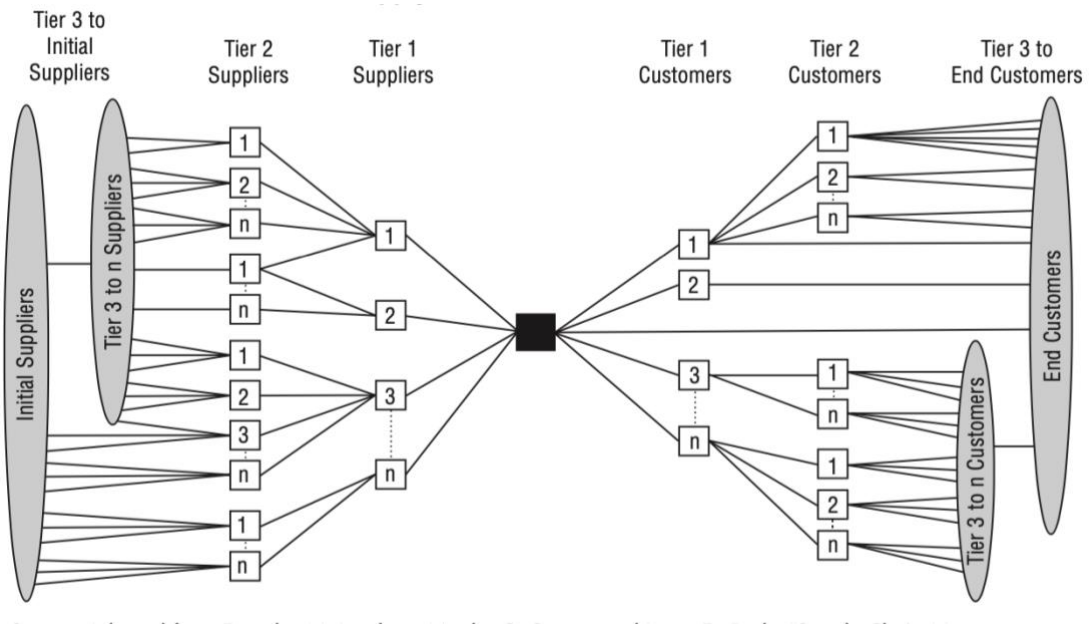
The concept of supply chain network structure is referred to as the links and relationships between supply chain members and companies (Lambert, Cooper, & Pagh, 1998). Supply chain networks are a value-added process that continues from the supplier's supplier to the customer's customer (Wissing & Tyssen, 2011). The main purpose of all members in the supply chain network is to create value. (Winter & Knemeyer, 2013) claim that the different members of the supply chain work together in a network structure and that appropriate links across these members are required to apply separate business processes. Having a clear knowledge and comprehension of how this supply chain network structure is formed is one of the most fundamental elements of supply chain management (Lambert, Cooper, & Pagh, 1998). However, this network is more complex and longer than we think, and it varies according to each company's supply chain and structure. To better understand, Agrell (2019) suggests that they have a tier linkage with primary suppliers and to consumers (figure 5) (Bourdeaux, 2020). Therefore, the focal company need to choose appropriate and adequate members or partners to be efficient. Because to work or have relationships with all members of the chain is not

effective. Therefore, it is essential to identify the members of the supply chain while determining the network structure (Lambert, Cooper, & Pagh, 1998).

In addition, company's network structure consists of three elements, first, the members of the supply chain, second the structural dimensions of the network, and last, different process linkages between the supply chain (Lambert, Cooper, & Pagh, 1998, p. 5). If so, all business divisions of the firm and functions should be included in the supply chain management (Winter & Knemeyer, 2013). In line with this, the supply chain network is interconnected across upstream and downstream relationships with different processes and activities (Winter & Knemeyer, 2013). As you can see in figure 5, the upstream starts from the first tier of the supplier to other suppliers, and the downstream is the flow from the first customer to the end customer. However, the supply chain network will differ depending on the different supply chain activities, processes, and firm's strategy.

The function or purpose of the supply chain network is to increase customer satisfaction maximum possible with minimum supply chain costs. This required minimum delivery times, economies of scale, and increased product diversity, which makes supply chain operation and process more complex, challenging, and disruptive (Rienkhemaniyom & Pazhani, 2015). However, those who manage the complexity and network of the supply chain will win and achieve their competitive strategies. Likewise, Lambert (2008) argues that companies can have a chance to increase their profit margins a lot by well managing their supplier networks Consequently, in this process, good management of relationships with suppliers and end customers, collaborations of each member, partnerships and through their value-oriented activities might ensure supply chains more successful and efficient (Lambert, 2008).

Figure 5: Supply Chain Network Structure



Source: (Lambert, Cooper, & Pagh, 1998).

2.4.4. Evolution of SCM

Supply chains have changed and developed over time according to the demands and needs of consumers. Because consumers began to be more conscious and desire different types of products, at the same time they began to be more curious than before about how products are produced and where they are sourced from. That is, supply chains have had to keep pace with these wants and needs to achieve the highest customer satisfaction. In this direction, companies have understood that it is necessary to develop and change their supply chains to be able to survive. As a result, they started to develop joint strategies and cooperate with suppliers. Thus, the concept of the supply chain began to evolve and change. Silvestre (2016) suggests that there may be an evolutionary process where supply chains evolve, learn, innovate, change, and become more sustainable over time (Silvestre, 2016). They began to implement newer, more advanced technologies, efficient and less costly, but also faster activities. It might be possible for the company or the supply chain to be successful, which keeps up with the innovations and responds the fastest to the changing demands of the customer. However, new terms also occurred with these activities, such as sustainability and transparency. Due to this competition, supply chains significantly waste insufficient natural resources and harm the environment, thus causing serious social and environmental problems (Gurzawska, 2019). Therefore, companies are now looking for new environmentally friendly solutions and systems that reduce the negative effects of their supply chains and increase their positive social and environmental impacts (Gurzawska, 2019).

It has become imperative for supply chains to protect the environment, manage resources, and be transparent to the customers. Sustainability is one of the most major issues of supply chains today. Traditional supply chains were focused only on economic growth and basically deliver the product from raw material to the end-customer. However, nowadays new concepts have emerged, firms and their supply chains are now aware of the existence of new opportunities rather than the traditional focus of short-term profit maximization (Silvestre, 2016). They are more customer-oriented, they aim to create value for customers and suppliers, also aim to achieve sustainability and innovation with advance technologies and systems. (Steven & Johnson, 2016) emphasize that the development of many supply chains accelerates the development of new business models and ways of working with technological developments, while the emergence of new and mature supply chain strategies, tools, and techniques, with increasing environmental and ethical problems, increased the adoption of supply chain management as the driving force of business performance. In addition, population growth, globalization of economies and supply chains, as well as cheaper alternatives, has led suppliers to seek lower-cost sourcing (Steven & Johnson, 2016).

Furthermore, as the demands of the consumers increased, the development and diversity of the products led to the extension of the supply network and the addition of new partners. Therefore, this caused supply chains more challenging and disruptive. As supply chains have grown and become more complex and uncertain networks than ever, they have become more and more difficult to understand and manage (Gurzawska, 2019).

2.5.Sustainable Supply Chain Management

2.5.1. Definition and Integration

Sustainable supply chain is an approach to improve the economic performance of the business in the long term, trying to meet the needs of social, environmental, and economic dimensions by creating value for all stakeholders in the material and service flows between the supplier, manufacturer, and customer. In other definition, sustainable supply chain management is the appropriate management of environmental, social and economic objectives in creating and maintaining effective and efficient global supply chains. There are several definitions have been published in the literature towards a sustainable supply chain management. Carter and Rogers (2008) define the SSCM as "*the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of*

key inter-organizational business processes for improving the long-term economic performance of the individual organization and its supply chains" (Carter & Rogers, 2008, p. 368). According to this definition by Carter and Rogers (2008), the SSCM is based on Elkington's (1998) Triple Bottom Line concept, as well as the four supporting aspects of sustainability which are risk management, transparency, strategy, and culture (Gurzawska, 2019; Carter & Rogers, 2008; Elkington, 1998). In this context, according to Seuring and Müller (2008), SSCM can be described as: *"The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements"* (Seuring & Muller, 2008, p. 1700). As we mentioned earlier, sustainability is not just green and environmentally friendly. Labor practices, minority employment, community support, volunteer work, employee training, and security practices and records are also an important topic in sustainability. Therefore, it occurs in the triple bottom where people, the planet, and profit intersect (Magreen, 2020). Indeed, SSCM is the integration of the sustainability concept into SCM. In line with this, Knemeyer and Winter (2013) suggest that supply chain management has a very close link with sustainability and that the concept of sustainability includes both the operational drivers of profitability and their relations with people and the environment (Winter & Knemeyer, 2013).

Sustainable supply chain management has become an increasingly important and popular concept. Companies face many new challenges, and they need to overcome these problems, for instance, they must address the problem of climate change, face the negative impacts of the financial crisis and the prices, with the increased public interest in ecology (i.e., Green Logistics, Green Computing) and provide environmental sustainability and energy efficiency (Teuteberg & Wittstruck, 2010). Due to increasing environmental and social problems, companies are integrating sustainability into their business models. Breque et al. (2021) argue that when the industry realizes the benefits of improving corporate image and saving energy and material costs, they will adopt naturally resource efficiency (Breque, Nul, & Petridis, 2021). For these reasons, Carter and Roger (2008) argue that involvement of sustainability, especially in Sustainable Supply Chain Management, is a necessity for a company (Carter & Rogers, 2008).

The industry is one of the biggest causes of greenhouse gas emissions, and multinational companies can promote long-term and collaborative solutions that allow to reducing emissions

from all supply chain (Campos, Straube, Wutke, & Cardoso, 2017). Accordingly, environmental factors should be considered in SCM to preserve the environment from harm caused by consumption of natural resources and other input factors, waste emissions, and other harmful or undesirable output factors (Brandenburg, Oelze, & Gruchmann, 2019). Azevedo et al. (2012) also argues that environmental problems should be integrated into SCM to achieve more sustainable business development. However, the other dimensions also must be adopted in SCM to ensure sustainability (Azevedo, Carvalho, Duarte, & Machado, 2012).

Cuthbertson (2011) stated that sustainable supply chain management, the potential effects of any application must be understood in the three dimensions of sustainability (social, economic, and environmental) (Cuthbertson, 2011). These effects should be considered not only throughout the company but also concerning business partners, the supply chain, and the external environment. In addition, he also stated that the development of even one single dimension will enable a more sustainable supply chain (Cuthbertson, 2011). By SSC practices, companies positively affect the natural environment and society, at the same time provide long-term economic benefits and competitive advantage for the entire supply network (Masoumik, Abdul-Rashid, Olugu, & Raja Ghazilla, 2014) . Moreover, sustainability practices allow emerging of new opportunities, help the management of economic, environmental, and social risks, thus companies can generate long-term value (Gurzawska, 2019).

Accordingly, Sustainable Supply Chain Management helps achieve the United Nations' Sustainable Development Goals (SDGs) (Diabat, Kannan, & Mathiyazhagan, 2014). In these goals, the duties of supply chains for a sustainable global economy are clearly stated (Thorlakson, Zegher, & Lambin, 2008). In other words, the sustainability of supply chains has a very important place and is the most success factors for the sustainable development goals of companies (Thorlakson, Zegher, & Lambin, 2008; Cetinkaya, et al., 2011). However, there is no comprehensive understanding of how companies handle sustainability in supply chains (Thorlakson, Zegher, & Lambin, 2008). In other words, some companies are not aware of sustainability practices or green practices, or they do not know how to do it and which technologies and sources. On the other hand, there is a lack of employee awareness about sustainability practices. The case study revealed that, although some companies are aware of these practices and aim to ensure sustainability, there is a lack of knowledge to implement them, and they do not know where to start. Besides, they consider the cost-benefit balance before starting the implementation, so if it is not beneficial for the company, they do not even start

sustainability practices. Therefore, the cost-benefit balance is one of the barriers to sustainability in supply chains. Thus, in practice, sustainability is not easy to implement in supply chains, especially food supply chains, because the main purpose is to produce food. Therefore, this study aimed to understand the barriers that food companies face in implementing green practices.

For successful SSCM require the involvement of supporting aspects which are organizational culture, strategy, risk management, and transparency (Carter & Rogers, 2008; Alexander, Walker, & Naim, 2014). In this case, the risk is known as the socio-ecological damage that can result from a company or its supply chain's products, services, and activities and must be managed by supply interruptions, contingency planning concepts (Brandenburg, Oelze, & Gruchmann, 2019). Transparency is related to stakeholder engagement and pointed up the improvement of transparency through vertical coordination across a supply chain and horizontal coordination across networks (Carter & Rogers, 2008; Brandenburg, Oelze, & Gruchmann, 2019).

SSCM theory includes the aspect of sustainability into the supply chain management and various concepts in the literature such as green supply chain management (GSCM), ethical or responsible supply chain management, corporate social responsibility (CSR) (Saeed, Waseek, & Kersten, 2017), also green purchasing, purchasing ethics, remanufacturing, safety management, supplier certification, carbon footprint, and reverse logistics (Winter & Knemeyer, 2013).

2.5.2. Drivers of Sustainable Supply Chain Management

2.5.2.1. *Internal Drivers*

SSCM's internal drivers contain corporate responsibility goals as well as organizational elements supported by efficiency goals and corporate values. Accordingly, they are divided into four groups which are **corporate strategy, organization's culture, organization's resources, and organization's characteristics** (Saeed & Kersten, 2019). Zimon et al. (2019) states that internal drivers consist of management commitment, organization's involvement, supporting culture, productivity development, and competitive opportunity (Zimon, Tyan, & Stroufe, 2019). Moreover, Saeed et al. (2017) state that internal drivers are the forces emerging within the firm and which anticipate the firm's proactive sustainability attitude (Saeed, Waseek, & Kersten, 2017).

In **corporate strategy**, objectives related to operational and economic SSCM can only be achieved through providing internal support in the organization and setting goals related to strategic sustainability performance (Saeed & Kersten, 2019). In addition, it contains top management commitment, the organization's sustainability strategies, cost pressures, and operation's performance (Saeed & Kersten, 2019). For the sustainability of the supply chain management, the awareness of the top management is very important to perceive the sustainability pressures from the stakeholders and to trigger the implementation of sustainability practices in the company and throughout the supply chain (Saeed & Kersten, 2019). Therefore, the role and support of top management are crucial to achieving a sustainable supply chain. In line with this, for the organization to successfully achieve its sustainability goals, the principle of sustainability must be integrated at the strategic level (Saeed, Waseek, & Kersten, 2017, p. 166). In **organization's culture**, organizations' ethical obligations to society and their liabilities to meet the expectations of stakeholders directly affect organizations and their supply chains also (Saeed & Kersten, 2019), sustainability motivation of the organization (Saeed, Waseek, & Kersten, 2017). Information dissemination, innovativeness, health and safety problems, and the organization's code of conduct are the important elements of organization's culture (Saeed, Waseek, & Kersten, 2017).

One of the main drivers of the adoption of sustainability is the **scarcity and depletion of natural resources** (Saeed & Kersten, 2019). Therefore, organizations are under pressure to choose sustainable practices in their supply chains to avoid these problems (Ibid, 2019). Accordingly, Seidel et al. (2006) state that to achieve sustainability, high costs for disposal, air pollution, frequency of natural disasters, and environmental problems with landfills are also important drivers (Seidel & Shahbazpour, 2006). The organization's management must ensure sufficient resources to carry out its sustainability objectives (Saeed & Kersten, 2019). However, if organizations cannot access sufficient resources such as technology, equipment, skills and capabilities, employees, human resources (Saeed, Waseek, & Kersten, 2017), etc., they can fail in this process. Therefore, the allocation of **organization's resources** plays a very important role in the realization of sustainability practices (Saeed & Kersten, 2019).

Pressures to embrace sustainability does not only rely on internal and external factors, but also on the **characteristics of the organization**. For instance, organization' size, current level of environmental actions, the level of internationalization, geographical location, position in the supply chain, industrial sector, etc. (Saeed & Kersten, 2019).

2.5.2.2. External Drivers

External drivers are factors that come from outside the organization but have extremely important effects on the organization (Saeed & Kersten, 2019). External pressures of SSCM encourage or motivate focal companies to embrace sustainability practices (*Ibid*, 2019), also divided into three groups which are **regulatory pressures, societal pressures, and market pressures** (Saeed & Kersten, 2019). External pressures consist of business social compliance, environmental regulation compliance, green product, and reverse logistics requirements, customer, and supplier involvement (Zimon, Tyan, & Stroufe, 2019, p. 222). Zimon et al. (2019) classified external pressures into three groups as customers, suppliers, and third parties (Zimon, Tyan, & Stroufe, 2019, p. 222).

Regulatory pressures are very important and effective in encouraging organizations to assume sustainability activities (Saeed & Kersten, 2019). Zimon et al. (2019) argue that regulatory pressures are the effective driving forces for SSCM implementation within other internal and external drivers (Zimon, Tyan, & Stroufe, 2019). These pressures comprise drivers from government agencies, regional or international regulators, also, standards, laws, certifications (i.e., ISO), procedures and incentives, associations to adopt sustainability practices (Saeed, Waseek, & Kersten, 2017). **Societal pressures** are drivers from NGOs and social groups, community, value-based networks, and consumer organizations to encourage and influence organizations and their supply chains to raise public awareness and improve their sustainability through communication channels such as the media and press, etc. (Saeed, Waseek, & Kersten, 2017). **Market pressures** are drivers that organizations and their supply chains face from different market factors, as shareholders and suppliers, to gain competitive advantage and advance sustainable technologies. Also, contains pressures which come downstream customers, competitors, shareholders, suppliers and buyers, investors, reputation, and financial institutions (Saeed & Kersten, 2019).

2.5.3. Fundamental challenges of SSCM

One of the most important challenges faced in the Sustainable Supply Chain is integrating all three dimensions of sustainability into the supply chain management. For instance, finding the balance between the cost and benefit of sustainable practices, also innovative technologies. Today, choosing the right practices and finding the balance between innovation and cost is a very difficult task. Knemeyer & Winter (2013) argues that in the SCM, the main challenges are the synergies and balance which occur at the interfaces between the three dimensions (Winter & Knemeyer, 2013). Besides, other challenges in the successful implementation of SSCM are

uncertainty, complexity, operationalization, cost and mindset, also cultural change (Alexander, Walker, & Naim, 2014). Many of these risks and uncertainties mentioned are the social and environmental impacts of businesses' activities on society. Likewise, it is social and environmental effects on businesses (Zvezdov & Akhavan, 2018).

Moreover, most sustainability problems occur in the upstream supply chain (Bourdeaux, 2020). Accordingly, the spread of sufficient upstream SCM practices becomes a key issue in businesses sustainability (Azevedo, Carvalho, Duarte, & Machado, 2012). Also, Seuring and Muller (2008) emphasized the requirement of collaboration of focal companies with suppliers in upstream SCM practices to improve the sustainability of their businesses processes (Azevedo, Carvalho, Duarte, & Machado, 2012). Therefore, collaboration is required in the entire supply chain, upstream suppliers, and downstream customers. That is, they should aim to achieve the same goals, and have the same strategies. In line with this, Hartmann (2018) argues that green supply chain theory should be implemented across the whole value chain by sharing managerial strategies as an aimed strategy or external alliance (Hartmann, Stehr, & Struve, 2018).

Due to the globalization of economies, SCM has become increasingly important and has a strong interest in terms of responsibility and sustainability, however, it has become significantly difficult to manage since supply chains grow, become complex and unclear networks (Gurzawska, 2019). On the other hand, Gurzawska (2019) suggests that SCM should be considered as proactive and responsive to different stakeholders and their needs, as well as all sustainability dimensions, cooperation, and strong relationships among members of the supply chain (Gurzawska, 2019). These two elements define as responsible and sustainable SCM, and these issues arise largely from the difficulties in determining risks such as lack of resources, population growth, rising urbanization, market developments and globalization, changing consumption habits, technological advances, and disruptions (*Ibid*, 2019). Furthermore, Schaltegger & Burritt (2014) argues that developments related to risk, opportunity, trade-off, and innovation are a specific challenge faced by focal companies to develop strategies for effective and efficient management and measurement of the sustainability of their supply chains (Schaltegger & Burritt, 2014).

2.6.Conclusion

Sustainability is a very important topic and on the agenda of businesses today, and it has also started to be implemented by companies. There are many definitions and research in the literature regarding sustainability. Sustainability is described as meeting the needs of the present without compromising the ability of future generations to meet their own needs (SCCG, 2018). Sustainability occurs at the point where the triple bottom line – planet, profit, and people intersect – that is, concerns working to protect the environment while keeping the firm financially stable, it also deals with people and society (SCCG, 2018).

Supply chain operations have a direct impact on the environment as consumers grow and their needs increase, so companies try to meet their growing needs (Johar, 2019), thus they overproduce. In addition, main sustainability issues occur in the upstream supply chain (Reuter, 2019), supply chains also provide a competitive advantage and require companies with common goals to come together and collaborate to meet customers' needs effectively and efficiently (Konys, 2019). On the other hand, supply chains create enormous footprints and cause significant social and environmental problems (Gurzawska, 2019). Therefore, the sustainability of the supply chain is very important for the profitability of the business, the environment, and society. Supply chains contribute significantly to the global economy (Gurzawska, 2019). Furthermore, supply chains should address economic, political, societal, legal, human rights, ethical, and environmental issues (Gurzawska, 2019). To implement sustainability practices in the supply chain all actors in the chain should collaborate, integrate, and act together. With the globalization of economies, supply chains are growing and becoming increasingly difficult to manage as they become complex and uncertain networks (Gurzawska, 2019).

Numerous literatures on SSCM includes various topics as green purchasing, purchasing ethics, remanufacturing, safety management, supplier certification, carbon footprint, and reverse logistics (Winter & Knemeyer, 2013). On the other hand, environmental concerns are also important and must be incorporated into SCM to achieve sustainable business development (Azevedo, Carvalho, Duarte, & Machado, 2012). Organizations are affected by internal and external pressures to implement and adopt sustainable supply chain initiatives (Saeed & Kersten, 2019). External drivers contain outside factors e.g., regulatory pressures, societal pressures, market pressures. Internal drivers contain organizational factors as corporate strategy, organizational culture, organizational resources, organizational characteristics (Saeed & Kersten, 2019) The major challenge of SSCM is synergies, trade-offs, finding the balance

between sustainability dimensions, and connections between dimensions (Winter & Knemeyer, 2013).

3. CHAPTER 2: Role of Green Manufacturing Practices in Development of Sustainable Supply Chain Management

3.1.Green Supply Chain Management

3.1.1. GSCM Concept and practices

The concept is also known as environmental supply chain management as it covers environmental factors and considers more environmental dimension of sustainability. GSCM term emerged with the integration of "green" approach into the SCM, in other words, environmentally friendly practices. Recently, greening the supply chain is a hot topic in the literature and desirable concept in the business due to the environmental problems. In addition, since environmental problems have increasingly become a crucial concept in supply chain management, managers perceive developments in 'green' performance as a competitive advantage alongside low cost, short delivery time, and high quality (Mutingi, Mapfaira, & Monageng, 2014). Similarly, Lintukangas et al. (2015) stated that the research and importance of the green supply management concept are growing (Lintukangas, Hallikas, & Kähkönen , 2015). Moreover, increasing green concerns and green transactions in the market have forced managers to manage their corporate performance in an ecological or environmental way (Mutingi, Mapfaira, & Monageng, 2014). On the other hand, customer requirements, environmental legislation and regulation are factors of the adoption of green practices (Green Jr., Zelbst, Meacham, & Bhadauria, 2012). Lintukangas et al. (2015) observed that the key drivers of green supply management are the company's commitment, supplier assessment, and supplier cooperation in environmental problems, as well as a linkage among the firm performance (Lintukangas, Hallikas, & Kähkönen , 2015).

Srivastava described GSCM as "*integrating environmental thinking into supply chain management, with product design, material sourcing and selection, manufacturing processes, final product delivery to customers also end-of-life disposal*" (Azevedo, Carvalho, Duarte, & Machado, 2012, p. 754) . In other words, it is the implementation of all processes and activities of the supply chain without harming the environment. Indeed, GSCM is to minimize or eliminate waste within the supply chain such as hazardous chemicals, emissions, energy, and

solid wastes (Chin, Sulaiman, Huam, & Zainon, 2015). Furthermore, the green management approach is accepted that it leads to the reduction of costs by using resources such as water, energy, and raw materials more efficiently (Azevedo, Carvalho, Duarte, & Machado, 2012). Besides, renewable energy sources help to reduce these costs and allow for less depletion of natural resources. That is, green supply chain, is a modern supply chain that aimed to less impactful than other classic and competitive supply chains, or a supply chain that has been transformed to reduce its impact (Chen, Simon, Reich-Weiser, & Woo, 2013). Consequently, green practices prevent harming natural resources, ensure efficiency and zero waste in production, as well as help firms reduce their cost and achieve economic growth. Therefore, green supply chain management plays a crucial role in the sustainable development of companies. In addition, Alp (2020) states that green supply chain is a paradigm in which product development and environmentally friendly production strategies are combined (Alp, 2019). In parallel, Chin et al. (2015) argue that green supply chain management enabled companies to achieve their profit and market share target meantime minimizing environmental risk and increasing ecological efficiency (Chin, Sulaiman, Huam, & Zainon, 2015).

GSCM is a form of management that extends from the green purchasing from supplier to manufacturer, to customer, and to reverse logic to the integrated supply chain (Toke, Gupta, & Dandekar, 2013). As well as GSCM consists of four components which are “green procurement + green production + green distribution + reverse logistics” (Toke, Gupta, & Dandekar, 2013; Mutingi, Mapfaira, & Monageng, 2014). Indeed, the addition of the term "green" to supply chain management aims to integrate green thinking into all supply chain processes, including green purchasing, green manufacturing, green materials management, green distribution, green marketing, and reverse logistics (Masoumik, Abdul-Rashid, Olugu, & Raja Ghazilla, 2014).

Green Jr et al. (2012) argue that GSCM practices focus on eliminating waste related to environmental sustainability and reducing these wastes should allow to lower costs resulting in developed economic performance (Green Jr., Zelbst, Meacham, & Bhadauria, 2012). They also argue that “*the implementation of GSCM practices is expected to result in improved environmental performance as measured by reductions in air emissions, effluent waste, solid waste, and the consumption of toxic materials*” (Green Jr., Zelbst, Meacham, & Bhadauria, 2012, p. 291). As a result, through GSCM practices organizations maximize efficiency, minimize cost, reduce management impact, improve service, increase sales, and market share, profit, also company's reputation (Chin, Sulaiman, Huam, & Zainon, 2015; Lintukangas,

Hallikas, & Kähkönen , 2015). On the other hand, these practices enable them to avoid possible environmental problems that may threaten their business success (Chen, Simon, Reich-Weiser, & Woo, 2013).

3.1.2. Role of GSCM in the Development of SSCM

Although green supply chain management in general is focusing on the environmental dimension of sustainability, it has a crucial role in development of firm's sustainability. Since organization by green applications improve their performance and gain economic benefits. However, the social dimension was not seen as significant as the environmental dimension or given the same value. Silvestre (2016) suggests that supply chains are dynamic entities that evolve over time, and they can learn, innovate, change, and become more sustainable (Silvestre, 2016). Therefore, companies can evolve from a green supply chain to a sustainable supply chain over time as they develop and find trade-offs between dimensions. Since the green supply chain management includes a variety of environmentally friendly and efficient practices, it helps a lot in the sustainability development of companies. In similar, Chin et al. (2015) observed that it is very important for manufacturers to apply GSCM practices in their company to achieve sustainability (Chin, Sulaiman, Huam, & Zainon, 2015).

Green supply chain practices also influence other dimensions of sustainability. In other words, Lintukangas et al. (2015) argue that green supply management is linked to many focal value-creating concepts, thus, supporting activities are necessary to increase an understanding of green concerns in supply management (Lintukangas, Hallikas, & Kähkönen , 2015). It is also seen as an important intermediary in the development of a firm's sustainability. In addition, these practices carry out companies' environmental policies so they can reduce sustainability-related risks related to upstream suppliers (*Ibid*, 2015). It is very crucial for companies to interact with their suppliers and develop strong business relationships, because good management of supplier relations and attempts to transform into a transparent supply chain contribute to the trust, loyalty, and satisfaction of customers and thus profit can be obtained (*Ibid*, 2015). As a result, the adoption of green objectives and practices has a comprehensive and multidimensional effect on the performance of the firm (Mutingi, Mapfaira, & Monageng, 2014).

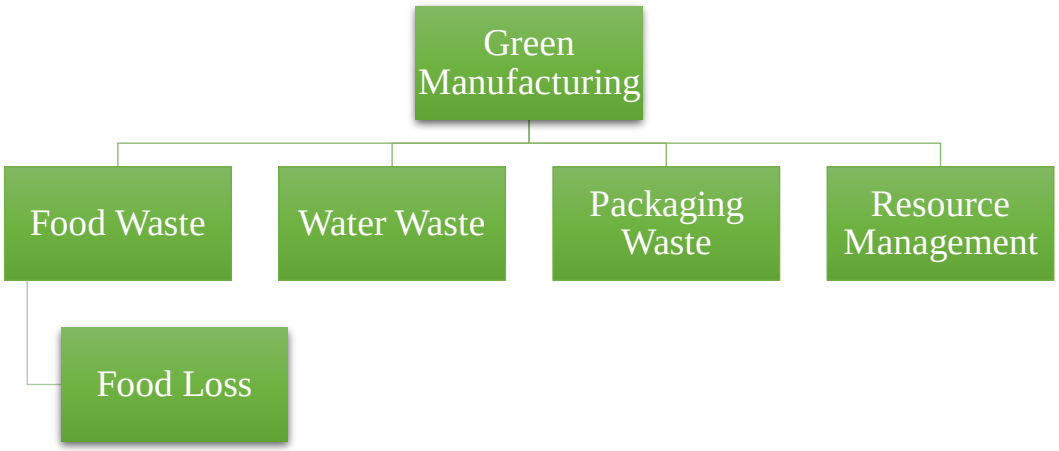
3.2.Green Manufacturing Practices

3.2.1. Green Manufacturing

The manufacturing process is a very important part of the supply chain and one of the main drivers of economic growth (Sriyogi, Agrawal, & Sharma, 2013). However, the damages caused by manufacturing firms or the production process to the environment cannot be ignored. Moreover, due to the over increased production and consumer demands, and overconsumption directly affects the environment. These mean more energy, water, natural resource consumption, CO2 emissions, air and environmental pollution, global temperatures, and more waste. Alongside to greenhouse gas emissions, it also causes issues such as water scarcity, land use problems, toxic waste, deforestation (Johar, 2019). These waste and environmental pollutions cause danger and diseases to people. On the other hand, operations will become more challenging, expensive, and less sustainable in terms of energy cost, processing/disposal cost of waste products and materials (Dornfeld, Yuan, Diaz, Zhang, & Vijayaraghavan, 2013). Therefore, environmentally friendly/green manufacturing practices and technologies should be adopted by organizations and manufacturers. Individuals are also responsible for this transition by changing their consumption habits. Many companies are aware of these issues and have already started to implement green manufacturing practices in their supply chains since they realize the advantages. In addition, companies are searching for new and innovative ways to minimize their impact on the environment, and they aim efficient consumption of resources, preserve energy, decrease impacts of energy production, and develop waste management systems (Fratila, 2013).

There are various and similar definitions of the concept of green manufacturing in the literature. GM is called in different names in the literature as clean manufacturing, environmentally conscious manufacturing, environmentally benign manufacturing, environmentally responsible manufacturing, and sustainable manufacturing. However, the objectives of minimizing the negative impacts on the environment through production, use, and disposal are the same (Rehman & Shrivastava, 2013).

Figure 6:Elements of Green Manufacturing



Source: illustrated by the author, 2021

Green manufacturing is mostly expressed as "*a manufacturing methodology that minimizes waste and pollution*" (Davim, 2012, p. v). That is, it develops energy-efficient production processes and techniques to transform materials into products that cause less greenhouse gas emissions, toxic materials, and waste (*Ibid*, 2012). Compared to traditional production systems, green production has less or no impact on the environment. Indeed, this theory is referred to as manufacturing processes that use inputs with low environmental impacts, and which are very efficient, and cause little or zero waste or pollution (Toke, Gupta, & Dandekar, 2013; Mutingi, Mapfaira, & Monageng, 2014). Therefore, it is a solution to many problems we face, also an opportunity for businesses to improve their supply chains. GM contains the whole product lifecycle, from conceptual design to harmless disposal with minimal use of resources (Rehman & Shrivastava, 2013). Green production elements are shown in figure 6.

In addition, Zhang et al. (1997) claims that GM technologies and design will enable manufacturers to transform waste into a profitable product (Rehman & Shrivastava, 2013). The main reasons are reuse, remanufacturing, and recycling practices of used products. Similarly, Mutingi et al. (2014) state that green production design reduces the number of components in a product, simplifies assembly and disassembly processes and provides material recovery. Therefore, there are many benefits to implement GM (Mutingi, Mapfaira, & Monageng, 2014). For instance, it may enable to shortening the life cycle of a product, thus it allows reduces the product's cost (Paul, Bhole, & Chaudhari, 2014). As a result, implementation of green

manufacturing practices is not just good for the environment, also beneficial for the businesses (*Ibid*, 2014).

3.2.1.1. Waste Management in Manufacturing

Manufacturing companies not only pollute the environment by emitting greenhouse gases but also pollute the environment by generating large amounts of liquid and solid waste. Therefore, companies should find solutions to minimize or eliminate wastes to reduce its impact on the environment. Reducing the generation of waste is one of the main goals of the green manufacturing practice (Dornfeld, Yuan, Diaz, Zhang, & Vijayaraghavan, 2013).

Waste management deals the recycling and removal of all wastes that occur throughout the production and after completion of process (Fratila, 2013). Franchetti & Spivak (2013) argue that the management of industrial solid waste and reduction is an important and effective system that businesses need today (Franchetti & Spivak, 2013). In addition, they argue that organizations realize while profiting through this method, they develop their company image as environmentally sensitive and responsible. However, there is huge competition across businesses and supply chains, thus waste disposal is ignored many times by manufacturers (*Ibid*, 2013). Companies can achieve waste minimization or zero waste with three applications. Reducing waste by monitoring supply inventory and simplifying the supply chain process (Johar, 2019), reuse and recycling. Similarly, Franchetti & Spivak (2013) suggest that firms first should consider reducing the waste, then reuse the wasted material, and recycle this material, finally disposal (Franchetti & Spivak, 2013).

Today, companies produce too much to meet the demands of customers, however if they don't sufficiently or right supply, then they may cause both wastes and costs. Therefore, efficient, and relevant supply and demand should be made to not cause inadequate or overproduction of raw materials, manufacturing, and distribution of products (Johar, 2019). In addition, León-Bravo et al. (2017) propose some examples of waste minimization practices as reducing waste and hazardous materials, generating organic waste, generating renewable energy, animal feed with waste, and recycling (León-Bravo, Caniato, Caridi , & Johnsen, 2017). Practices such as reducing measurable waste, reducing preventable mistakes and misalignments lead to a significant decrease in costs. Thus, it allows improvement in economic performance (Green Jr., Zelbst, Meacham, & Bhadauria, 2012). Governments, organizations, and NGOs have an objective to achieve zero waste. However, it could not be achieved in practice as they

did not make sufficient attempts to do so. Zero waste is a process to reduce the amount and harm of waste to the maximum quantity, protect and recover all resources, that is, not burning or dispose of them (Franchetti & Spivak, 2013). Franchetti & Spivak (2013) suggest that zero waste can be achieved through the waste assessment process and tool initiative. This led firms to build a green process, define waste reduction opportunities, and finally apply economically and efficiently (*Ibid*, 2013). Food loss and waste, and water waste are the most common problems encountered in food supply chains, and reducing these wastes is crucial to make supply chains green. That's why this research focused on the wastes of green production so that companies can gain theoretical and practical knowledge about reducing their waste, recycling it, and reusing it in other processes or products.

3.2.1.2. Food Waste

People face hunger and cannot access quality food, however, supply chains or companies wasting tons of food during production which causes many negative impacts. The fact that population and consumption increase constantly, the amount of production also increases directly, therefore, leads to excessive use of natural resources, especially land, water, and energy (Thyberg & Tonjes, 2016). These increases make difficult to determine the number of food production and cause wastes, also, unnecessary use of natural resources, pollution, and greenhouse gas emissions (FAO, 2019). At the same time, it has huge negative effects in terms of food safety, economic and environmental (Rezaei & Liu, 2017). On the other hand, food waste and loss can reduce food availability in the market, thus can raise food prices, affect, and reduce low-income consumers' ability to access food (Rezaei & Liu, 2017). For this reason, supply chains should be proactive and urgently find solutions to reduce food losses and wastes during all manufacturing processes.

Food waste and loss is a global problem that is very crucial for the world economy, society, and environment, which includes all stages of the food supply chain and addresses the sustainability of the world (Secondi, Principato, Ruini, & Guidi, 2019). In addition, food waste usually occurs at the retail and consumer levels, while food loss occurs at the production, post-harvest, and processing phases of the supply chain (Rezaei & Liu, 2017). Food waste is defined as food that is first meant for human consumption but then lost and removed from the food chain, either through choice or through poor inventory management or negligence (Rezaei & Liu, 2017). In addition, this type of food even if it is meant for other non-food use as animal feed, bioenergy, industrial usage etc. is referred to as food loss or waste (FAO, 2011).

According to the UN Environment Programme (2021), "*3 billion tons of food is wasted every year, whereas nearly 1 billion people are undernourished, and another 1 billion people go hungry*". In addition, it mentioned that approximately "*a billion tons of food is wasted annually at the retail, food-service and consumer level*" (UNEP, 2021). FAO has estimated that, "*in Belgium, approximately 3.6 million tons of food is wasted every year*" (MPI, 2016). These wastes cause huge costs for the supply chain, while they cause significant harm to the environment. Therefore, the first step should be aware of food waste, integrate applications into supply chains to prevent and minimize these wastes. In any process of the supply chain, these practices can help to reduce land and water usage (FAO, 2019). In addition, it is recognized as an important method of reducing production costs, increasing the efficiency of the food system, and improving environmental sustainability (*Ibid*, 2019). Food waste management and minimization is also a crucial concern in Sustainable Development Goals. According to the UNEP (2021), "*Sustainable Development Goal 12.3 includes a commitment to halve food waste at the retail and consumer level and reduce food loss in supply chains*" (UNEP, 2021).

Food losses occur at the production, post-harvest, and processing phases of the supply chain (FAO, 2019). These food losses can result from supply chain faulty practices or limitations as lack of suitable storage facilities, cold chain, appropriate food processing practices, infrastructure, packaging, or efficient marketing tools (FAO, 2011). Food losses also occur when supply chains produce more than desired or required quantities. In these cases, this waste or surplus crops are sold to processors as animal feed but is not considered financially profitable as it is sold at more affordable prices than retailers (FAO, 2011). In line with this, Céline Fremault in the Good Food Strategy Report (2015) stated that "*it is essential to prevent food waste at the source so as to avoid producing surplus quantities and consuming expensive natural resources unnecessarily*!" (Ronsmans, 2015). Besides, the reason for food losses in production is due to product line change, apart from overproduction. Roe (2018) argues that food loss may occur when manufacturer switch the line to produce another product, and while changing the line the machine must be run within a while (Roe, 2018).

In order to prevent and reduce food loss and waste, first of all, manufacturers should be aware of their wastes and should measure them. Dora observed that measuring is very important to determine output levels and will affect the final amount of food waste, also stated that a small number of companies measure their wastes (Jachec, 2019). Lawson suggests that food manufacturers should use ERP Software to reduce food waste, and she claims that "*by ERP*

software they can analyze shelf life, follow up slots, prevent cross-contamination, and prevent overstocking and accurate inventory orders" (Jachec, 2019). In addition, Dora suggests that "*food processing companies need to use innovative management systems such as lean manufacturing, Six Sigma and other techniques to prevent food loss"* (Jachec, 2019). If food resources are better managed and wastes are reduced, excess food can be used for charitable donations, thus can help to prevent hunger (Thyberg & Tonjes, 2016).

According to UN Environment Programme (2021), food waste reduction provides many benefits for people also for the environment as develop food safety, pay attention to climate change, save money, and decreasing pressures on natural resources and waste management systems (UNEP, 2021). In Belgium, Flanders and Wallonia are involved in food waste initiatives, and they aim to reduce food losses by 30% by 2025 compared to 2015 (Commission, 2019).

3.2.1.3. Water Waste

During food production and processing, companies use and lose huge amounts of water, which causes to the environment water waste and pollution. Wastewater from industries contains chemical compounds that may harm people, the environment also animals, so water pollution poses a great danger to human health. In addition, today, we are facing the problem of the ability to access clean and sufficient water, and this will continue and increase as production and industrial wastes increase, and manufacturers and processors do not find solutions and do not implement green practices. Therefore, manufacturers must consider alternative waters such as rainwater, treated wastewater instead of using fresh ones. Green manufacturing also requires reducing water use, reusing, recycling, and storing it.

Food processing includes a series of processes where water is required, as washing, boiling, evaporation, extraction, filtration, and cleaning (CIAA , 2007). In addition, the water used in the food and beverage industry is classified into categories such as general purpose, process, cooling and boiler feeding (Mcilvaine, 2015). Therefore, in food manufacturing, water is considered a product and a key ingredient, and an essential element for many steps also should guarantee hygiene standards (CIAA , 2007). However, this usage should be reduced, and alternative techniques should be adopted to consume less water. Vijayaraghavan et al. (2013) suggested that it is feasible to take water from the well or gather rainwater in the reservoir to reduce water consumption (Vijayaraghavan, Yuan, Diaz, Fleschutz, & Helu, 2013). In addition,

they stated that since rainwater is cost-free and is already de-ionized, thus it can be used directly in the cooling system, it is more beneficial and cost-effective than normal water. In some operations, clean water is not needed, therefore at this stage rainwater can be used (*Ibid*, 2013). However, in food manufacturing process rainwater is not considered a good solution due to the hygiene standards.

Another alternative application is wastewater treatment that European food and beverage manufacturers are developing and adopting important initiatives to provide healthy wastewater process that includes three stages (CIAA , 2007). First, minimize wastewater with efficient treatment systems, then improve the quality of wastewater through advanced technology water treatment, and finally, optimize the reuse, recycling, and recovery of wastewater by complying with the hygiene requirements (*Ibid*, 2007). Finally, more efficiency can be achieved through recycling, continuous investment, and the development of pre-treated wastewater in accordance with strict hygiene conditions (*Ibid*, 2007). Mcllvaine (2015) analyzed that "*food wastewater contains ruins that deplete oxygen in receiving streams, and Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD5) are measurements that commonly used to detect quality of water*" (Mcilvaine, 2015). He also argues that those measurements are significant to show lost product and wasteful practices.

There are methods of treating wastewater with chemical and non-chemical technologies (Harveston, 2019). The most common disinfection method is chlorination; however, it has been criticized because of the toxicity concerns to fresh water (Ibid, 2019). However, there are other methods without using chlorination, i.e., ozone disinfection and UV disinfection (Mcilvaine, 2015). The difference of ozonation method from the others is that it does not leave any residue in the purified water and does not produce as large disinfection by-products as chlorination (*Ibid*, 2015).

3.2.2. Resource Management

The increase in the world's population and therefore the increase in production to meet the demand for feeding will cause scarcity of natural resources, climate change, land degradation, water scarcity, water pollution, and loss of biodiversity (FAO, 2019). Therefore, providing ecological efficiency and adopting a resource management approach is very significant for environmental sustainability. Fratila (2013) argues that the necessity for ecological efficiency

is linked to generating minimum waste, toxic emissions to air, soil, and water, also consuming minimum energy at all life cycle stages (Fratila, 2013).

Countries need to use resource management approaches to adopt and recognize the direct and indirect factors of biodiversity loss (IRP, 2021). In addition, industries, governments, and societies need to change the way they produce and consume natural resources such as land, water, biomass, metals, minerals, and fossil fuels (*Ibid*, 2021). These natural resources are the core topic of the Sustainable Development Goals and 2030 Agenda for Sustainable Development (*Ibid*, 2021). According to Martin (2007), full use of raw material improves resource efficiency and productivity, reduces biodegradable waste, and contributes to the utilization of renewable resources (CIAA , 2007). Consequently, resource efficiency and circularity can minimize the negative impact on the environment, even can positively affect (IRP, 2021).

Food and drink manufacturers are increasingly playing a role in biorefineries, in which agricultural resources are converted into animal feed, fertilizers, cosmetics, pharmaceuticals, bioplastics, and biofuels (CIAA , 2007). Moreover, industrialization and production cause increases in energy consumption, greenhouse gas emissions, and carbon levels in the air. However, it is possible to overcome this with innovation, smarter production planning, and more energy-efficient technologies (Breque, Nul, & Petridis, 2021).

United Nations state that (2017) "*energy use is relatively high in Belgium, due to a poorly insulated housing park and well-developed intermediary industries which are heavy energy users*" (Nations, 2017). In addition, despite a 27% reduction in CO2 emissions in Belgium compared to 2019, by producing 10.8 metric tons of CO2 per capita, cause it the largest carbon footprint in the EU (Tiseo L. , 2021). Therefore, companies in Belgium, particularly food manufacturers must implement green technologies, renewable energies, and should use AI and big data. Artificial Intelligence and additive manufacturing significantly contribute to develop sustainability by optimizing resource efficiency and minimizing waste (Breque, Nul, & Petridis, 2021). Technological innovations may provide huge opportunities to food companies. Besides, industries will adopt these technologies and methods when they see the benefits of resource efficiency, an increased corporate image, and reduced on energy and material costs (*Ibid*, 2021).

3.3.Integration of Suppliers into Green Supply Chain Practices

Suppliers are the main players of the supply chain, thus, be able to implement green practices, it is necessary to cooperate with them and integrate into green practices. Besides, companies can give the training to educate them about green practices. On the other hand, supplier integration is become more crucial than before, since companies realized that they could improve green practices together, share risks, and reduce costs. Likewise, (Alp, 2019) argues that integrating suppliers into green design practices and encouraging them to build their own environmental programs is very essential to the continuity and effectiveness of practices. In this way, food companies will work closely with their suppliers and will be in a stronger position by minimizing their environmental and social impacts (Bové & Swartz, 2016). Similarly, Green Jr et al. (2012) suggest that these practices can be achieved by the cooperative work of suppliers and customers to develop the environmental sustainability of manufacturers (Green Jr., Zelbst, Meacham, & Bhadauria, 2012).

Supply chain integration becomes more difficult as companies become more reliant on their suppliers; however, supply chain integration can be established by constructive long-term supplier relationships (Weele, 2010, p. 397). In addition, Zhang et al. (2018) observed that internal trust affects the relationship between supplier integration and performance of the firm, therefore, it can help managers to develop the value of supplier integration (Zhang, Lettice, Chan, & Nguyen, 2018). Supplier integration and trust can encourage suppliers to adopt and develop environmental practices. Manufacturers can integrate their suppliers into green practices in many ways. For instance, the firm or manufacturer can integrate with suppliers by strategically collaborating, managing, and developing inter-organizational processes and by sharing their knowledge (*Ibid*, 2018). Thus, they can understand and overcome the difficulties or complexity of green practices and implement them more efficiently through collaboration. This can happen between upstream and downstream suppliers (Bourdeaux, 2020). Supplier integration has various benefits, the fact that it purposes to develop the efficiency and effectiveness of information and physical flow between manufacturer and suppliers, thus may ensure the establishment of seamless processes and connected supply networks (Zhang, Lettice, Chan, & Nguyen, 2018). In line with this, Villena & Gioia (2020) suggests that collaboration is crucial for the viability of sustainability initiatives (Villena & Gioia, 2020).

3.3.1. Green Supplier Selection

Supplier selection is very crucial for the implementation and continuous development of green practices. However, choosing a green supplier is quite challenging for many companies, as the environmental standards are often not complied with. In this regard, Seuring and Müller (2008) state that supplier selection, auditing, and monitoring are much more important than supplier integration and development to improve performance of sustainability (Seuring & Muller, 2008). Due to the desire of companies to reduce their negative impact on the environment, they started to pay more attention to choosing their suppliers. In line with this Konys (2019) argues that the fact that increased awareness about environmental protection and its long-term positive effects, the selection of green suppliers is increasing the attention between researchers and practitioners (Konys, 2019). Since well-chosen green suppliers led firms to put its green initiatives into practice, thus can improve the firm's performance and sustainability. However, choosing the wrong supplier can also cause big problems. Likewise, Konys (2019) claims that supplier selection can impact directly and indirectly the results of bad decision-making processes (Konys, 2019). For these reasons, the supplier selection challenge is the main competition barrier for businesses (*Ibid,* 2019). In addition, choosing the ideal green supplier is a challenging and multidimensional problem as companies need to improve their practices and technologies in green supply chain management (*Ibid,* 2019).

On the other hand, Chen et al. (2013) argues that to implement green initiatives, the company must first decide whether it prefers a greener supplier or keep to its own existing suppliers and works with them for sustainability (Chen, Simon, Reich-Weiser, & Woo, 2013). Both decisions are very complex and critical for companies as they cause huge costs and influence the sustainability of the company. Indeed, working with existing suppliers can cost more time and money than choosing another supplier if those suppliers do not have the capacities or equipment for sustainability (Chen, Simon, Reich-Weiser, & Woo, 2013). However, choosing a new supplier will cause other issues such as a green supplier selection time and restructuring efforts (*Ibid,* 2013).

Konys (2019) observed that most of the supplier selection criteria are chosen according to their relevance, but that the diversity of products, industries, and technologies can affect some criteria (Konys, 2019). Therefore, he suggests that different sets of criteria are required to provide a more concrete supplier selection process and to obtain more accurate results. In addition, other companies need suppliers to be selected to comply with certain pre-determined

criteria and to work together continuously for sustainability after the contract is signed (Chen, Simon, Reich-Weiser, & Woo, 2013).

3.3.2. Supplier Evaluation, Monitoring and Compliance

Suppliers are a major source of the supply chain as they provide competitive advantage for companies. However, they can also cause significant problems (Weele, 2010, p. 390). Therefore, choosing the right supplier is very crucial for companies. In addition, suppliers are positioned upstream in the green supply chain and can transfer downstream. Therefore, supplier evaluation is very essential in the green supply chain also becomes a highly important research topic (Hou & Xie, 2019). Especially, supplier evaluation concerns green supply chains optimization issue (*Ibid*, 2019). Besides, due to the increase in competition, environmental problems, and increasing public awareness, green supplier evaluation methods have recently started to develop and attract more attention (Zhang, Lettice, Chan, & Nguyen, 2018).

In traditional supplier selection, only the economic factors considered as price, quality, and delivery to choose green suppliers, however, in recent years, these criteria have changed, as companies started to focalize environmental performance in purchasing due to rigorous regulations and pressures from several stakeholders, besides social factors have started to be considered to select a sustainable supplier for improving the sustainability of supply chain (Zhang, Lettice, Chan, & Nguyen, 2018). In addition, Zhang et al. (2020) observed that the most used green assessment criteria are quality, resource consumption, price, green design, environmental management system, and greenhouse gas emission (Zhang, Lettice, Chan, & Nguyen, 2018). However, some companies still do not consider green criteria while supplier selection to reduce their negative environmental impacts. In this context, Ngcingwnana (2012) states that straightforward evaluation tools for green supply chain management are inadequate, and a few private and public companies have their regulatory structure to evaluate environmental propositions (Ngcingwnana, 2012). However, the firms can develop the effectiveness of implementing green concerns in supply chain management based on the assessment (Sellitto, Hermann, Blezs, & Barbosa-Póvoa, 2019).

In addition, the evaluation of selection criteria provides sustainable development opportunities by adding individual green orientation to entrepreneurial intent models to grow the explanatory powers of the supplier along with the services provided and material quality (Konys, 2019). Therefore, companies need to develop more their green policies for supply chain

management (*Ibid*, 2019). After evaluating and selecting suppliers, monitoring, and auditing suppliers are essential for the continuity and effectiveness of green practices. Although there is much literature on main green criteria, measuring the suppliers' capacity to meet these criteria is very important for the success of the green supply chain (*Ibid*, 2019). Similarly, Gavronski et al. (2011) claim that monitoring and auditing enable suppliers to continuously control and develop their environmental performance (Yarahmadi, Clements, & Higgins, 2012) . Moreover, Weele (2010) suggests that "*operational processes of suppliers need to be controlled and monitored for compliance*" (Weele, 2010, p. 397). Big manufacturers aim to achieve green supply chains by mandating first-tier suppliers to pass on their environmental policies to their second-tier suppliers (*Ibid*, 2010). Likewise, Amemba et al. (2013) state that buyers put pressure on their suppliers to improve their environmental performance, thus motivating them more to cooperate with buyers for environmental goals (Amemba, Nyaboke, Osoro, & Mburu, 2013).

3.3.3. Certifications

Green manufacturing companies promote and obliged their first-tier suppliers to develop an environmental management system (EMS) (Azevedo, Carvalho, Duarte, & Machado, 2012), compliant with ISO 14000 standards and get ISO 14001 certification to comply with regulations of their business (Ngcingwnana, 2012). EMS is very important for manufacturing companies as it enables the determining of new methods and opportunities for the effective management of environmental effects and their successful application (Ngcingwnana, 2012). Furthermore, for this purpose, EMS contains principles that define policies, systems, and audit protocols (Islam, Karia, Fauzi, & Soliman, 2017). Islam et al. (2017) pointed out that The International Organization for Standardization (ISO) 14000 series is the most well-known and implemented standard (Islam, Karia, Fauzi, & Soliman, 2017).

ISO 14000 standards mandated by stakeholders, community, and regulators managed by strict environmental regulations, which were developed to provide a path for developing a comprehensive technique for environmental management and to regulate fundamental environmental tools (Islam, Karia, Fauzi, & Soliman, 2017). In addition, it is aimed to be used by a company that seeks to manage its environmental responsibilities in a systematic way that improve the environmental aspect of sustainability (ISO, ISO 14001:2015 Environmental management systems — Requirements with guidance for use, 2015). Besides, ISO 14001 can indirectly influence all supply chain members, and from the first tier to the second tier of the

supply chain, to choose more green practices (Islam, Karia, Fauzi, & Soliman, 2017). Therefore, the ISO 14001 standard is important for the adoption and implementation of green supply chain practices by supply chain members. This standard is not only beneficial for the green supply chain practices, but it also has a positive impact on the company in many ways. In line with this, Nadae & Carvalho (2019) suggest that ISO 14001 is a fundamental step in firms through sustainability and begins to establish company policies on environmental sustainability that lead the company from an economic dimension to a more comprehensive approach of sustainability (Nadae & Carvalho, 2019). Similarly, several authors stated that it is essential for a systematic method to decrease the negative environmental impacts of companies, reduce resource depletion and waste, and ultimately ensure improvement of quality (Islam, Karia, Fauzi, & Soliman, 2017). Furthermore, it is a very useful tool for environmental activities that can finally provide financial advantages like cost reduction and revenue growth through market competition or firm development (Reis, Neves, Hikichi, Salgado, & Beijo, 2018). However, although this standard has many benefits, companies still have difficulties in implementing it or some barriers stop them from applying. Reis et al. (2018) observed that there are factors such as financial struggles, changes in the initial investment, changes, training, and awareness of all current employees in the company, and the fact that some countries are constantly in a disadvantaged position, and that legislative changes make this process more difficult (Reis, Neves, Hikichi, Salgado, & Beijo, 2018).

In addition, companies can also ensure their supplier comply with ISO 9001 (2015) which is a quality management system (QMS) standard, and it helps customers obtain consistent (ISO, 2015), good-quality products and services, also ISO 20400 (2017) certification to ensure sustainable procurement (ISO, 2017). Besides these standards, there are some specific standards in the food sector as Alliance for Water Stewardship certification, Ecovadis, Forestry Certificate Council.

3.4.Conclusion

SCM has a direct link with sustainability, because with sustainability, companies both provide profitability in their operations and encompass their relationships with society and the environment (Winter & Knemeyer, 2013). SSCM includes the combination of objectives of TBL and the coordination of business operations to ensure long-term performance, increase supply chain efficiency and profitability while minimizing environmental impacts, and maximize social well-being (Zvezdov & Akhavan, 2018). Therefore, sustainable supply chain

management the main contributor for companies to achieve sustainable development (Cetinkaya, 2011). Caroll expressed (1991) this phenomenon as, *"sustainable profitability can only be achieved if the company is able to balance the interests of customers, employees, the environment, and its shareholders, i.e., serving the needs of People, Planet, Profit"* (Weele, 2010, p. 388). Sustainable development is a solution to reduce waste as it provides efficient use of resources (Diabat, Kannan, & Mathiyazhagan, 2014). However, supply chains are also the main contributors to hunger, pollution, resource scarcity, emissions, and climate change. Therefore, companies must tackle challenges and handle climate change, financial crisis, and the prices, increasing consumers' interest in ecology, providing environmental sustainability and energy efficiency (Teuteberg & Wittstruck, 2010). However, there are barriers in SSCM as financial cost, green investments, and lack of suppliers' capabilities to make innovations (Hartmann, Stehr, & Struve, 2018).

To tackle problems of supply chains and ensure efficiency and eliminate wastes green supply chain should be implemented in the whole value chain (Hartmann, Stehr, & Struve, 2018). The GSC enables companies to avoid environmental problems that jeopardize their environmental performance, reputation, and business success (Chen, Simon, Reich-Weiser, & Woo, 2013). Minimizing wastes allow companies to reduce costs and increase economic performance (Green Jr., Zelbst, Meacham, & Bhadauria, 2012). On the other hand, through GSCM companies gain competitiveness and improve their economic and environmental performance by reducing their carbon emissions, effluent, solid waste, and the use of toxic materials (Green Jr., Zelbst, Meacham, & Bhadauria, 2012), minimizing water and food waste, recycling and reusing them. Green production has a strong relationship with the three dimensions of sustainability, as developing one dimension allows companies to move from one to another (see appendix A), and by reducing food loss and waste, companies can achieve many of the Sustainable Development Goals such as ensuring access to food and reduce hunger, improve water quality and water use efficiency, improve air quality and waste management, strengthen resilience and adaptive capacity (see appendix C) (FAO, 2019).

4. CHAPTER 3: Research Methodology

4.1.Research Design

After literature review research, a multiple case studies method was conducted as a research design to find answers to research questions. The case study is a research approach to gain concrete, contextual, in-depth knowledge about the specific subject i.e., a person, event,

organization, or a phenomenon, and to understand the real-life complex issues (Crowe, et al., 2011). In order to build a case study, "why" and "how" questions were aimed to answer. On the other hand, as the aim of the study was to gain detailed information about the concept and phenomenon, specific questions were asked about the GM topic. Therefore, this study was conducted in the framework of a descriptive research design and based on five case studies in the food companies which have manufacturing factories in Belgium, particularly bakery and dairy manufacturing, and specific innovation projects. In this way, research questions were investigated in detail with multiple case studies, also cross-case analyses were carried out, thus, the similarities and differences of the cases were compared to better understand the problem. Through the case studies of selected companies and projects this thesis aimed to answer the following questions:

- How do food companies in Belgium implement green practices in their manufacturing? If they do not what are the implementation barriers?
    - How do companies reduce their food waste in manufacturing?
    - How do companies reduce their water waste? (Wastewater treatment, recycling water, etc.)
    - Do companies measure their wastes to prevent these wastes?
    - What concrete actions do companies doing to reduce carbon emissions in production?
- How do they cope with these barriers and successfully integrate green practices into their manufacturing?

Case studies can lead managers to determine and prioritize their sustainability goals, improve their environmental initiatives, and gain a competitive advantage (Lynch, 2016). In addition, through case studies, managers can integrate them into their own sustainability practices by observing the challenges of selected companies and how they have overcome these challenges and succeeded in implementation. Therefore, case studies may be beneficial and examples for organizations, NGO's and other businesses who aim to develop green practices and implement them into their supply chains and overall businesses. According to Ngcingwnana (2012), the case study approach is generally a qualitative research study of an organization (Ngcingwnana, 2012). The qualitative case study is a research method that allows examining a specific phenomenon or problem in-depth and in detail through different data sources, and it enables an investigation of the multifaceted aspects of the problem (Rashid, Rashid, Warraich, Sabir, &

Waseem, 2019). This study was analyzed how these companies in Belgium implement green practices such as waste management (food waste and water waste in manufacturing), resource efficiency, green supplier selection, green technologies, on the other hand, their implementation barriers.

4.2.Selecting Cases

After determining the research question and problem, it is very important to choose the right cases, be able to find the right answers to the research questions, new insights, and to be related to the phenomenon or the problem. There are not any specific criteria for cases selection, however, the researcher must select the appropriate cases according to the thesis topic and the context. Therefore, it is a very important decision that should be thought about, and some research made before selecting (Crowe, et al., 2011). In this case study, the selected companies were chosen not because they were models for other companies, but because they were achieved some of the green practices. In multiple case studies, cases are chosen carefully, and it provides an opportunity to compare several situations or similarities and differences (Crowe, et al., 2011). On the other hand, companies with different strategies, sustainability achievements, and different sizes were considered to understand the challenges faced. In addition, it was taken into consideration that the selected cases were beneficial, could give detailed examples or insights, and could answer the research questions accurately. As case studies are more in-depth research, specific and interesting information had to be gathered from different food companies that has manufacturing plants in Belgium.

Besides, it has been considered whether companies give importance to sustainability, specifically green supply chain practices. Because if the company does not know and apply green practices, could not give suitable answers to the research questions. Therefore, companies that were aiming to have a sustainable supply chain were selected for the case study. Otherwise, the answers to the research questions and possible solutions to the problem could not be gathered. According to McCombes (2020), a good case study should provide new or unexpected insights into the topic, challenge or complicate existing assumptions and theories, suggest practical courses of action to solve a problem, show new directions for future research (McCombes, 2019). In addition, in this thesis, to analyze green manufacturing activities, food companies with production factories in Belgium were selected, however, the size of the firms was not considered. Especially, green applications such as reducing food waste, reducing water waste, wastewater treatments, green technologies, clean energies in production were analyzed.

In this study, to analyze green supply chain management practices in the food industry, four food companies that have production factory in Belgium and one innovation platform for Flemish food companies were selected. These are Company A, Company B, Company C, Company D, and Flemish Innovation Platform. As you noticed, companies desired to remain anonymous, so their names were not mentioned in this thesis. However, in Appendix G structure of the interview was explained in detail. The reason I chose the Flemish Platform is that they carry out many projects in the food industry, but also bring together food companies to improve their business, most importantly, develop many innovative, effective, and sustainable activities and technologies. Therefore, these projects can be very beneficial for companies and help them achieve their sustainability goals.

The background of the companies is shown in Table 1 below. The result of providing this information can be that the emotional burden linked with participation, or the organizational disruption associated with supporting practical work is believed too significant, that people do not accept participation (Crowe, et al., 2011). The ethical implications of the case study were considered while selecting the companies, and necessary information was given to potential participants to make an informed choice to participate in the research. In addition, the fact that each company has different characteristics, sustainability, and green objectives, offers various types of products with very high quality, has a large product range, has selected for this study, for instance, bakery, dairy, pastry, etc. Moreover, the services, or products they offer were selected in relation to the thesis. Therefore, it was assumed that the selection of these companies would add meaningful and different information to the thesis.

Table 1. Demographic of interviewed companies

Criteria	Company A	Company B	Company C	Company D	Platform
Sector	FMCG (Food & beverage)	Patisserie, chocolate & bakery	Bakery & pastry	Dairy sector	Innovation platform for food industry
Size (number of employees)	273,000 employees	9.318 employees	4,500 employees	2.000 employees	300 members

EMS/Certificates	Platinum level of Alliance for Water Stewardship (AWS), the Forest Stewardship Council	ISO 14001, SEDEX, Ecovadis, Beyond Chocolate, Cocoa Forest Initiative, World Cocoa Foundation, Fedima, and Fevia	International Food Standards (IFS) certification, invest in IFS, ISO, BRC	Farms: Integral Quality Care Milk (IKM), Voka Charter Sustainable Entrepreneurship, Unitar, SMETA, EcoVadis (Silver)	No
Product range	Powdered and liquid beverage, petcare, nutrition and health science, prepared dishes and cooking aids, milk products and ice cream, confectionery, water	Patisserie, chocolate, and bakery products	Bakery products and margarine, culinary oils & fats Bakery products: bread, pastry, sweet treats, Italian savory, and pastry	Dairy Product & Ingredients (DPI), Consumer Products & Services (CPS), and Ice Cream (Ysco)	No
Sustainability Vision	None of their packaging, plastics, increasing recycling and identifying packaging alternatives, using their size and reach to provide information that helps suppliers,	Based on six pillars: planet, responsible sourcing, healthy and quality products, heritage, people, and communities	Based on three main goals: balanced nutrition, protecting nature, and enhancing lives. Protecting nature: Sourcing responsibly, aiming for zero carbon emissions, aiming for zero food waste, and contributing to circular packaging	Based on four pillars: socio-economic, climate and environment, animal welfare, and health & nutrition. Sustainability goals under 'Five Ps': Peace, People, Planet, Prosperity, and Partnership	They don't have a sustainability vision, however, help companies to achieve sustainability goals

Sustainability Achievements	-%50 of electricity from renewable sources, -37% reduction in GHG emissions per tonne of product, -32% reduced direct water withdrawals per tonne of product	Awarded a Grade B for reporting to CDP Climate, %67 of electricity used from renewable sources, -CO2 emissions by %24	100% renewable electricity in its production facilities and offices, 33% reduction of food waste in bakery products, a 12% of in margarine, culinary oils, and fats (compared to 2017)	77% of dairy farmers recycle by-products, 56% of total water is recycled wastewater, 29% reduced total water consumption, 40% increased water reuse	They have severeal roadmaps and projects: Food from food, RepEAT, Sucr'eau, SmartWaterUse

Source: compiled by author, 2021

4.3.Problem Statement

In this study, after the cases were selected, their main obstacles and problems in green practices were determined. Then, a problem statement was formed by asking the following questions: What problems exist and why? who is responsible for them? and how do these issues affect the organization and supply chain?

Nowadays, there are many problems and shortcomings in supply chain management and practices in the food industry in Belgium. First, the most important problems realized in the case studies are the lack of communication between suppliers and the insufficient participation, integration, and effort of partners of the supply chain into the green practices. Unstructured communication and insufficient cooperation between suppliers and other partners make green practices more difficult to implement. Because implementing green practices such as reducing food waste and water waste, and wastewater treatment require a lot of collaboration among supply chain partners. In this regard, Sellitto et al. (2019) suggest that "*if a company cooperates with its suppliers and communicates effectively with partners, it may be easier to embrace green purchasing, also sell waste or by-products as raw materials to the customers*" (Sellitto, Hermann, Blezs, & Barbosa-Póvoa, 2019, p. 2). Collaboration can occur with upstream and downstream partners. However, big companies do not integrate their lower tiers suppliers into sustainability programs. Also, multinational companies do not have direct contractual relations with lower-tier suppliers, and most of the lower-tier suppliers are not well known (Villena & Gioia, 2020). Therefore, they receive less attention and pressure from media, NGOs compared to the other stakeholders.

On the other hand, another important problem is that although companies or supply chain members are aware of and desire to implement green practices, they do not know how to implement them and which techniques and technologies to use. Even if large organizations are aware of and implement these practices, medium and small-sized companies still do not have the knowledge and technologies to implement them. In addition, some companies are not aware of their waste in production, in other words, they do not measure food and water usage and wastes. However, only a few companies use certain metrics to determine the amount of water or raw materials used. Therefore, it is crucial to use measurements in the manufacturing process to predict the amount of usage, in this way, measurements can allow companies to reduce resources use and minimize their wastes. According to Dora, food companies should measure their food waste in manufacturing, not only because of environmental effects but also because of cost-effectiveness (Jachec, 2019).

In addition, insufficient technologies and a lack of investment are important problems in the green manufacturing process. Large firms make investments in environmental practices and green technologies; however, small, and medium-sized firms pay attention to whether the application is profitable for the company due to the risks of investments. FAO (2014) states that some green technologies might be more profitable than less environmentally friendly technologies, however, other technologies such as alternative energy sources may reduce profits. Therefore, for small enterprises investing in such technologies is very difficult (FAO, 2014).

4.4.Data Collection

This thesis followed the principles of qualitative research based on a case study. Because case studies are often analyzed through qualitative data using methods such as interviews, observations, and primary and secondary sources (McCombes, 2019). The main aim was to understand how food companies implement green practices in their manufacturing, also their challenges during implementation. Therefore, conceptual theory on Green Supply Chain Management strategies in the Food Companies formalized through empirical research. Also, it is based on the researcher's observations and assumptions. Firstly, secondary data was gathered from external such as government reports, published sources, books, articles, journals, literature reviews, official documents, company websites, business magazines, press releases, internet, and internal such as company annual and sustainability reports from different food companies, company presentations, and videos (shared by companies confidentially).

Moreover, the secondary data were collected from various sources and platforms such as Uclouvain Discovery, Wiley Online Library, Google Scholar, Science Direct, Emerald, Research Gate, Academia, Shift, Fevia, Comeos, and Flanders Food. Secondly, after carefully selecting cases, a semi-structured interview guide was built by several sections from broad questions to specific questions. In section 1, information about participants was questioned such as position within the company, role in the organization, daily job, and how long they are working. In section 2, the company's relation with Sustainability and Sustainable Development was asked, such as the company's vision and strategies regarding sustainability. However, in section 3, more specific questions were asked about Green Supply Chain Management, afterward, narrowed down to green manufacturing practices such as food waste in production, water waste, water measurement, green technologies to gather more valuable information about the topic. In this way, primary data were gathered directly from selected case companies about managerial perspectives and experiences, particularly about the topic that was explored.

Six semi-structured interviews were conducted to gain a comprehensive understanding and as detailed information as possible about the case and its context. Indeed, five interviews of six were working in the food companies which are; Interviewee 1 is Operation Manager at Company A, Interviewee 2 is Sustainability Manager at Company B, Interviewee 3 is Group Environmental Sustainability Program Manager at Company B, Interviewee 4 is Operational Excellence Manager at Company C, Interviewee 5 is Group Procurement Category Manager at Company D, and the other respondent Interviewee 6 is Innovation Manager at Flemish innovation platform for food companies. The interview guide was sent to the respondents before the interview, and permission was requested to record the interviews. Therefore, the data were collected through Microsoft Teams recordings, transcriptions, and taking notes. The interview questions can be found in Appendix G, also the transcripts can be found in Appendix H.1 to H.6.

4.5.Data Analysis

After identifying key problems of the cases, semi-structured interview data were analyzed through cross-case analysis method to find similarities and differences between the cases. Specifically, common problems of the Food companies were examined. McCombes (2020) suggests that multiple case studies enable researchers to examine the main elements, meanings, and significance of the case (McCombes, 2019). In addition, the sustainability and annual reports of companies, presentations obtained from company websites were also examined.

First, each case was studied individually, also their background information was provided in the analysis. Later, the cases were analyzed in-depth under the sub-headings of the GM practices by comparison method. In this way, it enabled to reveal of different aspects of the research problem. Afterward, substantial benefits of implementing GM practices were analyzed for each case. Furthermore, potential solutions were determined and suggested for each case. Then, the advantages and disadvantages of GM practices were examined to find out the best solution. After carrying out a cross-case analysis, the findings and the study were concluded. Afterward, some recommendations were made to the companies, organizations, NGOs, and governments. Finally, the limitations of the study were described.

5. CHAPTER 4: Cross-Case Analysis of GM Practices in Food Companies, Findings and Discussion

5.1.Background of Case Companies

To make a cross-case analysis of green supply chain applications, the background information of the selected cases is defined first. All relevant and necessary elements have been brought together to provide as comprehensive a view as possible of the topic. In addition, I examined the main problems that the cases are facing in the supply chain, especially in manufacturing. Four case studies represent food companies in Belgium; however, the other case represents an innovation platform for the Flemish agri-food industry. Each case has different characteristics, product range, business strategies, and sustainability goals.

5.1.1. Company A

Company A represents the world-leading consumer good, food and beverage company in nutrition, health, and wellness (Company A, 2021). It has numerous product groups and brands. In addition, it provides products with high-quality such as baby food, hot drinks, cereals, chocolates, water, medical nutrition, culinary dairy products, and pet products. The company has established in Belgium in 1925, and headquartered in Vevey, Switzerland. Company A as operates 186 countries, and has 273,000 employees around the world, is the largest food group in the world (Annual Review, 2020). However, since it is a very large company and has many production factories worldwide, its impact on the environment is much higher than small companies. Tiseo (2020) states that in 2019, Company A's greenhouse gas emissions were equivalent to 3.3 million metric tons of carbon dioxide. Therefore, it has a crucial role in reducing the negative effects and pollution on the environment and in the implementation of

green supply chain practices. Company A has several production plants in Belgium, which operate chocolate production in Antwerp, production of fresh dairy products and cold meats in West Flanders, infant products, and frozen Maggi products in Liège. On the other hand, more than 800 employees work in various companies of the group (Company A, 2021).

Another reason I chose this company was its clear sustainability vision, health, social and environmental commitments (Annual Review, 2020). In addition, the company's ambition of tackling climate change, halving greenhouse gas (GHG) emissions by 2030, and achieving net-zero emission by 2050 (Net-Zero Roadmap, 2021) was an important motive to select for this thesis.

In this regard, the CEO of the Company (2021) states that "*tackling climate change can't wait and neither can we. It is imperative to the long-term success of our business. We will work together with farmers, industry partners, governments, non-governmental organizations and our consumers to reduce our environmental footprint*" (Company A, 2021). Company A was considered significant for this thesis as it focused on sustainable strategies, invested heavily in these goals, and implemented many sustainable practices. For instance, strategies related to environmental sustainability practices, such as promoting the efficient use of natural resources and the use of sustainably managed renewable resources and aim to reduce waste to zero (Company A, 2020). Moreover, the company has achieved its many objectives as reducing food loss and waste, and reducing water withdrawals[1], on the other hand, tackling climate change by decreasing their emissions. Indeed, the company is proud to announce that since 2010, they achieved a -37% reduction in GHG emissions per tonne of product in their manufacturing, zero waste disposal in their 368 factories, and procured -%50 of their electricity from renewable sources (Annual Review, 2020). However, being a large company requires them to have major responsibilities on climate change, reduce their impact, and make measurements on their resources use. Therefore, there are still many practices and investments that can be made to tackle these problems. These measures should also be taken and implemented in Belgium.

5.1.2. Company B

The company represents an international food group offering products, raw materials and application expertise in the patisserie, chocolate, and bakery industries. It is a family own

[1] Water withdrawal refers to the total amount of freshwater drawn, either permanently or temporarily, from underground and surface water resources (OECD, 2021).

company that is based in Belgium and was founded in 1919 (interviewee 2, 2021). The company is present worldwide, and sells to over 100 countries, and has 65 factories in 52 countries, subsidiaries in 81 countries, 9.318 employees, and 93 innovation centers around the world (Annual Sustainability Report, 2020, p.7). The company has a turnover of around 2 billion euros, 2,44% of revenue was invested in R&D, and 10.8M euros was invested in different sustainability projects (Annual Sustainability Report, 2020). The reason for choosing Company A is that it is a large food company that has many production factories around the world, whereas put in place many sustainable activities and invests in green applications and technologies such as renewable energies, wastewater treatments, reduction in CO2 emissions. These applications were very significant for the case study and were provided meaningful insights into the subject.

The other important motive was company's vision and strategies regarding sustainability and sustainability development. Sustainability is the part of the company's business and a way of working that they try to professionalize and structure (interviewee 2, 2021). In addition, the company's sustainability strategies are based on a circle that comes out several principles and six sustainability pillars; these are planet, responsible sourcing, healthy and quality products, heritage, people, and communities (interviewee 2, 2021). Company B views sustainability as the way of converting growing economic, environmental, social, and cultural challenges into opportunities, also it is integrated into their business and decision-making processes and embedded in their corporate strategy (Annual Sustainability Report, 2020, p.11). Moreover, the company has several commitments and objectives for environmental sustainability, such as reducing its environmental footprint, water consumption, waste generation, saving energy, and becoming carbon neutral in operation. In line with this, the Chairman of the Board of Directors and CEO of Company B state that:

> "*Our commitments to you and to future generations" are getting more and more integrated in the way we do things at Company B. Our social and environmental responsibilities are embedded into our entire value chain, going from the sourcing of raw materials up to the use of our products by consumers. We feel that as a responsible food company it is important to deliver a life changing social contribution in all locations in which we operate*" (Annual Sustainability Report, 2020, p.5).

The company has already achieved some of its objectives in 2020, such as being awarded a Grade B for reporting to CDP[2] Climate, being awarded a Grade B for its first reporting to CDP Water, and %67 of electricity used from renewable sources (Company B, 2021). On the other hand, the company has reduced CO2 emissions by %24 globally and has invested in 13 energy efficiency projects (Company B, 2021). However, the company can progress its green practices and achieve further reductions in water use, CO2 emissions, electricity, and food waste. In 2020, the company was used 1.8 million liters of water, and the gross emission was equivalent to 111,000 tonnes of carbon (CO2) emissions (Company B, 2021), so the company can still make investments to reduce them.

5.1.3. Company C

Company C is the leading European large food group that was established in 1899 in Izegem, Belgium (Company C, 2021). In addition, it is a family food company that operates in bakery products and margarine, culinary oils & fats business segments (Sustainability Report, 2020), and headquartered in Ghent, Belgium. Bakery products contain bread, pastry, sweet treats, Italian savory, and pastry (Company C, 2021). The company has 31 manufacturing factories in Europe, also exports to 95 countries worldwide, also operates in 12 European countries and the US (Sustainability Report, 2020, p.10). Moreover, it produces and sells high-quality food products, and has many brands, so in 2020 had a turnover of around 1.2. billion euros and 4,500 employees (Company C, 2021). The most important reason to choose this company was that it is a large food company that is aware of its environmental footprint, and it aims to achieve sustainability in its businesses and supply chains for many years. The operational excellence manager of Company C was stated that "*our company old and big, we are one the leading company in the food sector, who also push in the sustainability transformation*" (interviewee 4, 2021). Interviewee 4 (2021) also pointed out that "*the relation with sustainability is a big deal because sustainability is the main tool to differentiate from other companies. Thus, we try to be the leading role*".

The company's vision statement and strategies regarding sustainability are based on three main goals: balanced nutrition, protecting nature, and enhancing lives. The goal of protecting nature consists of 4 commitments which are sourcing responsibly, aiming for zero carbon

[2] CDP (Carbon Disclosure Project) is a non-profit organization that uses scoring technic to help companies, investors, cities, and states measure and manage their environmental impacts by several questionnaires on climate change, forests, and water security, and each of them has a specific scoring method (CDP, 2021).

emissions, aiming for zero food waste, and contributing to circular packaging (Sustainability Report, 2020, p.16). These commitments are very significant for this study as showing that the company aims to reduce its environmental impact and are related to the topic explored. However, the company first computed its carbon footprint in 2020 (Company C, 2021). This is the biggest problem that many companies do, they do not measure their usage of water and raw materials in production, thus causing huge amounts of waste and emissions. However, the company became a member of the Belgian Alliance for Climate Action (BACA)[3], for sustainability development and reducing carbon emissions through Science-Based targets and measurements (Company C, 2021). Besides Company A gives importance to operational efficiency and aims to achieve zero food loss and lessen their energy intensity to minimize their carbon footprint (Sustainability Report, 2020, p.10). For instance, the company uses 100% renewable electricity in its production facilities and offices (*Ibid*, 2020). On the other hand, the company has achieved a 33% reduction of food waste in bakery products, a 12% of in margarine, culinary oils, and fats compared to 2017 (Ibid, 2020, p.9).

Company C has an equivalence of around 2 million tons of CO2 emissions per year, %4 comes from their production plants and offices, and around 96% comes from goods transport and the purchased raw materials (Sustainability Report, 2020, p.38). In addition, the company used 14% more water in 2020 than in 2015 (*Ibid*, 2020, p.41). Therefore, more reduction practices and investments should be made to tackle this. For this purpose, Company C stated that they have launched some initiatives to decrease water usage, as the automatization of cooling towers and investments in new cleaning techniques and utensils (*Ibid*, 2020, p.41).

Interviewee 4 (2021) described the role of food companies in sustainability as: "*we aim to produce more sustainable products. The mission of our company is to shape a tasty future sustainable for a few years. That means that less fat, less sugar, better packaging, zero-emission as well as a sustainable relationship with peopl*e".

5.1.4. Company D

Company D is the largest dairy cooperative that was established in 2004 and was started first time in 1906 in Belgium (Company D, 2021). In addition, the company collects milk from their farms and processes it to dairy products such as consumer cheese, ingredient cheese, milk

[3] BACA is a community of Belgian organizations and is an initiative founded by The Shift and WWF Belgium, to help companies, both for-profit and non-profit, to reduce their environmental footprint in line with the Paris Agreement by science-based targets (BACA, 2021).

powder, ice cream, butter, cream, and whey, on the other hand, commercializes the milk of approximately 2.000 dairy farms (*Ibid*, 2021). The company operates in 3 business divisions which are Dairy Product & Ingredients (DPI), Consumer Products & Services (CPS), and Ice Cream (Ysco). DPI contain cheese ingredients, milk powder, butterfat, and whey, these are sold to over 100 countries (*Ibid*, 2021). CPS is the core segment of the company as it includes several leading brands, a wide range of cheeses and is also responsible for the processing, production, and commercialization of milk and dairy products (*Ibid*, 2021). Moreover, it is responsible for slicing, packaging, and distribution to the domestic market and abroad, also processes over 300 million liters of milk per year (*Ibid*, 2021). The ice cream segment is an independent subsidiary of Company D that was founded in 1949, and two plants produce over 180 million liters of ice cream per year, also the factory in Langemark is the largest ice cream factory in the Benelux region since it is responsible for 120 million liters (*Ibid*, 2021). This business unit contains scooping ice cream, cones, jumbos, sticks, cakes, cups. The fact that the company has a large production and processing facility has a significant role in reducing its negative impact on the environment such as reducing water usage, CO2 emissions, and ensuring resource efficiency.

Besides, the largest cooperative company has 2.000 employees, 2.400 local dairy farmers, 5 facilities in Belgium, and 1 site in France. The company processed 1,7 billion liters of milk in 2019 and earned 1,26-billion-euro turnover in 2020 (Presentation, 2021). The company has a strong position in the dairy market, as has a strong portfolio of branded cheeses, 2 private label (Interviewee 5, 2021), 2 modern factories in Belgium and France, has over €1 billion euros of revenues from exports, around 17% of its sales are outside of Europe, and the third-largest ingredient mozzarella producer (Presentation, 2021).

The company's sustainability vision is based on 4 pillars, these are **socio-economic**, **climate and environment**, **animal welfare**, and **health & nutrition** (Interviewee 5, 2021). The socio-economic role refers to ensuring the income to farmers and their families, and employees (Company D, 2021), also working closely together all along the chain to assure a sustainable future for the dairy industry in Belgium (Interviewee 5, 2021). In addition, respect for their cows, dairy farmers, employees, customers, and consumers is the fundamental socio-economic value of Company D (Presentation, 2021). On the other hand, interviewee 5 (2021) was specified that their roles for their farmers as a dairy cooperative in sustainability consist of 4 roles, which are transaction, governance, shareholdership, and purpose. They have also a proactive role in climate and environment that are the most relevant and important for this study,

in fact, they make efforts along the chain; in dairy farms, transport, and milk processing (Presentation, 2021). For instance, in their dairy farms, they produce 91% of their roughage, 77% of their dairy farmers recycle by-products from the food industry, use 62% alternative water sources, and produce %40 of their sustainable energy (Presentation, 2021). In production, they also achieved many efforts such as they have reduced energy usage by %26 per 1000L of milk in 5 years, have recycled %56 of water out of total water usage in 2018, and have decreased water consumption by %29 in 5 years (*Ibid*, 2021).

Moreover, the sustainability topic is very high on the agenda within the company, also the company has several commitments for the UN SDGs (Interviewee 5, 2021). In this regard, interviewee 5 (2021) stated that, "*as the cooperative business model puts an intrinsically strong focus on the long-term perspective, it is obvious that particular attention is paid at all levels of Company D to the integration of sustainability initiatives*". Their sustainability initiatives are designed to achieve the 17 SDGs as determined by the UN and are based on the 'Five Ps' which are **Peace**, **People**, **Planet**, **Prosperity**, and **Partnership** (Interviewee 5, 2021).

5.1.5. Platform

This case represents an innovation platform for the Flemish agri-food industry (Platform, 2021), and a spearhead cluster that tries to work with companies, governments, research institutions to stimulate and help companies in innovation in the agri-food business (Interviewee 6, 2021). The platform tries to push companies in innovation through several projects, such as collective projects that are for the group of sectors, and company-specific projects that companies work with minimum three companies for the project, also through events, workshops to encourage food companies in some trends or technologies (Interviewee 6, 2021). That is, the platform gives so much importance to collaboration by working with other companies in the same sector. By working with their members, businesses, research institutions, organizations, universities, and federations they support food companies to develop and implement innovations in food products, production systems, new business notions and apply efficient, sustainable practices (Platform, 2021). Therefore, with these aspects, this platform was relevant to the topic researched and valuable for the thesis. Because collaboration is the core of this platform and helps companies to succeed in their goals, and in the food sector. On the other hand, the fact that companies do not know how to start and where to start to make innovations in the supply chain and implement green practices, it was meaningful to select this platform. The platform was established in 2005 by a federation for the food industry (Fevia Vlaanderen)

and has around 300 members from food companies and businesses in related sectors (Platform, 2021).

Furthermore, the platform tries to stimulate innovation by picking up the needs of the companies such as technologies, fundings, etc., things that the companies aim to investigate on a research level, that is, the platform tries to find all these needs and layout roadmap for the next ten years as a strategic roadmap, then start up to several projects that suit with this roadmap (Interviewee 6, 2021). Therefore, the platform has a big role for companies to implement more efficient supply chain processes and reduce their negative environmental impacts by these roadmaps.

The most important reason for choosing this platform was the "world-class food production" program, which is very relevant to the research topic, and the roadmaps in this program. These roadmaps are **food safety**, **towards the food factory of the future**, **food packaging of the future**, and **eco-production** (Platform, 2021). Since the research topic was specific and concerning green manufacturing practices, I focused on the eco-production roadmap. However, the platform has another interesting roadmap to use more plant-based resources, called "**New and Shifting Resources**" (Interviewee 6, 2021). The platform has not a clear vision regarding sustainability. However, interviewee 6 (2021) stated that they talk about more and more SDGs inside the platform, and for them, sustainability is on different levels, such as economic level, planet level, also social level, thus, they try to keep a balance between these three aspects, and it depends on different projects.

5.2.Green Manufacturing Practices

Green manufacturing specifically includes waste management such as food and water waste, waste recycling and reuse of in other processes or products, waste reduction, as well as the reduction and effective management of the use of natural resources. Green manufacturing activities have started to gain importance due to the significant problems we face such as climate changes, global warming, environmental pollution, natural resource scarcity, and GHG emissions. In addition, with the growing population and the increase in production, these problems are on the rise, and they cannot be avoided, and companies do not or cannot take the necessary preventions. The biggest responsible for these problems is the production and processing stages of food companies. Because at these stages, food companies create a lot of waste, such as water waste, food waste, due to many reasons and mistakes. They also consume

tons of water, energy, and other natural resources. The impact of the manufacturing process on the environment is directly related to the use of energy, the consumption of resources and the generation of waste during the process of transforming raw materials into the final products (Rahman, Nezakati, Ho, & Ong, 2016, p. 2). For instance, Company A, a large food company, stated that they created 113 million tons of greenhouse gas emissions (CO2e) in 2018, and 7.0 million tons of CO2e came from production (Net Zero Roadmap, 2021, p.4).

In the analysis part of the research, how companies implement green manufacturing activities to prevent or reduce environmental problems, if they cannot, the reasons and their implementations barriers, and the companies that achieved to implement, how did they overcome these obstacles are analyzed for each case. On the other hand, the practical implications of green manufacturing were examined. In addition, the results that companies were obtained through green manufacturing practices were analyzed by the comparison method. Thus, common, and different points were presented. The main reason that green production activities are not implemented is the lack of adequate and advanced technologies, and the necessity for more investment. In line with this Hellstern et al. (2021) claim that "*new technologies represent a critical part of the world's decarbonization tool kit—and the world does not yet have all the technologies that it would need to solve the net-zero equation by balancing sources and sinks of greenhouse-gas (GHG) emissions*" (Hellstern, Henderson, Kane, & Rogers, 2021, p. 2). For that reason, companies have difficulties or avoid applying them. On the other hand, some companies stated that they do not have sufficient knowledge and equipment. However, large companies achieved some of their environmental goals as they have sustainability departments and income to invest in such practices. However, there are still many barriers that they face in these applications. In this regard, Company A stated that "*we need action from governments and regulators to create clear and fair rules for companies to make progress*" (Net Zero Roadmap, 2021, p.3).

5.2.1. Waste Management

Green manufacturing includes also minimizing environmental impact by reducing the liquid and solid wastes, pollution, and toxic substances generated during production and processing (Rehman & Shrivastava, 2013). Waste management is a very important issue for the food industry because food companies generate large amounts of water and food waste during processing, causing significant environmental problems. Therefore, the reduction and prevention of these wastes should be the main goal of food companies. However, just some of

the companies set measurements, reuse, and recycle their wastes. Besides, waste prevention in food packaging is also an important concept in the food industry and has many applications for waste management and for circularity (Wandosell, Meroño , Alcayde , & Baños , 2021). Company A stated that in 2020, they have achieved zero waste disposal in their 368 sites, which means %95 of their factories reached zero waste through reducing inefficiencies, as well as 88% by weight of their packaging is reusable or recyclable (Creating Shared Value, 2020). Although it is a very good method to completely remove the waste of the manufacturing processes, that is, to reach zero waste, however, it is currently not possible to implement it in practice due to technological insufficiency, therefore, companies must give priority and make efforts to reduce, recycle, and reuse (Fratila, 2013). Company A stated that "*transforming how we make, use, reuse, and recycle our packaging can play an important role in our journey to net-zero*" (Net-zero Roadmap, 2021, p. 24). Moreover, they invest in research and development to find an alternative solution for their packaging (Interviewee 1, 2021).

On the other hand, Company B mentioned that it is a very common wasting issue for them besides water and food waste, and they try to focus on not wasting packaging and try to recycle (Interviewee 3, 2021). In addition, they are trying to reduce waste to do their business well, as it affects their costs as well as protects the environment (Interviewee 2, 2021). However, Company C does it by improving the way they source their ingredients, by trying to reduce their carbon emissions to zero, by prohibiting food waste, and by focusing on circular packaging to minimize the use of single plastics (Sustainability Report, 2020).

5.2.1.1. Food Waste

One of the most encountered and important problems in food manufacturing is food loss and waste. It occurs in every stage of the food supply chain, from the farmer to the supermarket (Interviewee 6, 2021). There are various reasons these are bad weather conditions or climate change, processing issues, bad production planning, and confusion about expiration dates (Company C's Sustainability Report, 2020). As well as each company acts differently to prevent this issue. Some companies are not even aware of their losses, that is, they do not even know how much they use and how much output they have. Food wastes of companies not only pollute the environment and create emissions, but also increase hunger and decrease raw material availability. Company A expresses that food loss and waste are responsible for around 8% of all global GHG emissions (Creating Shared Value, 2020). Therefore, the company

believes that when it tackles food loss and the waste problems it also acts against climate change (*Ibid*, 2020).

When I asked the reasons for the food losses, it revealed that most of the companies face the same problems. These are quality and forecasting of production volume, and it occurs in every stage from raw material to the final product. In line with this, Lawson stated that due to a lack of forecasting, many manufacturers are incapable to define the right number of raw materials required for production, therefore, a significant amount of food is wasted (Jachec, 2019). While Company B focuses on food waste, they first look at the cause and problem of the waste (Interviewee 2, 2021). Interviewee 3 (2021) states that food waste is a part of operations and there are production errors. He added that with some of the ingredients they have created, if it is not a good quality that comes up, then food waste or ingredients must be managed because this product will be a waste, and it will affect financially the money that they spend on the products. Therefore, their objective is, not to make any difference for the formula or elements that need to be changed (Interviewee 3, 2021).

On the other hand, Company C has food losses due to the quality and cleaning process during the transition from one product to another (Interviewee 4, 2021). Because it is necessary to clean the machines in order not to contaminate the product while passing from one product to another, and in this process, the machines continue to work. That's why these losses occur in every food manufacturing process. Despite this, the company uses "Kg" as a KPI to better understand the food loss quantity, they do not use "percentage", also they calculate immediately during processing. In this way, they can always follow the process, and by this calculation, if there are some products losses, they can see it and act immediately (Interviewee 4, 2021). This production operator is called "mass-balance" and shows the waste (in kg) (Presentation shared by Interviewee 4, 2021). To reduce these food losses, e.g., if there is 300 kg of waste in the cleaning process the company reuses some of this amount in another product (Interviewee 4, 2021).

Although companies cannot eliminate food losses and wastes in manufacturing, they reduce and reuse them for other purposes with various methods. Company D (2021) reuse their waste materials and by-products as much as possible by using them for animal feed, recycling, and energy production. Moreover, it makes continuous improvements in its production processes to reduce raw material and resource use. Interviewee 5 (2021) expressed that 77% of dairy farmers

recycle by-products from the food industry and use them for cow feed, such as grain and beet pulp. As well as they produce 91% of their roughage themselves (Interviewee 5, 2021).

Furthermore, another important reason for food wastes is inefficiencies in production. Company C, for instance, has improved the quality of its products by making its baguettes just the right size to fit in a box to ensure efficiency and reduce waste (Sustainability Report, 2020). Interviewee 4 (2021) stated that they work on big data analysis and apply it to optimize change over programs, thus, they use this data to see whether they overproduce some products or not, if a product is overproduced, then they start to reduce its production. In 2020, the company achieved a food loss reduction of 33% in bakery products (BP) and 12% in margarines, culinary oils, and fats (MCOF) compared to 2017 (Sustainability Report, 2020). The company also has a management system called Kaizen Events to prevent food waste, so it's a multiple-day workshop where they measure and discuss waste at the operational level and try to find solutions on sustainability (Interviewee 4, 2021).

However, in the food industry, there are barriers such as cost-benefit balance for the food waste projects, because small companies have small batches of products, they don't have tons of products to process as large companies (Interviewee 6, 2021). Therefore, it will be difficult to make a cost-benefit balance, invest in food waste projects, as well as, finding the right technology to make a good product out of it due to the quality requirements of the product will be difficult to make (Interviewee 6, 2021). In other words, the financial part is always a barrier for the companies, especially for the small companies.

5.2.1.2. Water Waste

Water scarcity is a serious threat to companies in the food and beverage industry, but water conservation technics can limit their water footprint and enable them to operate more efficiently (Harveston, 2019). The other most important waste is the water waste caused by the food and beverage industries. The fact that water is a fundamental element of manufacturing and is requisite for every stage, the food companies use tons of water, e.g., washing, boiling, evaporation, extraction, filtration, and cleaning processes (CIAA , 2007). Wastewater treatment consists of three stages these are: reducing the amount of water waste by efficient processing method, improving the wastewater quality by state-of-the-art water treatment, and by optimizing the **re-use, recycling, and recovery of water waste** by complying with EU hygiene requirements (*Ibid*, 2007). However, in practice, these methods are very difficult to implement,

and many food companies do not know how to do it and with which technologies. In addition, since the purpose of food companies is only to produce food, they do not know about such applications, and they do not have sufficient technologies and equipment to do it (Interviewee 6, 2021). On the other hand, although they know how much water goes in and how much water comes out, they have no idea what to do when they don't have water, in other words, they don't know the water risks (Interviewee 6, 2021). Interviewer 6 (2021) stated that the water situation in Belgium is bad, and it is one of the driest countries in Europe, but companies do not know what priorities are about water scarcity, their emergency plans, and what they should do in case of water shortage. According to the Flemish Innovation Platform (2021), Belgium is one of the countries in the world that is at risk of serious water scarcity. The Platform (2021) also states that the major reasons for these are the high population density, large water consumption in the agriculture industry, and the huge increase in hard surface coating.

The companies I interviewed stated that they work with other water companies that are experts in this field to get help and implement these applications. Besides, companies need to measure the water they use to reduce massive usages, whereas most companies do not have measurement systems. However, Company C is investing in meters to measure water usage (Interviewee 4, 2021). Interviewee 4 (2021) stated that to find out the causes of water waste, they need to know exactly where the water is going, and this is to learn where the wastewater problems happen and to optimize it.

In this context, the Flemish Innovation Platform has launched a project called **“SmartWaterUse”** for companies to map their water risks and thus get an overview of water risks (Interviewee 6, 2021). The aim of this project is to map and tackle the water risks, looking for solutions in the (sea) food, aquaculture, textiles, and tourism sectors, and help smart use of water (Platform, 2021). This project can be very beneficial for companies to reduce their water risks. Because the project includes a tool which is called the **"Barometer"** that Vito developed, and this tool provides companies detailed insights into their water management (Interviewee 6, 2021), presents visually related costs, and a map shows the presence of alternative water sources in the vicinity (Platform, 2021). In addition, the companies can do simulations with the Barometer tool by filling in their details about where their waters come from (Interviewee 6, 2021), then they visualize their water balance with water flows and related costs (Vito, 2021). Moreover, based on the visualization the company gets a score (some indication that shows the risk of the resource), then proposes some measurements, that is, the companies can see

immediately the measure that is more interesting for them and to invest in (Interviewee 6, 2021). The company receives a better score with this tool after measurements are applied, so the company will be able to reduce its water risks (Platform, 2021).

There are various practices to reduce water usage and purify wastewater. Company B looks and checks the water once a day whether there is a problem or not, and they create a **water pool** for animals (Interviewee 2, 2021). Interviewee 3 (2021) stated that they have a clear vision internally for water risk, which is to use as little water as possible to reduce the water and ensure that safe water discharge. As external actions, their vision is, encourage others to improve water performance and support public water governance (Interviewee 2, 2021). Company B cleans the wastes in the discharge water after passing the wastewater through the filter, uses some of them in production, recycles some of them, and creates a water tank for the fish which is also called a **biological indicator**. The company can reduce huge amounts of water by using advanced technology (Interviewee 3, 2021). However, companies use a lot of water even if they purify their water, so it would be more profitable for them to reduce the rate or amount of water use, or use the purified water as much as possible, they will also contribute to the reduction of water scarcity and ensure circularity. In this regard, Company B finished a project to reuse treated wastewater as an alternative source of water supply in one of the biggest factories in Belgium in 2020. In this investment, they expect to reduce %20 of the factory's (in Andenne) water use, thus the company is expected to reduce its total water use by 4-5% (Annual Sustainability Report, 2020). The company states that the rainwater is necessary for recycling, and the rainwater harvesting system ensures the availability of fresh water (Interviewee 3, 2021). On the other hand, the source that they use for rainwater harvesting reduces carbon emissions (*Ibid*, 2021). The company believes that this application is an opportunity to reduce their carbon emission, water consumption, and generation of waste, and it has clear objectives as become CO2 neutral by 2025 and water balanced by 2030 (Annual sustainability report, 2020). Company B states that half of its wastewater is treated at urban wastewater treatment plants, and the other half is treated at its own treatment plants before being discharged into streams (Annual Sustainability Report, 2020). However, the company consumed same amount of water comparing last year which is 1.8 million cubic meters of water equivalent of 720 Olympic swimming pools (*Ibid*, 2020).

Besides that, Company C mentioned that they have a lot of water waste and use a lot of water in their production process, thus, they cooperate with other companies in this water

cleaning process to find solutions and reduce it (Interviewee 4, 2021). In addition, Interviewee 4 (2021) explained that the company re-use condenses which means water steam, also expressed that air cleaning also import to produce e-free products, otherwise create molds. They also have a type of machine learning and artificial intelligence (AI) that helps them optimize production planning (Interviewee 4, 2021).

On the other hand, Company D has also achieved some initiatives in their dairy farms and production. For instance, the company claims that all its facilities use wastewater treatment plants and claim that 56% of their total water consumption at their plants is recycled wastewater of drinking water quality (e.g., for equipment cleaning) (Company D, 2021). In addition, their most of dairy farmers use alternative water sources such as harvested rainwater, as well as they reuse water through water treatment and through reed beds (*Ibid*, 2021). Moreover, in its factories, the total water consumption is reduced, and more than half of water use is recycled, also all their factories have wastewater treatment plants (*Ibid*, 2021). Besides, the company states that its plants in Langemark and Moorslede which are in drought-prone regions, for environmental purposes reduces entire water use and salt levels in wastewater (*Ibid*, 2021). The company has also achieved some reductions in the production stage. For instance, water recycling accounted for 56% of their total water consumption in 2018, and they reduced their total water consumption by 29% and increased water reuse by 40% in 5 years (*Ibid*, 2021).

However, many companies still cannot find alternative sources and reduce them further. A VOKA survey claims that *%80 of companies cannot change to an alternative water source* (Vito, 2021), on the other hand, the Innovation Platform (2021) stated that 81% of companies cannot take preventative measures to decrease water consumption temporarily and significantly at short notice. Flemish Innovation Platform works on two projects that are very interesting and beneficial for these companies to help reduce and reuse their water. **Sucr'eau** which is the project that focuses on reusing and valorizing by-products while blanching water in the potato industry by reusing the hot water (Platform, 2021), so the main idea is to remove starches out to purify water and then reuse the water to save water and energy (Interviewee 6, 2021). The other project which is called **RepEat**, and a collaborative project that focuses on providing an innovative solution for the application of water recycling technology for wastewater and processing water, also tackle challenges the application of reverse osmosis (Platform, 2021).

5.2.2. Resource Management

The green manufacturing requires the minimum use of natural resources and less pollute the environment. Therefore, alternative sources or renewable sources should be preferred in production. However, this is not easy to implement in practice as requires high investments in renewable resources. Since, alternative energies and renewable energies require high investment, most companies face barriers in implementing these technologies. Amemba et al. (2013) state that companies can use solar energy, recycle raw materials, and use biodegradable energy sources in their manufacturing to effectively implement green manufacturing practices (Amemba, Nyaboke, Osoro, & Mburu, 2013).

Since Company A is a large food company, so their manufacturing emissions are also significantly high. Company A stated that their manufacturing is responsible for around %7 of all 2018 emissions (Net Zero Roadmap, 2021). In this regard, Company A claims that cutting emissions start with energy efficiency and continues with less energy-intensive processes (Net Zero Roadmap, 2021). The company gathered 34.5% of its electricity from renewable sources in 2018, and they aim to reach %100 use of renewable electricity by 2025 (*Ibid*, 2021). The company had 7 million tonnes of CO2e emissions in manufacturing, in 2018 (Net Zero Roadmap, 2021, p. 28). On the other hand, the company created 34.2 million tonnes of CO2e in 2018 in its dairy and livestock supply chains by sourcing its ingredients (*Ibid*, 2021, p.9). Most of the firm's GHG emissions come from the supply chain, so it focuses on there the most (*Ibid*, 2021). In addition, in 2018, they created approximately 94.8%, in other words, 107.3 million tons of CO2 emissions in both the upstream and downstream value chains, e.g., the supply and use of the products sold (*Ibid*, 2021, p. 6). Therefore, efficient use of resources is very important to reduce carbon emissions. The Company A stated that they make a huge effort to ensure efficiency in their operations, they aim to achieve it through renewable sources for energy needs and through increasing the renewable electricity they use (*Ibid*, 2021). In addition, the firm aims to work with suppliers to increase the availability of renewable thermal energy produced from sources such as biogas and biomass by 2030 (*Ibid*, 2021). The company aims to reduce manufacturing emissions by %20 by 2025 (Ibid, 2021). However, using these renewable energies will be very difficult for small companies as they are very costly, and their primary goal is to grow.

In this context, Company B aims to optimize its energy use in the most efficient way possible by researching the potential of baking bread through microwave technology and ohmic

heating (Annual Sustainability Report, 2020). In addition, the company aims to investigate how to re-use the by-products that they compose such as straw, chaff, and bran to eliminate waste and ensure a circular economy by continuous resource use (*Ibid*, 2020). So, each company has a different strategy and objective regarding resource efficiency according to their businesses. Moreover, Company B focuses on being carbon-neutral in manufacturing through 3 phases, in 2025. The first is to ensure energy efficiency through reducing, improving, and recovering. They start it by measuring their usage to identify potential savings in different aspects, the second is using renewable energy which is the aim is to gather all energies from renewable, then the last stage is carbon compensation (Interviewee 3, 2021). In addition, the company produces its renewable energy, e.g., produced 17% of its total electricity usage from on-site renewable energy, and saved 29 GWh/y, 6,500 t CO2/Y, 1,300 K €/Y (Interviewee 3, 2021).

Company B gives a lot of importance to green manufacturing practices. Interviewee 3 (2021) stated that they are purchasing green electricity such as they will be source 100% renewable electricity by 2023, %70 of companies 2020 electricity use is from a renewable source, purchased %100 renewable electricity in 7 countries, in 16 factories, 100 GWh from renewable to save 28000 tCO2 emissions. Their electricity sources are wind, solar, hydro, and geothermal. However, Interviewee 3 (2021) mentioned that "*producing energy is a difficult task, and we are a food company, not an energy company, we think first where we can make a big impact significantly"*.

Besides, Company C has a solar panel, LED-lightening, and investigation for solar panels (Interviewee 4, 2021). However, the company has no other alternatives for reducing carbon emissions (*Ibid*, 2021). Also, they give training to their drivers to learn about CO2 and have knowledge about economical driving in their transport system (*Ibid*, 2021). On the other hand, the company stated that all its energy in its production sites and offices comes from 100% renewable electricity (Sustainability Report, 2020). In addition, they aim to establish an optimal balance between conservation and sustainable packaging to ensure a circular economy, minimize waste, and protect natural resources, also they maintain materials in the cycle for as long as possible (*Ibid*, 2020). In this regard, Company D provides improvements in production processes to reduce the use of resources and raw materials, by reusing waste materials and by-products for animal feed, recycling, and energy production. Thus, the company produces 40% of its own electricity on their farms, and they have reduced their energy use by 26% in 5 years (Company D, 2021).

In addition, many applications were made by companies regarding the efficient use of water. Regarding water efficiency, Company A installed **"Aquassay"** technology at their factory in 2019 to monitor water from the source to discharge, in this way company wants to use water efficiently (Creating Shared Value and Sustainability Report, 2020). Since 2010, the company reduced direct water withdrawals per tonne of product by 32% through robust water management in Ontario and California plants, and thanks to this, the company received first-time platinum-level Alliance for Water Stewardship certification (*Ibid*, 2020). Company A collaborated with its stakeholders in the Spanish tomato supply chain to enhance water usage by installing the latest technologies such as buried irrigation, humidity sensors, and flow meters (*Ibid*, 2020). Moreover, since 2013 they reached more than 1 million m3 of water savings with their tomato suppliers, in this way Miajadas factory became the first European food factory to obtain AWS gold-level certification in 2020 (*Ibid*, 2020).

Company B stated that they invest significantly for water efficiency in their production process, and they created a system which is called the **4R** system and consists of **Reduce, Reuse, Recycle and Replace** (Interviewee 3, 2021). Interviewee 3 (2021) explained that they are doing step by step, first, they collect the **rainwater harvesting** as a source, then **water treatment** ensures improving control, the next step is a **distribution** to stop leaks, then they use for **CIP[4] cleaning optimization** cubs, afterward, using for **cooling tower control system** then **wastewater recycling**, and **reuse** which is the most difficult part. Interviewee 3 (2021) stated that this cycle diagram is very important for water efficiency and impact on internal water management. Furthermore, the company was awarded a Grade B for first reporting to CDP Water in 2020 thanks to their coordinated action on water problems (Annual Sustainability Report, 2020). In 2020, the company used 1.8 million liters of water which is 1% less than 2019, and 7% more than 2016 (Annual Sustainability Report, 2020).

On the other hand, in 2020 Company C used 14% more water than the year 2015 due to new legal requirements regarding food safety regulations, and more frequent cleaning workplaces (Sustainability Report, 2020). However, the company tackled several initiatives to reduce water usage, for instance the automatization of cooling towers, and investments in new cleaning techniques and utensils (Sustainability Report, 2020). In addition, Company D uses

[4] CIP (Clean-in-place) is a cleaning system used to prevent product contamination and maintain processing efficiency and properly clean processing equipment (CSI, 2021).

62% alternative water sources in their dairy farms, and produce 91% their own roughage (Company D, 2021).

Apart from these, companies can take more and effective measures against the water shortage we face and invest more in new technologies and techniques, it will be more practical if they create a roadmap and cooperate with their suppliers. Although some companies achieved to implement several measures, still there are a lot of barriers in the food industry to ensure resource efficiency, especially invest in renewable sources.

5.2.3. Supplier Collaboration, Evaluation and Certifications

Evaluating and monitoring the environmental performance of suppliers is crucial to the development of green practices. Green practices can be implemented through collaboration and engaging with suppliers, and suppliers should have environmental management systems, also green practices require mandating for their first suppliers. It also includes green purchasing guidelines. In addition, the certificate of companies for green practices were examined in the study. There are many barriers while working with suppliers for environmental practices, for instance, there is a lack of knowledge about lower-tier suppliers and they receive little attention from governments, and they do not have much equipment to implement green practices (Villena & Gioia, 2020). Therefore, managing lower-tier supplier sustainability is very critical to implementing green practices. Collaboration with suppliers allows technological and environmental developments in the supply chain and manufacturing practices.

Company A has a several commitments to engage proactively with their suppliers on climate change. For instance, they have achieved the commitment of promoting transparency and long-term engagement in climate policy (Net Zero Roadmap, 2021). The other commitment is to work with their raw material suppliers and the other fundamental stakeholders to address GHG emissions through promoting regenerative agriculture practices to support biodiversity (Net Zero Roadmap, 2021). In addition, the company seeks to collaborate with agricultural suppliers and local communities to invest in water-saving technologies that deliver both environmental and social benefits (*Ibid*, 2021). However, Company A could not meet its objective of generating more than 80% of total spending and volume sourcing from audited and compliant suppliers for the first-tier suppliers, by 2020 (*Ibid*, 2021). The company aims to work with suppliers so that renewable thermal energy produced from sources such as biogas and biomass can be used by 2030 (*Ibid*, 2021). However, the firm could not achieve to meet its goal of sourcing from audited and compliant suppliers. Indeed, in 2020 they worked on an auditing

program, changed the calculation method and scope of the audits, which is based on the site compliance rather than spending and volume percentages, by focusing on the higher risk and key suppliers (*Ibid*, 2021). Consequently, the scope and key performance indicators of their program have developed, causing this objective not to be met for 2020 (*Ibid*, 2021). On the other hand, the company mentioned that they use various tools as supply chain mapping, certification, on-the-ground assessments, and satellite technologies to frequently monitor their supply chains e.g., deforestation practices (*Ibid*, 2021). However, the company mentioned that they should increase more in their collaborative practices to increase to make a significant impact (*Ibid*, 2021).

Company B has guidelines to address environmental issues as ISO 14001 (Interviewee 3, 2021). In addition, the company has some certificates that they use, however, the Interviewee 2 (2021) mentioned that they have there are many challenges due to most companies offering certificates that they have in the market. When the company acts for water safety, they pay attention to issues such as supporting public water governance, ensuring constant dialogue with stakeholders, encouraging others to improve water performance and promoting collective action as well as sustainable water management in river basins (Interviewee 3, 2021). The firm also encourages its suppliers to meet green supply chain requirements, such as reducing the water stress faced by its operations and its suppliers' operations, and strengthening reputation and reliability, as well as to ensure a reliable supply of water (Interviewee 3, 2021). Interviewee 2 (2021) stated that they have certain policies that must follow, and when there is a problem in the supply chain, they handle the problem by asking them if they use action plans, guidelines, and rules. Besides, Interviewee 3 (2021) stated that they cooperate with suppliers to achieve environmental goals. For instance, regarding the water they use, they share the resources they create with the companies and cities they agree with, and while doing this, they come to a common issue and decision (Interviewee 3, 2021). They also offer better options by sharing their results, and they try to succeed by evaluating their shortcomings and mistakes (*Ibid*, 2021). On the other hand, they minimize their mistakes by sharing the information they search for unsuccessful results and experiments (*Ibid*, 2021). Interviewee 3 (2021) stated that they move forward by informing and training their suppliers about exactly how the raw material should be, by complying with them, they ensure that they do not make the mistakes made again. Also stated that their business has to ensure that other companies or other stakeholders use the same resource in a sustainable manner (*Ibid*, 2021).

On the other hand, Interviewee 2 mentioned that when they decide together on the resources that they produce as a company all the material they give them, they look at what they exactly

expect, and focus on the one that is long term. The company looks specific certificate and project that has rules and must be complied for green suppliers, and every year they look at how the reaction unfolds and what other parts are missing, they develop it with different projects (Interviewee 2, 2021). While choosing their suppliers they make sure that they comply with the criteria they have developed (Interviewee 3, 2021).

Company B examines the environmental performance of suppliers under the headings of Measure, Manage, Engage, and Disclose, such as water risk management, water strategy, stakeholders engagement, and water disclosure (Interviewee 3, 2021). Some of the firm's sustainable partnerships and certification programs are SEDEX, Ecovadis, Beyond Chocolate, Cocoa Forest Initiative, World Cocoa Foundation, Fedima, and Fevia (Annual Report, 2020).

However, Company C mentioned that working with kind of guidelines is difficult. On the other hand, sustainability is crucial for them and their customers, however, they think that it is also difficult to compete with other companies in the same business (Interviewee 4, 2021). Therefore, applying these kinds of governmental guidelines becomes much more complicated for them (Interviewee 4, 2021). For instance, the company stated that even if they invest in systems such as IFS, ISO, BRC, etc. the government does not help them because those are not drivers in the business (*Ibid*, 2021). Interviewee 4 (2021) stated that the financial benefit is always beyond sustainability, so even if they try to be sustainable, they must consider their financial benefits as well. For instance, they do not have carbon passports for their suppliers which shows how much energy they have used for producing the product, and where does the product come from etc. The company believes that the government should verify and do these kinds of programs to lead companies to create a green supply chain as the wastewater and water cleaning calculations and/or environmental management programs (Interviewee 4, 2021). In addition, the company collaborates with their suppliers regarding these problems even if it is difficult to do, also they collaborate with the machine builders, in which they do kind of co-development of sustainable technologies with partners. However, the company mentioned that it is more difficult with suppliers and customers (*Ibid*, 2021). In manufacturing, the company has a detection mechanism that in the process of production, through this mechanism they detect and aware of their food waste, and they can handle this loss. However, the company mentioned that this mechanism is new and expensive, it can be easier to access with a partnership. To select green suppliers, the company does audits for their suppliers and looks for sustainability parameters in which they check different criteria as sustainability, however, this criterion is not the main criterion and not the most important driver for the selection of suppliers (*Ibid*, 2021). Many companies do not consider green criteria when choosing suppliers, there are various

criteria such as quality and delivery, but sustainability and green practices are not important or main criteria. Interviewee 4 (2021) stated that they have an International Food Standards (IFS) certification in which suppliers should comply with the IFS, and there is a sustainability criterion, if a supplier does not have IFS, the company does not work together. On the other hand, the company sources raw materials such as palm oil, wheat, cocoa, and eggs to produce their products, thus they as their suppliers to sign their code of conduct. The company by providing clear traceability, allows them to monitor where raw materials come from and how they are produced (Sustainability Report, 2020, p.11).

Company D engages with their members in 4 methods, these are guaranteed milk collection, valorizing diversity through differentiation of products and milk flows, better valorization of one's own member milk via more cheese, strong functioning of their member structures, open communication, dialogue, and cooperation (Presentation, 2021). The company has certification of Integral Quality Care Milk (IKM) which addresses 136 targets (*Ibid*, 2021). Compliance with these criteria and being certified is an important requirement for the company (Company D, 2021). The company committed 100% to collaboration and connection with their dairy farmers, customers, stakeholders, and employees, this allows them to increase the strength, identity, and uniqueness of their dairy farmers (Company D, 2021). Company D has various commitments and certificates concerning sustainability. The company is an active partner in sustainability charter initiatives for more than twenty years, and the Environment Charter of the province of West Flanders was the first commitment, all their charters are audited yearly by VOKA, Flanders' Chamber of Commerce and Industry (*Ibid*, 2021). This year, all its offices and factories were awarded the Sustainable Entrepreneurship Declaration, which is issued every year (*Ibid*, 2021). Company D has several certificates in their dairy farmers and many product categories. For instance, farms have IKM and sustainability monitor, CPS has Voka Charter Sustainable Entrepreneurship, Unitar SDG pioneer, DPI has Voka Charter Sustainable Entrepreneurship, Unitar SDG pioneer, SMETA and EcoVadis, YSCO has Voka Charter Sustainable Entrepreneurship, Unitar SDG pioneer, SMETA, and EcoVadis (*Ibid*, 2021). Furthermore, the company obtained the silver medal for DPI and Ysco, therefore it became one of the 25% best scoring companies in the industry (*Ibid*, 2021).

5.3.Substantial Benefits of Implementing GM Practices

Green manufacturing has numerous benefits as contributing to food loss and waste reduction, reducing water risk and waste, GHG emissions, and pollution of companies, and allowing collaboration and partnerships with suppliers, customers, and stakeholders, on the

other hand, it allows companies to obtain several certifications. In this study, it observed that the companies obtained many environmental and social benefits through green manufacturing practices as waste management, resource efficiency, supplier selection, evaluation and collaboration, and certifications. As well as they achieved economic benefits by reducing their consumption of resources, managing their wastes, etc. On the other hand, through green manufacturing practices and advanced technologies they reduced their negative environmental impacts.

For instance, Company A, since the beginning of 2020, commitment to improve water management in their upstream supply chain, the company developed long term initiatives to develop water efficiency (Creating Shared Value and Sustainability Report, 2020). Since 2013 the company achieved water savings of over 1 million m3 through collaboration with their tomato suppliers, using advanced technologies and best practices (*Ibid*, 2020). On the other hand, since 2010 the company reduced their direct water withdrawals per tonne of product by %32 (*Ibid*, 2020). The company by developing a state-of-the-art method that extracts water from processed milk could recycle recovered water into operations, thus they help reduce the pressure on water resources near several factories (*Ibid*, 2020). The company reduced food waste by giving surplus food to people in need. Thus, while providing the benefit of reducing food waste, it also provided a benefit for reducing hunger (Net Zero Roadmap, 2021). The firm's natural climate solutions such as agroforestry, silvopasture, and the restoration of forests and peatlands are the most important methods to remove CO2, helping them deliver a wide variety of co-benefits (*Ibid*, 2021).

Company B, by smart hot water grid and cogeneration technology, produced its own heat electricity in Belgium, on-site, it allowed the company to save energy, water at the same time CO2 (Interviewee 3, 2021). In addition, the company saved 750 tCO2/y and 900 k€/y, the heat was also recycled in the different heat circuits. It was a big project which led to massive savings for the company (*Ibid*, 2021). Moreover, the company Belgium gained reward a bronze Ecovadis rating in 2020, however, it developed 8 points compared to the last assessment (Annual Report, 2020). On the other hand, the company became a member of Beyond Chocolate which is a partnership that strives for sustainable Belgian chocolate in 2018 (Annual Report, 2020). Regarding resource efficiency, Company B, through recycling water and reducing energy saved huge amounts of money, at the same time they preserved the environment (Interviewee 2, 2021). In addition, Interviewee 2 (2021) stated that relation with

the supplier is also important to consider because using technology and spending money increases the benefits and revenues. Company B, by minimizing water and food waste in the recycling systems gained many benefits for the environment, also after passing the wastewater through the filter, they clean the waste in it from discharge water, through this advanced technology the company reduced large of amounts water (Interviewee 3, 2021). Interviewee 3 (2021) stated that using rainwater is very advantageous for the company as the company is exposed to rainwater and accumulates due to its geographical location, also as it is recycled to the nature, and it is positive for the planet.

Company C achieved a food loss reduction of 12% in margarines, culinary oils, and fats, and 33% in bakery products between 2017 and 2020 (Sustainability Report, 2020). Company C, by green manufacturing, gathered an economical benefit to receive less energy cost and less waste which is a direct financial benefit but also considers employee work sustainably. However, the company mentioned that it is not only cost-saving but also value creation (Interviewee 4, 2021). For instance, less packaging, less plastic is more difficult to produce, so it increases the cost, although the costs are increasing, products become more environmentally friendly and sustainable (*Ibid*, 2021). Interviewee 4 (2021) mentioned that they have machine learning and artificial intelligence (AI) tools that allowed to optimize production scheduling, and mentioned that, in the food industry using big data is very important. The company stated that through green practices they make a comparative advantage and stated that they are a kind of value driver (Interviewee 4, 2021). Besides, the company in these processes has financial savings.

Company D also gained many benefits in its dairy farms and operations by green manufacturing practices. The company's %77 of dairy farmers recycles by-products from the food industry such as spent grain and beet pulp for animal feed (Company D, 2021). Fine-tuning the components of feed rations and additives allowed them to reduce the cows' methane emissions (Company D, 2021). The company obtained the silver medal for DPI and Ysco, thus, became one of the 25% best scoring companies in the industry (*Ibid*, 2021).

5.4.Potential Solutions

According to the case study analysis, various potential solutions were found by comparing the companies' barriers, different and similar green practices, technologies, and methods. The selected case companies even if achieved many reductions and sustainability developments in

their manufacturing and implemented several technologies, they still create significant negative environmental impacts and have many barriers. Some barriers are finding the right technology, supplier integration into the green manufacturing practices, determine the cost-benefit balance, the cost of advanced technologies, law regulations, lack of employee awareness about green practices and technics, also companies' lack of knowledge regarding green practices such as how to reuse their waste and recycle them, consumers' perception about products that made by wastes, logistics, also adapt new technologies and methods in the operation. However, there are some solutions that companies can implement to reduce food loss and waste, treat wastewater, and reuse it for another production process, ensure resource efficiency and reduce emissions of productions in their supply chains. On the other hand, there are several innovative technologies, software, and methods available that food companies can implement. In this regard, Hellstern et al. (2021) state that advanced technologies are essential to stopping climate change, and the desire to develop and scale them is growing (Hellstern, Henderson, Kane, & Rogers, 2021). However, we don't yet have the technologies we'll need to decarbonize the world and solve the net-zero equation by balancing resources and greenhouse gas (GHG) emissions (*Ibid*, 2021).

Some solutions analyzed for water treatment and reuse of wastewater, reducing food waste, supplier integration and collaboration, green supplier selection, employee awareness, reducing energy use, and ensuring resource efficiency. For instance, for food waste, it analyzed that the companies are not aware of their waste and usage at the manufacturing level, therefore, the first action should be raising awareness for the issue of food waste and measuring their consumption and wastes. As long as the company is aware of its waste, it can reduce, reuse it as much as possible for animal feed, recycling, energy generation, or donation. In addition, companies can recycle by-products to create a circular economy and produce new foods with almost no waste. Therefore, companies should make investments in the right technologies to make a new product out of their waste, to do this they can collaborate or partner with technology companies or do collective food waste projects with other food companies regarding how to use food waste in certain food products. In addition, they can collaborate with food banks, research institutes and companies that specialize in food waste valorization.

Besides, the main reason for food loss is not predicting the production and supply amount, so companies can make forecasting to reduce overproduction, use KPIs and the big data analysis to understand whether they overproduce or not, this allows companies to be efficient. On the other hand, in the production process, the losses occur due to bad handling of foods and human

errors so products are thrown away, therefore companies should train their employees to reduce human errors. Other most of the food losses happen in the cleaning process during production, because while cleaning the machine the company continues to produce and foods get thrown away, therefore, companies can use more efficient technologies or systems in the cleaning stage as "Clean in Place Cycle", however companies can also reuse these wastes in the other cycle of production. Another solution can create a supply map to tackle the transport problem and to see the companies nearby, when you have a supply map and look for food products, it is a good way to see suppliers nearby and connect, also reducing transport costs. The major barrier in reducing food waste is consumer perception concerning food waste. Therefore, companies should raise awareness for consumers about issue of food wastes, and consumers also act in this point by purchasing products made from waste for the environment, therefore marketing campaigns, and communication activities with consumers should improve. Dora stated that interaction between stakeholders in the food chain is significantly important and requires the involvement of downstream actors as retailers and consumers as the big contributors to food loss and waste, also upstream actors as farmers (Jachec, 2019). New packaging solutions are also important for reducing food waste and extending product expiration dates. In addition, designing a roadmap for the next ten years can be a good solution for companies.

To reduce water waste companies can first understand, identify and map their water risk according to their factories' location. Because many companies are not aware of their water risks and how to measure their water usage and waste. Innovative technologies can be a solution for reducing water waste, such as water treatment technologies and monitoring water waste. For instance, there is technology as the Water Barometer tool that Vito developed and which is a visualization tool, gives an indication of water risks, and proposes some measurements. Companies can use such visualization tools to see the risks of water sources and ensure efficiency and cost can be reduced. Water treatment and reuse of wastewater are also important practices for efficiently using water, such as reusing hot water for the second cycle of the production process, technologies like smart hot water grid. The rainwater harvesting system can be used as an alternative water source, treated with a filtration system, and reused for another production step. For this purpose, Company A used a reverse osmosis system to purify water, and installed Aquassay technology in many factories to use water inefficient way, also various new technologies used as buried irrigation, humidity sensors, and flow meters (Creating Shared Value and Sustainability Report, 2020). They have been developed these technologies by collaboration with their suppliers and through advanced technologies. Therefore, cooperation

and partnerships with suppliers, stakeholders, and technology companies are very important in this stage. The companies can also use alternative water resources, and governments should help with clarifying water legislation, law regulations, reducing taxes and administrative works, or being strict on wastes. Companies can also use AI, data digitization, real-time insights to reduce and preserve water usage.

It is very important to use energy efficiently to reduce emissions and ensure green production, and there are various technologies to achieve this. The companies can use renewable energy sources like solar, wind, hydroelectric, geothermal, and biomass energy. Company B (2021) implemented an Electric Heat Pump system to produce hot water very efficiently through this heat energy recovered from the outdoor environment or process cooling and gained huge energy optimization. In addition, cogeneration is a very efficient technology to produce own electricity and heat, and which is called Combined Heat Power (CHP), Company B (2021) gained huge savings, reduced carbon emissions, and saved energy by this technology. The companies can install Led lighting systems in their factories to generate energy efficiency.

Moreover, Quintelier (2021) suggested a pinch analysis which is a method for reducing energy usage of processes by calculating thermodynamically possible energy targets, and by optimizing heat recovery systems, energy supply methods and process operating conditions (Quintelier, 2021). Efficient, low-cost, and sustainable technologies, sufficient storage and packaging solutions, road infrastructure and market connections, and providing training to chain members and consumers, are interventions that enhance efficiency, so, it reduces food loss and waste (Rezaei & Liu, 2017).

6. Overall Conclusion

6.1.Conclusion

The findings show that the analyzed companies produce high volumes of products as they hold leading positions in the food industry and dairy, bakery, and chocolate as sub-sectors. That means food companies cause significant negative environmental impacts even if they implement some sustainable practices. Because manufacturing process is the main contributor of food losses and wastes, water waste, GHG emissions, natural resources consumption, and pollution. Therefore, adopting sustainability in the supply chain especially green supply chain management is crucial to reduce impacts of supply chains, not only to preserve the environment

but also to improve production efficiency, reduce raw material costs, and for society. However, the findings showed that the food companies just focus on producing foods, and sustainability is not the main objective of their businesses, and cost benefit should be balanced. The major barrier is finding the right technology and its high cost. For this reason, companies stated that it is a difficult task to find the balance between technology investments and cost, that is, companies consider whether the applications are beneficial and do not implement them if they are too expensive and not advantageous. However, if companies find highly innovative technologies, companies ensure production efficiency and reduce their costs and have sustainability goals at the same time. In this regard, companies can develop sustainability in the supply chain by implementing green manufacturing practices. Because companies through green manufacturing practices strive for zero waste, minimize their impact, at the same time reduce hunger, increase health and safety. On the other hand, companies can increase their competitiveness, company image, and improve their business models by establishing green production practices and innovative technologies. The findings indicated that companies gained many benefits thanks to the green practices, which led to massive savings, at the same time, reduced their negative impacts on the environment, and contributed to the development of their sustainability goals.

The major cause of food losses are quality reasons, the cleaning process of the machines, lack of forecasting of production, supplier locations, lack of employee awareness, and inefficiencies. The findings indicate that analyzed food companies focus on several practices to reduce food loss and waste as reusing by-products, big data analysis, some measurements to prevent food losses, supply maps, and reuse waste for animal feed. However, the food supply chains in Belgium have many barriers in reducing and reusing their waste. For instance, supply amount is a barrier if companies have small batches of supply amount it will be not so beneficial, and the cost will be so high to make a new product from waste, so companies hesitate to do it. The other barrier is logistic problems due to the cost of transport every day, also transport of water. In addition, sometimes products are exported to other countries, so due to the long transport the products are damaged, and the quality of the product decreases, thus, the food goes to waste. Therefore, having a supply map would be a good solution to find food suppliers nearby, indeed, the companies that have too much of one certain food product have the same map, so have those companies nearby, and it allows companies to connect. However, improvements are still needed and invested in more efficient technologies to eliminate waste, as well as the quality of products should be improved. Because if the product does not meet the

desired quality, they throw away the food, so quality is an important criterion to reduce food waste.

Furthermore, regarding water waste, the findings show that companies are not aware of the water situation of Belgium, their water risks, and how to reduce these risks. They don't know where the priorities, and don't know what to do with their waste because they stated their main goal is to produce food. It revealed that, although they know how to purify wastewater and reuse it, they still use a lot of water in their production, and there is a lack of knowledge about reducing it. They try to find solutions to use alternative waters by cooperating with their suppliers. On the other hand, companies use some renewable energies like solar, wind, hydroelectric, geothermal, biomass energy, Combined Heat Power (CHP), cogeneration to efficiently use and generate electricity and reduce carbon emissions. However, there are also many barriers as these energies require huge investments and are difficult to apply.

Also, another major obstacle is collaborating with suppliers and integrating them into green manufacturing practices and managing lower-tier supplier sustainability. Lower-tier suppliers are not well known, not given as much attention as first-tier suppliers, and they do not use KPIs to monitor supplier sustainability. However, all actors in the supply chain, that is, upstream and downstream suppliers should be integrated into green manufacturing practices to implement it effectively. On the other hand, the lowest-tier suppliers have little equipment to meet their sustainability requirements. In addition, companies do not have strict criteria for selecting green suppliers, and there is a lack of environmental management system.

6.2.Recommendations

It is recommended that future studies focus on new systems, software, or tools such as the measurement system, visualizing the data, simulation, real-time production insights, sensor-based systems, production monitoring, and control systems to ensure production efficiency, save cost, enable them to get faster information and notified through alerts or messages in case of problems, allow them to react immediately in case of abnormalities.

One important area future research should focus on is improving collaboration among supply chain partners such as suppliers, shareholders, production managers, farmers, consumers, retailers, and logistics. It is suggested that additional studies focus on partnerships with technology companies and companies which are in the food sector. Collaboration can enable firms to overcome their production issues, find effective solutions, share information,

develop new products, create value together, share costs and resources, ensure an efficient and sustainable production process. In addition, additional research is needed for training employees about green manufacturing practices to eliminate inefficiencies and human errors in production, raising awareness on waste products for consumers, trade-offs between sustainability dimensions, and for finding the cost-benefit balance.

6.3.Implication and Limitations

This study provides valuable and in-depth insights into the topic of green supply chain management practices, specifically green manufacturing practices. These findings may help better understand the advantages of green manufacturing practices such as waste management, harvesting rainwater, wastewater treatment, food waste reduction, renewable energies, valorization of by-products, generating green energy, resource efficiency, and reducing the environmental impact of manufacturing, also how the food companies implement them. These results clearly show that food companies can earn many benefits through green manufacturing practices such as saving money, ensuring operation efficiency, improving the quality of the product, implementing innovative technologies, increasing competitiveness and profit, giving value to suppliers, customers, and consumers, reducing their negative environmental impact. This research and case studies make an important contribution to understanding barriers of implementations, defining, and prioritizing their sustainability and green production goals. This paper can be beneficial to other food companies who aim to move to a green supply chain and become efficient, proactive, innovative in manufacturing practices and ensure minimum waste, pollution, and emissions.

However, an important limitation of this study was that there were not many food production factories in Belgium, there were many small and medium-sized food companies that produce chocolate and fries, so case selection was difficult. The limited case studies and interviews did not allow to obtain more detailed and different information. With more case studies, much more information concerning green production and implementations could be gathered, thus the cases could be compared better to understand the phenomenon. In addition, this study specifically focused only on the environmental aspects of sustainability but also focused on some environmental manufacturing activities. Having a specific subject caused limitations in the search for practical information and literature review, and the knowledge of companies regarding these activities was very limited. Therefore, future research could focus on the other dimensions, trade-offs, gaps between sustainability dimensions.

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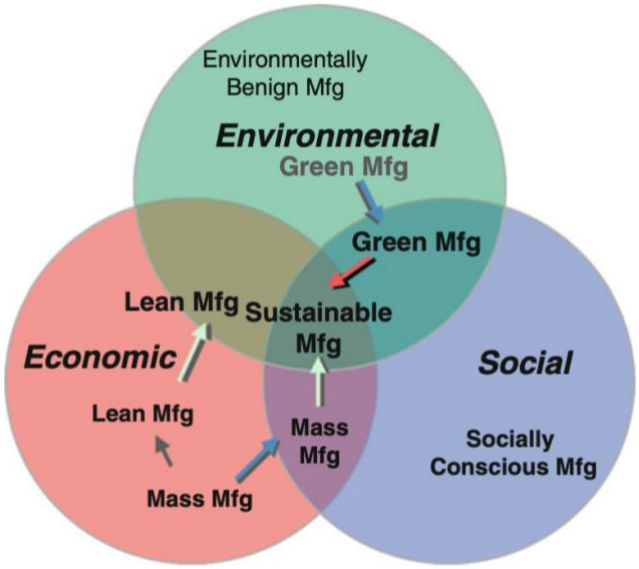
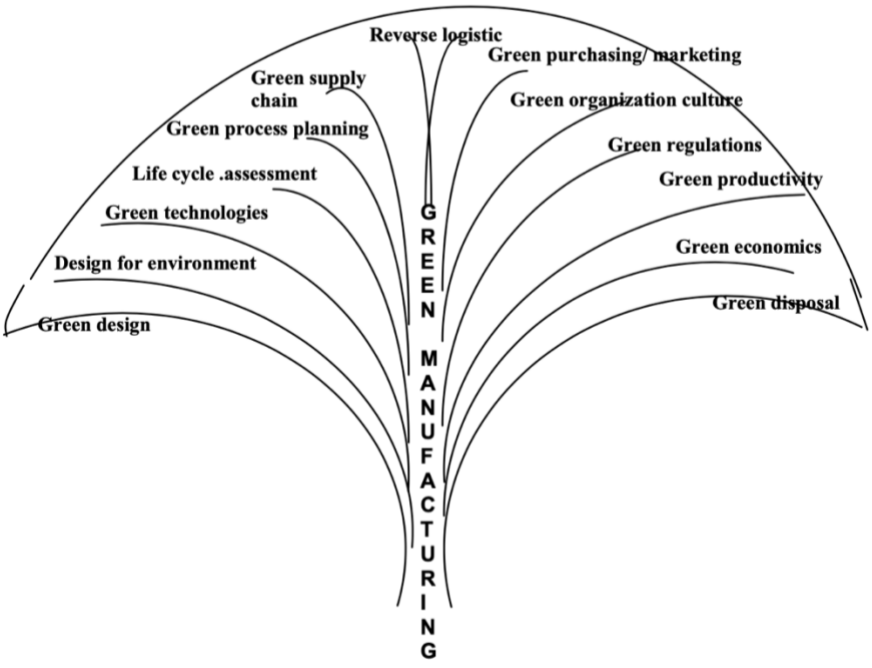
Appendixes

Appendix A: Manufacturing in relation to the three pillars of sustainability



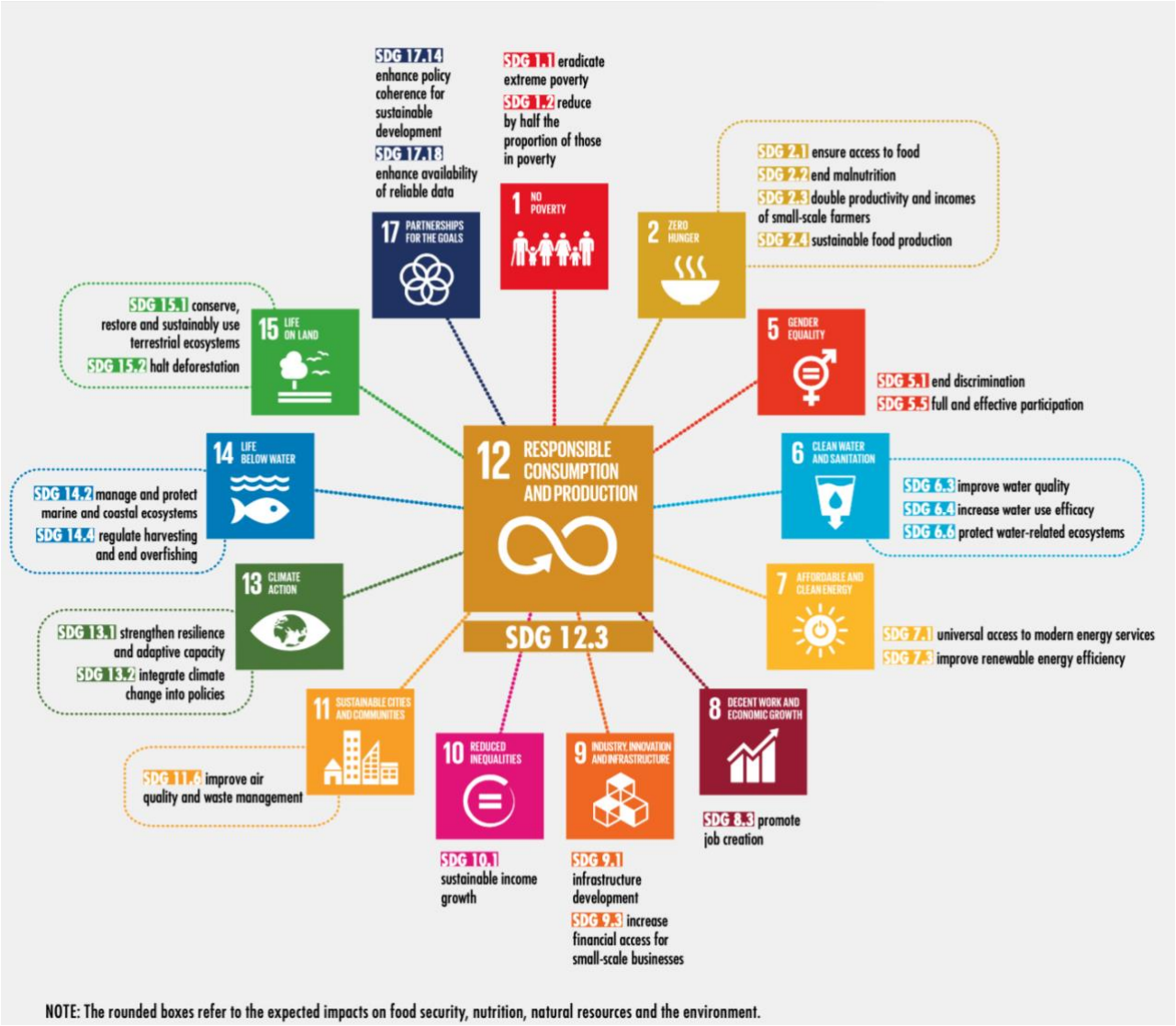
Source: (Dornfeld et al., 2013)

Appendix B: Green Manufacturing Tree



Source: (Rehman & Shrivastava, 2013)

Appendix C: The Relation of Food Loss and Waste to the SDGs



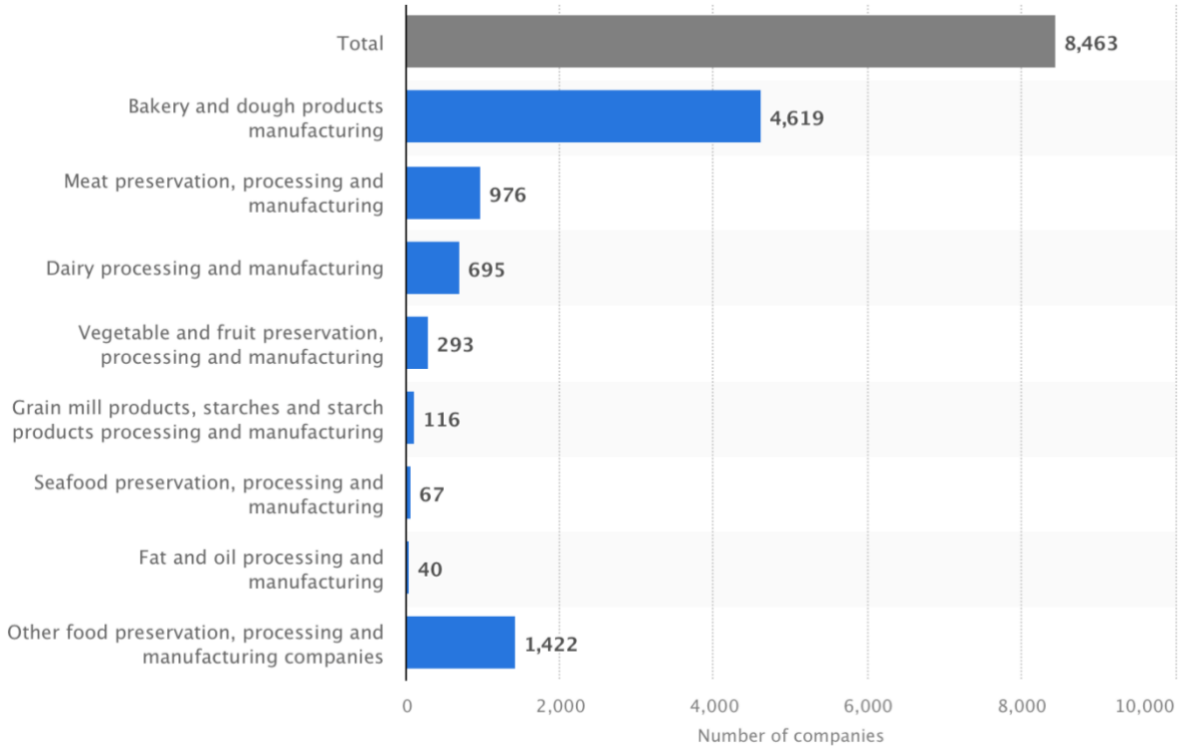
Source : (FAO, 2019)

Appendix D: Green Supply Chain Management Concepts

Authors	Concept	Definitions	Method	Method / Main findings
Carter *et al.* (1998)	Environmental purchasing	'activities that include reduction, reuse and recycling of materials'	Survey, quantitative analysis	Scale development for environmental purchasing. Middle management support and setting of departmental goals are related to the level of environmental purchasing in U.S. and German firms.
Zsidisin and Hendrick (1998)	Environmental concerns in purchasing and supply management	Several issues covering pollution, waste, recycling, unsafe finished products, hazardous materials etc.	Survey, quantitative analysis	Purchasing's involvement in environmental issues differs between countries. Purchasing managers want more authority to participate to the planning and management of environmental issues.
Bowen *et al.* (2001)	Green supply	'activities that are attempts to improve the environmental performance of purchased inputs, or of the suppliers that provide them'	Survey, quantitative analysis	Implementation of green supply is explained by development of firm's internal supply management capabilities.
Zhu and Sarkis (2006)	Green supply chain management (GSCM)	'environmental impacts occurring at all stages of a product's life cycle'	Survey, quantitative analysis	Drivers of GSCM adoption and implementation levels of GSCM in firms differ between industries.
Carter *et al.* (2000)	Environmental purchasing	'purchasing's involvement in supply chain management activities in order to facilitate recycling, reuse and resource reduction'	Survey, quantitative analysis	Environmental purchasing is positively related to firm performance.
Gold *et al.* (2009)	Sustainable supply chain management	See Bowen *et al.* (2001)	Literature review, content analysis	Inter-firm resources, capabilities and collaboration, are essential when incorporating social and environmental goals in supply chains.
Reuter *et al.* (2010)	Sustainable global supplier management (SGSM)	'joint integration of environmental and social criteria into economic supplier management process'	Multiple case study, qualitative analysis	First-mover advantages are available for those who implement SGSM process in early stage.
Walker and Brammer (2012)	Sustainable procurement	'the pursuit of sustainable development objectives through the purchasing and supply process, incorporating social, environmental and economic aspects'	Literature review, survey, quantitative analysis	Communication and use of e-procurement tools support environmental supply practices and labour, health and safety.
Giunipero *et al.* (2012)	Sustainable supply management	'the extent to which supply management incorporates environmental, social and economic value into the selection, evaluation and management of its supply base'	Delphi method, qualitative analysis	Main drivers to adopt green practices were top management initiatives and compliance laws and regulations. Main barriers were investment on green practices and economic uncertainty.
Tate *et al.* (2012)	Environmental purchasing and supplier management (EPSM)	'supplier-related environmental purchasing impacts'	Literature review, content analysis	Suppliers have remarkable impact on the firm's environmental footprint. Hence, purchasing's role in supplier selection and management is crucial when implementing green practices.

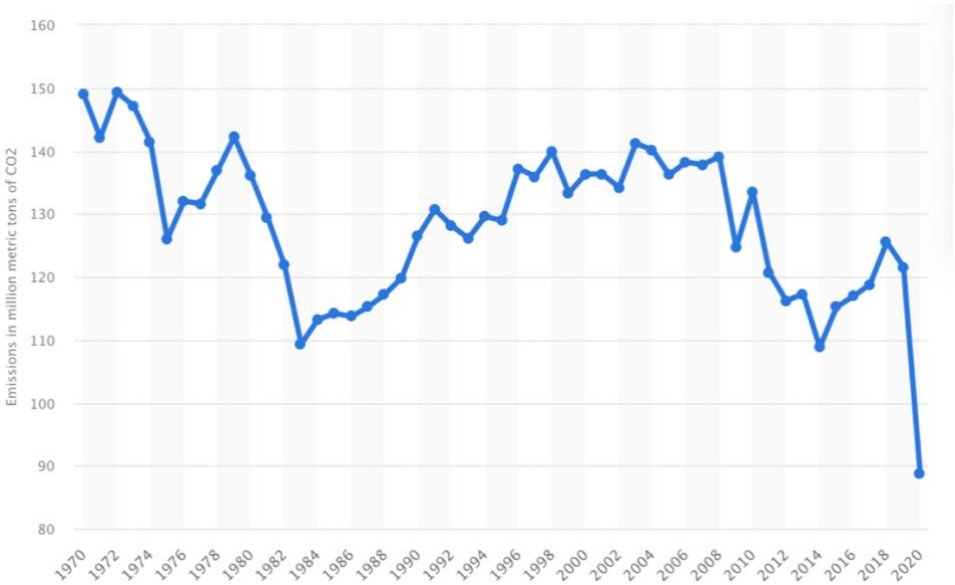
Source : (K. Lintukangas et al., 2015, p.323)

Appendix E: Number of companies in the food manufacturing industry in Belgium in 2020, by sector



Source: (Statista, 2021)

Appendix F: Annual CO2 emissions in Belgium (in million metric tons of CO2)



Source: (Statista, 2021)

Appendix G: Interview Questions

Section 1: Information about the participant

1. Can you briefly introduce yourself? (Position within the company, how long have you been working there? etc.)
2. What is your role in the organization? What does your job involve on a daily?

Section 2: Sustainability and Sustainable Development

3. How would you describe your company's relationship with sustainability? According to you what is the role of food companies in sustainability?
4. What are the company's vision and strategies regarding sustainability?
5. How do your businesses reduce their environmental impact in production? How does it affect economic and social performance?

Section 3: Green Supply Chain Management (Green Manufacturing)

1. Green Practices: Which green practices do you implement in your manufacturing? If not, why you don't use if applicable?

    a. How do you reduce food waste in production (raw material, surplus food)?
    b. What are the major reasons of food loss in production? In which stages?
    c. How do you deal with surplus food? Which methods or tools (KPI's) do you use to prevent and measure food loss? Do you use management systems as lean manufacturing, Six Sigma, ERP Software, high level, invest or other techniques to prevent food loss?
    d. How do you reduce water waste? (Wastewater treatment, recycling water, etc.)
    e. How do you measure water usage?
    f. Which green technologies do you use? Which resource management techniques do you use? How do you minimize resource consumption?
    g. How did advanced technologies impact your green practices?
    h. What concrete actions are you doing to reduce carbon emissions (in production)?
2. Alternatives: What are the alternatives? Are these alternatives more promising or more effective?

3. Best practices: What are the best successful practices that you implement? How did you succeed? Why do you think that they are successful? Could you give some examples?
4. Benefits: What benefits did you gain through green manufacturing practices? (Saving money, protect the environment, competitive advantage, etc.)
5. Regulations: What type of guidelines do you have to cover environmental problems (ISO 14001)?
    a. Do you encourage your suppliers (lowest tier suppliers) to handle green supply chain requirements and/or have environmental management program? If not, what are the obstacles?
6. Supplier Network: Do you collaborate with your suppliers to achieve environmental goals? How do you collaborate? If not, what are the barriers?
    a. How do you integrate your suppliers (raw material) into the manufacturing process to develop GM?
    b. How do you evaluate your suppliers? Which criteria are you looking for to select green suppliers? (Green supplier selection)
    c. How do you monitor suppliers' environmental performance? And how do you improve it?
7. Barriers: What are the biggest obstacles did you faced during the implementation of green practices (technologies, cost, regulations, employee awareness, etc.)? How could you overcome them?
    a. How do you figure out the cost of green manufacturing?
    b. How did you overcome lack of employee awareness about green practices and sustainability? Did you train your employees to properly pursue green practices?
    c. How did you overcome adopting new technologies, software, and innovation, in your production?