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Improving Seafood Waste Management in Västra Götaland, for a more environmental sustainable future

Master Thesis - Logistics and Transport Management
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Abstract

Waste management has become a major concern around the world. The amount of waste is significantly growing, resulting in a negative impact on the environment. It is important to address this issue by managing waste effectively and reducing its environmental impact.

The purpose of this research is to provide a broad overview of food waste management and its implication on greenhouse gasses. The focus will mostly be on the seafood supply chain and the challenges and opportunities regarding the improvement of waste management in Västra Götaland, with the help of logistic approaches. The methodology is based on a qualitative approach where a literature review has been conducted to get a better understanding of the topic and interviews have been conducted with actors involved in the food/seafood supply chain, in order to provide us with a practical perspective.

This thesis has emphasized the crucial role of waste management systems in the food supply chain. At every stage of the chain, waste is generated, making it essential to adopt effective management strategies to minimize the adverse environmental impact. It is imperative for all actors involved in the supply chain to address the challenges associated with food waste, food security, and sustainable food production. By leveraging modern technology, implementing food safety practices, fostering collaboration among actors and stakeholders. Additionally, adopting Lean philosophy, conducting Life Cycle Assessments, and embracing the Circular Economy, waste flow management can be greatly enhanced. These strategies and approaches contribute to reducing waste, identifying areas of high environmental impact, and promoting sustainable practices throughout the waste management lifecycle.

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1. Introduction

We all need to eat to survive and sustain a healthy lifestyle, but how much that is put into consideration regarding the food that we throw is not enough. The way we eat and throw away food that is considered leftovers that can be used is not sustainable and bad for our environment. The average amount of food thrown away by an individual in Sweden in 2020 is 127 kilograms (Jordbruksaktuellt, 2022). There is significant importance to following up the food waste and creating statistics in order to develop an image of how vast the issue is (Lindow, 2021). Questions regarding how eliminating waste in its entirety could be managed are often unsolved. Waste of food occurs in the entire chain of food supply, therefore the responsibility is partly managed by industries but also by lawmakers and governments (Lindow, 2021).

Successful concepts and methods to ensure sustainability have been developed throughout the years. Some methods include labels whereas industries can inherit by fulfilling the criteria of a certain degree being environmentally efficient. Eco-labels and organic food are produced more or less with regard to climate and are based on rules and regulations (Livsmedelsverket, 2022). The seafood industry in Sweden includes three main Eco-labels: MSC, ASC, and KRAV. Labels that take the climate into consideration are based on different aspects and are a way to restrict overfishing and pollution. These Labels are controlled at least once a year by independent control companies (Livsmedelverket, 2022).

- MSC (Marine Stewardship Council) is a certificate to encourage sustainable fishing, meaning that fish with MSC labels are caught with the environment in consideration.
- ASC (Aquaculture Stewardship Council) is a certificate aimed to encourage sustainable farming in regards to seafood.
- KRAV is a certificate to ensure sustainability in regards to producing and or farming food but it also takes ecological aspects and work environment into consideration when producing and or farming

1.1 Background and problem description

1.1.1 Food waste and the food supply chain

Food waste is a big issue that is common in several countries like Norway, USA, and Australia who are taking action towards this issue. Around one billion tons of food go to waste every year (SKG, 2021). The different types of waste that are included in that number are waste from the household, food service, and retail. With hundreds of millions of people experiencing food insecurity worldwide, reducing food waste is essential to building resilient, low-impact food systems. Reducing food waste benefits people, the planet, and prosperity in a variety of ways. It increases food security, deals with the world's issues of pollution, biodiversity loss, and climate change, and eases the pressure on waste management systems (SKG, 2021).

Wasted food costs money, time, and resources, like animals and plats. It requires coordinated efforts and a more diverse, resilient, and sustainable food system if it is to see genuine change. There are social, economical, and environmental benefits to reducing food waste. In order to track the generation of food waste per capita at the national level, there is a need to step up our efforts to record the amount of food and non-edible elements that are discarded.

The food supply chain can be explained as the process that all food products go through, from production to consumption (Lewis, 2022). The entire process that food products go through as they flow from producers to consumers and customers is known as the food supply chain (Lewis, 2022). In order to safely consume and comprehend the food you eat, it is crucial to understand the food supply chain. Food supply chains have experienced a massive period of growth recently more than ever. The food supply chains will inevitably become more spread, despite the fact that this may first be viewed as beneficial. This makes it more difficult for consumers to easily trace their food to its origins, often with food being transported from all corners of the world, over a long time frame (Lewis, 2022). There are different stages included in the food supply chain, including: Production, Handling and storage, Processing and packaging, Distribution, Retailing, and Consumption (Lewis, 2022).

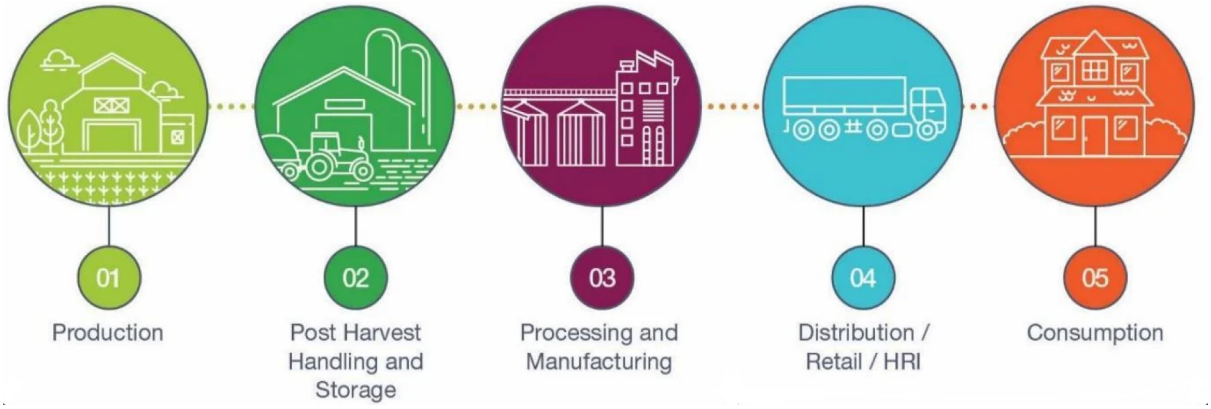

Figure 1. *The different stages of the food supply chain (EIT Food, 2022).*

1.1.2 Waste Management in Sweden - Västra Götaland

The most important task in Sweden is to identify challenges and opportunities for sustainable consumption and to connect public behavior to waste management planning (Smart City Sweden, 2022). The primary measures in Swedish waste management practices are waste prevention, reuse, and reparation. Waste is something that affects everyone, households, industries, and municipalities. Therefore it's possible that everyone contributes to decreasing the amount of waste that is created (Smart City Sweden, 2022).

In Swedish households, the priority is material recycling and source separation of waste. The key success of Sweden's successful waste management is the awareness of the population, this has led to Sweden being considered one of the world leaders in the field of sustainable waste management. A significant portion of the waste produced is burned in waste-to-energy facilities, which also provide power and water for district heating (Smart City Sweden, 2022).

Less than 1% of the nation's total waste, if all safety measures are performed, will be dumped in landfills (Smart City Sweden, 2022). The European and Swedish waste laws set the framework for waste management in Sweden. In Sweden, using landfills to dispose of waste is the least preferred choice. Avoiding waste generation and reusing and mending items is the best course of action. Recycling the materials should be the first priority if waste production continues (Smart City Sweden, 2022).

There are 290 municipalities in Sweden that are responsible for collecting waste, each is responsible to ensure that household type of waste is transported and recycled or disposed of. This includes waste types that do not fall under the Extended Producers' Responsibility, which means that some products' end-of-life collection and treatment are the responsibility of obligated producers, such as residual waste, organic waste, food waste, bulky waste, and household hazardous waste (Naturvårdsverket, n.d). The collection and treatment are done in different ways, adapted to the varied conditions in different municipalities, depending on whether it is a city, rural countryside, or less populated area (Naturvårdsverket, n.d). Typically, municipalities use doorstep collection systems to collect food waste and household residual waste utilizing bins and containers. Bulky waste, including garden waste and household hazardous waste, is collected at municipal recycling facilities where residents can drop off a variety of waste types (Naturvårdsverket, n.d). Most of the collected waste is treated in Sweden. Waste that remains is burned. Anaerobic digestion is a natural process where organic waste breaks down in the absence of oxygen, producing biogas (mainly methane) for energy and a nutrient-rich byproduct, while reducing greenhouse gas emissions and waste volume. Anaerobic digestion is used to process food waste. The majority of garden waste is composted. Bulky waste is divided up into different parts and either recycled, burned, or landfilled (Naturvårdsverket, n.d).

Region Västra Götaland seeks to be a resource-efficient region with limited climate impact (Västra Götaland Regionen, 2017). Region Västra Götaland also invests in infrastructure and technology development which can help the region to be a pioneer in developing, implementing and disseminating sustainable solutions for the climate and a fossil free region by 2030 (Västra Götaland Regionen, 2017). Some commitments that Region Västra Götaland has to meet involve implementing more broad agreements and initiatives for sustainable development, and creating environmental solutions with the goal of having a beneficial impact on environmental efforts worldwide (Västra Götaland Regionen, 2017). Another initiative with great relevance for the regional efforts focusing on the environment and waste management is the circular economy, which is constantly followed by the Brussels Office who’s working with the EU Environmental Policy (Västra Götaland Regionen, 2017).

1.1.3 Problem description

The growing issue of food waste management has become a pressing concern for governments and businesses around the world. With the rise in consumerism and globalization, the generation of waste has increased significantly, leading to negative impacts on the environment, such as land, air, and water pollution, and the depletion of natural resources. It is crucial to address this issue by managing waste effectively and reducing its environmental impact. The focus of this thesis will be on waste flow management, particularly in the food supply chain with a focus on seafood in Västra Götaland which is a region in Sweden, and the impact it has on the environment regarding greenhouse gasses. The port of Gothenburg is one of the largest ports in Sweden and is the reason why Västra Götaland is the region that is relevant to the question of waste management in the seafood industry. The food supply chain is crucial in waste management due to the significant amount of waste generated during production, distribution, and consumption. Various types of waste can arise, posing environmental risks if not properly managed. Challenges can arise in the food supply chain, including issues of food waste, food security, and sustainable food production.

1.2 Research purpose

The aim of this research is to provide a broad overview of food waste management and its implication on greenhouse gasses, and the amount of food waste in the food supply chain. This research will explore the challenges and opportunities regarding the improvement of the food waste flow system, with the help of logistic methods. The main focus will be on waste management's role in the seafood supply chain. This research will also explore the value that companies and authorities can have, in managing a sustainable waste flow system. Insight into how different actors define the value will be included to fulfill the purpose of this research. In conclusion, this thesis aims to contribute to the broader discourse on waste management and sustainability and to provide insights and recommendations for improving the waste flow management system.

1.3 Specification of Research Questions

The two research questions listed below have been compiled with the thesis's objective in mind. They will be addressed throughout the thesis. The first research question is motivated by the growing concerns about the impacts waste management has on our environment in regard to greenhouse gasses and food waste in the supply chain. The latter one is aimed toward the seafood supply chain, as it generates waste in different stages like any other supply chain. The motive behind this is to understand these sources in order to improve waste management practices in the region of Västra Götaland.

RQ1: *How can waste flow management in the food supply chain be enhanced to reduce food waste and the environmental impacts of greenhouse gasses?*

RQ2: *What are the main sources of waste in the seafood supply chain, and how can these be addressed in order to improve waste management practices in Västra Götaland?*

2. Literature review

The literature review section is going to include important topics that later on will be a foundation whereas theory in comparison to practice will provide a result based on the research questions. The included topics of this segment are waste management and the food supply chain and its waste as well as seafood supply chain. This section is important due to the scientific papers that are included, which present an overview of previous research in order to get a better understanding of the topic in this study.

2.1 Food Supply Chain

Food waste is a significant problem that results in the wasteful utilization of natural resources (Göbel et al., 2015). In order to effectively prevent and reduce food waste, it is crucial to systematically identify the main causes throughout the food supply chain. Food waste occurs at various stages within the chain, making it impractical to blame a single entity (Göbel et al., 2015). Additionally, the reasons for food waste differ among different product groups, emphasizing the need for diverse solutions. Causes and effects of food waste are distributed across different stages of the value chain, highlighting the importance of improved communication and a renewed appreciation for food among all stakeholders involved in the food supply chain (Göbel et al., 2015). It is essential to share information about food waste among all actors in the supply chain and for them to collectively take responsibility and collaborate to reduce food waste effectively.

Food losses and waste (FLW) have a significant impact on food security, nutrition, and the sustainability of food systems (De Boni et al., 2022). Quantifying the adverse effects of FLW is a complex task that requires a comprehensive approach encompassing quantification, economic evaluation, environmental considerations, and social dimensions (De Boni et al., 2022). Developing effective measures to manage FLW throughout the food supply chain calls for the establishment of robust and shared benchmarks. Identifying the hotspots and critical points in FLW enables the development of targeted policy actions that can enhance the efficiency and sustainability of the food supply chain. This requires an integrated approach involving all key stakeholders and considering diverse production contexts. By implementing such measures, it becomes possible to prevent, reduce, and valorize food waste effectively (De Boni et al., 2022).

Environmental issues associated with FLW include the squandering of limited resources such as water, energy, and land, as well as the generation of greenhouse gas emissions and other pollutants during food production and disposal (De Boni et al., 2022). Economic concerns arise from the significant economic losses incurred due to wasted resources and investments, as well as increased costs associated with waste management (De Boni et al., 2022). Social implications of FLW encompass the ethical and moral aspects of wasting food when there are populations suffering from hunger and malnutrition, as well as the unequal distribution of resources and food access (De Boni et al., 2022).

Policy measures aimed at addressing FLW within the food supply chain can contribute to environmental sustainability by promoting resource conservation, reducing emissions, and minimizing ecological impacts (De Boni et al., 2022). From an economic perspective, preventing and reducing FLW can lead to cost savings and improved resource efficiency throughout the food system. Socially, such measures can foster equitable access to food by reducing waste and redirecting surplus food to those in need, thereby addressing food insecurity and supporting vulnerable populations (De Boni et al., 2022). To effectively tackle FLW, policy measures should focus on various areas. These may include implementing better storage and transportation practices, enhancing infrastructure and technology for food processing and preservation, and raising consumer awareness about food waste and responsible consumption (De Boni et al., 2022). An integrated and coordinated approach involving governments, businesses, civil society, and consumers is crucial for the successful prevention, reduction, and valorization of food waste within the food supply chain (De Boni et al., 2022).

2.1.1 Sustainable food supply chain methods

According to Sonesson et al. (2016) explore in their study how the food supply chain can become more sustainable. The study argues that a more sustainable food supply chain can be achieved by using an integrated approach that takes into account a product's whole lifecycle, from manufacture to disposal.

One of the most crucial methods for developing a sustainable food supply chain is life cycle assessment (LCA) (Sonesson et al., 2016). LCA is an approach that assesses a product's environmental impact based on its lifecycle. According to Sonesson et al. (2016), performing an LCA can aid in identifying severe environmental impacts and creating mitigation plans. Optimizing feed production is a different approach that Sonesson et al. (2016) offer. The production of feed can have a big impact on how the production of food affects the environment. Utilizing environmentally friendly feed components, such as locally grown food, and reducing waste and emissions produced during the feed manufacturing process can lessen the impact food production has on the environment. Sonesson et al. (2016) also suggest that a circular economy approach can be used to promote a more sustainable food supply chain. As part of the circular economy idea, resources are reused and recycled in order to reduce waste. In food production, this can involve using by-products for animal feed and other purposes, rather than disposing of them as waste (Sonesson et al., 2016).

Sonesson et al. (2016) suggest that an integrated approach and methods such as life cycle assessment, efficient resource use, optimization of feed production, and a circular economy can all help in order to make the food supply chain more sustainable. In order to reduce waste and improve sustainability in food supply chains, the study by Batista et al. (2021) examines various strategies. In order to evaluate food supply chains and pinpoint places where circular economy strategies could be applied to boost sustainability, the authors employed a qualitative mapping approach (Batista et al., 2021).

The study suggests that waste flows in food supply chains occur at various stages. This includes production, processing, distribution, and consumption (Batista et al., 2021). The authors identified several areas where circular economy practices could be implemented and used to reduce waste, including reducing food waste through improved supply chain coordination and better management of food surpluses as well as recovering valuable resources from waste streams (Batista et al., 2021). The beneficial effects that a circular economy could have on the food supply chain were another important study conclusion. This involves lessening the impact on the environment, increasing economic effectiveness, and enhancing social benefits. For instance, lowering food waste through enhanced supply chain coordination may cut costs for growers, processors, and distributors while also enhancing consumer food security (Batista et al., 2021).

The study also presents several approaches to reducing food waste and streamlining waste flow systems in food supply chains. By structuring supply, demand and decreasing overproduction, better coordination and communication among the people involved in the food supply chain help reduce food waste (Batista et al., 2021). It's crucial to successfully manage food surpluses by giving them to those in need or feeding them to livestock. Recovering valuable resources like energy and nutrients from waste streams can cut waste and increase the sustainability of food supply networks (Batista et al., 2021). These are only a few examples of the approaches suggested in the study to reduce waste and improve waste flow systems in food supply chains. The study highlights the necessity of collaboration and cooperation among all actors involved in the supply chain as well as the significance of a holistic and systematic approach to minimizing waste in the food supply chains (Batista et al., 2021).

According to Ekren and Kumar (2022), reducing food loss and food waste in supply chains requires implementing various strategies across the entire supply chain. These strategies aim to address different stages of the supply chain process, from production to consumption. One crucial strategy is improved forecasting and demand planning (Ekren & Kumar, 2022). Accurate forecasting helps prevent overproduction, which can lead to food waste. By leveraging advanced data analytics and machine learning algorithms, supply chain stakeholders can better understand consumer demand patterns and adjust production accordingly (Ekren & Kumar, 2022). Real-time data from multiple sources can be integrated to provide more accurate demand forecasts, enabling companies to optimize production levels and minimize waste. Effective inventory management is another key approach. Techniques such as just-in-time (JIT) inventory management ensures that products are used or sold before their expiration dates. By closely monitoring inventory levels, companies can minimize the risk of food spoilage and expiration, reducing waste (Ekren & Kumar, 2022). Optimal packaging and storage play a significant role in reducing food loss and waste. Utilizing appropriate packaging materials and technologies helps extend the shelf life of perishable goods. Additionally, maintaining proper temperature-controlled storage conditions throughout the supply chain is crucial for preserving the quality and freshness of food items (Ekren & Kumar, 2022).

Collaboration and coordination among supply chain stakeholders are vital in tackling food loss and waste. Establishing strong partnerships and sharing information and best practices among farmers, processors, retailers, and consumers can help identify and address food loss and waste hotspots (Ekren & Kumar, 2022). By working together, stakeholders can implement joint initiatives to optimize processes and reduce waste throughout the supply chain. Consumer education and awareness also play a crucial role. Educating consumers about the impact of food waste and providing guidance on proper food handling, storage, and interpretation of expiration dates can empower individuals to make informed choices. By raising awareness and promoting responsible consumption, consumers can actively contribute to reducing food waste at the household level (Ekren & Kumar, 2022).

2.1.2 Environmental sustainability

Food waste is a significant issue in many countries and plays a major role in environmental changes. It affects all aspects of waste management, from collection to disposal (Wani et al., 2023). To address this problem, it is essential to involve all participants in the food supply chain, including farmers, manufacturers, distributors, and consumers (Wani et al., 2023). Additionally, ensuring global food sustainability and security is crucial to guarantee that everyone has access to food.

Global sustainable development goal 2 focuses on ending hunger, achieving food security, enhancing nutrition, and promoting sustainable agriculture (Wani et al., 2023). Therefore, sustainable food waste management technology is necessary. Recently, there has been increased attention on global food loss and waste, with one-third of food produced for human consumption being wasted annually (Wani et al., 2023). The most promising strategy to tackle this issue involves source reduction, which limits food losses and waste, along with implementing contemporary treatment technologies. These approaches can transform food waste into safe, nutritious, and value-added feed products, contributing to sustainability goals (Wani et al., 2023). However, traditional food waste reduction strategies have proven ineffective in reducing greenhouse gas (GHG) emissions and treating food waste properly. This highlights the need for innovative and sustainable approaches to address food waste and the trade-offs involved in ensuring food safety, sustainability, and security (Wani et al., 2023).

Lin et al. (2009) discuss how waste management affects food security and safety as well as how it helps the food supply chain reduce its emissions of greenhouse gasses. Since inappropriate waste disposal can cause environmental contamination and the spread of illness, waste management is essential for guaranteeing the safety and security of food (Lin et al., 2009). Waste management can therefore also help reduce GHG emissions in the food supply chain. Food waste produces methane gas when it decomposes in landfills, which is a significant source of greenhouse gas emissions. Methane is a powerful greenhouse gas that traps heat in the atmosphere 21 times better than carbon dioxide (Lin et al., 2009).

Transportation, processing, and production of food all contribute to greenhouse gas emissions as well. Lin et al. (2009) imply that waste management and waste reduction techniques, such as recycling, composting, and waste-to-energy technology, can aid in lowering greenhouse gas emissions caused by food waste.

List of greenhouse gasses monitored by The Global Atmosphere Watch (World Meteorological Organization, 2022):
- Carbon Dioxide
- Methane
- Nitrous Oxide
- Halocarbons
- Molecular Hydrogen

Waste management may improve food sustainability, safety, and security while also playing a significant role in lowering greenhouse gas emissions throughout the food supply chain. Lin et al. (2009) suggest that it is possible to lessen the environmental impact of food waste and work towards a more sustainable and resilient food system by putting waste reduction and management measures into practice.

Bhatia et al. (2023) discuss the connection between food waste and GHG. Also, there is a chance that using food waste will lower carbon emissions and increase environmental sustainability. Food waste contributes significantly to greenhouse gas emissions which leads to a major contribution to air pollution (Bhatia et al., 2023). Methane, a strong GHG that is more detrimental to the environment than carbon dioxide, is released when food waste decomposes in landfills (Bhatia et al., 2023). Food waste transportation and disposal also produce vehicle emissions, which can contribute to air pollution. Bhatia et al. (2023) suggest that the use of food waste through composting, anaerobic digestion, and other waste-to-energy technologies can help reduce GHG emissions and improve air quality. Composting involves the natural decomposition of organic material to produce nutrient-rich soil, while anaerobic digestion converts organic waste into biogas that can be used for energy production (Bhatia et al., 2023). Bhatia et al. (2023) demonstrate how the use of food waste can help to reduce the need for new resources, such as energy and fertilizers, which can help to further reduce the air pollution and greenhouse gas emissions associated with their extraction and transportation.

2.1.3 General food law regulation

There are regulations at both international and regional levels subjected to the food supply chain. There are crucial roles played by international and European agencies in ensuring food safety, regarding consumption (Lalor, 2016). One of the most crucial legislations in the EU is Regulation (EC) No 178/2002, also known as the General Food Law Regulation (Lalor, 2016). This regulation created the European Food Safety Authority (EFSA), which is tasked with performing risk assessments and offering scientific advice to the EU institutions regarding food safety, as well as the fundamental principles and requirements of EU food law (Lalor, 2016).

The General Food Law Regulation also establishes a framework for food safety that covers all stages of the food supply chain, from production to consumption (Lalor, 2016). Food business owners are required to make sure that their products are safe to eat, track their products along the supply chain, and respond appropriately if a risk to human health is discovered. There are other important European agencies, in addition to the EFSA. For example, the development and implementation of food-related policies and regulations in the EU is the responsibility of the Directorate-General for Health and Food Safety (DG SANTE) of the European Commission (Lalor, 2016). On an international level, The Codex Alimentarius Commission is crucial in establishing global standards and regulations for food. The Food and Agricultural Organization (FAO) and the World Health Organization (WHO) collaborate to create the Commission, which creates global standards for commerce, quality, and food safety (Lalor, 2016). These agencies and laws are crucial in making sure that food can be consumed safely. In particular, the General Food Law Regulation sets the appropriate legal framework to ensure that food industry operators are held accountable for their activities and guarantees that food safety is of the utmost importance across the whole food supply chain (Lalor, 2016).

Trade-offs in achieving food safety, sustainability, and security arise from various factors. For instance, implementing strict food safety regulations may require additional resources and processes that could increase costs for food producers and potentially affect accessibility for certain populations (Wani et al., 2023). Balancing sustainability and security can also pose challenges, as sustainable agricultural practices may yield lower crop quantities initially, impacting food availability. Additionally, ensuring food security by increasing production might lead to environmental degradation if unsustainable farming practices are employed (Wani et al., 2023). Trade-offs can be minimized by adopting holistic approaches that consider the interconnectedness of food systems. This involves integrating sustainable agricultural practices, efficient food production and distribution systems, effective waste management, and consumer education (Wani et al., 2023). Collaborative efforts among stakeholders, including governments, farmers, the food industry, and consumers, are crucial for finding sustainable solutions that prioritize food safety, sustainability, and security while minimizing trade-offs (Wani et al., 2023).

2.2 Food Waste in Sweden

According to Rezaei and Liu (2017), food loss and waste relate to a reduction in the amount or quality of edible food meant for human consumption. It is crucial to distinguish between the two phrases since they arise in different situations and call for different methods of problem-solving. According to Rezaei and Liu (2017), issues with the food production and supply chain, as well as institutional and policy constraints, are the main causes of food loss. It may be caused by administrative and technical failings, including inadequate storage facilities, a lack of an effective cold chain infrastructure, inappropriate food handling procedures, insufficient packaging, and ineffective marketing strategies (Rezaei & Liu, 2017).

Contrarily, food waste happens when food that is fit for human consumption but is removed from the supply chain. This may occur voluntarily or as a result of spoiling or expiration brought on by negligent or inadequate stock management. Food loss is more widespread in the initial phases of the supply chain, such as production, post-harvest, and processing, but food waste is frequently seen at the retail and consumer levels (Rezaei & Liu, 2017). Food security, the economy, and the environment all suffer greatly from food loss and waste. They lessen the supply of food on the market, which raises food prices and restricts access for people with low incomes. Furthermore, when food quality deteriorates to the extent that it must be sold at a lower price or discarded, farmers and producers face adverse livelihood effects (Rezaei & Liu, 2017).

The environmental effects of agriculture can be reduced, the livelihoods of chain participants can be improved, and food and nutrition security for low-income consumers can be increased by addressing food loss and waste across the supply chain (Rezaei & Liu, 2017). Modern food supply chains are lengthy and complex, thus an integrated strategy is required. This entails making investments in processing technologies that are effective, affordable, and sustainable; suitable storage and packaging solutions; road infrastructure; market connections; and training and educating all stakeholders, including consumers (Rezaei & Liu, 2017). The effectiveness of the food supply chain can be increased through the use of such interventions, which will decrease food loss and waste.

Causes of food waste within the supply chain can be attributed to several factors. Inefficient farming practices, such as overproduction, inadequate storage facilities, and suboptimal harvesting techniques, contribute to food waste during the production and harvesting stages (Göbel et al., 2015). Inadequate quality control measures, equipment malfunctions, and inefficiencies in processing and manufacturing operations result in the rejection or discarding of edible food during processing and manufacturing (Göbel et al., 2015). Challenges in coordinating supply and demand, inaccurate forecasting, poor inventory management, and transportation issues contribute to food waste during distribution and logistics (Göbel et al., 2015). At the retail and consumer level, food waste occurs due to retailers discarding imperfect or expired food based on aesthetic standards or concerns about food safety. Consumer behavior, including overbuying, improper storage, and confusion regarding expiration dates, also contributes to food waste at the household level (Göbel et al., 2015).

2.2.1 Food waste in primary production

According to Hartikainen et al. (2018) research, various factors contribute to food waste in primary production in Sweden. All operations involving the harvest, handling, and storage of food products before they proceed to processing or distribution are included in this initial stage of the chain. These factors include:

- Rejection due to cosmetic defects or overproduction
- Losses in storage and transportation
- Discards in processing

The research estimates that the total amount of food waste in primary production in Sweden was approximately 811,000 tonnes in 2015, including vegetables and fruits accounting for most (33%) of the waste. The waste generated in primary production represents approximately 4% of the total food waste generated in Sweden. There are different approaches that are being implemented in Sweden in order to reduce food waste. According to Hartikainen et al. (2018), some of these approaches are:

- Development of new technologies for waste reduction and utilization
- Promotion of best practices in primary production to reduce waste
- Collaboration between different actors in the food chain to reduce waste

Hartikainen et al. (2018) found that rejection due to cosmetic defects and overproduction was the main cause of food waste in primary production in Sweden. This includes products that do not meet the strict cosmetic standards set by retailers, as well as surplus products that cannot be sold in time. Some other reasons or causes for food waste in Sweden could be related to storage and transportation. According to Hartikainen et al. (2018), losses in storage and transportation were another significant cause of food waste. This includes produce that is damaged or spoiled due to temperature fluctuations or poor storage conditions, as well as products that are discarded during transportation due to damage or because it is no longer fit for sale. Hartikainen et al. (2018) also highlights that discards in processing, such as in the preparation of ready-to-eat meals, also contribute to food waste in primary production in Sweden. This is due to the need to maintain strict quality control, as well as the use of just-in-time production methods that result in surplus produce that cannot be used Hartikainen et al. (2018).

There is ongoing research and development aimed at reducing food waste through the use of new technologies. This includes for example the development of new packaging methods to extend the shelf life of produce, as well as the use of sensors and data analytics to optimize storage and transportation (Hartikainen et al., 2018). The study highlights the importance of promoting best practices in primary production to reduce food waste. According to Hartikainen et al. (2018), this can include promoting the use of more sustainable production methods for example, such as reducing the use of pesticides and fertilizers, as well as improving the management of storage and transportation to minimize losses.

Hartikainen et al. (2018) also mention the need for collaboration between different actors in the food chain is also important, including primary producers, retailers, and processors, to reduce food waste. This includes the development of new business models that incentivize waste reduction and the sharing of best practices across the food chain Hartikainen et al. (2018).

Leveraging technology is crucial in addressing food loss and waste. Implementing robust product tracking systems throughout the supply chain allows for better monitoring and management of food (Houghton, 2021). Assessing the quality of produce at the time of harvest and during transportation can help identify potential issues early on and prevent spoilage. Developing non-destructive methods to detect the freshness and quality of products without damaging it is an innovative approach to minimizing waste. Targeting the reduction of the most commonly wasted foods during production can lead to significant improvements (Houghton, 2021). Monitoring and documenting food waste trends in the restaurant and hospitality industries can provide valuable insights and guide interventions. Identifying areas of significant loss across various industries can help prioritize efforts and resources. Additionally, researching the creation of plant-based, edible coverings that prolong produce's shelf life can aid in decreasing waste and boosting food availability (Houghton, 2021). Significant progress can be made in reducing food loss and waste, boosting sustainability, and enhancing overall food systems by focusing on these areas and utilizing technology (Houghton, 2021). To create a more effective and accountable food system, a comprehensive strategy including all participants in the food supply chain—from producers to consumers—is necessary (Houghton, 2021).

2.2.2 Identifying food waste

Addressing the major causes of food loss and waste requires significant reforms within the supply chain as well as changes in consumer behavior (Houghton, 2021). Initiatives are being developed and implemented worldwide to focus on key areas that are critical to addressing this issue (Houghton, 2021). Increasing awareness among consumers is crucial. It involves educating them about where they can purchase fresh, local produce and promoting the utilization of all edible parts of plants. Additionally, creating awareness about donation and composting options for excess food is essential (Houghton, 2021).

The research by Eriksson et al. (2018), aims to identify the methods used to measure food waste in the food sector in Sweden. The study provides insights into the challenges and opportunities for reducing food waste in the food service industry (Eriksson et al., 2018). According to the study conducted by Eriksson et al. (2018), the food service sector faces both opportunities and challenges regarding reducing food waste. The food service industry has significant opportunities to reduce food waste as they handle vast quantities of food regularly (Eriksson et al., 2018). There are numerous ways to accomplish this, such as controlling portions, proper storage, utilizing leftovers, and redistributing food. By reducing food waste in this sector, cost savings can be realized while also providing environmental and societal benefits (Eriksson et al., 2018).

There are different factors that can contribute to food waste in the food service sector. These can be seen as challenges, including oversights in planning and preparation, high turnover in staff, and consumer behavior. There may be some cultural and behavioral barriers to reducing food waste in the food service sector, some of these are for example perception that surplus food should be discarded, rather than used for another purpose (Eriksson et al., 2018). The food service sector faces a number of challenges in the logistics area as well as in reducing food waste, including the need for proper storage facilities, transportation, and distribution systems.

In their study, Eriksson et al. (2012) examine the problem of food losses in retail establishments. For instance, they concentrate on food waste involving fruits and vegetables. Six retail establishments in Sweden were the subject of the study to determine the degree of food waste and its causes. The authors found that the main cause of food losses was the over-ordering of fresh produce by the stores, leading to excessive quantities delivered and subsequent wastage (Eriksson et al., 2012). Other factors contributing to food losses included improper storage conditions, damage during transportation and handling, and poor product appearance. Eriksson et al. (2012) advise retail establishments to adopt improved inventory management procedures, such as demand forecasting and ordering fewer quantities of fresh produce, in order to decrease food losses. Additionally, they believe that better transportation and storage options can aid in lowering food waste (Eriksson et al., 2012). Food losses are a growing issue in the retail sector because they not only cost the retailers money but also pollute energy, water, and land that could have been utilized to produce more food. From a sustainability standpoint, the issue of food losses is also crucial since minimizing food waste can assist to lessen the environmental impact that the food sector has (Eriksson et al., 2012).

The results of their findings imply that decreasing food losses could benefit waste management because less food would be thrown away. As fewer resources would be required to create food that eventually goes to waste, lowering food losses could help to lessen the environmental impact of food production and waste management (Eriksson et al., 2012). It is important to remember that food losses and waste management are related issues, as reducing food losses can help to reduce the amount of waste generated (Eriksson et al., 2012). Therefore improving waste management practices can help to reduce the amount of food waste. By properly managing food waste through composting, recycling, or anaerobic digestion we can help to recover resources and reduce greenhouse gas emissions while reducing food losses can help to conserve these same resources (Eriksson et al., 2012).

2.2.3 Recycling

By lowering greenhouse gas emissions, Henningsson et al. (2001) contend that improving waste management systems can benefit the environment. Methane gas emissions from organic waste decomposition in landfills are one of the major causes of greenhouse gas emissions (Henningsson et al., 2001). Businesses can cut back on the amount of methane gas discharged into the atmosphere by enhancing their waste management processes and avoiding putting organic waste in landfills (Henningsson et al., 2001).

Companies can implement composting programs or work with nearby composting facilities to turn organic waste into nutrient-rich soil amendments, for example. As a result, there is a decrease in greenhouse gas emissions as well as a sustainable source of fertilizer for landscaping and agriculture (Henningsson et al., 2001).

Abrahamsson's (2022) research focuses on the potential to turn food waste into resources like compost and biogas. Sweden's municipal food recycling program may make this achievable. Anaerobic digestion, which breaks down the organic content in food waste in the absence of oxygen, is how biogas is created. The resulting gas, which is mostly methane, can be used as a fuel for heating or electricity generation. Contrarily, compost is created through the aerobic breakdown of food waste and the finished product is nutrient-rich and suitable for use as a soil additive to enhance soil fertility. According to Abrahamsson (2022), the process of municipal food recycling in Sweden has resulted in success. It is possible to turn food waste into resources. According to Abrahamsson (2022), this approach will address the issue of food waste while also promoting the growth of a more sustainable and circular economy. According to Abrahamsson (2022), this approach will lessen the quantity of food waste that ends up in landfills. The negative environmental effects of waste management are minimized by preventing food waste from ending up in landfills and turning it into valuable goods. Furthermore, the production of biogas from food waste can help to cut down on the consumption of fossil fuels and the associated greenhouse gas emissions.

2.3 Seafood Supply Chain

There are several stages involved in the Seafood supply chain. This includes aquaculture, processing, packaging, transportation, and distribution (Denham et al., 2015). The stage regarding harvesting involves capturing or farming fish, shellfish, and other seafood products. This is usually done by independent fishermen or larger businesses that specialize in fishing or aquaculture (Denham et al., 2015). When harvesting is done, the seafood is transported to different facilities in order to be processed. In these facilities, the seafood is cleaned, gutted, and filleted. The different products can also be frozen or smoked depending on the type of seafood (Denham et al., 2015). After processing the products, they are packed and ready to be transported to retailers or wholesalers. The case of packaging can be made in different forms, including jars or sealed bags. When the products are packed, they are transported to distribution centers. In the distribution center, the products are sorted and prepared to be delivered to retailers and wholesalers (Denham et al., 2015). When the products are delivered to retailers and wholesalers, they can be sold to consumers, restaurants, and different food service companies (Denham et al., 2015). In the supply chain, it can happen that international trades are involved, regarding import and export.

2.3.1 Sustainable seafood supply chain methods

Tseng et al. (2022) identify several methods, in their study, that can be used to make the seafood supply chain more sustainable. The first method described by Tseng et al. (2022) is collaboration. In a supply chain, it is crucial to work together in order to reduce waste, improve product quality, and adopt sustainable practices, and this requires cooperation among actors involved in the supply chain (Tseng et al., 2022). The different actors in the seafood supply chain involve fishers, processors, distributors, and retailers.

The importance of collaboration in this matter is very important. An example of the importance of this matter is, processors and retailers, for instance, can choose which goods to buy and sell by exchanging information about the source of the seafood and the circumstances under which it was caught (Tseng et al., 2022). Another example is that Cooperation can also be used to discover and address sustainability issues that can be particular to certain fisheries or geographical areas.

The second method described by Tseng et al. (2022) is lean management. This is an approach that aims to reduce waste and increase supply chain efficiency. In the context of the seafood industry, This may entail using fewer resources, such as water, energy, and packaging materials, as well as producing less waste (Tseng et al., 2022). An example of the use of lean management is that processors can cut back on energy use and waste by using more energy-efficient machinery and production techniques. Another example is that Retailers can also utilize recyclable or reusable packing materials that are better for the environment.

The use of traceability is the third technique Tseng et al. (2022) describe. This is necessary to guarantee the supply chain's sustainability and food safety. It enables the tracking of seafood items from the place of catch to the place of consumption, assisting in the prevention of unreported, unregulated, or illegal fishing. Additionally, traceability aids consumers in selecting the proper products and foods to consume. By implementing a trustworthy traceability system, suppliers like manufacturers and retailers may demonstrate their dedication to sustainability and boost consumer trust in their goods (Tseng et al., 2022).

Lastly, Tseng et al. (2022) present the use of certification schemes, such as the Marine Stewardship Council (MSC) and the Aquaculture Stewardship Council (ASC). This is a way to gain confidence in customers to identify sustainable products. These schemes establish criteria for ethical fishing and aquaculture, and seafood products that meet these criteria can hold the MSC or ASC certification. By adopting these certification schemes, seafood producers and retailers can demonstrate their commitment to sustainability and differentiate themselves in the marketplace (Tseng et al., 2022). Retailers in seafood may find this to be of special importance because they can use sustainability as a selling factor to draw in environmentally sensitive customers.

Tseng et al. (2022), suggest that using or combining these methods can make the seafood supply chain more sustainable. The seafood industry may lessen its environmental effect and assure long-term sustainability by cooperating and implementing best practices (Tseng et al., 2022).

2.3.1.1 Lean Principles

The study by Sundin et al. (2011) describes how lean principles can be applied to the design of recycling centers to create more efficient and effective waste management systems.
In much the same manner as standard production systems, Sundin et al. (2011) contend that waste management systems can profit from the use of lean concepts. Lean principles emphasize the elimination of non-value-adding activities as well as the improvement of workflow and process design in an effort to minimize waste and promote value creation (Sundin et al., 2011). Lean principles can be applied to waste management to speed up material flow through the system and save the amount of time and manpower needed for handling and processing waste (Sundin et al., 2011). The result showed a more effective system that required less travel and storage, had shorter wait times, and involved fewer non-value-adding tasks by applying lean principles to the layout design of recycling centers (Sundin et al., 2011).

For example, Sundin et al. (2011) found that by using a lean approach, they were able to reduce the number of storage containers required by 50% while maintaining the same level of service. This was accomplished by redesigning the recycling center's floor in order to cut down on the number of containers required and enhance the flow of materials through the system. Also, they discovered that a more effective layout allowed them to minimize the distance traveled by waste vehicles by 25%, substantially lowering the waste management system's environmental impact (Sundin et al., 2011).

Regarding lean production, Sundin et al. (2011) argue in their research how this principle can be useful and help streamline waste flow management systems. As mentioned, the concept of lean in this context aims to help reduce waste and improve processes regarding effectiveness and efficiency. Sundin et al. (2011) suggest that applying Lean principles can lead to a more efficient and effective system for managing waste. The research provides us with a case study done on recycling centers by implementing lean production principles. In the context of streamlining waste flow systems, these principles can improve the flow of materials and people, reduce waiting times, and decrease defects in the waste management process. Also by using a systematic approach, it will be easier to identify waste and eliminate it.

In general, the application of lean concepts to waste management systems has the potential to provide more enduring and effective systems that are advantageous to society and the environment (Sundin et al., 2011). Lean concepts can aid in developing more effective and efficient waste management systems that contribute to a more sustainable future by minimizing waste and maximizing value generation (Sundin et al., 2011).

Faccio et al. (2013) present an argument for applying lean principles to food logistics and supply chain management as a means to reduce waste, increase efficiency, and improve overall performance. Faccio et al. (2013) identify five main principles of lean thinking that can be applied to the food supply chain, which include defining value, mapping the value stream, creating flow, establishing pull, and pursuing perfection.

Finding out what is important to the customer is the first stage in defining value, after which the focus should be on effectively delivering it. Mapping the value stream entails defining the entire process of delivering the product, from raw materials to final goods, in order to identify areas of waste and inefficiency (Faccio et al., 2013). Creating flow refers to ensuring that the product goes continuously and without interruption through the value stream. Pull involves only manufacturing things when customers ask for them. To achieve perfection, one must continuously work to reduce waste and enhance the value stream (Faccio et al., 2013).

According to Faccio et al. (2013), applying these principles to food logistics and supply chain management can lead to several benefits. By detecting and removing waste in the food supply chain, such as excess inventory, overproduction, and inefficient transportation, for instance, lean principles may be used to reduce food waste (Faccio et al., 2013). By outlining the value stream and identifying areas of waste, which can subsequently be reduced to decrease inefficiencies, lean principles can also increase efficiency. Also, by emphasizing customer value and ensuring that products are produced only when they are required, lean principles can improve the quality of food products, resulting in high and consistent quality (Faccio et al., 2013). Using lean concepts can also save costs by decreasing waste and increasing productivity, which will ultimately increase profitability. In conclusion, Faccio et al. (2013) suggest using lean concepts in food logistics and supply chain management can reduce waste, increase productivity, enhance quality, and lower costs—all of which are advantageous to the sector as a whole and customers (Faccio et al., 2013).

2.3.1.2 Life cycle assessment

An established technique called life cycle assessment (LCA) is used to assess how items and processes affect the environment throughout their entire life cycle. Although LCA has been widely used in many different industries, until recently, the marine goods and seafood industry received relatively little attention (Ruiz-Salmón et al., 2021). However, there has been a growing interest in comprehending the environmental implications of seafood products throughout the supply chain, from capture to end-of-life (Ruiz-Salmón et al., 2021). This is because global fish production has been steadily increasing, peaking at about 179 million tonnes in 2018 (Ruiz-Salmón et al., 2021). A systematic assessment of the environmental effects linked to each phase of a product's life cycle is part of the current LCA framework. This typically includes raw material extraction, manufacturing processes, distribution, use, and disposal or recycling (Ruiz-Salmón et al., 2021). LCA assesses various impact categories such as greenhouse gas emissions, energy consumption, water use, and ecosystem impacts to provide a comprehensive understanding of a product's environmental performance.

However, applying LCA to the seafood sector comes with its own set of challenges. One significant challenge is the complexity and variability of seafood supply chains, which can involve multiple stakeholders, diverse fishing or farming practices, and varied processing and distribution systems (Ruiz-Salmón et al., 2021). Gathering accurate and representative data across the entire life cycle can be challenging, particularly for small-scale and artisanal fisheries or aquaculture operations.

Additionally, the spatial and temporal dynamics of marine ecosystems pose difficulties in quantifying the environmental impacts of fishing activities (Ruiz-Salmón et al., 2021).
Another challenge is the lack of standardized methodologies and data for seafood-specific processes and impact categories. Developing consistent and reliable data sets for specific seafood products, considering regional and species-specific variations, is essential for accurate assessments. Furthermore, addressing the dynamic nature of the seafood sector, including changes in fishing practices, technological advancements, and evolving consumer preferences, presents ongoing challenges for LCA practitioners (Ruiz-Salmón et al., 2021). To overcome these challenges, collaboration between industry stakeholders, and policymakers is essential to enhance the application of LCA in the seafood sector and ensure the integration of environmental considerations into decision-making processes.

2.3.2 Environmental Impacts

Denham et al. (2015) go over a variety of environmental effects connected to seafood production and supply systems. Overfishing and depletion of fish stocks have environmental effects (Denham et al., 2015). This is because fish populations worldwide are currently overfished, which may result in population losses, modifications to the dynamics of the environment, and the potential collapse of fisheries. The disruption of habitats can also have an environmental effect because seafood activities damage, for example, coral reefs, seafloor habitats, and other sensitive ecosystems (Denham et al., 2015). This can later result in reductions in ecosystems and biodiversity. A variety of pollutants, such as extra nutrients, pesticides, and chemicals used in aquaculture, can be produced during the production of seafood. Eutrophication, hazardous algal blooms, and other detrimental effects on the water quality and marine ecosystems can be brought on by these pollutants (Denham et al., 2015).

Greenhouse gasses are another environmental impact on seafood production and the seafood supply chain (Denham et al., 2015). The supply chain can generate a huge amount of GHG emissions through transportation and storage. Furthermore, to have a huge social and economic impact, environmental issues related to the production of seafood can also have a substantial influence on local communities that depend on fishing and other marine-related industries (Denham et al., 2015).

Packaging plays a crucial role in preserving and transporting food, including seafood products. However, the production and management of packaging materials contribute to environmental burdens (Almeida et al., 2022). From an environmental perspective, packaging plays a significant role in the seafood supply chain (Almeida et al., 2022).

Proper packaging ensures the preservation and quality of seafood during transportation and storage, reducing the risk of spoilage and food waste. However, the environmental impact of packaging arises from various stages, including the extraction of raw materials, manufacturing processes, and transportation (Almeida et al., 2022).

Packaging materials, particularly those with high carbon footprints like aluminum and glass, contribute to greenhouse gas emissions and climate change. Additionally, the disposal of packaging waste, if not properly managed, can lead to pollution and environmental degradation (Almeida et al., 2022). Therefore, it is essential to consider sustainable packaging alternatives, such as recyclable or biodegradable materials, as well as promote effective waste management practices. In the seafood industry, sustainable packaging choices can enhance the environmental performance of products and contribute to a more sustainable supply chain (Almeida et al., 2022). The seafood industry may lessen its ecological impact and support environmental sustainability by minimizing the environmental impact of packaging materials, optimizing package design for efficient use of resources, and encouraging recycling and appropriate waste management (Almeida et al., 2022). Additionally, customer involvement and understanding in selecting goods with eco-friendly packaging may motivate improvements across all sectors and promote a more sustainable seafood sector (Almeida et al., 2022).

2.3.3 Seafood safety

According to Duxbury (2004), the importance of traceability in ensuring the safety of seafood products. Seafood products have unique challenges when it comes to food safety due to the perishable nature of seafood and the potential for contamination during harvesting, processing, transportation, and storage (Duxbury, 2004). The meaning of "Traceability", refers to the point of origin to the point of use, tracing a product. For seafood products, this entails being able to identify the precise fishery or aquaculture farm where the product was caught or raised (Duxbury, 2004). There are several reasons for the importance of traceability. First, In the event of a food safety risk, it permits rapid and efficient recalls. Second, locating the source of contamination, aids in the prevention of the spread of foodborne illnesses. Third, promoting transparency and responsibility throughout the seafood supply chain can aid in the promotion of sustainable fishing methods (Duxbury, 2004). Furthermore, Duxbury (2004) highlights a variety of methods that can be used in order to improve traceability in the seafood industry. These methods include radio frequency identification (RFID), and blockchain technology (Duxbury, 2004). With the help of these methods, real-time tracking of seafood products and improved transparency and communication between stakeholders in the supply chain are possible (Duxbury, 2004). It is also important to consider other food safety considerations. In the case of seafood products, this involves proper handling and storage, adequate cooking temperatures, and prevention of cross-contamination (Duxbury, 2004). Good manufacturing practices (GMPs) and Hazard Analysis and Critical Control Points (HACCP) programs should be put in place in order to assure the safety of seafood products (Duxbury, 2004). Seafood products clearly have food safety issues, but these risks can be mitigated with proper traceability and the application of food safety rules, giving customers the assurance that their seafood is safe and sustainably sourced.

Fish and seafood products are an important source of nutrients for human consumption and play a significant role in global food security. However, the seafood industry generates a considerable amount of waste and by-products throughout the supply chain, resulting in environmental damage (Hassoun et al., 2023). To address these challenges, it is crucial to find innovative solutions and alternative approaches for managing seafood discards more effectively and reducing their impact on the environment (Hassoun et al., 2023).

Application of cutting-edge technology, such as Industry 4.0 developments like Artificial Intelligence (AI), Big Data, and smart sensors, is one effective approach (Hassoun et al., 2023). The efficiency, traceability, and sustainability of these technologies have the potential to completely transform the seafood supply chain. Seafood producers may enhance forecasting accuracy, cut waste, and optimize production processes by using AI and Big Data analytics. Fishermen and farmers can make better decisions by utilizing real-time environmental data provided by smart sensors built into fishing boats and aquaculture equipment (Hassoun et al., 2023). These technologies also make it possible to valorize byproducts and waste from the seafood industry. According to Hassoun et al. (2023), AI algorithms can find valuable components in waste streams like proteins, oils, and minerals that can be extracted and used to make nutritional supplements, aquaculture feed, or even biodegradable packaging materials. This promotes a more circular and sustainable economy while also reducing waste and generating new sources of income.

Overall, the integration of emerging technologies in the seafood supply chain holds great potential for enhancing the blue economy and promoting global food sustainability. Through improved waste management, increased efficiency, and the development of value-added products, technology-driven solutions can minimize environmental burdens, reduce economic losses, and ensure a more sustainable future for the seafood industry (Hassoun et al., 2023).

2.3.4 Seafood in Sweden

Swedish professional fishing and aquaculture give us healthy, good, and sustainable raw materials that consumers in Sweden should eat more of. But the blue industry in Sweden is so much more than just primary production. The entire value chain from sea to table consists of a large number of companies with a combined turnover of close to 30 billion Swedish SEK, shows a survey made by the Norwegian Federation of the Fisheries Industry (Fiskbranschen, 2022).

After the catches are taken ashore, there is extensive trade in seafood between various value chain actors, such as processing, wholesalers, retailers, and restaurants. The fish processing industry in Sweden handles and processes an estimated 100,000 tonnes of fish annually, according to information from “Landsbygdsnätverket" (Fiskbranschen, 2022). Of Swedish landings from the fishery, it is mainly herring and cod that are processed in Sweden. In addition, large quantities of Norwegian-farmed salmon are imported and processed. Fish processing gives the industry better profitability, creates employment in the countryside, and contributes to more sustainable use of seas and lakes.

Although the blue industry already generates great value for society today, the organization Sweden Food Arena believes that there are enormous opportunities to increase value creation. The key is to look after the entire value chain and think of industrial symbiosis. It is important to refine the raw material and take advantage of residual streams. In this way, more jobs will be created, and increase export revenue, technological development, and a lot of spin-offs. The blue industry is sitting on incredible opportunities (Fiskbranschen, 2022).
It's of significant importance to understand the value of this innovative method.

2.4 Waste Management

In order to preserve a sustainable ecosystem and promote appropriate development, waste management is crucial and the preservation of the environment is essential (Kesri, 2021). Effective waste management helps to protect the environment by lowering pollutants and preventing the release of hazardous substances into the air, water, and soil (Kesri, 2021). The contamination of ecosystems and natural resources can be prevented by using the right waste treatment and disposal techniques. Furthermore, waste management plays a vital role in protecting public health. Improper waste management can spread diseases, attract pests and vermin, and contaminate food and water sources. However, by adopting sound waste management strategies such as proper waste collection, disposal, and recycling, the potential health hazards can be significantly reduced (Kesri, 2021).

Waste management is closely intertwined with climate change mitigation efforts. Proper waste disposal and treatment can minimize greenhouse gas emissions, particularly methane, which is a potent contributor to global warming (Kesri, 2021). Landfills and the anaerobic decomposition of organic waste are major sources of methane, making effective waste management practices essential in mitigating climate change (Kesri, 2021). Lastly, waste management aligns with the principles of sustainable development. Waste management helps communities and economies remain sustainable overall by lowering waste generation, boosting recycling and waste reduction, and implementing environmentally friendly practices (Kesri, 2021). Waste management is crucial, and that cannot be emphasized enough. It safeguards the environment, public health, resource conservation, climate change mitigation, and sustainable development (Kesri, 2021). We can all live in a cleaner, healthier, and more sustainable future by putting proper waste management practices into place.

Sales et al. (2023) discuss several challenges regarding waste management that need to be addressed in order to manage waste effectively. The reason for these challenges depends on several factors, including lack of coordination, inadequate infrastructure, limited resources, lack of public awareness, and technological challenges (Sales et al., 2023). The issue of lacking coordination between various stakeholders, including government agencies, waste collectors, and waste generators, is a major challenge (Sales et al., 2023). When this group of actors doesn't work effectively, it can lead to increased waste generation due to inefficiency. For instance, if waste collectors and waste generators do not successfully communicate about appropriate sorting and disposal techniques, recyclables may be contaminated and the amount of waste sent to landfills may increase (Sales et al., 2023).

The lack of waste management infrastructure is another issue. Insufficient infrastructure, such as recycling facilities and composting sites (Sales et al., 2023). These facilities are frequently insufficient or insufficient to handle the demand for waste management services. The result of this can lead to either an exposure of waste in landfills or unlawful waste dumping, both of which have detrimental effects on the environment and public health (Sales et al., 2023).

Financial and human resources are both included in the issue of limited resources, which is a significant challenge for waste management (Sales et al., 2023). There might not be enough funds or employees in some places to manage waste properly. This may result in inadequate staffing levels or funds for waste management activities like public awareness campaigns or community composting education programs. The lack of public awareness has a major significance on the environmental impact that waste has, which is another challenge for waste management (Sales et al., 2023). The public may be unaware of how crucial proper waste disposal methods are or how waste affects local communities. As a result, waste management projects may not receive the support they need, and people may be reluctant to adopt new habits like cutting back on waste or correctly sorting recyclables.

Last but not least, difficulties with technology may also seem to be obstacles to efficient waste management (Sales et al., 2023). Due to the high costs and need for specialized knowledge, implementing new waste management techniques, including waste-to-energy systems, can be challenging. These issues are addressed by Sales et al. (2023), who also emphasizes the importance of having efficient waste management policies and plans. It will be necessary to address these issues in order to effectively manage waste and reduce the harmful effects of waste on the environment and human health.

2.4.1 Sustainable waste management methods

In the study by Kutty and Abdalla (2020), tools and methods are presented that can be used in order to improve waste management practices and reduce environmental impacts that are related to food waste, such as greenhouse gasses. Kutty and Abdalla (2020) single out the use of data analytics as one method. With the aid of this technology, it might be possible to comprehend how food waste is produced, what it is made of, and how it is managed (Kutty & Abdalla, 2020). Stakeholders can more easily try to prevent this or at least reduce the quantity by identifying the source of where the waste being generated with the aid of data analysis. This might be achieved by keeping an eye on food waste during various phases of the supply chain, such as during manufacturing, transit, and storage, and using this data to improve waste management procedures (Kutty & Abdalla, 2020).

According to Kutty and Abdalla (2020), the implementation of a circular economy can improve waste management. This involves designing waste out of the system by creating closed-loop systems referring to a supply chain model that integrates reverse logistics, enabling the efficient and sustainable movement of products, materials, or components from consumers back to manufacturers, where waste is reused, recycled, or repurposed (Kutty & Abdalla, 2020).

For instance, food waste can be utilized to produce animal feed or anaerobically digested waste can be turned into biogas, which can be used to produce electricity (Kutty & Abdalla, 2020). Lastly, the importance of waste management systems is discussed as it's important to implement effective food waste management systems, which involve a combination of policies, technologies, and infrastructure (Kutty & Abdalla, 2020). This can involve putting legislation into place that demands a reduction in food waste and enhancing waste collection and processing systems.

The tools and methods presented by Kutty and Abdalla (2020) provide a variety of strategies that can be applied to enhance waste management. The use of data analytics, implementing circular economy principles, and developing effective waste management systems, could result in a more environmentally sustainable waste management approach.

2.4.2 Carbon footprint of food waste management

The carbon footprint related to waste disposal can also be decreased by improving waste management systems. Companies can lower back on the amount of fuel used and emissions produced during waste disposal by enhancing waste collection and transportation routes and utilizing more effective waste management systems (Henningsson et al., 2001). This can involve employing alternative waste treatment technologies like anaerobic digestion, deploying electric or hybrid waste collection vehicles, and putting in place recycling initiatives to divert recyclable materials from the waste stream (Henningsson et al., 2001).

In general, Henningsson et al. (2001) suggest improving waste management practices can benefit the environment by cutting down on greenhouse gas emissions related to waste disposal. Sustainable waste management techniques can help companies increase profitability over the long term by lowering their impact on the environment as well as their appeal to environmentally aware customers (Henningsson et al., 2001).

The goal of a study by Eriksson et al. (2015) was to evaluate the carbon footprint of several Swedish methods of managing food waste. The total greenhouse gas emissions linked to each method were examined using a life cycle assessment (LCA) methodology. The framework for the investigation was the waste hierarchy, which assesses waste management alternatives according to how they affect the environment. Reduction, Reuse, Recycling, Incineration, and Landfilling were the choices that were looked at in the study (Eriksson et al., 2015). The results revealed that the waste reduction and recycling methods had the lowest carbon footprint compared to disposal methods such as incineration and landfilling. Notably, the study found that recycling had the lowest carbon footprint among all the options. This study emphasizes the substantial environmental impact waste management may have, particularly in terms of carbon footprint. Communities can lessen the carbon footprint of waste management and help to create a more sustainable future by giving priority to waste reduction and recycling programs (Eriksson et al., 2015).

In their study, Eriksson et al. (2015) evaluated not only the carbon footprint of food waste management options but also their social and economic impacts in Sweden. From a social point of view, the authors found that waste reduction and recycling programs can bring job opportunities and support local economies. By diverting waste away from landfills and incinerators, communities can also decrease unpleasant odors, pests, and other waste management-related nuisances (Eriksson et al., 2015). Economically speaking, the study showed that waste reduction and recycling programs can be cost-effective in the long run, as they reduce the need for new landfills and incineration facilities. Furthermore, the recovery of valuable materials from waste through recycling can bring financial gains. On the environmental side, the study demonstrated that waste reduction and recycling options have a lower carbon footprint compared to disposal options, thus contributing to the mitigation of climate change. The study also showed that reducing the amount of waste sent to landfills through waste reduction and recycling can decrease the production of methane, a potent greenhouse gas, from landfills (Eriksson et al., 2015).

Eriksson et al. (2015) present several options on how options can be implemented, these options for a more sustainable future in the study. They also highlight the importance of following waste hierarchy, which means highlighting the important options of waste management from the least to the highest environmentally friendly option. This is important because it helps in decision-making, used as a framework (Eriksson et al., 2015). This hierarchy puts a lot of focus on reducing waste through the options of reducing, reusing, and recycling, which the study found to have the lowest carbon footprint among all the options. It is also important to bring awareness to society.

If the public is educated on the matter and with the help of communities increases participation in educating programs it would bring awareness to the public about reducing waste and improving environmental sustainability. In the study, it is also mentioned that communities can help encourage businesses to implement more sustainable waste management practices by providing incentives, such as tax credits or grants, for implementing waste reduction and recycling programs. Governments can also regulate waste management practices by setting goals and targets for waste reduction and recycling (Eriksson et al., 2015). Food waste, particularly perishable food waste, has a significant impact on the environment. Landfilled food waste produces methane, a potent greenhouse gas, as it decomposes in the absence of oxygen. Incineration of food waste also contributes to greenhouse gas emissions, as well as air and water pollution. In contrast, waste reduction and recycling options can help to reduce the carbon footprint of perishable food waste. Food donation can provide nutritious food to those in need, while composting and anaerobic digestion can turn food waste into valuable compost and biogas, respectively. The importance of reducing perishable food waste in particular and implementing options in order to decrease the carbon footprint of food waste management is presented in the research by Eriksson et al. (2015).

2.4.3 Impact from a life cycle perspective

According to Hanssen (1998), it is important to examine the environmental impacts of product systems from a life cycle perspective. According to Hanssen (1998), products have a significant impact on the environment throughout their entire life cycle, encompassing production, distribution, use, and disposal, rather than solely during their use phase. The waste management stage plays a crucial role, as improper management can lead to substantial environmental consequences. Different waste management strategies such as recycling, incineration, and landfilling can have both positive and negative environmental effects (Hanssen, 1998). For example, incineration may result in air pollution, while landfilling can release toxic gases into the environment and leachate into groundwater (Hanssen, 1998). Conversely, recycling can contribute to the preservation of natural resources and reduce the amount of waste sent to landfills. Hanssen (1998) emphasizes the importance of considering the entire life cycle of a product when assessing its environmental impact, as well as the necessity of implementing environmentally friendly waste management practices to prevent adverse effects. The author thoroughly discusses the environmental impacts associated with various stages in a product's life cycle, including raw material extraction, distribution, use, and waste management (Hanssen, 1998). Furthermore, the research highlights the need to adopt environmentally friendly waste management methods and underscores the significance of comprehensive life cycle assessment for evaluating a product's environmental impact. The ideas presented in this research provide a solid framework for understanding the environmental implications of products and promote the development of sustainable production systems that mitigate negative environmental effects (Hanssen, 1998).

This study by Brancoli et al. (2020) focuses on the environmental impacts of waste management in Sweden. Their main focus regards surplus bread. Brancoli et al. (2020) provide a theoretical framework for evaluating the environmental impact of different waste management strategies for surplus bread, including landfilling, and incineration. The framework uses life cycle assessment (LCA) to evaluate the environmental impacts, including greenhouse gas emissions, energy consumption, and land use. The results show that recovery for animal feed had the lowest environmental impact, while incineration had the highest impact. Brancoli et al. (2020) also discuss the economic and logistic challenges of implementing these waste management strategies.

The study suggests that an effective waste management strategy for surplus bread should consider both environmental impact and economic viability. Brancoli et al. (2020) suggest that recovery for animal feed is the most environmentally-friendly option, but more research is needed to assess its feasibility in practice. Brancoli et al. (2020) also discuss the logistic and economic challenges regarding the implementation of waste management strategies for surplus bread in Sweden.

Regarding the logistic challenges, Brancoli et al. (2020) mention that recovering surplus bread for animal feed requires a well-organized distribution system to ensure that the surplus bread is transported to the right location, stored properly, and distributed to the right animals. There are also hygiene and safety concerns that need to be addressed, such as the presence of chemical contaminants or pathogens. From an economic perspective, Brancoli et al. (2020) note that recovery for animal feed is a relatively low-value option compared to other waste management strategies. This suggests that there may not be enough financial motivation for waste management companies to make recovery for animal feed a priority. The expense of gathering and transporting the extra bread to the locations where animal feed is produced could also prevent implementation (Brancoli et al., 2020).

3. Theoretical Framework

This section will describe in more detail different logistic methods and approaches that can be used within the food supply chain and seafood supply chain. The reason why this section is important is to give a general insight and understanding of how waste management works and how different logistic tools can help enhance waste management systems in respective fields.

3.1 Waste Flow Management System

The generation, collection, and disposal of waste are seen as a system (Seadon, 2010). In order to create more sustainable behaviors, a systems approach that reveals its relationship to other system components should be considered. The transition to a more sustainable society calls for more sophisticated waste management. Traditional reductionist methods lack adaptability and long-term thinking, which makes them unsustainable (Seadon, 2010). A system for managing waste that is sustainable has feedback loops, focuses on processes, is adaptable, and diverts waste from disposal (Seadon, 2010). Finding and using leverage points that cause change is necessary for the transition to a sustainable waste management system.

The formal waste management system approach includes generation, collection, and disposal which is planned as unattached operations (Seadon, 2010). All three, nevertheless, are intricately interrelated, and anyone can have an impact on the others. Planning for these activities necessitates creating an equilibrium between manufacturing, transportation, land use, urban growth and development, and public health considerations subsystems (Seadon, 2010). The possibility for improved operational sustainability improves when waste is viewed as a component of a production system because it reveals the relationship between waste and other system components (Seadon, 2010).

3.1.1 Food waste management

Waste of food occurs in the whole food chain having its root cause early in the chain whereas harvesting with errors makes the main reason for having high quantities of food residuals (Tiwari, 2022). Consumers also tend to create a situation where food waste is inevitable by purchasing and consuming without planning, therefore making it an important lead factor to lower food waste. When talking about food waste in general, there is one aspect where food becomes waste in the harvesting, production, and distribution periods where errors occur.

The second aspect is based on consumer needs and behaviors (Tiwari, 2022). Food defects can vary from one raw material to another, raw material can in some cases be used for another purpose creating a different end product than originally designated, having a purpose of being environmentally efficient and at the same time being diverse in supply (European Environment Agency, 2021).

Ultimately consumer needs and behaviors need to change in order to maintain an environmentally efficient way of consuming, whereas planning and consuming is correlated and an important factor in terms of needs being met, purchasing patterns being environmentally efficient and over-consumption being reduced as a result (European Environment Agency, 2021).

3.1.2 Seafood waste management

The Waste management system in the seafood industry includes several practices with the aim to reduce waste production, recover valuable resources from waste and minimize the negative impact of waste on the environment (Dubrey et al., 2021). There are some key factors in waste management regarding the seafood industry. This includes Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Points (HACCP) (Dubrey et al., 2021). These work as safety management systems with the aim of preventing waste generation with the help of increased process efficiency, and increasing product quality and safety. Waste reduction and segregation are also key factors in waste management. This involves reducing waste at the source by optimizing fish processing operations, reducing the use of packaging materials, promoting the reuse of containers, and segregating waste for recycling (Dubrey et al., 2021). The recovery of fish meal, fish oil, and other value-added products from fish waste as valuable resources are also key factors. Moreover, fish waste can be used as feedstock for the creation of biogas, which is a renewable energy source (Dubrey et al., 2021).

3.2 Supply Chain Management

The movement of goods and services can be characterized as the definition of supply chain management (SCM), which also encompasses all procedures that convert raw materials into finished items (Fernando, 2022). In order to maximize consumer value and gain a competitive edge in the market, a company's supply-side activities must be purposefully simplified as part of its supply chain. Through SCM, suppliers try to run supply chains that are as efficient and affordable as is practical (Fernando, 2022). Supply chains cover all aspects of production, product development, and the information systems needed to coordinate these activities (Fernando, 2022). The SCM tries to control or create a link between the production, shipment, and distribution of a product. By managing the supply chain, businesses can reduce unnecessary costs and expedite the delivery of goods to customers (Fernando, 2029). Internal inventories, internal production, internal distribution, internal sales, and the inventories of firm vendors are all closely monitored to achieve this (Fernando, 2022). There is a supply chain manager who tries to avoid shortages and maintain affordability. It is important to understand that the job is not only about logistics and purchasing inventory.

There are five key elements included in SCM - planning, sourcing raw materials, manufacturing, delivery, and returns (Fernando, 2022). The planning phase entails creating a comprehensive supply chain strategy, whereas the other four components focus on the essential conditions for putting that strategy into action.

3.2.1 Food supply chain

As mentioned before, the food supply chain involves all stages/steps that products have to go through during the movement from production to consumer (Lewis, 2022).

- Production: In this stage, the beginning of food SC starts and the product is sourced. It's important to follow local and international guidelines in order to secure quality and food safety.

- Handling and storage: This stage describes the final preparations and procedures that food goes through after it has been harvested. Before the food is delivered to be processed.

- Processing and packaging: When food is processed, it turns into an edible form. This procedure takes place in this stage. It is important that the product before it is packed for sale and distribution, fulfills all food safety criteria.

- Distribution: After the processing stage the product is ready to be transported to retailers and suppliers.

- Retailing: This stage involves the process of delivering products to consumers.

- Consumption: The final stage is where customers buy the products from retailers.

3.3 Distribution Systems

A distribution system is a network of interconnected warehouses and transportation systems that receive stocks of commodities and eventually convey them to consumers in the supply chain (Hayes, 2022). It acts as a link between the producer and the buyer, either directly or through a retail network. A prompt and trustworthy distribution network is essential in today's instant gratification consumer society (Hayes, 2022). One of the key elements in a business's success is developing a good distribution system. It is a component of strategic planning that allows a business's products to reach customers swiftly and effectively while also managing expenses enabling the business to attain larger profit margins. (Hayes, 2022).

Depending on the product and the location of the final consumers, the supply chain for goods may contain a vast distribution system (Hayes, 2022) A manufacturer might have a distribution system to serve wholesalers, and wholesalers might, in turn, have their own network to ship to retailers' distribution system, which would be the final link in the supply chain before the products were sold in retailers' physical locations (Hayes, 2022).

A company must plan out its demands for personnel, vehicles, IT infrastructure, and other resources for the complete distribution system. Distribution systems involve all phases that deliver finished items into the hands of consumers and are located at the flow of goods and services in the post-manufacturing stage of a supply chain (Hayes, 2022).

3.3.1 The use of distribution systems

Distribution is a key component in the food supply chain (Validi et al., 2014). It involves the transportation, storage, and handling of products. These products are often perishable, which means that they have special requirements regarding storage (Validi et al., 2014). The main goal of a distribution system is to minimize waste and lessen the supply chain's impact on the environment, it is important to make sure that food products are transported to the final customer in a timely, effective, and safe manner. There is also a need for the use of technology, such as refrigeration and tracking systems. This can help improve the efficiency of the distribution system by making certain that food products are transported and stored under the best possible conditions for humidity and temperature. Minimizing food loss and deterioration during storage and transportation can also help to reduce waste (Validi et al., 2014).

3.4 Life cycle assessment

The process of life cycle analysis (LCA), usually referred to as life cycle assessment, looks at how a product or service affects the environment over its entire lifespan (Golsteijn, 2022). The environment may be impacted differently by each stage of a product's life cycle, including the extraction of raw materials from the environment, manufacturing, use, and disposal. These stages of a product's life cycle are referred to as life cycle stages. The environmental impacts of what you are selling can be evaluated using LCA at every stage of its life cycle, from the beginning to the end (Golsteijn, 2022).

LCA can be very beneficial, results from an LCA can assist you in strengthening your marketing, strategic planning, and even policymaking (Golsteijn, 2022). Sustainability managers can evaluate the portfolio and determine what is required to meet carbon footprint targets. Marketing teams can obtain reliable information for communicating sustainability. The purchasing division can find out which vendors use the greenest products and production processes (Golsteijn, 2022).

Because LCA is a standardized method it is reliable and transparent (Golsteijn, 2022). The International Organization for Standardization (ISO) provides guidelines for LCA in ISO 14040 and 14044 (Golsteijn, 2022). These standards describe the four main phases of an LCA: Goal and scope definition, Inventory analysis, Impact assessment, and Interpretation (Golsteijn, 2022).

3.4.1 LCA in Food supply chain

The use of Life cycle assessment (LCA) could be beneficial for the food supply chain for a variety of reasons. It can help to identify areas where the environmental impact is the largest in the food supply chain (Videgar et al., 2021). This would help in order to make efforts to reduce the amount of impact in those areas. This approach can be used to identify areas in the supply chain where the amount of food waste is the largest and also areas that need to be improved. LCA can highlight this issue and serve as a catalyst for initiatives to decrease food waste and enhance the sustainability of the food supply chain (Videgar et al., 2021).

Using LCA, one can examine several food products and supply chain layouts to establish which alternatives are the most environmentally sustainable. Making more informed judgments about food preferences and legislation can benefit consumers, producers, and legislators (Videgar et al., 2021)

3.4.2 LCA in Seafood supply chain

The use of Life cycle assessment (LCA) can be used as a tool in the seafood industry and have an environmental impact on the production and supply chain (Denham et al., 2015). LCA is a method employed to assess a product or service's environmental impact over the course of its full life cycle, from the extraction of raw materials to disposal. LCA can be used in the seafood supply chain in order to identify hotspots, or areas of high environmental impact, such as greenhouse gas emissions from processing facilities (Denham et al., 2015). With the help of identifying these areas, companies can implement strategies in order to reduce their environmental impact. These environmental impacts can be utilizing more energy-efficient tools or obtaining fish from more sustainably managed fisheries.

With the help of using LCA in the seafood industry companies are better able to make judgments regarding their operations and supply chain activities, which will ultimately result in a more environmentally friendly and sustainable market (Denham et al., 2015).

3.5 Circular Economy

The definition of Circular Economy is basically operations driven in a cycle, whereas, for example, raw materials turn into end products and then again enter the cycle by being recycled (European parliament, 2023). The extraction and use of raw materials in our economic system are not circular in pure definition, end products tend to be thrown away and left unused. Governments are pursuing a circular economy by laws and regulations to ensure that end products are recycled to the extent where raw material can be extracted to “reenter” the circle (European parliament, 2023).

Consumer habits are the main factor in regard to creating and maintaining a circular economy; consumption and recycling habits need to change in order to pursue a circular economy (European parliament, 2023). An important factor in recycling is to be able to maintain quality in the materials that will reenter the circle to the extent to satisfy consumers' needs. Lack of quality in recycled products will have the opposite effect of the desire to pursue a circular economy (European parliament, 2023).

3.6 Just-In-Time

With a just-in-time (JIT) inventory system, suppliers can place orders for raw materials that are directly in line with production schedules. The JIT system can therefore be explained as a management strategy (Banton, 2023). Companies that implement this strategy expect to increase efficiency and decrease waste with the help of reducing inventory expenses by only obtaining products they actually need for manufacturing. In order to expect this result, producers need to forecast demand accurately (Banton, 2023).

As explained, the purpose of the JIT inventory system is to minimize inventory and increase efficiency (Banton, 2023). The result of implementing JIT will reduce inventory costs since firms receive the supplies and components they require for production on demand and save on expenses. Also, if an order is canceled or not fulfilled, manufacturers are not left with extra inventory (Banton, 2023).

3.6.1 The use of just-In-Time

To be on time in regard to an industry-based end-date product such as perishables is highly sought after in terms of reducing waste. To have a system where perishables are delivered on time is the ideal concept of a JIT system which also is important (Kesavan, 2022). The importance of a JIT-based food supply chain is that perishables with end dates arrive at designated destinations without delays. Delayed perishables lead to a reduced consumption time which in turn leads to more waste if not consumed within time. A Just in Time-based food supply chain is crucial to maintain the quality and safety of certain perishables. There is a greater significance between different perishables whereas meat-based perishables such as meat and seafood are either sold fresh or frozen down to maintain a durable end date that lasts longer. Nevertheless, the importance of having the climate set in the distribution system of the supply chain for fresh or frozen perishables is important to maintain good quality (Chhonker & Rai, 2021).

3.7 Lean Production Principles

The definition of Lean production principles in its entirety is to eliminate waste, it's a philosophy to ensure an efficient value-creating system to please the desires of end customers (Kanbanize, n.d). The Lean method is broadly used and applied in production and manufacturing operations and is at its core a way of showcasing problematics visually. The flow of information in regards to showcasing problems is also correlated and important in order to increase a leaner production flow. There are 7 different main wastes that are brought up when analyzing a production whereas Lean principles are set to be integrated for increased efficiency (Kanbanize, n.d). The following operations in the following case fall under the subject of muda (wasteful activities): Defects, Motion, Transportation, Inventory, Overproduction, and Over-processing (Kanbanize, n.d).

The performance of a company is based in large portions on how value is sought upon, a large operation of integrating lean in production, for example, can result in enhancing the efficiency in all sectors. The following wastes however vary in different companies and could partially be eliminated whereas inevitable in other companies, and this is taken in regard when analyzing a particular industry sector integrating Lean (Kanbanize, n.d).

There is great significance in articulating the milestones to ensure added value when integrating lean in production and there is also great significance in using the correct tools and methods that correlate with the Lean philosophy (Kenton, 2022). Lean 6-Sigma is used to enhance the efficiency of lean production, in order to articulate and reduce or eliminate muda in a company whereas lean production is integrated 6-sigma acts as a tool. DMAIC, a tool used to conduct and lead operations of improvements (Define, Measure, Analyze, Improve, Control) falls within 6-Sigma and is broadly used in correlation with Lean production (Kenton, 2022).

3.7.1 The use of lean principles

As known, the Lean philosophy focuses on reducing waste and increasing efficiency in production (Sjögren, 2014). In the food supply chain, lean has the aim to reduce waste in every stage of the production. This means from production to distribution and delivery.

The principles of lean can be applied in different activities within the food supply chain. Those activities involve sourcing, processing, packaging, and transportation (Sjögren, 2014). An example of using lean can be related to reducing excess inventory, streamlining production processes, and implementing just-in-time systems (Sjögren, 2014).

With the help of Lean practices, the food supply chain can gain several benefits. These benefits can help companies achieve a more sustainable work way and improve their bottom line, by reducing waste and improving efficiency (Sjögren, 2014).

3.8 Triple Bottom Line

Businesses should commit to treating social and environmental issues with the same priority as they do financial concerns, according to the triple bottom line (TBL). The three bottom lines that should be considered are profit, people, and the environment, according to TBL theory (Kenton, 2023). A TBL seeks to assess an organization's level of adherence to corporate social responsibility as well as its long-term environmental impacts (Kenton, 2023).

According to TBL theory, companies should be working simultaneously on these three bottom lines (Kenton, 2023):

- Profit: The profit and loss statement is a method used for calculating company profit.
- People: This determines how socially conscious a company has been over the years.
- Planet: This assesses a company's commitment to sustainability.

The social dimension of TBL relates to how an organization's operations affect its constituents, such as its workers, clients, communities, and society as a whole (Tamplin, 2023). TBL emphasizes the importance of social responsibility and how businesses should conduct themselves to support the welfare of their stakeholders. The creation of jobs in the community, offering employees equitable salaries and benefits, making investments in their training and development, and supporting community projects are some examples of social impact (Tamplin, 2023).

The impact of an organization's operations on the environment is referred to as the environmental dimension of TBL. TBL places a high priority on environmental responsibility because it understands that companies have a duty to operate in a way that causes the least amount of environmental harm. Reducing greenhouse gas emissions, cutting down on waste and pollution, protecting natural resources, and promoting the use of renewable energy sources are a few examples of environmental effects (Tamplin, 2023).

The economic aspect of TBL relates to how an organization's operations affect its stakeholders and the organization's own financial well-being. Economic responsibility is essential to TBL because it acknowledges that businesses have a duty to act in a way that promotes long-term financial viability (Tamplin, 2023). Revenue generation, the creation of business prospects, and employment creation are some examples of economic impact (Tamplin, 2023).

4. Research method

This section of the study will present the research approach, in order to get a better understanding of how the research was conducted. This study was conducted with a qualitative approach therefore data collection and data analysis will be presented in detail.

4.1 Research process

This work began by chance in search of an interesting topic to write about. The purpose and thoughts behind a possible topic involved a relevant topic and a current issue that involves everyone in our society. By chance, we got in touch with a start-up company, Upcyclr, that works in the seafood industry. An introduction to Waste Management caught our attention and ideas on how we could conduct a study on this topic became more clear. Before we started the work, we sat down and discussed possible research questions. The subject is very broad and by having the right questions we could limit our work. Afterward, it was time to work on the literature and become more familiar with the subject as it was relatively new to us. The literature review was afterward supplemented with a theoretical framework.

Previously, we had decided that a qualitative study was the best option for us. With the help of Upcyclr, we knew we could get in touch with relevant actors in the supply chain, which we did. After conducting the interviews, we had all the data in order to analyze and compare previous research with the actual work in practice.

4.1.1 Upcyclr

Upcyclr is a start-up, founded by two serial entrepreneurs with several start-up successes and considerable experience within the food industry in general, and the seafood industry specifically, and access to raw materials in the suggested projects. The general concept is to establish an industry using a unique set of patented techniques whereas we change the way industries manage side streams of seafood to maximize the output. In correlation with this concept, Upcyclr desires to fulfill and comply with environmental labels and sustainable development goals adopted by the United Nations whereas Sweden is included.

The collaboration with Upcyclr will help in order to get a better understanding of the seafood industry in Sweden, its challenges, and the necessity of waste management. The collaboration with Upcyclr will also make it possible to conduct interviews with some of their partners, actors involved in the seafood supply chain, and authorities, in order to get different perspectives on the relationship between the seafood industry, waste management, and the food supply chain.

4.2 Qualitative research

Qualitative research is a method that is suitable for describing phenomena in their context, in order to present against that background an interpretation that gives an increased understanding of the phenomenon (Justesen & Mik-Meyer, 2011). For example, a student works qualitatively when he chooses to interview a group of people and then carefully interprets his material. Qualitative inquiries encompass various perspectives and are employed by researchers adopting realist, phenomenological, or constructivist approaches. These perspectives assume that the phenomenon under investigation possesses an inherent existence within reality (Justesen & Mik-Meyer, 2011).

The aim is to explore and understand complex phenomena in their natural settings. Unlike quantitative methods that focus on numerical data and statistical analysis, qualitative methods involve gathering rich, non-numerical data such as interviews, observations, and textual materials (Justesen & Mik-Meyer, 2011). These methods emphasize capturing the meanings, experiences, and social contexts surrounding the phenomenon of interest. Qualitative research often involves inductive reasoning, where researchers generate theories and concepts based on the collected data. It seeks to uncover insights, patterns, and themes that can enhance our understanding of human behavior, social interactions, cultural practices, and subjective experiences (Justesen & Mik-Meyer, 2011).

Common qualitative methods include interviews, focus groups, participant observations, case studies, content analysis, and narrative analysis. Qualitative research is highly flexible and adaptable, allowing researchers to explore complex and nuanced aspects of a subject. It provides a deeper understanding of individuals' perspectives (Justesen & Mik-Meyer, 2011).

4.3 Data Collection and Analysis

4.3.1 Primary data

The most common method used to gather qualitative data is through interviewing a number of individuals, as we have chosen to base our research on a qualitative approach. In order to get different perspectives, different actors from the supply chain were interviewed and all actors were asked the same questions, which helped us get a broader view from a practical perspective. The interviews that were conducted were semi-structured with pre-prepared questions based on the literature review, theoretical framework, and research questions. The number of individuals that were interviewed was limited, due to time and access. Because of those reasons, also the number of interviews that were desired did not happen.

The number of individuals that were interviewed, with pseudonym to keep confidentiality:

- **David**, involved in fishing control and seafood safety at the authority “Hav och Vatten”.
- **Eric** At Gothenburg’s fish auction, receives fish from fishermen and sells it at the auction.
- **Anna** at “Bröderna Hansson", the primary producer in the supply chain.
- **Anders** at RE:OCEAN, primary producer in the supply chain.
- **Camilla** at “Blomlöfs Rökeri”, a secondary producer in the supply chain.

The interviews were semi-structured with pre-prepared questions. This approach gave us the opportunity to receive answers directly to the questions but also it gave the interviewee the opportunity to speak freely, which gave us more information and a broader perspective.
Some of the interviews were conducted from online sessions due to the thigh schedules some of the interviewees had. Communication was done through mail and some also answered questions through mail after having a conversation on the phone. We had the opportunity to visit the port of Gothenburg and conduct interviews in place.

4.3.2 Secondary data

A literature review has been conducted in order to get a better knowledge of waste management and the food supply chain. With the help of this approach, a more in-depth understanding of the topic, challenges, and solutions will be made. The use of Scopus and Gothenburg University's internal online database were used to collect data. The literature review was then supplemented with a theoretical framework, in order to get a better understanding of logistic methods, approaches, and tools. Data from news and reliable online sources were also collected in order to get more up-to-date information because some scientific publications could be a few years old.

4.3.3 Data analysis

In order to analyze the acquired data a comparison of the primary and secondary data has been done. The research questions and the interview questions are formed in a way for us to be able to do this comparison. The two forms of data have been compared in order to find similarities and differences to understand and discuss the possibility of implementing theory into practice. These findings will be discussed further in the discussion section of our study.

4.4 Reliability and validity

Reliability pertains to the consistency of a method in measuring a particular aspect. When the same methods are employed under the same conditions and consistently yield identical results, the measurement is deemed reliable (Middleton, 2023). The validity, on the other hand, concerns the accuracy of a method in measuring its intended target. If research exhibits high validity, it means that the results obtained align with genuine properties, characteristics, and variations in the physical or social realm (Middleton, 2023).

Evaluating validity is a more challenging task than assessing reliability, yet it holds even greater significance. In order to obtain meaningful outcomes, the data collection methods employed must possess validity: the research must accurately measure what it claims to measure (Middleton, 2023). This guarantees that the discussion of the data and the conclusions drawn from it are also valid.

The degree of confidence that extra variables or factors are not affecting the causal relationship under investigation is referred to as internal validity (Streefkerk, 2022). The confidence that any observable changes or effects may be traced to the particular variables under research rather than other factors is what it is all about. The extent to which your study's results can be applied to various situations or groups is referred to as external validity. It entails determining if the results that were observed are applicable to situations in the actual world and hold true outside of the immediate experimental context (Streefkerk, 2022).

The validity of the study is intricately tied to the design you employ. A well-designed study incorporates measures to ensure both internal and external validity. By carefully controlling and manipulating variables, you enhance the internal validity of your study, reducing the potential for confounding factors to cloud the observed causal relationships (Streefkerk, 2022). Simultaneously, incorporating diverse samples, relevant settings, and realistic conditions into your study design strengthens its external validity, increasing the likelihood that your findings can be generalized to broader contexts (Streefkerk, 2022).

Therefore, in this study, the focus will be on external validity. This denotes the extent to which the findings can be implemented in other settings and systems.

4.5 Study limitation

The study was limited to the food supply chain with a focus on seafood, and the findings may not be generalizable to other industries or supply chains. Also, the geographic limitation to Västra Götaland in Sweden may influence the results, as the waste flow management practices and regulations in other countries may be different. Some of the data collected could be challenging to analyze, as a semi-structured questionnaire was used that allows participants to freely express their thoughts which can be seen as time-consuming from the participant's perspective and could be challenging to analyze.

5. Result

In this section of the study, the answers from the interviews will be presented. The structure is based on which interview was done first, in other words first to last. The interview questions are presented in the appendix at the end of this paper. The answers from the interviews will, later on, be discussed in the discussion section of this study and be connected to the literature review and theoretical framework. The structure of the result will start with a small introduction about the answer of each interviewee, followed by a transcript of the full interview.

The order of the individuals who participated in this study will be presented, in order to get a better view of the narrative. Names will be fictional to respect the integrity of the respective individuals.

1. **David**, involved in fishing control and seafood safety at the authority “Hav och Vatten”.
2. **Erik** at Gothenburg’s fish auction receives fish from fishermen and sells them at the auction.
3. **Anna** at “Bröderna Hansson", the primary producer in the supply chain.
4. **Anders** at RE:OCEAN, primary producer in the supply chain.
5. **Camilla** at “Blomlöfs Rökeri”, a secondary producer in the supply chain.

5.1 Hav och Vatten

David at "Hav och Vatten" discusses waste management systems and policies in the context of the food supply chain, particularly focusing on the seafood industry. Other key points mentioned are sources of waste in the seafood supply chain and potential solutions and sustainability improvements.

Depending on the location, industry, and type of product, the waste management system is different from one another. In the food supply chain, waste management procedures typically involve minimizing, reusing, and recycling waste materials. These practices' ability to lessen environmental effects is limited. This is due in part to the lack of collaboration and openness among actors involved in the supply chain, which makes it challenging to develop efficient waste management procedures.

Policies and regulations can play an important role in improving waste management practices in the food supply chain. One can implement a carbon tax or create regulations for composting and recycling that can incentivize waste reduction. Implementing standardized reporting and measurement of waste can improve transparency and accountability in the food supply chain. The current policies and regulations regarding seafood products in Sweden include regulations for sustainable fishing practices and labeling requirements for seafood products, followed by the regulations set by the EU.

The main sources of waste in the seafood supply chain include discards, bycatch, and processing waste. These sources of waste vary across different stages of the supply chain. With the help of policies and regulations regarding composting and recycling, there is a possibility to decrease the amount of waste. Also, the use of traceability in order to sustain food safety can improve the sustainability of the supply chain. Within fisheries control, the work to counter unauthorized drafts is a central issue. The existing control tools have not been able to effectively identify individual violations. In the review of the EU's control regulations in the field of fishing that is currently underway, there are proposals to introduce requirements for cameras on board in certain cases.

5.2 Gothenburg's Fish Auction

Eric at Gothenburg's fish auction discusses the operations and waste management practices of Gothenburg's Fish Auction, which serves as the first link in the chain from fishery to the final consumer. Key points mentioned in this answer are the role of the Gothenburg's Fish Auction, management of unsold products, sources of waste in the production chain, utilization of residual products, Desire for development, and collaboration.

The products are not bought by themselves, but the fisherman, wholesaler, or producer owns the goods and we sell the products for them. Very little seafood goes unsold. If and when that happens, the goods remain at the auction during the day, which gives the customers an opportunity to return if they get the opportunity to buy more. Depending on the product, in some cases, it may be suitable to sell the products the next day and it happens that they also have extra auctions on Saturdays. If the product goes unsold because it is of inferior quality, they may have to discard the product. There is also an opportunity if the fisherman/producer wishes to donate the products to a charitable cause, in that case, the auction has contact with some aid organizations such as the Rescue Mission and the City Mission, and who have the opportunity to take care of some. Should there still be something that has to be discarded, it goes to animal feed production or digestion for energy/biogas. It is coordinated with residual waste from the fish retailers, who have a management system for this and where unsold products are put in place. There are lots of projects that aim to make use of residual products. Everything from making fish mince from meat left on the backbone of herring to various protein products from mussels and monkfish. The auction believes that collaboration between research and the fishing industry is the way to go, which is what we see results from in several different projects. The sources of waste in the production chain are mainly residues. It can be hides, bones, skins, and shells that become residual products after processing. The main task is to sell as much as possible so that there are few or no unsold products.

The auction has a great desire to develop Gothenburg's fishing harbor and become even more efficient and coordinate more between all the companies that are here in the fishing harbor and those who deliver here. They want to build a new efficient fishing port in order to be able to get better at coordinating resources such as electricity, cooling, heating, logistics, cleaning, etc. Also, they have a vision project that is currently on the building committee's table for decision, and which could put Gothenburg on the map for a marine center that encompasses the entire industry through research, sales, and processing.

As an industry, collaboration is important in the entire chain from fishing/farming to the end consumer. To make use of the fantastic resources there are and make sure to use them in a sustainable way, resulting in both good and useful food, and at the same time healthy and productive seas and lakes. Collaboration can be seen as a major factor in order to manage waste. To address this challenge, it is important to improve collaboration and communication among all actors involved and increase transparency in the supply chain.

5.3 Bröderna Hansson

Anna at Bröderna Hansson discusses several aspects related to supply chain efficiency, waste management, and the role of technology in the context of the operations of the company. Other key points mentioned are the importance of collaboration in the supply chain and implementing logistic tools.

Hansson buys small volumes of whole fish and hand cuts. From this comes what they define as “fish cleaner” (head, bones, entrails, skin). In 2022, the volumes were 46 tonnes.
Large volumes of fileted fish are bought and sold. Discarded volumes are defined as food waste (whole cooked seafood, fish filets). In order to develop and make the supply chain more efficient there is a need for increased value in terms of material, more collaboration between actors, and new systematic approaches. For Hansson, it is important to implement logistic approaches, like lean management in order to make their workplace more efficient. This approach is something that can be used throughout the chain. You have to think about the whole chain and it starts with fishing. Next, everyone involved in the logistics must have an idea about the handling and quality of the product. Transports must be fast and efficient to maintain quality. Some products are discarded when they arrive because the quality is not up to par. Perhaps it would be better to freeze the fish on site and ship it frozen to sell it as "refreshed" on the market. Technology can be used to enhance waste flow management in the supply chain through data analytics and smart logistics. Data analytics can help identify waste hotspots and optimize production processes to reduce waste. Smart logistics can improve the efficiency of transport and reduce waste.

5.4 RE:OCEAN

Anders at RE:OCEAN discusses various aspects related to waste management, sustainability measures, and the supply chain in the context of the company.

REO is a pioneer within its field, building the first large-scale land-based salmon farm in Sweden. The set-up includes fully controlled water purification in and outflows, securing sustainable measures. Electricity is produced by solar panels on the roof and a joint venture with Schneider Electric in building its own windmill. All waste from farming and value-added production is utilized to produce food products, fertilizers, and the last fraction biofuel. Waste in primary production is primarily guts, blood, fins, backbones, fins, and heads. The aim is to collect all waste separately to maximize its utilization. In order to measure waste and evaluate environmental impact, a third-party assessment is used.

By doing what they are doing – consolidating the value chain to fewer and more efficient facilities close to markets is an approach to improve waste management practices in the supply chain. Logistic tools are believed to be good structuring tools to conduct business and build continuous improvement programs. Traceability, data analysis, and circular economy principles are some examples of approaches to use in order to create a sustainable value chain.

They believe primary producers play a major role in increasing food efficiency. All businesses need to adapt to fully circular models to stay in business and want to be front runners in transforming the business line in order to improve sustainability and reduce environmental impacts.

5.5 Blomlöfs Rökeri

Camilla at Blomlöfs Rökeri discusses various aspects related to waste management practices and strategies to minimize waste throughout the supply chain. Other key points mentioned are sources of waste in secondary production, the importance of collaboration in the supply chain, and the use of lean, LCA, and circular economy.

Their role in waste management practices involves minimizing waste generated during production. This includes ensuring that any by-products or waste generated during the production process are sorted and managed effectively to minimize environmental impacts.
The main sources of waste in the secondary production stage include offcuts, trimmings, and other by-products generated. They manage these waste sources by implementing efficient waste management practices such as sorting, recycling, and reusing where possible.

Collaboration with primary producers to establish best practices for waste reduction and management throughout the supply chain, and also work closely with waste management companies to ensure that waste is managed in an environmentally responsible manner.
Waste management could be improved by the use of lean, LCA, and circular economy. While LCA can be used to assess the environmental effects of various production techniques, lean tools can be utilized to focus on minimizing waste. The ideas of the circular economy could be applied to find chances for recycling waste that is produced.

Regarding sorting and managing waste, it can be time-consuming and costly, so it's important to find ways to minimize waste and maximize value. To ensure that waste is sorted and managed effectively, they use waste management protocols that involve proper sorting and storage of waste, and disposal in a responsible manner. Increasing public awareness about the importance of waste reduction and management and investing in new technologies that can help minimize waste. Collaboration with primary producers and waste management companies is important to establish a good opportunity for waste reduction and management throughout the supply chain.

6. Discussion

This section of the study will discuss the data analysis, in order words see how much the literature review and theoretical framework are aligned with the results. The structure of this section will be based on the participants from the interviews and under each participant the primary and secondary data will be discussed and analyzed.

David

Both the literature review and David emphasize the importance of waste management and its value. The literature review highlights its positive impact on the environment, public health, climate change mitigation, and sustainable development (Kesri, 2021). Similarly, David emphasizes waste management procedures in the food supply chain to minimize negative environmental effects. The challenges faced in waste management are discussed by both the literature review and David. The literature review identifies challenges such as lack of coordination, inadequate infrastructure, limited resources, lack of public awareness, and technological barriers (Sales et al., 2023). David also mentions the lack of collaboration and openness among actors in the food supply chain, which hinders the development of efficient waste management procedures.

Both the literature review and David recognize the role of policies and regulations in improving waste management practices. The literature review suggests that effective waste management policies and strategies are crucial in addressing the challenges (Sales et al., 2023). Similarly, David highlights the importance of policies and regulations, such as carbon tax, composting and recycling regulations, and standardized reporting, in incentivizing waste reduction and enhancing transparency in the food supply chain. Regarding waste sources and reduction strategies, the literature review focuses on waste in the seafood supply chain, including discards, bycatch, and processing waste, and highlights composting and recycling as potential solutions (Sales et al., 2023). David also acknowledges the need for waste reduction in the food supply chain and suggests strategies such as minimizing, reusing, and recycling waste materials.

The technological challenges of waste management are briefly mentioned (Sales et al., 2023). In the interview, traceability is discussed as a means to improve food safety and supply chain sustainability. Additionally, the review of the EU's control regulations in fishing proposes the introduction of requirements for cameras on board in certain cases.

Both the literature review and David emphasize the significance of traceability in ensuring the safety of seafood products. The literature review (Duxbury, 2004) highlights that traceability enables swift and effective recalls in case of food safety risks, aids in identifying contamination sources, and promotes transparency and accountability throughout the seafood supply chain. David also recognizes the use of traceability to enhance sustainability in the supply chain.

Regarding traceability technologies, the literature review discusses the utilization of radio frequency identification (RFID) and blockchain in improving traceability within the seafood industry (Duxbury, 2004). Similarly, David suggests that implementing policies and regulations, such as the introduction of cameras on fishing vessels, can enhance traceability and prevent unauthorized activities. The literature review underscores the environmental harm caused by waste and by-products in the seafood supply chain (Hassoun et al., 2023). David acknowledges the existence of waste in the supply chain, including discards, bycatch, and processing waste, and suggests the possibility of waste reduction through policies, regulations, and improved waste management practices.

Both the literature review and David emphasize the potential of emerging technologies to promote sustainability in the seafood industry. The literature review mentions the application of Industry 4.0 technologies such as AI, Big Data, and smart sensors to optimize production processes, enhance forecasting accuracy, and reduce waste (Hassoun et al., 2023). David proposes that technology, such as traceability systems and standardized reporting, can contribute to waste reduction and improve overall sustainability.

Eric

The literature review highlights the close relationship between waste management and climate change mitigation efforts. Proper waste disposal and treatment can minimize greenhouse gas emissions, particularly methane, which is a potent contributor to global warming (Kesri, 2021). Eric also mentions the potential of anaerobic digestion of waste for producing biogas, which can be used to generate electricity. This aligns with the literature review's emphasis on waste management's role in mitigating climate change.

Kutty and Abdalla (2020) suggest that data analytics can be a valuable tool in understanding food waste generation, composition, and management. By monitoring food waste at various stages of the supply chain and analyzing the data, stakeholders can identify the sources of waste and take preventive measures. Eric mentions the importance of selling as much seafood as possible to minimize waste, indicating a focus on monitoring and managing unsold products. The implementation of a circular economy is emphasized in both the literature review and the interview. Kutty and Abdalla (2020) propose designing waste out of the system by creating closed-loop supply chain models that enable the reuse, recycling, or repurposing of waste materials. Similarly, Eric mentions various projects that aim to utilize residual products, such as making fish mince from herring leftovers. This reflects the application of circular economy principles to minimize waste and maximize resource efficiency.

Both the literature review and Eric emphasize the importance of collaboration and communication among stakeholders in the waste management process. The literature review highlights the need for collaboration between research and the fishing industry to achieve sustainable waste management practices (Kutty & Abdalla, 2020). Eric also stresses collaboration as a key factor in managing waste effectively, ensuring the sustainable use of resources, and promoting healthy and productive seas and lakes. The literature review and Eric emphasize the occurrence of food waste at various stages within the food supply chain. The literature review emphasizes the need to identify the primary causes throughout the chain (Göbel et al., 2015). Eric mentions that residues are the main sources of waste in the production chain, indicating a shared recognition of different stages and factors contributing to food waste.

The sources emphasize the importance of collaboration and coordination among stakeholders to effectively address food waste. The literature review highlights the need for improved communication and collaboration among all actors in the supply chain (Göbel et al., 2015). Eric emphasizes collaboration in the fishing industry and mentions ongoing projects aimed at utilizing residual products. This connection underscores the significance of cooperation in managing and reducing food waste. Both the literature review and Eric acknowledge the extensive impacts of food waste. The literature review discusses environmental issues such as resource wastage, greenhouse gas emissions, and economic concerns related to losses and increased waste management costs (De Boni et al., 2022). Similarly, Eric mentions the potential use of unsold products for animal feed production or energy/biogas, indicating an economic and environmental perspective. Furthermore, the literature review highlights social implications, including the ethical aspect of wasting food while there are populations suffering from hunger and malnutrition (De Boni et al., 2022). This connection underscores the multifaceted impacts of food waste.

Both the literature review and Eric emphasize the importance of implementing measures and policies to prevent and reduce food waste. The literature review suggests policy measures focusing on areas such as storage and transportation practices, food processing infrastructure and technology, and consumer awareness (De Boni et al., 2022). Eric highlights the auction's intention to develop the fishing harbor and improve coordination, indicating a potential focus on infrastructure and logistics. This similarity suggests that policy interventions and infrastructure improvements can contribute to waste reduction.

Batista et al. (2021) highlight the significance of a circular economy in reducing waste in food supply chains. Their study emphasizes the need for coordination and cooperation among supply chain actors to minimize waste at various stages, such as production, processing, distribution, and consumption. Circular economy practices, such as improved supply chain coordination and recovery of valuable resources from waste streams, can contribute to environmental, economic, and social benefits. Eric highlights the potential of a circular economy in reducing waste and promoting sustainability. They emphasize reusing resources, minimizing waste generation, and recovering valuable materials from waste streams.

Ekren and Kumar (2022) propose multiple strategies to address food loss and waste across the supply chain. These strategies include improved forecasting and demand planning, effective inventory management, optimal packaging and storage, collaboration among stakeholders, and consumer education. In order to align this with the interview with Eric, it is highlighted that collaboration among all the actors is emphasized.

The importance of sustainable food waste management is discussed for achieving global sustainable development goals Wani et al. (2023). They emphasize the need for source reduction, contemporary treatment technologies, and the transformation of food waste into value-added products. It acknowledges the trade-offs involved in ensuring food safety, sustainability, and security while reducing greenhouse gas emissions. Eric acknowledges the potential of waste-to-energy technologies, such as anaerobic digestion, in converting food waste into energy and reducing greenhouse gas emissions.

Anna

Both the literature review and interview with Anna emphasize the importance of collaboration among actors in the supply chain. Tseng et al. (2022) highlight collaboration as a method to reduce waste, improve product quality, and adopt sustainable practices. Anna also mentions the need for increased collaboration between actors in order to develop and make the supply chain more efficient.

The literature review discusses lean management as a method to reduce waste and increase supply chain efficiency (Tseng et al., 2022). Anna mentions implementing logistic approaches, like lean management, to make their workplace more efficient. This aligns with the concept of using lean management practices throughout the supply chain to optimize processes and minimize waste. The literature review (Faccio et al., 2013) discusses applying lean principles to food logistics and supply chain management to reduce waste and increase efficiency. It identifies five main principles of lean thinking: defining value, mapping the value stream, creating flow, establishing pull, and pursuing perfection. Anna highlights the importance of implementing logistic approaches, such as lean management, to make the workplace more efficient. It suggests that lean principles can be used throughout the supply chain, starting from fishing and extending to all actors involved in logistics.

The concept of Lean production is highlighted, which focuses on eliminating waste and creating an efficient value-creating system to meet customer desires (Kanbanize, n.d). It emphasizes the seven main wastes identified in Lean principles, including defects, motion, transportation, inventory, overproduction, and over-processing (Kanbanize, n.d). The review also mentions the significance of integrating Lean in production to enhance efficiency in different sectors (Kanbanize, n.d). Additionally, it discusses the importance of using tools and methods that align with the Lean philosophy, such as Lean 6-Sigma and DMAIC (Kenton, 2022).

Anna provides insights into the implementation of Lean practices in the food supply chain. It mentions the application of Lean principles in various activities within the chain, including sourcing, processing, packaging, and transportation (Sjögren, 2014). Anna highlights the need for increased value, collaboration, and systematic approaches to making the supply chain more efficient. They specifically mention the importance of logistic approaches, like Lean management, throughout the chain, starting from fishing (Sjögren, 2014). Anna also emphasizes the significance of fast and efficient transport to maintain product quality and suggests using technology, such as data analytics and smart logistics, to improve waste flow management and reduce waste (Sjögren, 2014).

Tseng et al. (2022) discuss the importance of traceability in ensuring food safety and sustainability in the seafood supply chain. Anna mentions the need for everyone involved in the logistics to have an idea about the handling and quality of the product, which can be facilitated through traceability. Traceability systems can also help identify waste hotspots and optimize production processes (Tseng et al., 2022). Both the literature review and interview highlight the role of technology and data analytics in waste flow management and supply chain efficiency. Tseng et al. (2022) mention that data analytics can help identify waste hotspots and optimize production processes. Anna mentions the use of technology, such as smart logistics and data analytics, to enhance waste flow management and improve the efficiency of transport.

The literature review highlights the need for an integrated approach to address food loss and waste. It suggests investing in efficient processing technologies, storage and packaging solutions, road infrastructure, market linkages, and providing training and education to all actors, including consumers (Göbel et al., 2015). Anna emphasizes the importance of thinking about the whole supply chain and implementing new systematic approaches to improve efficiency. It mentions using technology, data analytics, and smart logistics to enhance waste flow management and reduce waste. The literature review (Rezaei & Liu, 2017) explains that food loss can occur due to inadequate storage facilities, lack of proper cold chain infrastructure, and improper food handling practices, leading to quality deterioration. It also mentions the adverse effects on farmers and producers when food quality is compromised. Anna states that maintaining product quality is crucial, starting from fishing and throughout the logistics process. It suggests that fast and efficient transport is necessary to ensure product quality and mentions the possibility of freezing fish on-site and shipping it frozen to maintain freshness.

Both the literature review and Anna emphasize the importance of traceability in ensuring the safety of seafood products. The literature review highlights how traceability enables rapid recalls, aids in preventing the spread of foodborne illnesses, and promotes sustainable fishing methods (Duxbury, 2004).

Anna mentions the need for everyone involved in logistics to have an idea about the handling and quality of the product, emphasizing the importance of traceability throughout the supply chain. Both sources recognize the significance of traceability in maintaining food safety and ensuring quality throughout the seafood supply chain.

The literature review discusses the potential of emerging technologies, such as AI, Big Data, and smart sensors, to enhance efficiency and traceability in the seafood industry. Hassoun et al. (2023) mention that these technologies can optimize production processes, improve forecasting accuracy, and reduce waste. Anna suggests using technology, specifically data analytics and smart logistics, to enhance waste flow management in the supply chain, identify waste hotspots, and improve transportation efficiency. The results are aligned and acknowledge the role of technology, such as data analytics and smart logistics, in improving efficiency and waste management in the seafood supply chain.

The literature review mentions the challenges of waste generation and environmental damage in the seafood industry (Dubrey et al., 2021). It highlights the potential of emerging technologies to valorize seafood waste and by-products by identifying valuable components that can be extracted and used for various purposes. Anna discusses the importance of increasing value in terms of material and implementing logistic approaches to make the supply chain more efficient. It suggests freezing fish on-site and shipping it frozen as a way to reduce waste and maintain quality. The importance of waste management and suggestions for value-added approaches are highlighted, such as extracting valuable components from waste or optimizing logistic approaches, to reduce waste and improve efficiency in the seafood industry.

The literature review by Hartikainen et al. (2018) highlights that rejection due to cosmetic defects or overproduction, losses in storage and transportation, and discards in processing contribute to food waste in primary production. Anna mentions that they are experiencing food waste in their supply chain, specifically in terms of discarded volumes of whole-cooked seafood and fish filets. Both the literature review and Anna acknowledge the significance of collaboration among actors in the food supply chain to reduce waste. Hartikainen et al. (2018) mention collaboration between primary producers, retailers, and processors as a key approach to waste reduction. Similarly, Anna mentions the need for increased collaboration between actors in order to make the supply chain more efficient and reduce food waste. Both sources recognize the importance of leveraging technology to address food waste. The literature review mentions the use of new technologies for waste reduction and utilization, such as new packaging methods and sensors for optimizing storage and transportation. Anna suggests the use of technology, such as data analytics and smart logistics, to enhance waste flow management in the supply chain.

The literature review highlights various environmental effects associated with seafood production and supply systems, such as overfishing, habitat disruption, pollutants, and greenhouse gas emissions (Denham et al., 2015). Anna indirectly addresses the environmental impact by discussing the need for increased value in terms of material, more collaboration between actors, and new systematic approaches to make the seafood supply chain more efficient. This indicates a recognition of the environmental challenges and the importance of optimizing processes throughout the chain, including fishing, handling, quality control, and transportation.

The literature review emphasizes the role of packaging in preserving and transporting seafood while acknowledging its environmental impacts, such as greenhouse gas emissions and waste management issues (Almeida et al., 2022). Anna briefly mentions the difficulties the company faces in developing its use of packaging due to cost concerns. This connection suggests that the challenges related to packaging align with the literature's concerns about environmental burdens and the need for sustainable packaging alternatives. The concept of the triple bottom line (TBL) is introduced in the theoretical framework, which emphasizes the importance of considering profit, people, and the planet in business operations (Kenton, 2023). Anna indirectly touches upon this concept by discussing the need for logistic approaches like lean management to make the workplace more efficient, indicating an awareness of the economic aspect of TBL. Additionally, the mention of packaging challenges and the potential benefits of implementing TBL suggests a recognition of the social and environmental dimensions of corporate social responsibility.

Anders

The literature review and the interviewee both discuss challenges associated with waste management. The literature review mentions issues such as lack of coordination, inadequate infrastructure, limited resources, lack of public awareness, and technological challenges (Sales et al., 2023). Anders highlights the importance of logistic tools, traceability, data analysis, and circular economy principles as approaches to overcome these challenges and create a sustainable value chain. Sales et al. (2023) address the challenges of waste management, including lacking coordination, inadequate infrastructure, limited resources, and lack of public awareness. Anders emphasizes the use of logistic tools, traceability, and circular economy principles to improve waste management practices.

Both the literature review and the interviewee mention the importance of leveraging technology to improve waste management practices. The literature review discusses the use of new technologies for waste reduction, such as new packaging methods, sensors, and data analytics (Houghton, 2021). Anders highlights the use of solar panels, windmills, and third-party assessments for waste measurement and environmental impact evaluation.

The literature review and the interviewee both emphasize the importance of traceability in the seafood supply chain. Tseng et al. (2022) mention that traceability ensures food safety and helps consumers make informed decisions about their purchases. In the interview, Anders mentions utilizing third-party assessments to measure waste and evaluate environmental impact, which indicates the importance of traceability for waste management and sustainability. Tseng et al. (2022) and Anders make mention of managing waste in the seafood supply chain. In order to reduce waste, Tseng et al. (2022) talk about lean management and the usage of recyclable or reused packaging materials. Anders mentions utilizing all waste from farming and value-added production to produce food products, fertilizers, and biofuel, emphasizing a circular economy approach to waste utilization.

Both the literature review and the interviewee mention the importance of using data analytics and analysis tools to improve waste management practices and reduce environmental impacts (Kutty & Abdalla, 2020). Both suggest that analyzing data can help identify the sources of food waste generation and enable stakeholders to take preventive measures or reduce waste at various stages of the supply chain. Anders mentions the use of third-party assessments to measure waste and evaluate environmental impact, indicating the application of data analysis techniques. Kutty & Abdalla (2020) emphasizes the importance of implementing effective waste management systems in the food supply chain, involving policies, technologies, and infrastructure improvements. Anders has the aim of collecting all waste separately and utilizing it to produce food products, fertilizers, and biofuel, indicating the implementation of waste management practices. Both the literature review and the interviewee emphasize the importance of sustainable practices and resource optimization in waste management. Sonesson et al. (2016) mention optimizing feed production and using environmentally friendly feed sources to reduce the environmental impact of food production. Anders utilizes waste from farming and value-added production to produce food products, fertilizers, and biofuel, indicating resource optimization and waste utilization.

The literature review and the interviewee emphasize the importance of sustainable food waste management practices. The literature review discusses the need for innovative approaches to address food waste, reduce greenhouse gas emissions, and ensure food safety, sustainability, and security (Wani et al., 2023). Anders mentions how the company collects and utilizes waste from salmon farming and value-added production to produce food products, fertilizers, and biofuel. This aligns with the literature's emphasis on transforming food waste into valuable products through contemporary treatment technologies (Wani et al., 2023). Both sources discuss the link between food waste and greenhouse gas (GHG) emissions. The literature review highlights how inappropriate waste disposal and decomposition of food waste in landfills contribute to GHG emissions, particularly methane (Lin et al., 2009).
It also suggests waste management techniques such as recycling, composting, and waste-to-energy technologies as ways to lower GHG emissions in the food supply chain
(Lin et al., 2009). Anders mentions the company's efforts to measure waste and evaluate environmental impact, as well as its focus on building a sustainable value chain to reduce environmental impacts and improve waste management practices.

The company's usage of circular economy ideas as one of its strategies for developing a sustainable value chain is mentioned by Anders. This is consistent with the notion of the circular economy in the literature review in relation to sustainable packaging options in the seafood industry (Almeida et al., 2022). Both sources stress how crucial it is to adopt circular models and practices in order to increase sustainability, decrease waste, and lessen environmental effects.

The literature review emphasizes the need to involve all participants in the food supply chain, including farmers, manufacturers, distributors, and consumers, to address the food waste issue (Ruiz-Salmón et al., 2021). Anders mentions that primary producers play a major role in increasing food efficiency and that businesses need to adapt to fully circular models. Both sources recognize the importance of collaboration and engagement among stakeholders to achieve sustainable practices and reduce waste throughout the supply chain.

Camilla

To create a more sustainable food supply chain, Sonesson et al. (2016) emphasize the value of an integrated strategy that takes into account a product's whole lifecycle in the literature review. They emphasize the importance of LCA as a method for determining a product's overall environmental impact. Similarly to this, Camilla explains in the interview that LCA is used to evaluate the environmental impacts of various production methods. In the literature review, the idea of maximizing feed production as a way to lessen the environmental effect of food production is raised. This involves using environmentally friendly feed sources and minimizing waste and emissions during the manufacturing process (Sonesson et al., 2016). They also suggest adopting a circular economy approach where resources are reused and recycled, including using by-products for animal feed and other purposes. Camilla mentions that waste management protocols involve sorting and managing waste effectively, and the circular economy ideas can be applied to find opportunities for recycling waste.

Both Batista et al. (2021) and Ekren and Kumar (2022) emphasize the importance of collaboration and coordination among various actors in the food supply chain to reduce waste and improve sustainability. Batista et al. (2021) discuss the need for collaboration between different stakeholders to implement circular economy practices and reduce waste flows at various stages of the supply chain. Ekren and Kumar (2022) mention the significance of collaboration and information sharing among farmers, processors, retailers, and consumers to identify and address food loss and waste hotspots. Camilla emphasizes the significance of collaboration with primary producers and waste management companies to establish best practices for waste reduction and management throughout the supply chain. This aligns with the literature review, which also highlights the importance of collaboration among stakeholders. Both sources recognize the value of working together to optimize waste management and minimize waste generation.

Several strategies for waste reduction are identified in the literature review and from the interview with Camilla. These include improved forecasting and demand planning, optimal packaging and storage, development of new technologies for waste reduction (Hartikainen et al., 2018). These strategies aim to address different stages of the supply chain process and minimize waste generation. Camilla suggests that lean practices can be used to minimize waste. This concept resonates with the literature review, which discusses lean tools as a means to focus on waste minimization (Sundin et al., 2011). By implementing lean principles, such as streamlining processes and identifying areas of waste, the food supply chain can become more efficient and sustainable.

Camilla mentions that the circular economy ideas can be applied to find chances for recycling waste that is produced. This connection aligns with the literature review, which discusses the circular economy approach as a means to promote a more sustainable food supply chain (Batista et al., 2021). Both sources recognize the importance of reusing and recycling resources, including by-products, to reduce waste and enhance sustainability.

The literature review emphasizes the importance of efficient distribution systems in minimizing waste, while the interview focuses on waste management practices during the production process. These two aspects are interconnected because an efficient distribution system can help reduce waste during transportation and storage, while effective waste management practices in production can minimize waste generation (Validi et al., 2014).
Both sources discuss the role of sorting and proper storage in waste management. Camilla specifically mentions waste management protocols involving sorting and storage, while the literature review emphasizes the use of technology, such as tracking systems, to ensure appropriate storage conditions during distribution (Eriksson et al., 2018).

Camilla suggests life cycle assessment (LCA), and circular economy principles to improve waste management. These concepts align with the literature review's mention of using technology and tracking systems to enhance the efficiency of distribution systems and minimize waste. Furthermore, the literature review highlights the concept of value creation and maximizing value in waste management practices (Tseng et al., 2022). The literature review discusses how lean principles aim to minimize waste and promote value creation in waste management systems (Sundin et al., 2011). Camilla mentions the importance of finding ways to minimize waste and maximize value through proper sorting and storage of waste, as well as investing in new technologies to aid in waste reduction.

The literature review also mentions how lean principles can be applied to waste management systems to improve efficiency, speed up the material flow, and minimize waste (Faccio et al., 2013). Camilla suggests that lean tools can be utilized to focus on minimizing waste, and emphasizes the potential benefits of applying lean concepts to waste management practices. The result is aligned with the literature as shown but also it implicates lean as a useful approach because in the food supply chain, lean has the aim to reduce waste in every stage of the production (Sjögren, 2014).

The literature review and Camilla both stress the value of evaluating and controlling environmental issues, particularly those related to waste generation. The use of Life Cycle Assessment (LCA) to assess the environmental impact of products and processes is emphasized in the literature (Ruiz-Salmón et al., 2021). The secondary production stage is where Camilla focuses on waste management procedures. To reduce negative environmental effects, both sources emphasize the importance of efficient trash sorting, recycling, and responsible disposal (Ruiz-Salmón et al., 2021).

The application of LCA in the seafood sector is discussed, highlighting the increasing interest in understanding the environmental implications of seafood products throughout the supply chain. It mentions the challenges associated with seafood supply chains and the need for standardized methodologies and data for accurate assessments (Denham et al., 2015). Both the literature review and Camilla highlight the importance of waste management and its connection to the circular economy. The literature review emphasizes the implementation of a circular economy to improve waste management by creating closed-loop systems (Kutty & Abdalla, 2020). Camilla also mentions that waste management practices involve minimizing waste generated during production and implementing recycling and reusing strategies. The theoretical and practical perspectives both recognize the significance of circular economy principles in waste management practices, aiming to reduce waste and promote sustainability by closing the loop through recycling and reusing.

The literature review discusses various strategies to improve waste management in the food supply chain, such as coordination, better management of food surpluses, and recovering valuable resources from waste streams (Batista et al., 2021). Camilla also mentions using lean tools, life cycle assessment (LCA), and circular economy concepts to minimize waste and find opportunities for recycling. Strategies like coordination, resource recovery, and recycling are discussed from both perspectives to enhance waste management practices and make the process more sustainable.

7. Conclusion

In conclusion, this thesis has explored the current state of seafood waste management in Västra Götaland and identified the main sources of waste in the seafood supply chain. Through the investigation of two research questions, it was found that waste flow management in the food supply chain can be enhanced by implementing strategies in order to develop waste management systems by using new and modern technology, being aware of food safety, better communication, and collaboration between actors in the supply chain. Examples of new and modern technology can be waste-to-energy systems, tracking systems, and data analytics. Implementing a Lean philosophy would be very beneficial in order to focus on reducing waste and also improving the work environment and collaboration through the supply chain. Using a Life cycle assessment (LCA) approach can help identify areas where the environmental impact is the largest in the food supply chain and help reduce the environmental impact of greenhouse gas emissions.

Additionally, it was discovered that the main sources of waste in the seafood supply chain include discards, bycatch, and processing waste. These sources of waste vary across different stages of the supply chain. To address these issues, it is recommended that actors in the seafood supply chain work together to implement waste reduction strategies such as improved handling and storage practices, the development of new markets for by-products, and the adoption of circular economy principles and LCA. By taking action to improve seafood waste management, actors in the supply chain can move towards a more sustainable future.

Regarding the importance of this topic and contribution to this thesis, it has been shown that waste management systems play a crucial role in the food supply chain. With waste being produced at every stage of the chain, effective management strategies are necessary to minimize the negative environmental impact. Challenges related to food waste, food security, and sustainable food production must be addressed by actors throughout the supply chain. By implementing modern technology, practicing food safety, and improving communication and collaboration, actors in the supply chain can enhance waste flow management. The adoption of a Lean philosophy and a Life Cycle Assessment approach can also help to reduce waste and identify areas where the environmental impact is most significant. These strategies are particularly relevant in the seafood supply chain, where sources of waste such as discards, bycatch, and processing waste are prevalent. Addressing these issues through the development of new markets for by-products, improved handling and storage practices, and circular economy principles can lead to a more sustainable future for the seafood industry in Västra Götaland.

Based on the findings presented in this study, it is recommended that further research be conducted in this field to expand on the insights gained in this study. Additionally, the recommendations outlined in this study should be considered by actors in the food/seafood supply chain when implementing future regulations, policies, and practices. It is hoped that

this study serves as a starting point for future research and encourages the advancement of knowledge in waste management.

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Appendix

a. Interview Questions

Can you tell us about your role in the seafood supply chain and how it relates to waste management?

In your opinion, what are the main sources of waste in the seafood supply chain?

What steps, if any, has your organization taken to address these waste sources?

How do you think waste management practices in the seafood supply chain can be improved?

How do you measure and evaluate the environmental impacts of waste generated by your organization?

How do you think logistics tools such as lean, LCA or circular economy could be used to enhance waste management practices in the seafood/food supply chain?

In the context of reducing environmental impacts and food waste, what do you think your role should be in the supply chain?

How do you envision the future of waste management in the seafood supply chain? What changes do you think will need to be made in order to improve sustainability and reduce environmental impacts?

What are the current waste management practices in the food supply chain and how effective do you think they are in reducing environmental impacts?

What role can policies and regulations play in improving waste management practices in the supply chain?

What are the current policies and regulations related to waste management in the seafood supply chain in Sweden and how effective do you think they are?

In your opinion, what are the biggest challenges in managing waste in the food supply chain and how can they be addressed?

How can technology be used to enhance waste flow management in the seafood/food supply chain?

How can waste management practices be improved at each stage of the seafood/food supply chain to reduce waste?