Master's degree thesis

LOG950 Logistics

Circular Economy Implications for Sustainable Supply Chain Practices: Comparative case study within the Norwegian fish farming industry

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Preface

This master's thesis was conducted as part of the two-year logistics master program at Molde University College Specialized University in Logistics. Both of the authors are pursuing a Master of Science degree in Logistics with a specialization in Advanced Supply Chain Management. Through the subjects and seminars in our master's degree program, we have been introduced to the concepts of sustainability and circular economy. The dedicating and inspiring lecturers we encountered quickly sparked our interest in these topics and motivated us to explore them further.

As for our choice to focus on the fish farming industry, it was primarily driven by our curiosity. Being situated in close proximity to numerous fish farms, the university in Molde played a significant role in sparking our interest in this sector. With none of the authors having prior experience in this field, it presented an exhilarating opportunity for us to embrace a new challenge and immerse ourselves in an industry that we were unfamiliar with. Our aim was to investigate how circular economy principles contribute to the establishment of sustainable supply chain operations in the Norwegian fish farming industry.

Acknowledgement

We would like to thank our supervisor Antonina Tsvetkova and co-supervisor Øystein Klakegg for their outstanding collaboration and feedback. They have guided us through an exciting master`s thesis and given us motivation to constantly improve and enhance the text and content. We greatly appreciate your prompt responsiveness to our queries via emails, as well as our productive Zoom meetings. We constantly received detailed feedback and set goals for our subsequent sessions. We would also like to express our sincere appreciation to all the Respondents from the various companies attending the research. Their valuable insights and contributions have significantly enriched our master`s thesis, and it would not have been the same without their participation.
Lastly, we would like to acknowledge and give thanks to each other for a good collaboration throughout this semester, as this marks 5 years of studying together in Molde. Our collective efforts have not only allowed us to learn from one another but also made the journey enjoyable.

Molde, May 2023
Vilde Bjørhusdal
Sander Haugen

Abstract

Sustainability has long been important in Norwegian fish farming, but now there is a growing recognition of the need to integrate circular economy principles. While existing literature has addressed sustainability and the circular economy separately, few has explored their interconnectedness. Our goal is to investigate how circular economy principles can contribute to sustainable supply chain operations in the Norwegian fish farming industry.

This thesis examines two selected cases in the industry, comparing their sizes and operational phases while both utilizing land-based facilities. We conducted interviews with two supplement companies to gather information on sustainability and circular economy practices. These interviews provided valuable insights. To guide our study, we formulated four research questions. To address the theoretical gap, we used a qualitative method with an inductive and deductive approach, taking a social constructivism stance. Through a comparative case study approach, we collected data through interviews, personal observations, and scientific articles.

This master thesis examines the organization of supply chain operations, the implementation of circular economy (CE) principles, key challenges, and implications for sustainability in the Norwegian fish farming industry. Through case studies (Case A and Case B), the research explores sustainable practices, enablers of transition, and the role of stakeholders. The findings affirm the importance of communication, collaboration, government support, and technology adoption in achieving sustainability. Challenges include high costs of technology implementation, limited supplier options, and proper management of undesired outputs. Implementing CE principles contributes to resource optimization, environmental cleanliness, and high-quality products. The implications for theory underscore the significance of a holistic, long-term perspective on sustainability and stakeholder collaboration. The study offers practical guidance for fish farmers, emphasizing effective communication, technology adoption, and CE strategies. Suggestions for further research include defining a clear CE framework, exploring additional CE implementations, and investigating buyer-supplier interactions.

List of abbreviations

CE – Circular Economy

CRS – Corporate Social Responsibility

HFS – Hybrid Flow-through System

OM – Operation Management

RAS – Recirculating Aquaculture Systems

SC – Supply Chain

SCM – Supply Chain Management

SCO – Supply Chain Operations

SSCM – Sustainable Supply Chain Management

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1.0 Introduction

This chapter provides an overview of the study. It begins by presenting the background of the chosen topic. Next, we outline the purpose and research questions that guide this thesis. Lastly, we present the structure of this master's thesis.

1.1 Background of the study

Farmed fish is produced over large parts of Norway due to the country's extensive coastline and large sea areas, as it has favorable conditions set up. Norway plays a significant role as a global producer and exporter of sustainable food such as Atlantic salmon and rainbow trout to the European and Asian markets. It is an important and valuable local industry that serves as the foundation for jobs in both rural and coastal parts of Norway (Regjeringen, 2021). The Norwegian fish farming industry has alone an annual turnover of more than NOK 80 billion, which makes it a significant economic sector for the country (Misund, 2022a). With a product that has a relatively low expiration date and customers that are oftentimes placed outside of Norway, it is crucial to have the flow of goods and services done in an efficient manner.

In order to understand where value creation occurs and how the daily operations are managed in and between organizations, it is important to know the difference between supply chain management (SCM) and operations management (OM). SCM is in short about the flow of goods and services that includes all processes that transform raw materials into final products between businesses and locations. In other words, it adds value to the business, supporting more efficient processes and ultimately driving better revenue for the company. OM is another academic terminology that mostly adheres to the same principles as SCM. The main difference is that the SCM controls the process for having the product produced, but without a product, OM won't have a product to oversee operations for. This means that the manager for SC is mainly concerned with what happens outside the company by negotiating contracts and evaluating suppliers, while the person working with OM focus on what happens inside the company by planning and overseeing the daily operations and processes (Florida tech, n.d.). In recent years, there has been a growing emphasis on the interaction between sustainability and the supply chain, with its

operations, finance, policy, strategy, and supplier relations (Linton, Klassen, and Jayaraman, 2007).

When the Brundtland Commission in 1987 presented its report on sustainable development, it has since then gradually gained more significance, incorporating social, environmental, and economic responsibilities, with an emphasis on equal balance between the aspects. These aspects have in the last two decades begun to find their way into SCM literature (Seuring and Müller, 2008, Ansari and Kant, 2017). This development has seen the integration of environmental and social issues which has given rise to Sustainable Supply Chain Management or SSCM. However, the research tends to favor environmental or green issues, and the social aspect and integration of the three aspects seem to be lacking (Seuring and Müller, 2008; Quarshie, Salmi, and Leuschner, 2016). In parallel to this, the Circular Economy (CE) discourse has seen a rise in literature and practice, with the idea of creating self-sustaining production systems in which the materials are kept in production for as long as possible (Genovese et al., 2017).

As resource extraction and processing contribute to water stress, biodiversity loss, and climate change, the European Commission (2020) has increased its efforts to create a resource-efficient, climate-neutral, and competitive economy to influence its transition towards a regenerative growth model. Industries and organizations are under pressure to make their operations environmentally sustainable by adopting a Circular Economy, while others adopt it to improve quality, reduce manufacturing costs and reduce their carbon footprints (Jain et al. 2020). This has more or less become mandatory for enterprises that offer goods or services through the Transparency Act in Norway (Forbrukertilsynet, 2023).

It can be helpful to push CE solutions through regulations and policies, and thus, reach toward innovation in the market (Regueiro et al, 2022). According to findings from a study conducted by Ziegler et al. (2022), salmon goods create more emissions in 2017 compared to cod and herring goods, with fuel and feed consumption being the primary drivers, while goods sent by airfreight being the highest scorer. Suppliers can have a significant influence on the performance of a company, but they could also contribute to its environmental impact (Paulraj, 2011). While studies show that CE is connected to sustainability, by proposing how it can be used on the environmental and economical level, the social and

institutional implications are only marginally considered (Merli, Preziosi, and Acampora, 2018). As of our understanding, it seems that there is a lack of knowledge regarding the interplay between CE principles and sustainability aspects within supply chain operations in the Norwegian fish farming industry.

For a long time, a traditional linear model based on take-make-dispose has been used in industries and businesses globally. For the model to go from being linear to circular, simply explained, the circular model will remove the take and dispose part in the linear model and replace it with make and recycle, so it reads like make-use-recycle (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). Circular Economy is not only focused on recycling but using materials again when the original product has reached the end of its life. We wanted to figure out how CE connects with sustainable development, since it seems to us that it remains unexplored. Given their shared values, sustainability and CE are simple to mix, but we felt it was important to keep them separate and instead focus on their connections and analyze this in the context of the fish farming industry of Norway. When reading through dozens of articles on sustainability and CE, it becomes clear that of the three aspects: Economic, Environmental, and Social. The social aspect tends to be not as emphasized as the other two. Therefore, an opportunity presents itself to explore how Sustainable Supply Chains and CE have an effect on the social aspect of sustainability in the context of the Norwegian fish farming industry.

1.2 Research Purpose and Questions

Research purpose

The theoretical gaps have inspired the choice of the main purpose for our master's thesis, which is to explore:

H*ow circular economy principles contribute to sustainable supply chain operations within Case A and Case B in the Norwegian fish farming industry.*

We strongly believe that this research purpose will contribute to advancing academic understanding of the effects of the interplay between circular economy and sustainability within supply chain operations in the Norwegian fish farming industry.

Figure 1 below, illustrates the research questions for this master thesis. It begins with how the supply chain operations of both Case A and Case B are organized. Followed by how

the Case Companies are making their supply chains sustainable, and the enablers of this transition. Then there is discussion on the challenges that Case A and Case B experience when organizing their supply chain operations. At last, there are the implications CE has on the operations of Case A and Case B, and their sustainable aspects.

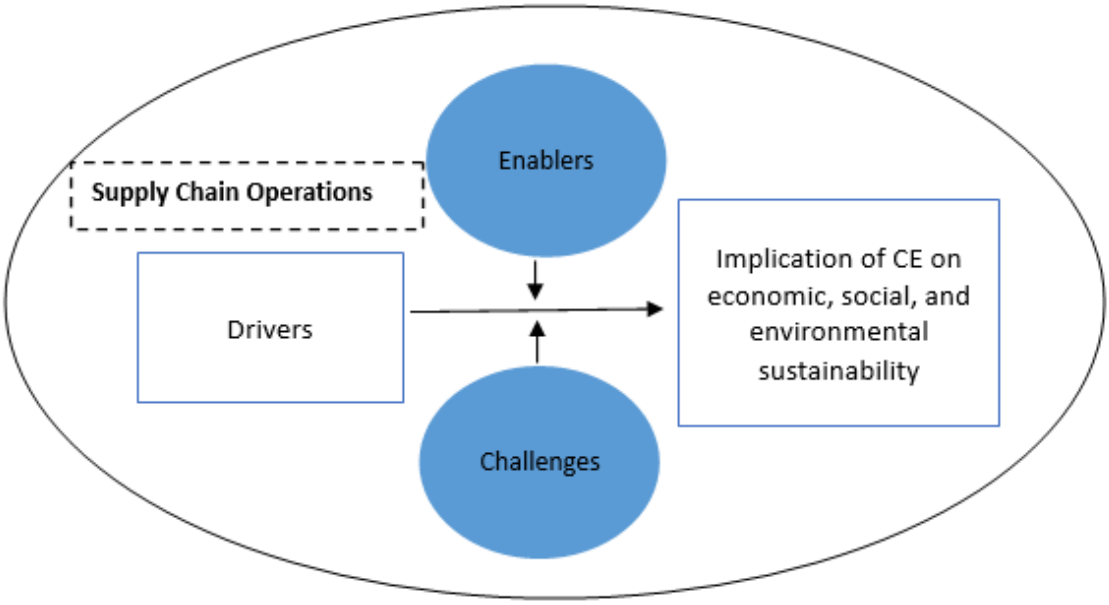

Figure 1: Drivers, enablers, challenges, and implications of CE on Sustainable Supply Chain Operations (the Authors' elaboration)

Research questions

In order to address the main purpose of this master's thesis, we formulated four research questions that aim to provide valuable insights. These questions have been carefully designed to encompass the key areas outlined in the problem statement of our thesis. The initial research question investigates how the operations of the supply chains are organized in the Norwegian fish farmer industry, as presented below:

RQ 1: How are the supply chain operations organized within the Norwegian fish farming Case A and Case B?

What are the stages that occur in the operations of these fish farms, from the raw material stage until the meal is delivered to its customers. Do these firms own or have partial ownership of the entire supply chain? What are the reasons as to why they are organized the way they are today.

Furthermore, we have a research question that explores and compares the efforts that Case A and Case B has made in making their supply chain operations sustainable.

RQ 2: How do the Norwegian fish farming Case A and Case B make their supply chain operations sustainable, and what are the enablers of this transition?

What works for one firm may not have the same effect on another, and it can be relevant to investigate the possibility of synergy effect in the industry. To map these drivers, perhaps there is a possibility to generalize and employ these in other companies and industries. How companies make their operations more sustainable correlate with what they perceive as sustainable, as this can affect what sustainable measures will be implemented. Therefore, it is important to investigate how they perceive their practices in terms of sustainability. To investigate what their contribution is to make their supply chain more sustainable, it can be useful to see whether this is also done among the other case companies. If there have been actions toward making their operations more sustainable, then what are the consequences?

With every change there is bound to be uncertainty and therefore, challenges. This has prompt us to dedicate the third research question to what challenges these farmers might experience when implementing CE principles:

RQ 3: What are the key challenges faced by Norwegian fish farming Case A and Case B in organizing their supply chain operations?

Are there challenges related to government regulations, shifting customer demands or high financial investments costs that affect this implementation? What are challenges that firms that already have implemented CE principles experience and if there are, how big of an obstacle do they have to be in order to disrupt their operations?

The fourth research question will investigate the circular economy aspect of the thesis, first of which will be on the environmental and economical aspect. We wanted to learn how the firm can become more prosperous as well as more sustainable in their operations with the help of circular economy.

RQ 4: How do fish farming Case A and Case B implement Circular Economy principles in their operations, and what impact does this have on their economic, social, and environmental sustainability?

Can CE principles promote economic growth for the fish farming industry? Can the principles offer competitive advantages or perhaps improve one's reputation? The environmental aspect of sustainability and the term sustainability can be hard to separate from each other, and so the previous research question 4 can be useful in determining what the companies perceive to be sustainable. Does the fish farmers treat the three aspects of a sustainable supply chain with a holistic approach, these being economic, environmental and social responsibilities, or is there is prioritizing among them.

Addressing the lack of research on social responsibility in academia, we took the opportunity to look into how circular principles can promote and contribute to a positive influence on its relevant stakeholders. Are there direct or indirect consequences of CE principles for the social aspect of sustainability? How can fish farming companies contribute to social sustainability? Is there any collaboration between the various stakeholders that operate and are affected by this industry?

There were used a qualitative method in this master´s thesis, to find answers to our research and the overall purpose. By using a comparative case-study approach, we had the possibility to investigate the barriers and challenges in the industry when it comes to sustainability and CE. This investigation took place through interviews and personal observations, which we later compared in detail. The two cases we choose provide unique empirical settings, in terms of their geographical location and the role they play in their respective supply chain. Both Nekton and Salmon Evolution have implemented CE principles in their operations.

1.3 Structure of the thesis

This master thesis is organized as follows:

Chapter 1 is the introduction where the study is explained and why it is relevant for both academia and fish farmers alike. The master´s thesis begins with the motivations and

background for this thesis along with what we will investigate and focus on in our research.

Chapter 2 presents the literature that gives context to understand what is being researched, it is also meant to strengthen the existing literature framework on which the thesis is based. The objective of this chapter is to inform how the research problem presented in Chapter 1 was investigated based on important sources and information and combine and interpret old material with new ones.

Chapter 3 focuses on the theoretical lenses that is employed in the master thesis, which in our master thesis is the stakeholder theory.

Chapter 4 introduces the research methodology this master's thesis applied. It explains the reasoning behind the data collection.

Chapter 5 explores the industry of Norwegian fish farming. The history is described as well as the production process for both Salmon and Cod. As this master thesis will explore salmon fish farming on land, but with empirical data from the cod farming industry, then there will be a need for information that will give the reader a better understanding of the industry.

Chapter 6 and 7 presents the findings from our interviews with Respondents from the industry. These interviews are conducted with an interview guide created with the tools presented in the methodology Chapter 4. The goal of these interviews is to find empirical data that can be used to investigate the research purpose and questions that is presented in Chapter 1.

Chapter 8 provides a discussion and analysis of our research based on literature and findings.

Chapter 9 concludes the master thesis with implications on both theory and practice, and an overview of the master thesis. It also presents limitations and potential future research.

2.0 Literature review

This chapter present state-of-the-art knowledge of our key concepts, such as supply chain management, sustainable supply chain management, circular economy, and the interplay between CE and sustainable practices theoretical perspectives on several subjects that provide relevant information about the various topics. The chapter defines also supply chain operations, sustainability, and economic, environmental, and social factors relevant to the master thesis purpose and research questions. The knowledge presented is the theoretical basis for conducting our investigation.

2.1 Supply Chain and Operations Management

The definition of Supply Chain Operations or SCO in short remains vague and elusive, making it difficult to provide a clear and concise description of its meaning. In this chapter, we combine both Supply Chain Management (SCM) and Operations Management (OM) notions to arrive at a comprehensive definition of SCO that is relevant to our phenomenon in this master's thesis.

Supply Chain Management

Supply Chain Management can be defined according to Mentzer et al. (2001, 18) as:

"The systemic, strategic coordination of traditional business functions and the methods across these business functions within a given company and across businesses within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole".

Later the Council of SCM Professionals (2013, 187) provided another definition of Supply Chain Management:

"SCM encompasses the planning and controlling of all processes involved in procurement, conversion, transportation, and distribution across a supply chain. SCM includes coordination and collaboration between partners, which can be suppliers, intermediaries,

third-party service providers, or customers. In essence, SCM integrates supply and demand management within and across companies".

It encompasses all of the management of logistics mentioned in the definition above, as well as manufacturing operations, and it supports process and activity coordination across marketing, product design, finance, information sharing, and sales. Supply Chain Management is an integrative role that is mainly responsible for linking important business processes and activities inside and between firms in order to create a high-performance and unified business model (CSCMP, 2013).

The manager of the supply chain coordinates the following five aspects of SC; Planning, sourcing, manufacturing, delivering, and returning (Harrison et al., 2019). Planning is important since businesses must anticipate their demands going forward and take appropriate action. This pertains to the raw materials required for each stage of manufacturing, equipment capacity and constraints, and staffing requirements throughout the SCM process. Assembly, testing, inspection, and packaging are a few examples of sub-processes that fall within the manufacturing process. A company should be aware of waste and other manageable issues that could lead to deviations from original intentions when producing. Once products are made and sales are finalized, a company must get the products into the hands of its customers. Given that the customer has not yet interacted with the goods, the distribution process is frequently viewed as a contributor to the brand's image and can provide competitive advantages for the company (Morash et al, 1996).

A business with effective SCM procedures has strong logistical skills and delivery channels to guarantee the timely, secure, and affordable delivery of products. The last aspect is return, which concludes with support for the product and customer returns. Whether a company is performing a product recall, or a customer is simply not satisfied with the product, the transaction with the customer must be remedied. A proper SCM can increase revenues, decrease costs, and impact a company´s bottom line (Fernando, 2022b).

The value of integration in supply chain management cannot be understated since it enables smooth collaboration across many organizations, which can result in cost savings, higher customer satisfaction, and better performance (Simatupang, Wright, and Sridharan

2002; Vickery et al. 2003; Flynn, Baofeng, and Xiande, 2010). By integrating activities and exchanging information, then expenses related to storing, management of inventory, and distribution can be reduced, and so, this enables the possibility to improve their operations further, and in the process, eliminate waste and have these savings benefit the customers. Integration can be used to improve the coordination of operations across the supply chain, decreasing lead times and delays, which in turn can promote efficient production and delivery of goods, resulting in improved sales and customer satisfaction (Simatupang, Wright, and Sridharan, 2002). Supply chain integration promotes the sharing of knowledge among various organizations, resulting in improved insight into inventory levels, delivery timelines, and production schedules, which can influence decision-making, be it both internal and external (Turkulainen et al., 2017). When information is shared across the supply chain, the parties involved can discover and fix issues more rapidly and collaborate to enhance quality.

Operations Management

To manage creating goods and services, there are three functions that are necessary not only for production but also for an organization's survival. The three functions are:

- Marketing
- Production/operations
- Finance/accounting.

Marketing generates demand since nothing happens until there is a sale, the production/operation does the creating, producing, and delivering of the product, while the financial/accounting tracks the financial part of the organization, pays the bills, and collects the money they earn. Heizer et al. (2019, 36) define operation management as:

"a set of activities that creates value in the form of goods and services by transforming inputs into outputs."

Operations management is fundamentally connected to a number of subjects, including facility design, capacity planning, aggregate planning, forecasting, process design, job scheduling, maintenance, and project management (Narasimham, 2014). However, operations management may be defined more generally as a problem-solving and decision-making process that employ quantitative methodologies from management science and

operations research (MS/OR) to effectively and efficiently allocate limited resources with the various operations of an organization (Narasimham, 2014). Mentzer et al. (2008, 36) define operations management as:

"Applying analytical tools and frameworks to improve business processes that cross ***internal functional*** *boundaries".*

The process of managing the resources and systems responsible for developing and delivering a company's goods or services is what is known as operations management, which is illustrated in figure 2 below. This involves organizing, coordinating, and directing the numerous activities and resources needed to make and deliver the services and goods which the companies offer their customers. In the fish farming industry, activities include breeding and raising the fish, feeding and treating them to ensure good quality, monitoring and measuring their health, and subsequently collecting and processing the goods for sale (MOWI, 2022). The tools for operations management can be demand forecasting which can analyze the market for sought-after demand, by having effective scheduling of production the fish farmers can have the right amount of labor, equipment feed, and other necessary inputs to optimize their production. With a good forecasting system and scheduling program, then the inventory levels can be at an acceptable level, be it on medical supplies for the fish or food for the fish, and with just-in-time and lean principles, then there is a possibility to reduce costs relevant for storing. Ensuring that the service levels are met is important as the wrong quality can result in a loss of income, and this can be done for example by checking and testing the fish for diseases and monitoring the water.

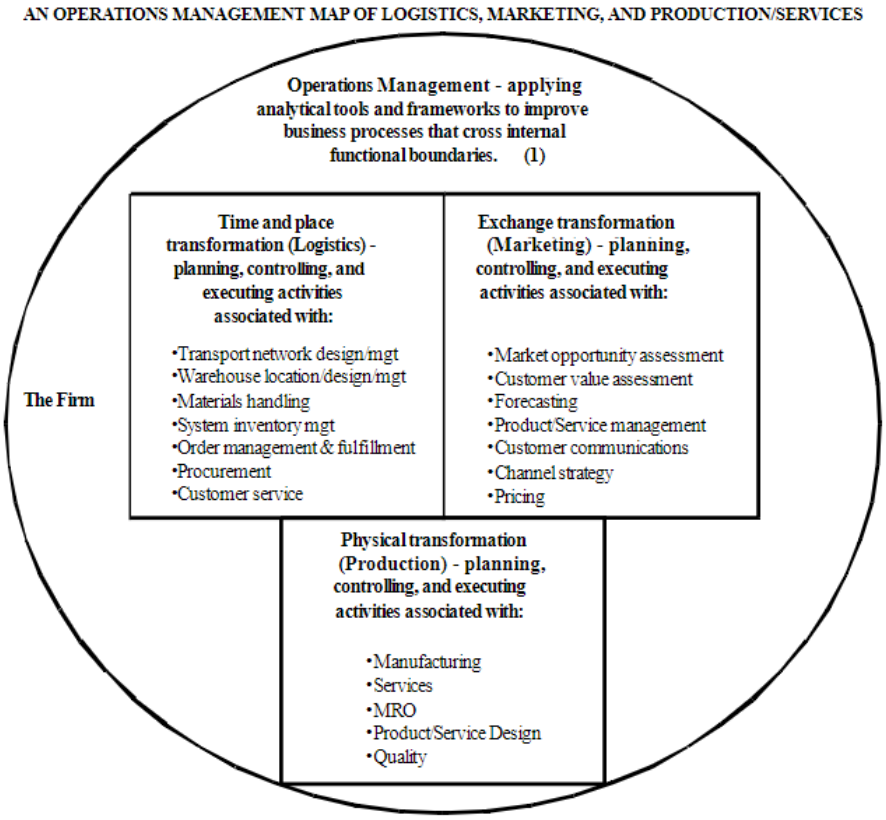

Figure 2: An operations management map of logistics, marketing, and production/services (Mentzer, Stank and Esper, 2008, 37)

Operations management serves an important role in businesses since it guarantees that services and goods are delivered effectively and efficiently. It involves making decisions about how to use and manage the resources needed to make and deliver goods and services (for example materials, equipment, and manual labor).

These activities also include establishing and upgrading systems and procedures to improve quality and efficiency and managing a company's supply chain and logistics. Effective operations management in the fish farming industry may be to assist in improving its efficiency and profitability while minimizing environmental impact and securing a long-term supply of goods of excellent quality for its customers. This is done by proper planning, coordination, and careful usage of its resources and services, resulting in goods and services being offered at the right time, quality, and price for its customers (Mentzer et al., 2008).

Supply Chain Operations

Drawing on these two notions, we can define Supply Chain Operations in the context of our master's thesis as the integrated activities involved in coordinating and managing services and goods across the supply chain, from the point of origin to consumption. This includes various activities such as production, inventory management, logistics, and distribution, which are crucial for ensuring the timely and efficient delivery of products to customers.

2.2 Sustainability

The concept of sustainability plays a big part in the research topic of this master´s thesis, and it has gained importance over the years. Yet the term sustainability remains vague, as it is used to describe a larger number of things related to a firm's goals, strategies, ambitions, concepts, and visions, being frequently discussed in business research and practices, management science and by policymakers (Linton, Klassen and Jayaraman, 2007). The word sustainability itself originates from the French verb *soutenir* which translates to "*to hold up or support*", and the modern meaning is derived from forestry with the principle that the wood harvested should not exceed the volume that would grow again (Geissdoerfer et al., 2017).

More calls for change in company practices and the need for others to adopt more sustainable perspectives have emerged in recent decades. One of the earliest yet most adopted definitions of sustainable development is in the "*Brundtland Commission"* report "*Our Common Future"* which was published in 1982, and there it is defined as *"... development that meet the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987, 8).

Geissdoerfer et al. (2017, 766) have defined sustainability as *"a balanced integration of social inclusion, environmental resilience, and economic performance for the benefit of current and future generations*".

The sustainability aspects attempt to optimize the usage of resources as well as reduce waste, and at the same time, incorporate economic, environmental as well as societal factors into the business. This implies that, aside from eliminating waste and improving resource efficiency, sustainability practices include the business's influence on the

environment, workers, and communities, and the long-term success of a business. Figure 3 below illustrates the three dimensions of sustainability:

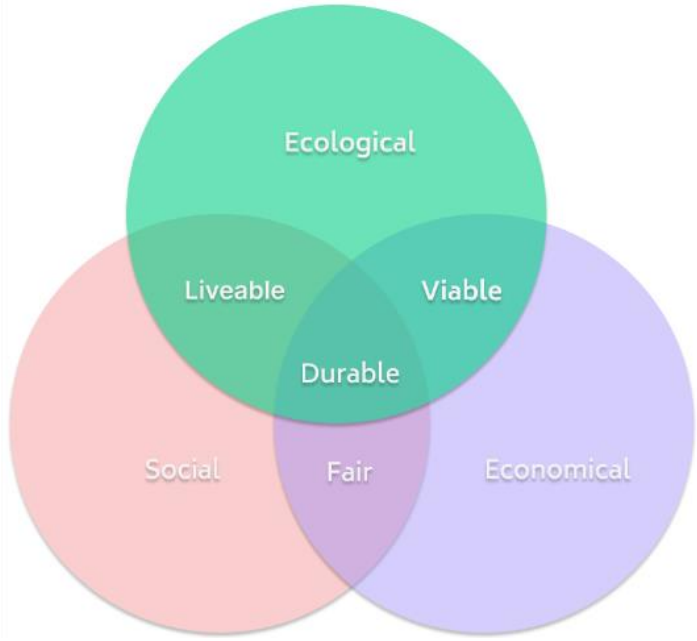

Figure 3: The three dimensions of sustainability (Safdie, 2023)

The emphasis on increasing profits alone is no longer sufficient, and there are emerging pressures to factor environmental and social issues into this prioritizing, which is illustrated in the figure above. This perspective is known as the "triple bottom line" (Kenton, 2022). The three P's, or planet, people, and profit, are said to capture the fundamental essence of sustainability through active effort on monitoring the different activities a corporation has both locally and globally, according to Slaper and Hall (2011). In literature on sustainability, the social aspect tends to be less researched compared to the environmental factor (Martins and Pato, 2019). As this notion of the triple bottom line considers elements that organizations have historically ignored, employing it can help businesses obtain a fresh perspective on how to conduct their affairs. These three aspects of sustainability will be investigated further in the subchapters below.

2.2.1 Economic dimension

Sustainability is defined by Kirchherr, Reike, and Hekkert (2017) as a balanced combination of environmental resilience, economic performance, and social inclusion that can be advantageous to both the present and future generations. This suggests that inclusiveness is sustainable, and might have an influence on profitability, going against what most businesses do, which is to purely focus on maximizing profits. However, the

inclusiveness that is sustainable might have additional good ripple consequences for the company both internally and externally.

This includes using resources efficiently and fairly, as well as developing economic systems that promote long-term environmental and social well-being through investments in sustainable economic growth, such as green infrastructure and renewable energy, and addressing poverty and income inequality. The economic side of sustainability is concerned with developing an economy that is both socially and environmentally aware, by making effective use of resources so that they are not exhausted faster than they can be regenerated or replenished. It also entails allocating resources equally so that everyone has access to the resources they require to achieve their fundamental needs (Slater, 2017).

Economic sustainability requires a change toward sustainable consumption and production. This includes adequate commodities and services that fulfill the fundamental requirements of the present without jeopardizing the future generations' capacity to meet their own needs. This includes decreasing waste and emissions, lowering resource utilization, and designing products that are simple to compost or recycle. A definition of corporate economic sustainability is given by Dyllick and Hockerts (2002, 133) as:

"Economically sustainable companies guarantee at any time cashflow sufficient to ensure liquidity while producing a persistent above average return to their shareholders".

By looking at the economic performance of a company, one can get an idea of how the firm is performing. Developing sustainable economic systems is critical for long-term environmental and social well-being, as well as resolving challenges of inequality of income and poverty through economic development and the creation of economic possibilities. This may be accomplished through enacting policies that promote social- and economic justice, such as social welfare programs, equal pay regulations, and higher taxes.

2.2.2 Environmental dimension

The environmental pillar of sustainability is concerned with the preservation and conservation of natural resources such as air, water, and land, as well as biodiversity.

Efforts to decrease waste, emissions, and pollution, as well as to manage the consequences of climate change, are also included. Monitoring the usage of energy, closing the loop with reverse logistics, green purchasing, and life-cycle management are examples of how a business can make its supply chain more environmentally friendly (Zhu, Sarkis, and Lai, 2008). As an important source of healthy food and income for many people around the world, the fish farming industry has been criticized for its harmful environmental effects, which include pollution, habitat damage, and disease transmission (MOWI, 2022).

Furthermore, this component of sustainability encompasses the preservation of natural resources and ecosystems both for their inherent worth and the services they offer to modern civilization. Wetlands, for example, assist in filtering water, rainforests such as the Amazon absorb CO^2 and influence the temperature, and oceans serve as an important factor in global climate systems. In order to become more sustainable there is the option to source feed responsibly, conservative usage of antibiotics and other medical supplies, closed-containment systems, and recirculating aquaculture systems, also known as RAS, which can all help to reduce negative environmental consequences in the fish farming industry (Martins et al., 2010; Nyhus, 2014; United Nations Environment Programme, 2023). With RAS technology, fish farmers can reduce usage of water, recycle nutrition's, and influence management of waste (Martins et al., 2010). A facility employing RAS technology is however expensive and demands much dedicated area, especially if it is land based (Bjørndal et al., 2018).

With the implementation of sustainable feed sourcing and closed containment systems, production costs can rise, and so, the following customer prices. However, this will have a positive effect on environmental issues such as escaped fish and health issues (Misund, 2022b). Fish farmers on both land and sea can optimize feed efficiency on farms, as it influences the environmental and economic impact, and a closed system enables them to have control over their inputs, however, it requires a significant amount of energy compared to an open system (Nyhus, 2014).

The environmental part of sustainability is about more than just protecting natural resources and minimizing pollution, it is also about understanding the necessity of keeping and sustaining the health of natural systems that support people and all forms of life. The Aquaculture Stewardship Council (ASC), Global G.A.P, the Best Aquaculture Practices

(BAP), and The Global Aquaculture Alliance (GAA) are some certification systems that encourage sustainable fish farming practices (Osmund et al., 2020). However, certifications tend to favor environmental and governance issues, and not sustainability as a whole. By incorporating these certifications into their operations, the firms can improve their reputation, create a learning tool for companies and attract new consumers and retailers who are concerned about environmental risks (Amundsen and Osmundsen, 2020).

The triple bottom line's planet component, often known as the natural aspect of sustainability, focuses on how a company's actions affect the environment, including the exploitation of its limited resources, pollution, emission, waste, and other issues (Slaper and Hall, 2011).

2.2.3 Social Dimension

This aspect of sustainability focuses on the relevant stakeholders of the firms and the involved public. These stakeholders may be internal and external to the firms yet are nonetheless influenced by the actions of the firms. According to literature, there is a disproportionate amount of literature on the aspects of economic, environmental, and social, with social being focused less on than the two other aspects (Dyllick and Kai, 2002; Ahi et al., 2018; Martins and Pato, 2019; Malek and Desai, 2020). How the firms should incorporate the social aspect into their businesses vary as some state that social dimension involves aspects like social inclusion, safety, and equality in income, whilst other articles are content with involving aspects like the well-being and conditions of its workers (D'Amoto et al., 2017; Shou et al., 2019). One definition for corporate social sustainability comes from Dyllick and Hockerts (2002, 134) as:

"Socially sustainable companies add value to the communities within which they operate by increasing the human capital of individual partners as well as furthering the societal capital of these communities. They manage social capital in such a way that stakeholders can understand its motivations and can broadly agree with the company's value system."

Corporate Social Responsibility (CRS) is a self-policing corporate strategy that enables an organization to be socially accountable to its customers, employees, and stakeholders

(Harrison et al., 2019, 172). Companies can be aware of their impact on society's social, economic, and environmental aspects by engaging in corporate social responsibility, often known as corporate citizenship (Szczuka, 2015; Harrison et al., 2019; Fernando, 2022a). This interaction can be beyond the interests of the firm, to ensure that their activities serve some social good (McWilliams et al., 2006). However, for social issues to be successfully managed in the supply chain, collaborative efforts and developing strategies to create trust and commitment are needed (Yawar and Seuring, 2017).

In their article on the link between competitive advantage and CRS, Porter and Kramer state that business thinking will need to drastically change if social responsibility is seen as creating shared value rather than damage control or a PR effort, nonetheless, they point out that they believe that CRS can play a big role in the future competitive success (2006). They continue by saying that the majority of the world's issues are not the corporation's fault, and they cannot address all of them. Each business can determine the specific collection of societal issues that it is best suited to contribute to the solution of and from which it can derive the most competitive advantage. Creating shared value in response to social concerns will result in self-sustaining solutions that are independent of financial support from the private or public sectors. A well-run company can have a bigger impact on social good than any institution or charitable organization when it uses its extensive resources, knowledge, and management skills to issues it knows and is invested in (Porter and Kramer, 2006).

2.3 Sustainable Supply Chain Management

From the time sustainability was first introduced into management literature in the early 1990s, the popularity of this concept has increased significantly among scholarly material, popular press, and policymakers. Since the supply chain considers the product from its initial stage of processing of raw materials to the delivery to the end customer, an opportunity presents itself to develop and adopt the concept of sustainability in the supply chains (Linton, Klassen, and Jayaraman, 2007). One definition of sustainable supply chain management comes from Seuring and Müller (2008, 1700), which is that:

"*The management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of*

sustainable development, I.e., economic, environmental and social, into account which is derived from customer and stakeholder requirements".

In order to improve the long-term financial performance of the specific company and its supply chain, Carter and Rogers define sustainable supply chain management as the systematic coordination of critical inter-organizational business activities for achieving an organization's social, environmental, and economic goals (2008). Another definition of a sustainable supply chain comes from Beamon (1999), in which all of the elements of the traditional supply chain are present in the fully integrated and extended supply chain, but the one-way chain is extended to create a semi-closed loop that includes packaging and product, recycling, re-use, and/or remanufacturing operations. Visible below in figure 4 is an illustration of how environmental and social aspects of sustainability have gradually become included in the SCM area:

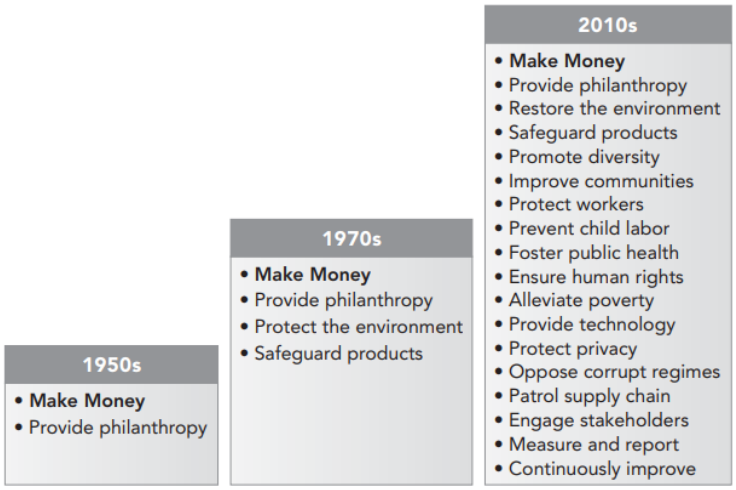

Figure 4: The Rise of Corporate Accountability and the Age of Sustainability (Savitz, 2013, 75)

Sustainable supply chain management involves taking into consideration the whole lifespan of a service or a good, from the extraction of raw materials until its eventual disposal, and throughout these stages reduce waste and maximize the utilization of its resources. In addition to this, the sustainable supply chain includes contributions to the society and environment. These contributions can be investments in renewable energy, working with and involving local communities, developing and utilizing sustainable technology, tackling environmental and societal issues, and collaborating with suppliers (Paulraj, 2011).

Since a supply chain considers the product from the initial phases of processing of raw materials to the delivery to the customers, it is a step forward towards adopting and

developing sustainability. Issues and flows such as the design of products, product life extension, end-of-life product, as well as recovery processes at end-of-life are flows and issues that have to be integrated (Linton, Klassen, and Jayaraman, 2007).

The elements and practices of an SSCM are very much the same as a regular supply chain, however with an environmentally and socially friendly approach (Morana, 2013, Savitz, 2013). The procurement department can ensure that the flow of supplies is sourced from a supplier that has been proven to operate in an environmentally friendly manner (Johnsen et al., 2019). When distributing goods and services with either suppliers or customers, packaging materials that are created from recycled materials can be used (Beamon, 1999). SSCM can be seen as encompassing the three aspects of sustainability, which often are referred to as the triple bottom line, however, research is more than often drawn to environmental lenses, and so, social responsibility tends to be explored in research related to corporate social responsibility and business ethics when focusing on SC topics (Quarshie, Salmi, and Leuschner, 2016).

2.3.1 Drivers and barriers for sustainable SCM

A supply chain cannot survive without external inputs such as natural resources and social capital, and so this can enable the transition towards a sustainable supply chain (Dyllick and Hockerts, 2002). With a rise in disruption risks, population growth, change in consumption patterns, and unpredictable growth projections, exploring sustainable opportunities with one's business can become challenging. However, troublesome times can quickly prove fruitful.

To make this change there is a need for incentives or pressures, and these might be pressures from social and environmental groups, a response to stakeholders, demands from customers, enforced regulations, to acquire competitive advantages, or due to fear of losing reputation (Seuring and Müller, 2008). Information gathered from a literature review with 15 years' worth of research has revealed that enablers of sustainable supply chain management are pressure from customers, reverse logistics, organizational competitiveness, innovation, environmental management, collaboration with partners, information sharing, top management commitment, and government laws are recognized as crucial enablers (Ansari and Kant, 2017).

The scientific community has created areas of study in sustainable supply chain management, drawing researchers from various topics as well as corporate partners from various industries. The realization that industries and businesses cannot address sustainability issues on their own in a world that is growing interconnected is one enabler of this trend. Therefore, increasing sustainability performance as collaborators along the supply chain is critical in order to address the environmental, social, and economic issues from a systems viewpoint. However, there is a danger in sharing sensitive information and handing over control to other supply chain actors, as it can promote opportunistic exploitation (Seuring and Gold, 2013).

Ansari and Kant (2017) present the major barriers to sustainable supply chain management implementation as supplier incompetence, financial implications, a lack of top management commitment, complex design, lack of IT implementation, lack of information and transparency, and a lack of relevant training. Seuring and Müller (2008) presents high cost, insufficient and/or lack of communication, and complexity and coordination efforts as barriers for implementing sustainability within a supply chain. A challenge lies in the complexity of the SC as it evolves over time and can provoke increased consumption and demand for services and goods provided by the firm, as the human population and its purchasing power are ever-growing. However, this newfound purchasing power can influence firms in their transition toward sustainability (Quarshie, Salmi, and Leuschner, 2016). Free trade and short life cycles on products have increased the dynamics of business complexity, with frequent usage of outsourcing over long distances, and employment of economies of scope, as well as the long distance between production and consumption (Abbasi, 2012; Morana 2013).

2.4 Circular Economy

A circular economy is a concept currently promoted by the European Union, several national governments, and businesses around the world, and has been advocated in parallel with the development of sustainable SCM approaches. It is recommended as an approach to economic growth that is in line with sustainable environmental and economic development (Korhonen et al. 2018). Based on different contributions, Geissdoerfer et al. (2017, 759) define the circular economy as:

"a regenerative system in which resource input and waste, emissions, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling".

Recent literature review (Kirchherr, Reike, and Hekkert, 2017) highlighted that the enablers of the circular economy are responsible customers and novel business models. Through engagement and education, a change in behavior can contribute to successful implementation, and with incentives, this is further realizable (Geissdoerfer et al., 2017). Another definition of a Circular Economy comes from the Ellen MacArthur Foundation (2013, 8) which is an organization that has been created to promote the circular economy, states that:

"A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the "end-of-life" concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models".

In this definition, three principles that the circular economy is based upon are presented. According to the Ellen MacArthur Foundation (2013), the first principle is to eliminate pollution and waste, as most of the traditional material loop results in a sizable amount of waste. The second principle is to circulate materials and products to maintain their value, and if they can't be kept as products, then as raw materials and components for later use. The last of the principles is to regenerate nature, and this is achievable by moving from a linear- to a circular economy. Visible below in figure 5 is an illustration from the Ellen MacArthur Foundation on the flow of material in the circular economy, with the diagram known as the butterfly diagram (2013):

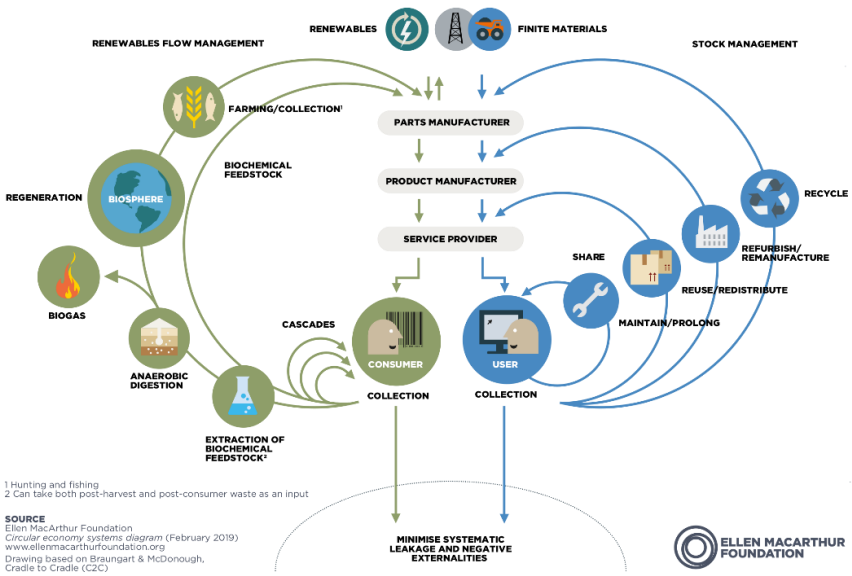

Figure 5: Circular economy systems diagram (Ellen MacArthur Foundation, 2013, 30)

A circular economy, as opposed to a linear- and recycling economy, will repair, reuse, recycle, or return the material used to create new material that can be used elsewhere. This continuous cycle, which is illustrated the figure 5 above, can be divided into biological and technological materials. Unlike biological materials, which can be recycled, technical materials can be used for a longer period as it is possible to maintain, remanufacture, or recycle this type of material (Ellen MacArthur Foundation, 2015).

Industries and businesses globally have used a traditional linear model where the focus has been to maintain a high profit. This is an approach to a take-make-dispose model, which is unsustainable, as resources are finite (Rashid et al., 2013). Now, the focus has begun to shift, and the circular economy provides the economic system with an alternative model, one that is cyclical. A circular economy brings positive wins for the environment, the economy, and society (Geissdoerfer et al., 2017). It reduces waste and emissions since the resources in production-consumption systems are used many times, not just once. Further, this will reduce raw material and energy costs, since the value of resources is used many times, not only once (Rashid et al., 2013). By using reusable materials costs that arise from environmental legislation, taxes, and insurance will be reduced. When it comes to social win, will new employment opportunities through new uses of the value embedded in resources. User groups can share the function and service of a physical product instead of individuals owning and consuming the physical product (Korhonen et al. 2018).

2.4.1 Transition towards Circular Economy

The traditional approach, known as the linear economy, holds that raw materials are gathered, and transformed into products that people use before discarding them as waste, frequently placing profit before sustainability. Visible in Figure 6 below is an illustration of how a typical linear economy operates:

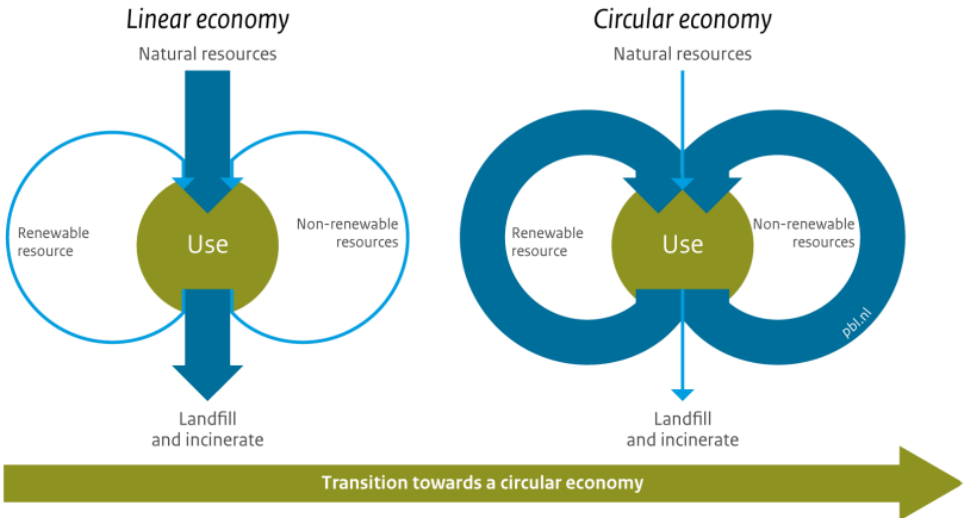

Figure 6: From a linear to a circular economy (Potting et al., 2017, 9)

It is crucial that this conventional attitude is changed, and that those who will be impacted by these acts are included because resources on this earth are finite. This is where the circular economy steps in and strives to adapt this model to reduce the net influence on the environment, by rethinking the design of the product with the purpose of having low amounts of inputs and waste (D'Amato et al., 2017). The circular economy will generate value in a more sustainable fashion by switching from a short-term life cycle to a long–life multiple cycles, focusing more on services than products, and reducing, recycling, and reusing (Kirchherr, Reike, and Hekkert, 2017).

Even though the circular economy has only recently been organized into a conceptual framework, Sariatli (2017) argued that it is still evident that crucial elements like eliminating waste through design, respecting society, the environment, and the economy, as well as maintaining a resource-based consciousness, can produce real benefits and can address challenges that are pertinent for both today and tomorrow. This is further acknowledged by Sanguino et al. (2020), that state that a circular economy can improve eco-efficiency, reform environmental management, and resource productivity, and help achieve sustainable development. However, they continue with that circular economy has

to allow for the reconciliation of business concerns with environmental stewardship, and that the concept of circular economy and its principles of reuse, recycle and reduce is not without difficulties.

2.4.2 Circular Economy Strategies

A Circular Economy promotes change in products to create mutually beneficial relationships between natural systems and economic growth, by going beyond traditional sustainability practices. Unlike a linear economy, which uses the environment as a garbage collector, CE concentrates on developing self-sustaining production systems that will try to reuse materials and energy for as long as possible. As a consequence, CE aims to not only reduce the exploitation of the environment, but also create a closed-loop system in which resources are used in an effective and sustainable manner (Genovese et al., 2017).

The closed-loop method for both energy and material that are used throughout several stages within a firm is central to CE. The principles of reduce, recycle, and reuse are frequently referred to as practical methods to accomplish this (Kirchherr, Reike, and Hekkert, 2017). These concepts have been pursued by environmental authorities in multiple nations as a strategy to address environmental issues, as governments strive to accomplish environmental protection by promoting sustainable growth within their society and economy (Sanguino et al., 2020). Visible below in Figure 7 are an expanded framework, depicting 9R´s that aim to reduce consumption of materials and resources:

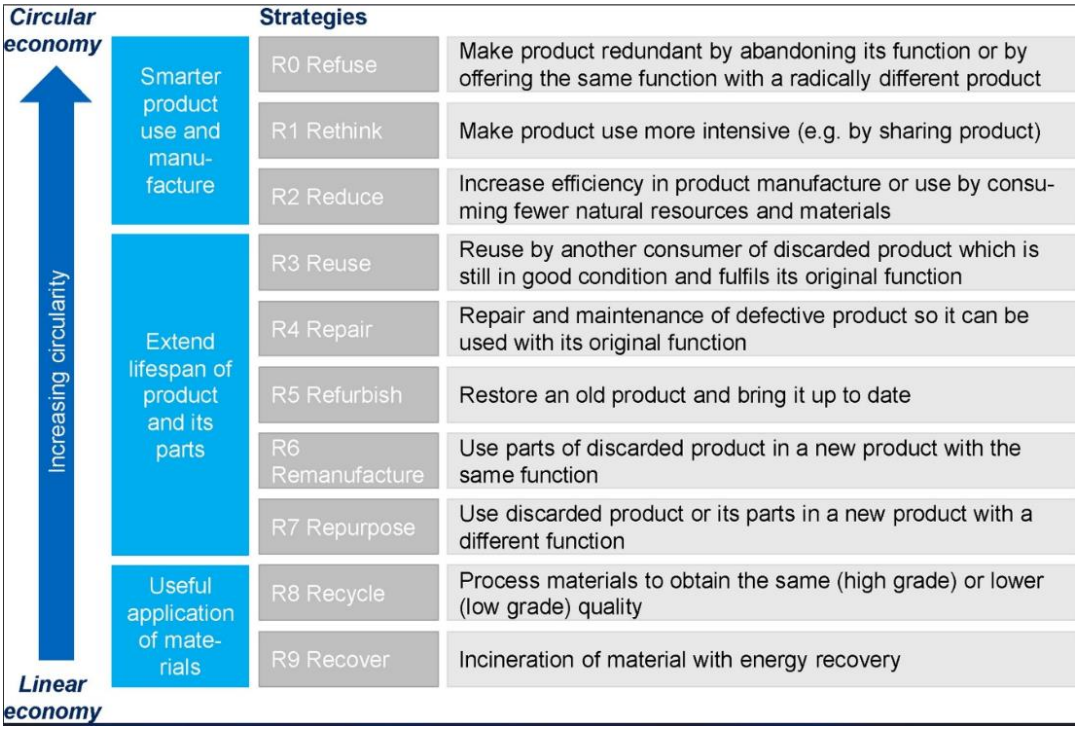

Figure 7: The 9R Framework (Kirchherr, Reike, and Hekkert, 2017, 224)

The list presented above in Figure 7 includes a range of strategies that are ordered by the level of circularity they offer, with the most circular strategy being the one with a low R-number and the least circular with the highest (Potting et al., 2017). The strategies with an R-number of either 0, 1, or 2 are focused on reducing the usage of natural materials and resources by requiring less of the product to achieve the same result. On the left-hand side is the indicator of how circular the strategy is, with the R9 Recover as the least circular strategy, and R0 Refuse as the most circular.

In order to succeed, the supply chain, product, and business model need to be designed to be able to cope with the dynamics of a closed-loop system (Rashid et al., 2013). In their article, Bocken et al. (2016) present 3 approaches to cycling resource flows. The first of which is slowing the resource loops, by designing products that have a longer life or by extension, this is achievable by repairing and remanufacturing for example. Then there is the closing of resource loops through recycling, which results in a circular flow of resources. The last approach is to improve resource efficiency or narrow the flow of resources, which means that there is a reduction of inputs per product. Illustrated below in Figure 8, with the sustainable business model aims at creating value through pro-active management of multiple stakeholders with a long-term perspective, and circular business models that aim at an alignment of stakeholder incentives and a circular supply chain:

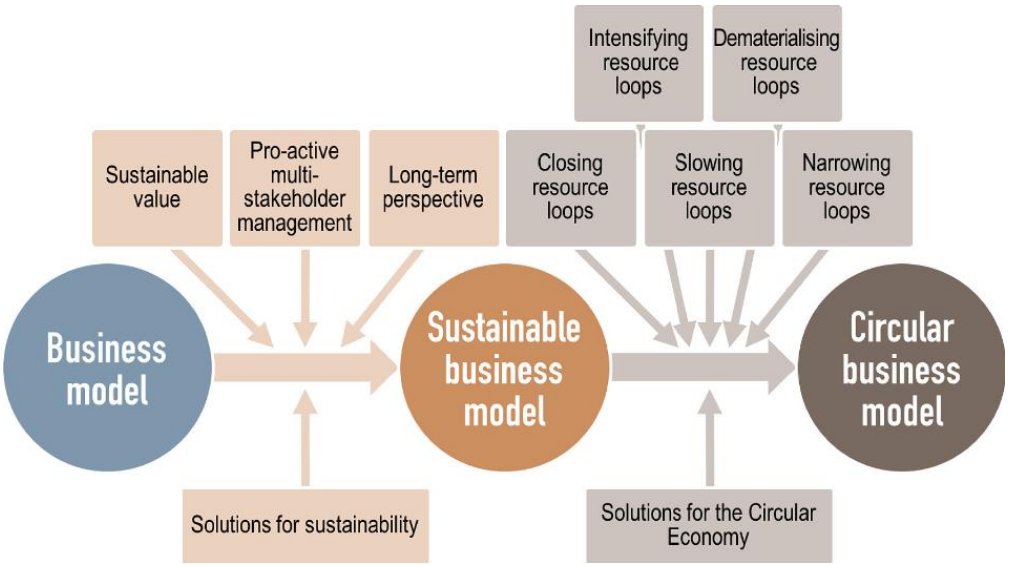

Figure 8: A comparison of traditional, sustainable, and circular business models (Geissdoerfer et al., 2018, 714)

Since sustainable solutions are not progressing as fast as expected, and improvements in production and material technology are becoming to a higher degree incremental, many researchers are empathizing innovations within business models as crucial to facilitating the necessary socio-technical transitions (Geissdoerfer et al., 2017). As business models dictate how a firm does its business, they are therefore important drivers for innovation, however once established, it can be difficult to change (Bocken et al., 2016). There seems to be a lack of discussion around business models within the CE discourse, even though it is regarded as a core enabler of CE (Kirchherr, Reike, and Hekkert, 2017).

A crucial role in the development of a sustainable business model and closed-loop systems is the design of the products of the firm, with the ability to recover products or components of the products, and the extension of their lives as important contributors (Rashid et al., 2013). It is however crucial to develop and implement efficient and ecologically friendly operations that will comply with environmental and governmental laws in order to generate economic revenue, as legislation can constrain industries to utilize operations that will result in negative environmental outcomes (Malek and Desai, 2020).

2.4.3 Barriers to implementing Circular Economy

This subchapter will aim to enlighten the reader on barriers that might hinder firms from transitioning toward a circular economy. The corporation may have some control over

these barriers or may have no control over them at all, and these barriers may be internal or external, and can vary depending on the individual firm, industry, and country (Kirchherr et al., 2018). In table 1 below, there are five types of barriers that firms will experience when implementing resource efficiency measurements.

Table 1: Types of resource efficiency implementation barriers (Lopez et al., 2019, 24)

Main types of resource efficiency implementation barriers		
Barrier type	**Definition**	**Examples**
Institutional	Barriers caused by (e.g. political) institutions framing the "rules of the game"	Rules and regulations, budgetary restrictions, and investment constraints
Market	Market conditions, economic climate, and value network conditions	Lack of knowledge, monopolies, government assistance, supplier leverage, disparities in labor, material, and energy costs, etc.
Organizational	Firms as social systems influenced by goals, routines, organizational structures, etc.	Lack of resources, inadequate financial support, inadequate management processes, etc.
Behavioral	Individuals' values and attitudes within companies	Lack of focus, a sense of being out of control, ignorance, the tendency of current market participants to be risk-averse, etc.
Technological	Availability or lack of knowledge, technical artifacts, or know-how	Lack of tools or equipment, market-undeveloped technology, high cost, inability to support technology, etc.

Cultural obstacles may prevent people from understanding and wanting to participate in CE, which can impede value-chain collaboration. Regulatory challenges can include a lack of circular procurement rules, obstructive laws and regulations, and a lack of international consensus. The lack of economic sustainability of circular business models is one of the market's barriers. Examples include a lack of standards and a lack of support for circular business models. The last obstacle is technology. This is based on the idea that there are not enough technologies available to apply CE, which makes it harder to offer high-quality remanufactured goods. Lack of information, such as on impacts, can result from this (Kirchherr et al., 2018).

According to policymakers and businesses, cultural barriers, such as a lack of enthusiasm and awareness on the part of consumers and a cautious corporate culture, were the biggest obstacles to the implementation of CE in the EU, as identified by 208 survey respondents and 47 expert interviews (Kirchherr et al., 2018). The authors of this article continued by saying that interventions from the government could overcome some of the previously mentioned barriers, but there was still no guarantee of success.

Findings from a literature review of 564 articles by Merli, Preziosi, and Acampora reveal that CE is commonly associated with the wider concept of sustainability (2018). They continue by saying that while the triple bottom line gives a clear approach to how to address environmental concerns, it does not include implications on the social aspect, or balance between the three pillars of sustainability. Furthermore, they state that there are no clear and specific definitions of CE, nor is there any universal consensus on the guiding principles for exercising CE. This is further implied by an article written by Geissdoerfer et al. (2017) where they state that most authors focus on the environmental performance of the CE rather than taking a holistic view of all the aspects of sustainability, and that social aspects are mentioned mostly with the creation of jobs.

2.5 Integration of Circular Economy principles and sustainability in the SCM practice

There has been a growing emphasis in recent years on incorporating Circular Economy principles and sustainability into the SCM practice. This integration may help businesses become more environmentally conscious, explore opportunities to develop and achieve innovation, and reduce waste. The Circular Economy model aims to optimize resource utilization by maintaining goods and materials for as long as possible, and reducing waste, all of which is accomplished in a variety of ways, which can for example be the usage of renewable energy in production, reducing waste in manufacturing processes, and designing products with regards to recycling and reuse. On the other hand, sustainability is concerned with meeting the requirements of today without jeopardizing future generations' ability to fulfill their own needs, with the core of sustainability containing the dimensions of social, economic, and environmental considerations.

While a circular economy is concerned with closing the input of resources, waste, and emissions, the goals of sustainability are more ambiguous, with not a clearly defined and with a significant number of objectives, that may change depending on the interest of the parties involved (Geissdoerfer et al., 2017). Furthermore, they state the similarities between these two concepts are the need for changes in systems, design, and innovation, possible risk, diversification, cost, and value creation opportunities, the necessity of cooperation between various stakeholders, incentives, and regulations as important implementation tools, business model innovation as an important industry transformation, and at how technology can have a positive influence yet can easily become a problem.

On the differences between sustainability and circular economy, Geissdoerfer et al. present that the beneficiaries of sustainability are the economy, society at large and the environment through a horizontal system that balances the aspects equally, on the other hand circular economy has a hierarchical system where the economic system is clearly prioritized with primary benefits to the environment, and the social aspect being implicitly addressed. While both of these concepts are related, they focus on different aspects of social and environmental responsibility, as sustainability is a broad holistic concept that accounts for a wide range of things, circular economy on the other hand focuses more on influencing systems and goods (2017).

In a supply chain, the principle of both Circular Economy and Sustainability can be integrated and influence the company. It is possible to integrate these concepts by creating designs for their products that are sustainable, with features that have a high degree of recyclability, reparability, and durability (Bocken et al., 2016). Collaboration with suppliers to commit to the principles of sustainability and Circular Economy, which can be sourced from sustainably responsible suppliers that prioritize sustainability's environmental and social dimensions. The company can reduce energy consumption and waste, minimize the usage of hazardous materials, and improve production processes in order to acquire more sustainable production practices. With a closed-loop production system on a supply chain level, the company can design the production processes to be simpler to disassemble, and seek to reuse materials for new products, which should contribute to a reduction of waste (Winkler, 2011). Implementing a circular supply chain with the strategies of recycling, reusing, and repairing products at the end of their lifecycle can reduce waste and maintain resources (Genovese et al., 2017).

Digital technology can also support circular strategies as it can help predict downtime in production, schedule maintenance, optimize energy consumption and predict the health of products (Kristoffersen et al., 2020). These are ways that digital tools can contribute to CE be it from recycling to reusing, and influence future design based on finds from analysis of data. However, according to Lopez et al. (2019), these technological solutions can come with a high cost.

Incorporating circular economy and sustainability principles into a firm's supply chain management can ensure a more resilient and sustainable company. With benefits such as higher loyalty among customers, improved reputation, lower costs, and all of this while contributing to reducing negative consequences for our precious planet. However, there is a wide spectrum of constraints, including cultural, economic, political, and technological limitations (Genovese et al., 2017).

3.0 Stakeholder Theory: Theoretical Framework

With a conceptual framework that outlines the research's fundamental ideas, concepts, and assumptions. It is a collection of interconnected thoughts and ideas that give a systematic approach to comprehending and describing a phenomenon or situation. Depending on the environment and study aim, these frameworks is built on existing ideas or constructed from scratch. The goal of the theoretical principles presented in this chapter is to assist research and guide data analysis and interpretation. A good amount of articles written about SCM tend to have a theoretical lens drawn from the theories of the resource-based and natural resource-based view, Actor-Network theory, and Stakeholder Theory, with other theories frequently mentioned being transaction cost economies, resource dependence theory, and Porter's value chain concept (Quarshie, Salmi, and Leuschner, 2016).

The stakeholder theory, which was developed by Dr. Freeman, suggests that the success of a company is not only dependent on its shareholders, but on all the stakeholders that are in some way involved in the organization (Simon, 2022). These stakeholders can be governmental organizations, political parties, business associations, labor unions, local communities, financiers, suppliers, employees, clients, and many more. Even competitors may occasionally be included in the list of stakeholders because of their potential to have an impact on the company and its other stakeholders (Freeman, 2016). The theory puts an emphasis on the importance of generating value for all stakeholders, not just shareholders, and implies that a partnership between the stakeholders and the company is important for the creation of value (Donaldson and Preston, 1995). The theory is frequently mentioned in management studies, and it highlights the responsibility that organizations have for their stakeholders in order to achieve competitive advantages. Freeman puts an emphasis that it is essential for the survival of a firm and its success to understand and meet the expectations of its stakeholders (Freudenreich et al., 2020). Therefore, the success of a firm is determined not by its relationship with its shareholders, but by the quality of its relationship with its stakeholders.

It is possible to distinguish the stakeholders into two categories, first of which are the internal stakeholders who are directly influenced by the actions of the company. Secondly, the external stakeholders, that are not a part of the company, yet are still affected by its

actions (Fernando, 2023). The actions of a firm affect not only itself, but also its surroundings, and are in many ways a direct contrast to the shareholder theory, which believes that it is the interest of the shareholders that is important for a company. Companies that emphasize the shareholder will focus on profit maximization and promote growth in order to satisfy their shareholders (Fernando, 2023). The stakeholder theory will, on the other hand, focus more on satisfying all stakeholders impacted by the actions of the company, and will determine its success based on this. In other words, good profit margins are not a good measurement of success, but also of how the company affects its surrounding stakeholders (Simon, 2022). For fish farming, stakeholders can influence the ethics and sustainability of seafood systems, raising issues regarding seafood consumption, food security, fish welfare, and social security (Lam, 2016).
Another theory that aligns with our philosophical positioning are the Actor-Network Theory. Actor-Network Theory focuses on the relationships between the actors within a system or network, asserting that all actors possess equal opportunity to shape the network (Latour, 2005). Contrasting with stakeholder theory, Actor-Network Theory focuses on the relationship and influences of all actors within a network, regardless of their status as a stakeholder (Marcon et al. 2023).

Actor-Network Theory can be useful for theory for Supply Chain Management in four areas (Hald and Spring, 2023). The first of these areas is that Actor-Network theory can help to improve the understanding of the delicate and dynamic processes of SCM reconfiguration, emergence, and change by assuming that objectives and their actors are performative. Further on, it put an emphasis on those that work with SCM by mapping and observing their efforts when trying to interact with others partaking in the supply chain, be they human or nonhuman. Thirdly, as Actor-Network assumes a distributed agency, it can therefore mirror the dynamics of SCM, and explore how the actors are trying to influence the SC based on various perspectives. The last area that Actor-Network Theory can offer the theory of SCM is that it can assist in creating a clear understanding and model of the politics involved to interpret, stabilize, and represent practices and systems belonging to SCM (Hald and Spring, 2023).

The resource-based view emphasizes the importance of a firm’s resources in gaining competitive advantage. Valuable, rare, imperfectly imitable, and difficult to substitute are crucial to achieve this advantage (Barney, 1991). A natural resource-based view has been

developed to address the environmental issues and offers strategies such as product stewardship, pollution prevention, and sustainable development for a sustainable competitive advantage (Hart, 1995). Leveraging unique raw materials with skilled workers will improve this advantage further (Freeman et al., 2021).

It should be worth mentioning that both the resource-based and natural resource-based views provide useful insight into how a company can perceive its products. But due to our philosophical positioning being social constructivism, we can't therefore employ both resource-based and natural resource-based view as our theoretical lens, as these views contradicts the purpose of our master thesis, which is to explore the interplay between CE and sustainability. As the master will explore those directly affected by the participants of the fish farming industry, the Actor-Network Theory will in turn try to cover multiple actors that influence the SC, which will prove to be difficult due to the limited timeframe. Despite good contributions, we have chosen the stakeholder theory framework as our theoretical lens and will use this as a guideline for our analysis in this master thesis.

4.0 Research Methodology

The purpose of the research methodology is to explain the reasoning behind the data collection procedures used in the study (Mohajan, 2018). This chapter outlines the methodology used in this master's thesis. We started to discuss our philosophical position, followed by the research design, which is a comparative case approach. We described our case and the data collection methods used, including both primary and secondary data. We also discussed how we selected interview participants and why we included personal observations in the study. In the final sections of this chapter, we explain the data analysis process, the importance of research quality and address the ethical considerations of the thesis. Before delving into the method section, we would like to refer to Figure 9. While inspired by Saunders et al. (2012), the figure is made by us researchers and represents all the key points covered in this chapter in a comprehensive manner.

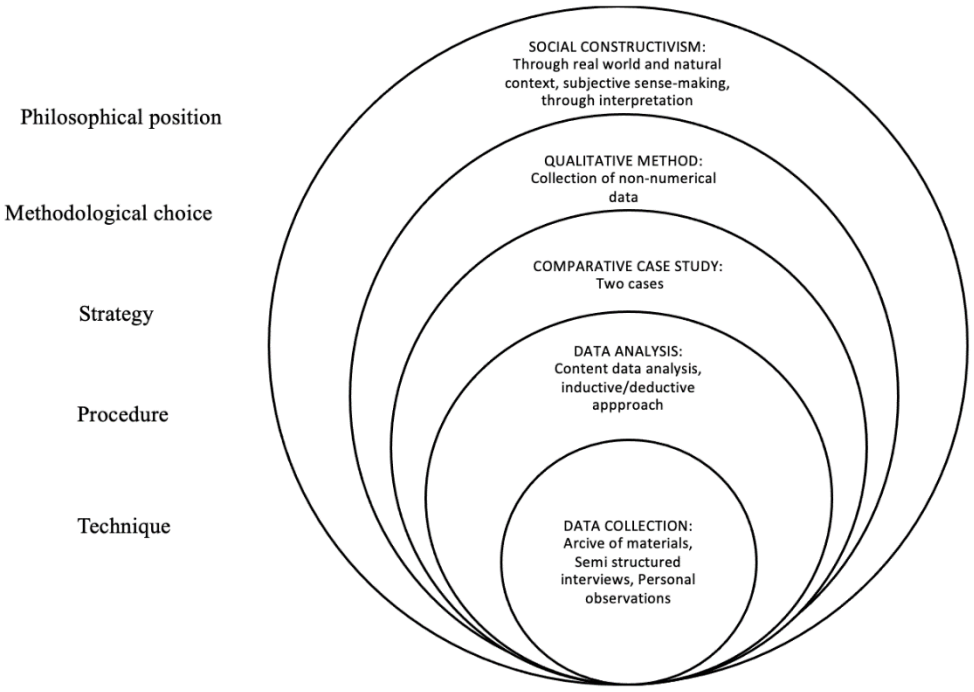

Figure 9: Our research "onion" (partly adopted from Saunders et al., 2012, 130)

4.1 Philosophical position

When we are undertaking a project in a such specific field, research philosophy refers to our set of beliefs and assumptions when it comes to knowledge development. Throughout the research process, we make various assumptions which impact both what we do, and how we interpret and understand what we investigate. These assumptions include the realities encountered in the research (ontological assumptions), human knowledge

(epistemological assumptions), and the impact of our personal values on the research process (axiological assumptions), which shape how we approach research questions, use methods, and interpret findings.

In our master`s thesis, we have adopted a social interpretive stance in terms of epistemology as a way of comprehending the respondent's knowledge and understanding of a situation, which is crucial for our investigation. This further influenced our decision-making during the research process. We believe that knowledge is created through engaging with real-world and natural contexts, and that events are comprehended through interpretation, influenced by interaction with a social setting. In an ontological way, this means that we view knowledge as subjective and personal, rather than objective and universal. Our goal is not to generalize, but to attain a deeper understanding in the data analysis through subjective sense-making. Our axiological assumptions revolve around the importance of the interaction between us as researchers and our respondents to collect knowledge that could answer the purpose of our thesis (Saunders et al. 2012).

We utilized methodological approaches that incorporate understanding and the meaning of human intentions to examine how circular economy principles contribute to sustainability within Case A and Case B`s supply chain operations within the Norwegian fish farming industry. Our philosophy was shaped by practical considerations and our idea of acceptable knowledge. We evaluated our assumptions and their appropriateness in our study by comprehending the different philosophical positions and our taken-for-granted assumptions about the functioning of the world.

4.2 Research design

Research design is the logical chain that links empirical data to a study´s initial research questions, findings and to its conclusion. Between the research questions and the conclusion, there are a number of major steps, such as collection and analysis of relevant data. It is important to note that research design is more than a work plan. The designs' main purpose is to avoid situations in which the evidence does not address the research questions (Yin, 2018). The research design provides further research with a direction, a structure, and a particular setting. The research design we decided for our study did clarify and established a link between what we asked and what we studied.

We provided a descriptive investigation in our master´s thesis, because it involves getting a detailed description of how circular economy principles contribute to sustainable supply chain operation within the Norwegian fish farming industry. There are two main research methods when conducting research; (1) Qualitative method, which is the collection of non-numerical data such as words through interviews, personal observations with pictures, video clips and other similar material. (2) Quantitative method that derives the collection of numerical data and data analysis procedure through surveys, graphs and statistics. We have applied a qualitative method for our master´s thesis. This method allowed us to go in-depth and create greater understanding about our phenomena in addition to using multiple sources of data collection. The qualitative method is really consistent with our philosophical position, namely social constructivism.

4.3 Comparative case study approach

We chose to apply a comparative case study approach for our research, which involved selecting cases that shared similarities and/or differences. This allowed us to analyze, compare and identify unique findings from the empirical cases in their real-world context. By examining multiple cases instead of a single case, we were able to identify unique contextual factors that impacted the phenomena under investigation in different ways (Yin, 2014). As our findings were informed by a range of empirical data, the evidence obtained from a comparative study was judged to be valid, reliable and contributed to the development of a more convincing theory. Our comparative case study thus allowed us to get a broader and deeper investigation of the research questions.

By using a comparative case study approach, it enabled us to examine and compare the relevant similarities and differences between Case A and Case B. This approach provided us with a comprehensive and detailed understanding of how the two cases differed in terms of their strategies, practices, and performance. We found it particularly interesting to identify similarities and differences between the two cases. It allowed us to identify best practices and areas for potential inspiration and knowledge-sharing, within the two cases and also with other companies in the industry.

4.3.1 Case description

For our master`s thesis, we have chosen two cases in the Norwegian fish farming industry: Case A, based on the "Nekton" company, and Case B, referred to as the "Salmon Evolution" company. The two empirical cases are located in the county of Møre og Romsdal.

Our selection of these cases was based on the fact that both specialize in the production of salmon for food. Case A operates a land-based hatchery and farming salmon for food in the sea, while Case B produces both hatchery and salmon for food on a land-based facility. We decided to investigate hatchery production in Case A and fish for food production in Case B, because there are several similarities and differences in these processes. By comparing the two cases, it allowed us to gain deeper understanding and to contrast the result in the similarities and differences in these production processes. A brief introduction of the two case companies is presented below.

A. **Nekton**

Nekton is one of the few Norwegian family-owned aquaculture companies that has been in the business since the 1970s. Since then, Nekton has created a unique aquaculture environment in the sea gap on Nordmøre. Sixty employees work every day with everything from roe to salmon, with particularly high quality. In Aure and Smøla, they breed roe, smolt and eventually salmon that is ready for harvesting, which are sold to the world market (Nekton, n.d.).
We chose this company as a case study, as they focus on producing salmon in an environmentally friendly way, by cutting the climate impact and at the same time protecting the welfare of the fish. We found this very interesting and thus wanted to investigate how this works in practice in a hatchery process.

B. **Salmon Evolution**

Salmon Evolution is a Norwegian salmon farming company that aims to revolutionize sustainable salmon farming by developing a concept for land-based fish farming in fresh Norwegian seawater. The company was founded in 2017 by a group of experienced

pioneers from the seafood industry. The company has developed an innovative technology that eliminates the challenges associated with conventional fish farming and improves fish welfare while reducing the impact on the environment (Salmon Evolution, n.d. a).

We chose Salmon Evolution as a case due to its commitment to environmental sustainability and fish welfare, which aligns with the values of the Nekton company. Our aim was to examine how these values are manifested in practice in an entirely land-based facility. Salmon Evolution acquired a family-owned smolt producer in Volda and initiated partnerships with foreign players to develop, construct, and operate land-based salmon farming facilities in South Korea and North America. In this way, they will enhance their proximity and accessibility to the global market (Salmon Evolution, n.d. a). These activities testify to Salmon Evolution's rapid growth in the industry and how rich and powerful they are. Taken together, these factors motivated our decision to choose Salmon Evolution as a case study.

4.4 Data collection

To address the purpose and research question selected for this thesis, we decided to utilize a qualitative research approach. In conjunction with this methodology, we employed a diverse array of primary and secondary sources to reinforce and elaborate on our investigative efforts, as well as to explicate and analyze our findings in depth.

4.4.1 Primary data

Face-to-face interviews, email correspondence, and personal observations were the primary data for this master's thesis. We had the chance to discuss the subject we are studying and ask follow-up questions during the interviews, which helped us get an in-depth understanding of how the businesses operate. Additionally, by visiting the companies, we were able to gather personal observations. This improved our knowledge of how the fish farmers operate in real-world situations. Therefore, all things considered, we gathered a ton of useful first-hand information about the topic studied.

Interviews

We conducted eight semi-structured interviews and used different techniques based on Teams, face-to-face and e-mail correspondence (*see Table 2)*. Semi-structured interviews allowed us to have more informal and open conversations with our respondents. They

could steer the conversation in the direction they thought was important, while also enabling us to adjust our questions based on their responses. Our interview guide consisted of open-ended questions and relevant topics related to our research questions to facilitate the completion of these interviews (s*ee appendix A)*. To ensure consistency across the interviews, we used the same interview guide for each of our respondents in order to have the same starting point in the interviews. In this way, we could more easily analyze similarities and differences in the findings, which we could take with us further in the discussion.

Table 2: List of organizations and respondents participating in the interviews (The authors elaboration)

Respondent number	Company	Case	Position	Date of interview	Duration of interview	Implemented circular economy	Technique
Respondent 1	Nekton Settefisk	A	Daily manager	22.02.2023	1h 15m	Yes	Teams
Respondent 2	Nekton Settefisk	A	Marine biologist and quality manager	22.02.2023	1h 15m	Yes	Teams
Respondent 3	Salmon Evolution	B	R&D specialist	21.02.2023	1h 30m	Yes	Face-to-face
Respondent 4	Salmon Evolution	B	Finance Manager	15.03.2023	1h	Yes	Teams
Respondent 5	Salmon Evolution	B	Quality coordinator	18.04.2023	50m	Yes	Teams
Respondent 6	NorCod		Quality manager		Written	Yes	e-mail correspondent
Respondent 7	Havlandet		Daily Manager	31.03.2023	1h 30m	Yes	Teams
Respondent 8	Havlandet		Administration	31.03.2023	1h 30m	Yes	Teams

The interview guide had 38 questions in total, which were divided into four categories, 1) introduction, 2) Supply chain and operations management, 3) Sustainability and circular economy, 4) other questions. Since one respondent was only able to provide answers via email, we designed a comprehensive interview guide to ensure detailed responses. This approach allowed us to gain a deeper understanding of the relevant issues, despite not being able to ask follow-up questions. Prior to the interview, we defined important technical terms such as supply chain management, operational management, sustainability, and circular economy. This was beneficial for our respondents who may not have been familiar with these terms.

As mentioned earlier, we used various techniques to conduct the interviews. One respondent was interviewed physically, one answered via e-mail correspondence, two respondents were interviewed individually via the Teams platform. Additionally, we

conducted two interviews with two respondents in each interview via the Teams platform. The individual interviews, in contrast to the interviews where two respondents participated, were not exposed to any influence from other participants. Nevertheless, these interviews demanded distinct answers, reflecting the respondents' specific areas of interest. Conversely, paired interviews gave an advantage in that the participants could exchange information, which led to a more comprehensive and nuanced response. We found the responses obtained via e-mail correspondence to be particularly useful and detailed. We were informed that the respondent who replied via email took the initiative to consult several employees within the company for their input on the questions. We viewed this as a positive aspect, considering we were unable to conduct interviews with a larger pool of individuals from the company.

At the beginning of February, we finalized the interview guide and distributed it to the respondents we had planned for interviews. This gave them time to prepare in advance. Since all our respondents were from Norway, we conducted both the interview guide and the interviews themselves in Norwegian to avoid any language-related misunderstandings. During the initial interviews, we observed that some questions did not provide as much useful information as we had expected. As a result, we decided not to change the interview guide, but omitted these questions from subsequent interviews.

Prior to conducting the interviews, we provided the participants with an interview guide and an information letter outlining the requirements of the master's thesis. They were required to sign this letter to confirm their understanding and agreement to participate. All the interviews, both through physical meetings and Teams were audio-recorded, as stated in the information letter. This allowed us to capture all critical information without relying solely on written notes. To minimize the risk of misinterpretation, we opted to use both methods. Following the interviews, we transcribed them in detail to ensure accurate and thorough analysis of the data received. Initially, the transcriptions were done in Norwegian to capture all nuances and later translated into English.

Sampling

By ensuring that the units we have studied are Respondent of the population that interests us, sampling assisted us to improve our findings. There are two sampling techniques, probability and non-probability which is further illustrated in Figure 10 (Saunders et al.,

2012). Since we conducted a qualitative method with a comparative case study approach, we used a non-probability sampling technique. In other words, our master's thesis respondents from the fish farming business were asked to take part because our sample selection was based on subjective judgment.

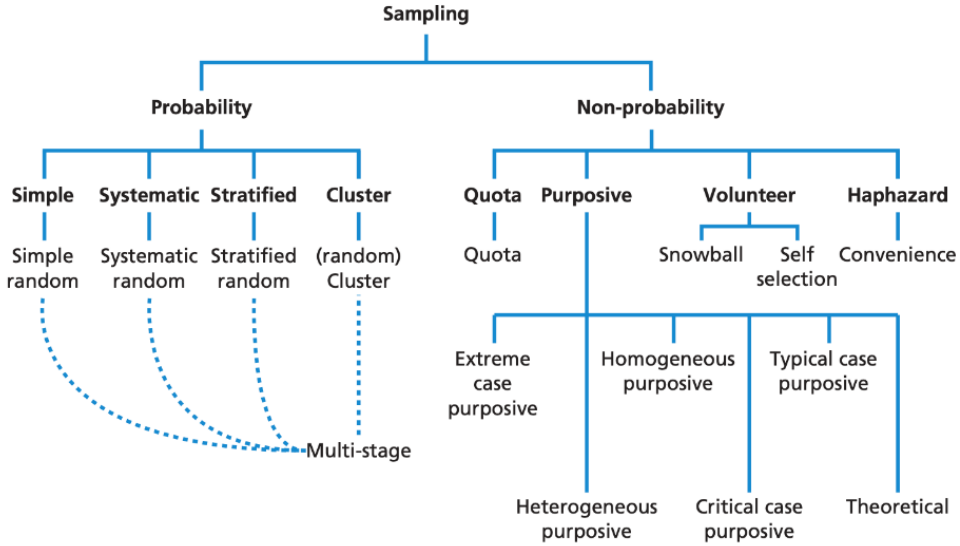

Figure 10: An overview of sampling techniques (Saunders et al., 2007, 207)

Through the non-probability technique, we mixed snowball and convenience for the sampling. We got our first contact through our supervisor, which again gave us a contact we actually used as a respondent. Further from here, the list of respondents (see table 2 for a complete overview) grew through *snowball sampling*, since the initial respondent gave us suggestions of colleagues we could interview. This means that our sample was somehow determined by the availability of the respondents or through *convenience sampling*.

In addition to Case A and B, we conducted interviews with two additional companies to gather diverse perspectives on their operations and experiences. These companies specialize in cod production, one operating in the sea and the other implementing a pilot project for land-based salmon and cod production. The insights gathered from these interviews served as supportive evidence in the discussion chapter of our thesis. We carefully selected these companies as they provide valuable information that can complement and enhance our research. They were serving as supplementary sources of information, particularly on specific topics or challenges that emerge from our findings and support our selected cases.

The first supplementary company is Norcod. Norcod is a Norwegian seafood company that specializes in farming and preparing Atlantic cod and was established in 2017. We chose Norcod due to their aim to produce sustainable seafood of the highest quality while minimizing their impact on the environment. Norcod manages their own farming and processing facilities, enabling them to have full control over the production process from start to finish (NorCod, n.d.). We chose this company in our study because it would provide insight and perspective on how fish farming at sea operates.

The other supplementary company is Havlandet RAS Pilot, which focuses on Recirculating Aquaculture Systems (RAS) that allow for the recycling of water in tanks in land-based facilities. More details about RAS are provided in chapter 5. They were established in 2002 and are located at Fjord Base in Florø, Havlandet has continuously developed their bloodline protocols and genetics since their inception and are currently producing the 7th generation of eggs from their strain. Havlandet RAS Pilot is a subsidiary founded in 2021 with the goal of producing both salmon and cod smolt and fish for food in the future. In order to gain the knowledge and experience necessary to manage large-scale production, the company is currently running a pilot project on a smaller scale, as this method is relatively new and challenging, particularly for different types of fish (Havlandet, n.d.). We chose this company in our study because it would provide insights into fish farming on land and share their experiences with RAS technology.

To ensure a diverse perspective in our master's thesis, we selected respondents from companies of varying sizes, operating methods, and experience with different fish species. Our sample included a family-run business specializing in farming salmon smolt and salmon for food in the sea, three land-based farms (one with salmon, one with cod, and one with both), as well as a company that farms cod in the sea. While ensuring diversity, we also aimed for consistency in the positions and responsibilities of our respondents. As such, we interviewed individuals in roles such as general manager, financial director, quality manager, quality coordinator, marine biologist, and administration.

Personal Observations

Yin (2014) suggests that conducting personal observations is a valuable method for gathering first-hand knowledge and gaining in-depth insight. During a visit to Salmar`s

visiting center in Molde in December 2022, both authors of the master`s thesis gained valuable knowledge about the technology and innovation used in the fish farming industry. The visit included a simulation of a control center overseeing multiple locations digitally and learning about the life cycle of salmon. It was during this visit the authors learned about the land-based farming of Salmon Evolution, which become one of the case companies in the thesis.

In March 2023, the first author had the opportunity to visit a MOWI fish hatchery facility as part of an event organized by Campus Kristiansund. The visit allowed the author to witness the production process from roe to young salmon, learn about daily routines, and understand how MOWI's recirculating water system works. Later that day, the author visited two more facilities for breeding cleaner fish species of Ballan Wrasse (Abrus Bergylta) and Lumpsuckers (Cyclopterus Lumpus) further up north. These visits provided practical knowledge and a better understanding of the fish farming industry.

4.4.2 Secondary data

According to Saunders et al. (2012), secondary data refers to information that has already been collected for a different purpose and is available for use by researchers. In this master's thesis, we obtained this type of data from published academic articles, books, government reports, and company websites through a literature search. This allowed us to supplement our prior knowledge and create our theoretical chapters to support our findings. Additionally, we used secondary data to supplement our primary data collection efforts and strengthen our information on particular topics that we may not have covered in our interviews. The secondary data we obtained mainly focused on theories related to fish farming in Norway, especially in relation to salmon and cod farming, as well as sustainability and circular economy topics. This approach provided us with a comprehensive understanding of the subject and a solid foundation for our research.

4.5 Content data analysis

The analysis of empirical evidence was conducted using both inductive and deductive approach. These approaches differ in their starting points, goals, and methods, but they can be used together to provide a more comprehensive and accurate understanding of a phenomenon or problem. Our master's thesis primarily adopts a deductive approach, whereby we begin with a theory based on academic literature and a research strategy to

test this theory. However, a mix of inductive and deductive approach is also utilized through data collection to explore phenomena and identify patterns (Saunders et al. 2012).

Inductive approach aimed to transform extensive and varied raw text data into a more concise format. This involved identifying patterns in the data using thematic codes (Thomas, 2006). By repeatedly reading the transcribed interviews, we were able to recognize patterns across the cases, allowing us to categorize codes and interpret the transcribed interviews and our personal observations. The most frequently occurring codes were circular economy, sustainability, land-based, sea-based, and challenges. Our main source of data was the information we obtained through the interviews, which provided us with individual perceptions and experiences of the respondents. From this data, we extracted quotes and information from the respondents that were used to support the claims made in our coherent description of the Norwegian fish farming industry.

The findings from each case were presented in separate chapters, allowing us to focus solely on the findings from one case at a time. In these chapters, we explored the findings related to the research questions, which included information on how each company operates, circular drivers of sustainability, enablers of sustainability, challenges related to economics, roe supply, optimization of feed, and implications for sustainable fish farming. We chose conducted a cross-case analysis, which involved comparing the selected cases to identify important differences and similarities within logistics activities, challenges, and operational processes (Khan and VanWynsberghe, 2008).

4.6 Research quality

When conducting research for our master thesis, it was important to collect information for our findings in a valuable way. It was crucial to persuade the reader that our findings are reliable and unaffected by our personal opinions. It was crucial to gather information in a valid and reliable way in order to write a thesis of high research quality.

4.6.1 Validity

Validity is widely regarded as the most critical criterion for research, as it ensures the integrity of the conclusions drawn from the research (Bryman and Bell, 2011). Exploratory case studies, on the other hand, are often criticized for their subjectivity, as personal

opinions can influence the results (Yin, 2018). Therefore, it is essential to use methods that can improve the quality and validity of research. This includes construct and external validity.

Construct validity is particularly important when investigating something that cannot be measured or observed directly. In our study, it was crucial to find respondents who had knowledge of the phenomenon. The selection process for respondents is also decisive for the external validity of the results (Bryman and Bell, 2011). To enhance these validities, we followed the replication logic proposed by Yin (2018), which aimed to prove correlation or lack of correlation in the cases. For instance, if we identified something interesting during the interviews with Case A, we made sure to ask about it during the interviews with Case B. Additionally, we created individual chapters for each case, which were then compared to reach conclusions across cases.

According to Bryman and Bell (2011), the aim of the case study approach is not to find general answers to what is being researched, but to focus on the uniqueness of the case to develop an understanding of the research's complexity. In Appendix A, we have attached the interview guide that was used during the interviews to provide insight into the questions asked. The interview guide, which was approved by Norwegian Department for Data Collection (NSD), and a consent letter were sent to the respondents well in advance of the interview. This increased the reliability of the results as respondents were prepared for the questions they were going to be asked. To further enhance the validity of our research, we conducted interviews with various companies and respondents, and we also visited companies to collect personal observations. For example, when a company talked about hatchery tanks, we knew what this looked like, which aided our understanding. Finally, we used external sources of evidence such as articles and reports to triangulate data and increase the validity of our research. This approach created a solid foundation in terms of construct validity.

4.6.2 Reliability

Reliability refers to the extent to which the results of a study can be replicated (Bryman & Bell, 2011). In our study, the majority of the interview questions were open-ended, allowing respondents to answer freely and flexibly. As a result, it is unlikely that identical findings would be obtained from future interviews conducted using the same guide due to

various factors, including changes in the research setting or increased knowledge among the participants. All the interviews we conducted with our respondents, either in person or via the Teams platform, were audio recorded. This was carefully transcribed, which gave us the opportunity to analyze our findings in detail.

4.6.3 Generalization

In qualitative research, the researcher is often concerned with being able to claim that findings can be generalized beyond the confirmations in the specific context in which the research was carried out. We often claim that the findings can apply to others than those who participated in the study, if the study is carried out using a questionnaire and a large selection of respondents. Due to the rarity of conducting interviews or surveys of a large population, it is important to generate a Respondent sample. This is where external validity comes in as it concerns you with the possibility of applying study findings to contexts beyond the original sample (Bryman & Bell, 2011). This is a comparative study that tests existing theory and compares findings from several companies. This strengthens the validity of the master's thesis, as these companies have different sizes and start-up dates. Additionally, they operate in different places in the supply chain, with different types of fish and whether they operate on land or at sea.

There were some elements that made the generalization of our findings somewhat challenging. When we contacted certain companies, we never received an answer as to whether or not they wanted to participate in this research. This meant that we were only left with the two cases in addition to the supplement companies. The advantage of these companies is that they are very different, so that we gained an insight into how their process works, and thus gained information to a wider extent than if we had only obtained companies that dealt with the same type of fish and operation. This allowed us to generalize across the companies, which indicates good external validity. None of the authors of this master's paper had previous knowledge of this industry, which meant that we got a very subjective perspective.

4.7 Ethical issues

This master's thesis collected data from respondents who work in the fish farming industry. It was to understand real-world phenomena, improve the validity of research, and maintain

scientific integrity. This involved us having to take key ethical considerations into account, which involved protecting the rights of the respondents (Bhandari, 2021).

Before we started interviewing the companies, we delivered the interview guide to the Norwegian Department for Data Collection (NSD) for approvement. The interview guide and follow-up questions were constructed using neutral language, avoiding any offensive, discriminatory, or otherwise unacceptable terminology, and remained neutral with regards to political views, ethnicity, and beliefs. Through this application, a consent agreement was drawn up containing 11 separate categories of information about the project, its purpose, the subject and the respondents' rights. As soon as NSD approved our interview guide, we started contacting companies to see if they had employees who would like to be interviewed. From there, both the interview guide and the consent agreement were sent to the relevant respondent, in order to be able to see what the task would be about, and what would be required of them if they participated. The consent agreement had to be signed and, as said, it informed the respondent's rights, including that participation was completely voluntary and that they could withdraw from the research at any stage. This had meant that they were at any time allowed to ask the researchers to delete all data that was collected from any one time. This process was carried out to comply with the regulations.

To ensure the privacy of our respondents, we took several measures. We adhered to Molde University's data collection guidelines, which included using an approved audio recorder. The interview recordings were not stored, and only the authors had access to them for transcription purposes. The information shared during the interviews was kept confidential and was not discussed with anyone except for the thesis supervisor. While the respondents' real names were not used in the thesis, we received permission to use their companies' real names and their job titles. Once we had carefully transcribed the interviews and incorporated the information into the finding's chapters, we shared the text with the respndents. This step was taken to provide them with the opportunity to review and suggest changes to the text in case of any misunderstandings, inaccuracies, or if new information had surfaced since the interviews were conducted.

When it comes to the use of secondary data, we have referenced all citations and theoretical aspects using the Chicago reference system when we have acknowledged the

work of other authors and previous studies used in our thesis. It has made it clear what our own work and thoughts are and what is not. Finally, we have also remained exploratory in the analysis and discussion in order to remain as objective as possible with regard to results and implications.

5.0 The Norwegian Fish Farming industry

In this chapter, we will give contextual information regarding the industry that the master´s thesis aims to investigate. The first is historical information to give the reader a better understanding of what actions and consequences have led us to where we are today. Furthermore, there is a sub-chapter on the firms that have contributed with data and information to the master thesis. At last, there are the production process for the fish.

5.1 The history of farmed salmon

In the 1950s and 1960s, industry and research began collaborating on farming experiments, however, it took a lot of trial and error before we saw a farming industry that is as prosperous and rewarding as it is today. The farming industry with its fish cages first emerged in the 1970s, and it is believed that the brothers Ove and Sivert Grøntvedt's release of 20,000 salmon smolt at Hitra in the early 1970s marked the beginning of the farming sector as we know it today. Leaving the salmon in marine cages was a more economically sound option than building a facility on land because it was less expensive to establish and operate (Laks, n.d.).

Production in the sector reached 8,000 tonnes in the 1980s, whereas in the previous decade, it was 500 tonnes. Hordaland, Møre and Romsdal, and Trøndelag accounted for 70% of production. Following several concessions, more facilities started to sprout in northern Norway, and the entire coast was soon covered in installations. In the 1980s, the industry's growth began to accelerate, and until 1991, there were stringent rules requiring local ownership. A 1991 modification to the Farming Act made it feasible for a single owner to have several licenses. Additionally, foreign money was allowed, and the ownership limits were lowered (Misund, 2022a). This made it possible for the sector to flourish the way it has so far, and due to industry consolidations, we now have big businesses with lots of resources available. As a result of the ability to conduct technical development and research throughout the supply chain, the sector has experienced significant growth.

Production increased to 170,000 tonnes in the following ten years from 8,000 tonnes in the 1980's. During this time an innovative solution known as a freezing arrangement came to be an option for the industry, this being used as a production regulation measure. The fish

is frozen in this situation, causing the market to settle and the price to rise once more. This is exactly what was done to account for the significant fluctuations in offers. In Norway, there were 1,220 farms that raised salmon and trout as of the mid-1990s, according to the website laksefakta.no (2020). From the period of 2004, the export of Norwegian fresh salmon increased from 335,850 metric tons to 809,936 metric tons in 2014, with members of EU and countries with "large GDP" having respectively 79% and 91% of the receiving shipment of farmed salmon (Asche et al., 2021). With a product that is of high value and highly perishable, innovations have made it competitive to transport these products over longer distances, however, unlike bulk products it favors shipment frequency to economies of scale due to the freshness of the product (Asche et al., 2021).

In Norway, output remained stagnant in the year 2012, while demand has been strong and continues to grow. Furthermore, Chile, the world's second-largest salmon-producing country, faced significant issues due to an algal bloom, which has reduced the availability of salmon globally (Berge, 2016). As a result, salmon commodities prices have reached new highs. The stalemate in Norway is connected to rigorous industrial regulation as a result of, among other things, salmon lice concerns. Below is figure 8, which depicts the number of companies in other countries that farm salmon.

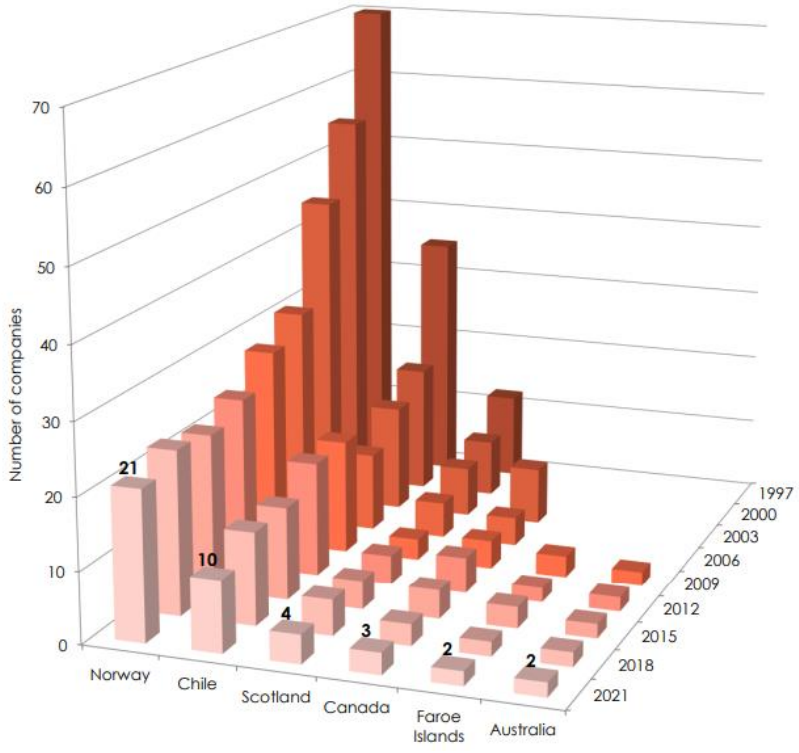

Figure 11: Number of companies in producing countries (MOWI, 2022, 49)

In the year 2021, the seafood industry of the economy expanded significantly. There are now 105,900 individuals employed in the business, up 13,000 over the previous year, both directly and indirectly. As a result of the seafood industry's purchases of goods and services and investments, there was an increase in employment that was fairly split between industry employees (the direct effects) and employees in other industries (the indirect effects). The value creation, including the ripple effects, was NOK 120 billion, while the tax impact was NOK 34 billion (Lillegård, 2022).

On 15 November 2022, the population of the world reached 8 billion. This remarkable increase is the result of incremental advancements in human longevity due to advances in public health, diet, personal cleanliness, medicine, and a result of high and persistent fertility rates in some nations (United Nations, 2022). This will result in an increase in food demand, especially for nutritious and healthy products. As water covers around 70% of the earth's surface, but only 5% of global food production is supplied from the sea, there is an opportunity rather than depending on traditional green fields on land to supply food, the future will focus on the "*field of blue"* to ensure that the ever-growing population is fed (FAO, 2022).

5.2 The history of farmed cod

The first attempt of farming Atlantic cod took place at the end of 1880´s with large exposed to yolk sac larvae. At the station in Flødevigen was about 5000 cod fry farmed on natural zooplankton. About 100 years later, was the same method used in Austevoll. This led to the first "cod-boom" where fry was produced in ponds. In the early 1990s it was a decline in interest in cod aquaculture due to shortage of fry, optimal feed, early sexual maturation, and shifts in the economic climate. However, the pond "Parisvannet" was preserved in Øygarden by the institute of Marine Research, and it provided some breeders with fry. Around the turn of the century, the second "cod-boom" began. Cod hatcheries and food fish farms grew quickly after Tromsø had been chosen as a cod stockfish hub for Norway. In the middle of 2000s, there was around 30 companies that farmed cod in Norway that produced a total of 19,000 tonnes of cod for food a year.

One challenge in cod farming is the bacterial infection that came in 2004. It led to a high rate of mortality in Norwegian cod farming. In the end, the issue with cod aquaculture was

the bacterium francisella noatunensis. The bacteria lives inside the fish´s cell, which means antibiotics are ineffective and there isn't vaccine against it either. The bacteria at the time turned out to be primary an issue in the southern Norway, since it was also found in wild fish. Since the development of the disease is temperature-dependent, the issue is less served or non-existent in the north, so the hatcheries were moved from south to north (Havforskningsinstituttet, 2023.). Later in 2008 the industry had an abrupt halt. This is because the cod eating each other and a lack of effective vaccines. At the same time, quotas for wild-caught cod were increased, which lead to a sudden rise in quantity in the market. This results that the price fell, and famed cod remained sold at a loss. The same year came the financial crises, and many went bankrupt. It was only two companies that continuing the breeding program even though all the customers disappeared.

Getting wild cod to consume pellets was the challenge for 2003. It was difficult because up until this point, it had only spit out the food. At the same time, the cod was also known for its capricious behaviour. The breeding program has produced a well farmed cod that has been adapted to a life in cages. It swims around calmly, does not bite the cages, withstands transport and handling very well, as well as it is growing quickly, has low wastage and low feed factor (Skretting, n.d.).

5.3 Industry influencers

Regulatory measures and policy frameworks

With a coastal line that provides favorable conditions for both fishing and aquaculture-related activities, which range from farming aquatic organisms in inland and coastal areas. The Norwegian government has implemented strict regulations regarding the environment and health of fish farming to ensure safety and sustainability within the industry.

Effective management and production of marine resources are critical due to the transboundary nature of ocean issues, as Frankic and Hershner stated in 2003. Without proper management of the ecosystem, viability can become threatened, as sustainable aquaculture has been proven to revitalize economic development in both coastal and rural communities. The Norwegian Ministry of Industry and Fisheries has stated that the objective of their fishery policies is to establish sustainable management of the living marine resources that will support and develop the fishery industry economically

(Regjeringen, 2021). This is achieved through a focus on increased market orientation and value-adding, with a focus on creating living opportunities in blossoming coastal communities.

To accomplish this, a generic institutional and legislative framework will be proposed to address environmental issues and encourage integrated aquaculture management, as proposed by Frankic and Hershner (2003). In addition, management systems and traditional tenure should be recognized for their possible benefits, and so, incorporated into regulations where they can be significant for sustainable use and conservation.
Under the EEA Agreement, Norwegian laws controlling fish feed items have been aligned with those of the European Union (Salmonfacts, 2016). These rules aim to preserve ethical profitability, ensure safe products, and enhance the health of animals. Multiple departments, including the Ministry of Trade, Industry, Fisheries, Agriculture, and the Ministry of Health and Care Services, draft the rules and regulations that are enforced through this Food Act ("Matloven" in Norwegian) and other related laws regarding food safety and production.

International rules for due diligence and openness are already in existence, however, they are mostly voluntary. The Transparency Act has made some of these obligations legally obligatory and was in Norway put into effect the 1 July 2022 (Forbrukertilsynet, 2023). This implies that companies must undertake due diligence, publicly report on this due diligence, and be open to provide with information.

Technology

There are two systems that are created for land-based fish production facilities, Recirculating Aquaculture Systems (RAS) and Hybrid flow-through system (HFS). The vast majority of land-based projects uses RAS as they prevent fish to escapes and lice from the sea, it produces minimal waste, it gives the ideal temperature and minimal handling of the fish. HFS on the other hand is currently only used by one company. HFS does everything RAS does, but they also provide high water freshness, minimal H_2S risk and minimal biological complexity. For example, several tanks can share a biofilter via RAS, but with HFS each tank has a separate biological zone (Norskfisk, 2022, 10).

To get rid of water metabolic wastes, the RAS filters the water and recirculates it. In other words, biological filtration, sterilization, and oxygenation all contribute to the water's purification. By implementing RAS, there is possibility of water reuse up to 90 percent which can improve waste management while also lowering water consumption and promoting nutrient recycling (Ahmed & Turchini, 2021). The HFS system does not employ biological filtration, but rather change the water more frequently to remove the nitrogen. Afterward, the water is purified through UV light to eliminate parasites and bacteria. This allows HFS technology to provide access to abundant, fresh seawater while ensuring high water quality for the fish. The HFS system provides controlled and ideal growth conditions, eliminates the risk of parasites, and reduces the likelihood of infection. Additionally, it reduces energy consumption by reusing around 65% of the water through mechanical filtration (Salmon Evolution, n.d., b). Both RAS and HFS are very similar as their principle and purpose is the same. The amount of water to be recycled is calculated by balancing cost and operational risk. Higher reuse levels require the introduction of more filtration and water treatment and lead to an exponential increase in risk. On the other hand, a lower level of reuse will lead to significantly higher energy costs in connection with pumping and heating of water (Salmon Evolution, 2022b).

AKVA fishtalk is a digital solution that comprehensively covers feeding assistance, process control, production control, and planning needs, resulting in optimum efficiency, excellent fish quality, and increased profitability. Building on this foundation, customers have the option to add other modules to their AKVA fishtalk solution, which can increase the potential for precision fish farming by providing better control, overview, and optimization of the production process. The AKVA fishtalk portfolio captures data from broodstock to harvest, including biology planning, finance, budgeting, economy control, production cost, and more, and is equipped with powerful reporting and analysis capabilities. When combined with the finance and planning modules, AKVA fishtalk becomes an indispensable tool for day-to-day use on a single site or for mapping out a 5-year plan for the entire company (akvagroup, n.d.).

5.4 Production process of Atlantic Salmon

This master’s thesis will primarily explore the farming of Atlantic Salmon, hereby referred to as salmon. Salmon is the commonly used term for numerous species of fish in the family Salmonidae (MOWI, 2022). Salmon is widespread throughout the Norwegian

waters, where mating and egg laying have occurred in the country's rivers since the last ice age, followed by an on-growing phase at sea. Salmon has been fished in wild populations since earlier civilizations, both in rivers and in the open waters. Along with cod and trout, salmon is undoubtedly the most sought-after fish species among those living along the Norwegian coast. In the figure below is the traditional production process for farmed Atlantic Salmon in Norway:

Figure 12: The Atlantic salmon life/production cycle (MOWI, 2022, 52)

The production process begins in freshwater tanks in periods of approximately 10 to 16 months until they are large enough to be moved to seawater tanks, where they typically grow over the next 12 to 24 months before being processed. The entire production process for farmed Atlantic Salmon can be between 22 to 40 months, depending on various factors (MOWI, 2022). The life cycle for the Atlantic Salmon begins with broodstock production, where roe from the female fish and milk from male fishes are collected from spawning broodstock and fertilized by mixing these two together. In the wild, this process happens in freshwater.

The next phase of the life cycle is the period after hatching where the fish now known as fry will be produced, and placed in freshwater tanks in which the fish will grow to a certain size before being sent to the saltwater cages. After a period in the freshwater tanks, the fish can now survive in salt water. This period is known as smoltification and the

salmon fry is now known as smolts, which is visible in figure 9 above, this process can take between 10 to 16 months according to the Salmon Farming Industry Handbook created by MOWI (2022).

The last stage begins when the fish reaches the salt water, where they will live until they have reached an acceptable size which allows them to be sold to customers and retailers. This period is spent with cleaner fish such as lumpfish, goldsinny wrasse, and corkwing wrasse. These fish types are used to feed on the salmon lice that prey on the farmed fish. The use of cleaner fish is not a perfect substitute for medicinal use, as the amount of cleaning fish that survive the production process is relatively low, and the capturing of wild cleaner fish has affected the stock as a whole (Erkinharju et al, 2021).

In the fish farming industry, system inputs include regulating feeding, water, and energy supply to the marine cages where the fish live. The output of these marine cages is fish and waste, and through constantly monitoring and measuring the fish and ensuring that the conditions are followed, will yield a good foundation for further processing.

5.5 Production process of Atlantic Cod

The production process of Atlantic Cod usually starts with an egg. The fecundity is accordingly high with 500 000-1 000 000 egg per kg female weight for farmed cod. This egg come from either their own broodstock or from a supplier. From February to April is the natural time where the cod spawn, but now they can easy be manipulated to spawn whenever using photoperiod adjustment. Fertilized eggs can be collected by naturally spawned eggs from spawning tanks where both females and males' lives, or by artificial fertilization where the ova and spleen get stripped. The eggs are planktonic and hatch after approximately two-three weeks (Banrie, 2012). A newly hatched cod larva is no more than 4 mm long when it starts feeding and increases its weight up to 4,000 times during its first 50 days. One difference between farmed salmon and farmed cod is that salmon accept dry food from the start, while the cod must have live feed. Traditionally, the larvae are fed rotifers at first, and then artemia (Havforskningsinstituttet, 2023).

The rearing temperature should be at 6-8 °C during the early larval stage. That is to reduce challenges with malformations, but when it becomes juvenile cod, the temperature can increase up to 12 °C. The cod juveniles can be transferred to into sea cages when it hit a

size of approximately 0,5 gram or 4 centimetres. - but they are usually kept in tanks until they reach a larger size. An alternative to the hatchery produced juveniles is to collect young and wild cod, where they go straight into cages in the sea to feed them up to market size. See Figur 13 for an illustration of the production cycle of cod.

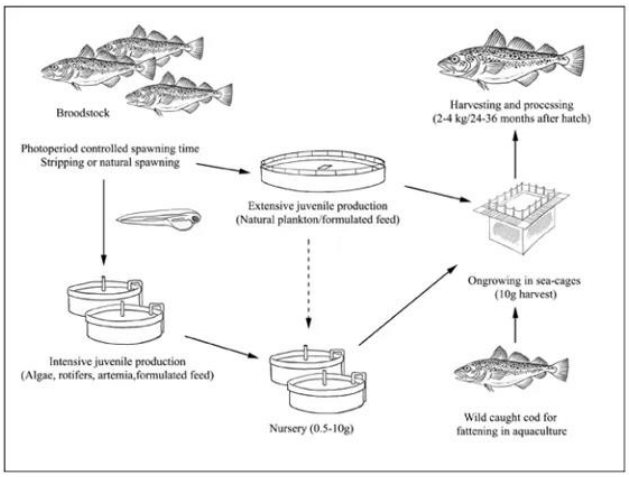

Figure 13: Production cycle of cod. (Banrie, 2012).

One challenge under farming conditions, is that some male cod mature sexually at one year old, while the rest of the males and all females will normally mature at age of two. Early maturation is a major threat to cod farming from an economical point of view, since it must be used light over the cages which reduce, but not completely removes the problem (Banrie, 2012). Studies have shown that fertilized eggs from farmed cod can escape and survive until they are sexually mature and will start to spawning on the spawning grounds. Therefore, can genes from farmed cod easily spread without the farmed cod actually escaping form the cages. At the same time, the absense of the natural signals for sexual maturatuin and spawning can cause the females to have problems relaesing mature eggs. That means that the eggs can swell up in the abdomen so the fish gets “spawn burst”, which is a major walefare problem for the fish that are affected. Also, sexual maturation takes a lot of energy from the fish. This energy come from food and get used to build eggs and milk, rather than grow larger. This will increase the use of feed per kilogram of fish than is the case when the fish is immature (Havforskningsinstituttet, 2023).

A challenge when it comes to food is that the cod need another composition of feed than the salmon. The cod needs a higher protein to fat ratio and do not utilize carbohydrates effectively. So, the feed is mainly based on marine protein which makes it more expensive. Plant and oil can replace some of the marine ingredients to make it less expensive, but it can affect the welfare of the fish due to deficiencies in certain nutrients and taste (Banrie,

2012). After 21 months in the sea cages, is the farmed cod around three kilograms and is ready to be harvested when the marked ask for it (Nofima, 2022).

6.0 Empirical Findings Case A

This chapter presents the empirical findings from one of our empirical cases, with the location in the northern part of Møre og Romsdal. The chapter describes fish farming operations within Case A based on the "Nekton" company. Our storytelling in this chapter is presented according to our research questions presented in Chapter 1, including supply chain operations, drivers and enablers for sustainable practices, challenges, and the implications of sustainable fish farming practices.

6.1 How are the supply chain operations organized within Case A?

Our first research question explores the various operations that occur during the production of farmed fish in the case companies. This question investigates how the company manage its SC, its suppliers, and its distribution network, and can shed light on the flow of services and goods, coordinated activities, and processes involved.

For the hatchery firm located in Smøla, their part of the production process for farmed fish as told by Respondent 1, begins when they buy roe from their supplier, which is sent to the hatchery, where the roe is subsequently hatched. There it eventually will become a yolk sac fry, and once the fish is finished with the yolk sac, it will be moved to the next phase of production, which is where we start feeding. Now the fry will begin to eat pellets and continues to do so until the fish reach a certain size. When the fry reaches a weight of 40 grams, it will be vaccinated and fed until it reaches a size between 100 to 200 grams. After they have reached an acceptable weight, it is sent to cages in the sea with either well-boats or car transport. In Figure 10 is an illustration on how the supply chain operations looks like for Case A, where the one can see the various operations in the production process, and the inputs and the output. Case A is according to Respondent 2, mainly involved in the freshwater phase of the production of Atlantic Salmon, where the fish is vaccinated and fed before being sent to customers. As told by Respondent 2:

"Our company supplies smolt to multiple food fish producers. To give a brief overview, we are a family-owned business that is mainly involved in the freshwater phase of the farmed salmon".

One of the changes Case A has experienced in recent years, is that there is a need for roe all year round. As it is now, there is not good access throughout the year, but that it is going in the right direction. Besides that, it has not been any changes to their supply chain. Respondent 2 continues by telling us that there are 4 suppliers of roe, and that the production is complicated due to strict biosecurity requirements and is quite different from what they are doing at their facilities. Also, the delivery goes smoothly and is a cheaper alternative to producing it at their own facilities. Therefore, due to cost and a complicated production process, the production of roe is not something Case A does themselves. Visible in Figure 14 below is the supply chain operations of which Case A are involved in.

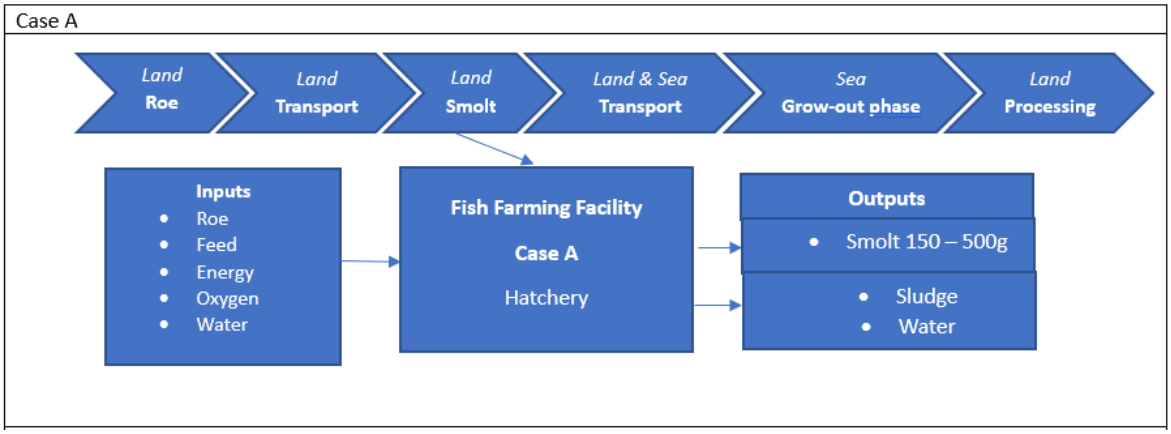

Figure 14: Supply Chain Operations involved within Case A land-based facilities (The authors' elaboration)

The roe which Case A buys from its supplier arrives in crates delivered by trucks. The crates that are used in the initial transport are discarded to waste disposal, as the requirement for the crates is that they should hold the roe and not have them be crushed from inside. Once the fish has reached the stage where it is ready for the first round of feeding, it is moved to tanks where it will remain until the next phase of the production process. When the salmon has grown to roughly 100 to 250 grams, it will be moved to a car by fish pumps and hoses, then the water is filtered so the flow of fish goes smoothly over to the car. Here it will be in saltwater tanks until it is moved from a hose that is connected to the car and sent to a well boat that transports and pump the fish to the next phase of the production process, which is the growth period in the cages in the sea. During this time, the temperature will be held steadily around 14 degrees, because this increases the growth rate for the fish. When talking about the difficulties they experience during their work, Respondent 2 says:

"Mortality can occur when handling fish, but it is most common during the early production stage when the roe arrives at our facilities."

When the fish is moved or handeled, it can become stressed, and in the worst case can increase the mortality. This stress does not affect the shelf life of the fish when it is swimming in the tank, but stress just before slaughter can probably affect something. Therefore, it is imporant to keep the fish calm. Respondent 2 continues by saying that from the time the roe has arrived until its first feeding, they experience a mortality rate of approximately 9 percent. Respondent 1 chime in and elaborates on how logistics play an important role as the fish grows, as mentioned earlier that it is necessary to maintain a stress-free environment. The tank used initially to hold a large quantity of fish are not suitable in the long run, since they will continue to grow. So, they have a limit of 70 kg per cubic meter with volumes of fish per tank, as it can be stressful to have it crowdy in such a relatively little place.

Case A receives two batches of roe every year, with an estimated of 1 million fish in each batch. The sizes of this may vary somewhat. Typically, the fish will be kept for 9-12 months, and each production cycle utilizes the entire facility, which comprises of 5 hatching cabinets, 21 beginning feedings tanks, and 21 growth tanks. With a total of three stages, the first phase lasts around 8 weeks and involves the development of fish from roe. The second phase lasts up to 3 months and involves the period from when the fish grows from 0.2 to 10 grams. The last phase lasts around 5-8 months and involves the growth of the fish to its maximum weight of between 10 to 250 grams. After the fish has reached an acceptable weight, it will be sent to numerous customers, where most of which end up in a grow-out phase at the sea. This is visible in Figure 15 below, with fewer tanks and rough numbers just to visualize how a production line look like for Case A.

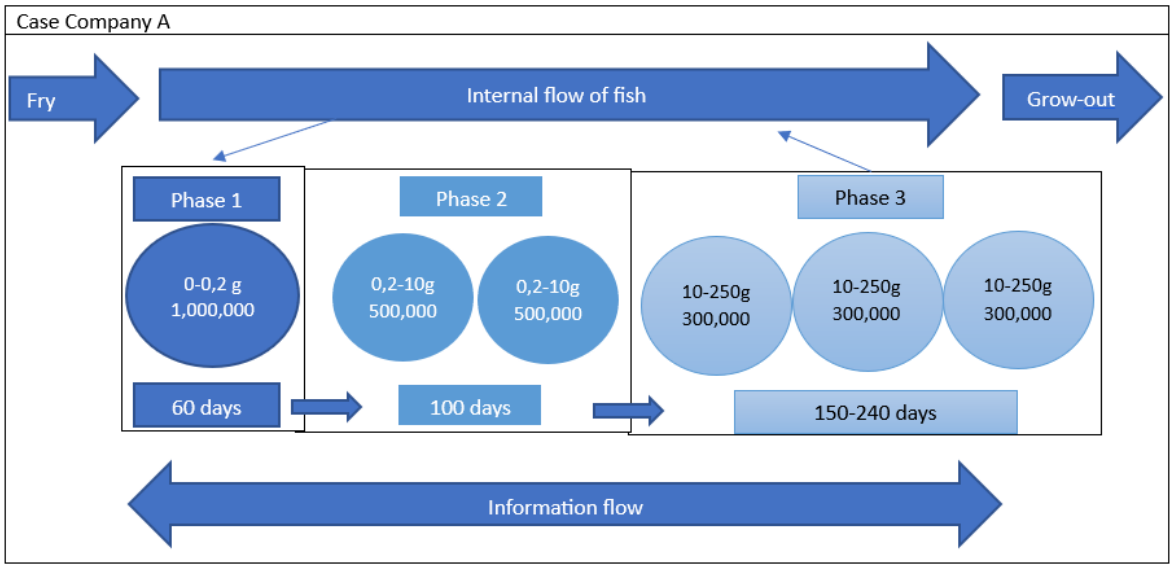

Figure 15: One production line for Case A (the authors' elaboration)

6.2 Drivers to sustainability

Through the interview with Nekton, several things came up that they do to have a sustainable operation. Respondent 1 mentioned that they are working on measures on technology that are energy-saving for their hatchery firm. By using Recirculating Aquaculture System (RAS) they can reuse and recycle water through a mechanical and biological filter system that cleans the water before it is sent to the tank. This technology of production is more sustainable and uses less water and has given them increased production as Respondent 1 explained:

"We use RAS technology with water reuse, water heating with water recovery and heat pump, and all that, so it has given us a profit in terms of increased production. It has also given us more environmental benefits as well".

When it comes to the equipment used in the operations, they have purchased high-quality machines that will last for many years. They use technicians on machines if something breaks down and have parts sent from the supplier to extend the life of the machine. As Respondent 2 said:

"We have technicians present all the time to make sure the machines work as it should because it is very extensive".

If they need to change machines, it is because new technology which can be useful to become more sustainable or circular are available. Respondent 1 mentioned that they buy a lot of used machines and equipment and sell the things they don't need any more as second-hand items.

"We often buy second-hand equipment instead of new, and we also sell our used items on to others."

The equipment used are used for as long as possible, as Respondent 1 said:

"The equipment lasts a long time, but it does have a lifespan, typically 10-20 years, so new technology has usually come along which makes it useful to change or upgrade."

Even though the equipment may still be functional, upgrading it with may offer advantages such as increased productivity, improved efficiency, reduced maintenance costs.

Fish welfare

It is important for the company to maintain good fish welfare, as this improves the quality of the smolt they offer their customers. One way they do this is to ensure that there is a calm environment for the fish, as Respondent 1 stated:

"We try to keep the fish as calm as possible, so there are some logistical problems with space in the tanks".

The logistical problems Respondent 1 mentions are related to the growth of the fish. When the roe arrives at the facility, it weighs somewhere around 0,2 grams, and when it is ready to be forwarded, it can weigh up to 250 grams. The shipment of roe can be up to 1 million, therefore, there is need to ensure that the tanks are not crowded, and the solution for Case A is to split the tanks, as told by Respondent 1:

"We have a limit of 70 kg per cubic meter, with fish volume per tank to prevent stress".

Once the fish reach this limit, the tank will be split, and depending on the place in the production cycle, the company can split the fish into 5 hatching cabinets, 21 beginning feeding tanks, and 21 growth tanks.

In the early phase, cod can exhibit cannibalistic behaviour if there is insufficient feeding and large differences in fish size. The larger fish may bully and consume smaller fish. To reduce this behaviour, sorting combined with optimized feeding is necessary. Respondent 7 notes that there is weekly sorting during the early phase, as there can be significant differences in fish size of 0.1-0.2 grams. Respondent 8 adds that although handling is stressful for fish, it is more detrimental to leave them in a tank where they are bullied and eaten. Such assessments are frequently made.

Adequate space for the fish is crucial, and so is proper feeding arrangements. To have good health and ensure growth, then there is need for a proper and balanced diet. The feed used should contain all the necessary nutrients so that the fish can grow, and there are several options to determine what type should be used, as told by Respondent 1:

"We also have standard feed and winter feed which are more nutritious, then we have feed which helps with smoltification and quality feed, but these come at different prices".

However, the feeding has to happen when the fish is hungry, and this can be tricky as Respondent 1 explained:

"If we overfeed the fish or use more feed than necessary, then there will be a discharge or insufficient utilization, so it is important that we feed the right amount based on how hungry the fish is".

Overfeed can have a bad influence on the water quality that the fish live in. As the fish is dependent on the water they live in, poor quality can have bad repercussions on the well-being of the fish. Therefore, factors such as temperature, oxygen, ammonia and pH level, and feed particles are monitored. To follow up that the quality is acceptable, the company use different tools, and over the years these tools has gradually become more digital.

Respondent 8 mentions that they consistently work to maintain the feed balance in cod farming. Since cod is a voracious fish, it tends to eat as much as it can. Even if they set the feeders to a certain amount of feed, they still need to be vigilant as overfeeding is a significant concern and can adversely affect fish welfare.

Digital tools

When asked about information flow and digital tools used in production, Respondent 1 from Case A mention FishTalk, which is a production control and planning system that visualizes and monitors the flow of fish and its size, feed, tank capacity, and the relocation of fish. This technology will register if they overfeed the fishes or give them more food than necessary that will affects the environment the fish live in. The system gather data from the production and creates useful information that can be used for decision making, as well as sharing of knowledge between the relevant stakeholders.

Annual and monthly operations meetings are according to Respondent 1 used to discuss production-related topics like relocation, sorting, vaccination, and delivery. Mandatory meetings to evaluate water quality, feeding, appetite, mortality, and other measures that might be relevant. Additionally, there are monthly check-ups by veterinarians to receive recommendations that will influence the production.

Communication and coordination between the different departments are important, as told by Respondent 2:

> *"We depend on good information flow to be able to coordinate with each other. Departments must finish their work before other departments can begin theirs, so information flow is important".*

Case A engages in customer dialogue to determine the agreements of delivery and other issues. Once the fish reach a certain size, they are transferred to sea-based cages, as the tanks used in the production process have limited space for growth. Collaboration with customers is essential to manage the growth phase and address common challenges. As Case A have two hatchery facilities, the meetings are shared, and all relevant departments participate during these meetings in discussions on the growth phase and in solving shared difficulties.

Handling of undesired output

According to information provided by respondent 6, environmental investigations have been conducted to determine the impact of sludge on bottom conditions, habitat, and wildlife. The findings of the survey indicate that the impact is minimal. The dispersion of sludge depends on various factors, including how easily it dissolves, ocean currents, and depth.

Currently, the sludge that is collected from the tanks is being transported to the sea. However, Respondent 1 mentioned that there is potential in utilizing the sludge for other purposes, such as producing biogas. Although Case A has not begun using the sludge this way, there are ongoing efforts to explore the possibility. With biogas production, Respondent 1 said that this could have its use:

"We use energy to heat up the tank to maintain the temperature we have now. When using biogas, we can use this energy to heat up or cool down our tanks."

By producing locally on a small scale, there is an opportunity to use the undesired output such as sludge to heat up the water. This can be energy- and cost-efficient, and a way to reduce reliance on external energy sources. The reason why the company would want to heat up the water is to improve the growth of the fish, as told by Respondent 1:

"To maintain an even temperature of 14 degrees in the water is demanding, but that is when the fish grow fastest".

Respondent 1 explains that there are work undergoing to transition towards circular economy:

"We are now working to remove waste and emissions, and then reuse this as a resource in the form of energy. We are now thinking of using the residual product as fertilizer, so we are working on implementing a circular economy".

6.3 Enablers of sustainability

When interviewed regarding why they have chosen to implement circular economy practices into their business, Respondents 1 and 2 from Case A say they use public incentives such as grants that go to environmental measures to get public support. Projects

can oftentimes be expensive, and they have spent a lot of money on environmental measures such as the one with biogas, but it does not necessarily create any more value or income for the company, as Respondent 1 puts it:

"Our customers do not choose hatchery suppliers based on those with the best biogas facilities, but those with the best smolt, so the incentives from public subsidies are what help us become more environmentally friendly".

Strict requirements for production as well as government regulations prompt the industry to innovate and improve their ways of production. Respondent 2 mentions that sustainability is in many ways a government requirement, with environmental regulations in place for cleaning facilities. They have investigated biogas investments as a way to meet these requirements, and they acknowledge the benefits of reusing water. However, they say that it may prove more difficult to produce at sea with similar measures, and the fact that they are land-based is a benefit.

Further on, Respondent 1 said that statutory environmental measures and environmentally friendly measures to improve the environment are prioritized, and a cost-benefit assessment is conducted before any changes are implemented. While the employees do not require any incentives to be motivated, some environmental measures as previously mentioned can be expensive and so, requires funding from the public sector. Also, according to Respondent 1 some statutory requirements may be difficult for employees to understand, such as restrictions on medicine with good effects. Nonetheless, they believe that these measures are necessary for the greater good. However, it can be costly, as told by Respondent 2:

"In terms of environmental sustainability, we spend a lot of money on government regulations and certification of our facilities, which is expensive but necessary since we sell smolt and such".

The certification that Respondent 2 mentioned is the Global G.A.P, which aims to influence the environmental impact of farming operations, reduce the use of chemicals, and that employees have good conditions, as well as good animal welfare within the company. Case A is also currently working on implementing the Transparency Act which

came into effect on July 1, 2022. The law is designed to promote decent working conditions and basic human rights and ensures that the public has access to how a company is conducting its business.

6.4 Challenges

Economic barriers

In our interview with case company A, Respondent 1 pointed out that the cost is the biggest barrier to implementing a circular economy. As of right now, they are losing money, which means they are spending money on implementing and upgrading solutions but not profiting from them. Respondent 2 mentions that for their supply chain, it is the last stage of production before the salmon is sent to customers, where they experience a higher degree of cost, as the fish are now in a growing stage and demand a great deal of both energy and feed.

Another challenge is also a technological one, the RAS system, they employ as Respondent 1 mentions, since there are lots of pumps that have to be monitored and have to work all the time, in order to get oxygen access to keep the fish alive. When asked to compare these costs, it becomes clear that feed is the expensive input factor, closely followed by energy with somewhere around 10 percent, however, if this were to be produced on the sea however, the feed costs could according to Respondent 2 contribute to between 40 percent to 60 percent of expenditures.

Roe supply

Another challenge according to Respondent 2 is when it comes to the packaging of roe when delivered. The roe must remain entire and not be crushed during transportation. Today, there are no circular options when it comes to the packaging of roe. The same goes for the packaging of the feed. Both get compressed in a plastic press before being sent to the local waste disposal facility. There have been discussions about using feed boxes that they can return in place of the feed's current packaging, but they have not yet located a supplier that can do this.

Optimization of feed

One of the challenges related to sustainability and feed is the risk of discharging excess feed or failing to utilize it effectively if the fish is overfed. It is important to balance the correct amount of feed based on the appetite of the fish. As Respondent 1 said:

"The challenges in terms of sustainability and feed are that if we overfeed the fish or use more feed than necessary, there will be waste or insufficient utilization, so it is important that we feed the right amount based on how hungry the fish are."

Balancing the right amount of feed is crucial, as excess feed and waste can lead to poor water quality, which in turn can affect the growth rate of the fish, as well as increase the probability of diseases and other harmful consequences for the fish.

In Norway, there are according to Respondent 2 only three to four feed producers, so, quality and price are essential considerations when choosing feed suppliers. Although price is an important priority, the technical quality of the feed is also critical as poor quality feed can have a negative impact on the environment in the tanks. Respondent 1 mentions that currently, sustainability is not a primary concern, particularly regarding the raw materials used by suppliers. The use of marine-based raw materials is prevalent in the hatchery fish feed when compared to the sea phase, where oftentimes the plant-based feed is more environmentally friendly. Although there have been limited changes to the feed used in the hatchery phase, producers of feed can use plant-based feed in the sea phase to reduce their environmental impact.

Through our interview with Havlandet RAS-pilot, we found out that feeding salmon and cod pose both similar and distinct challenges. One of the most resource-intensive aspects of cod farming is the feed. According to respondent 8, it takes approximately two months for cod to reach the same size as salmon after hatching. Unlike salmon, cod require live feed that is not visible to the naked eye during the initial stages. Providing this type of feed is resource intensive as it must contain the right nutrients for the cod to thrive. Given that it is a living organism, a separate facility is needed to produce this type of feed.

6.5 Implications for sustainable fish farming for Case A

Implications

Respondent 1 noted that their sustainability efforts have resulted in increased costs, particularly in regard to cleaning wastewater from their fish hatcheries. However, they have also implemented profitable technologies like the RAS that reuse the water supply and heat pumps that recover heat. These technologies have not only yield increased production and profits, but also provided environmental benefits, as pointed out by Respondent 2:

"We produce 10 times more fish by using RAS and heat pumps. Otherwise, we would have trouble with the supply of water, which would affect production".

Using these technologies has allowed them to produce ten times as many fish by reusing the water that otherwise would have been a resource that would prove to be difficult to maintain a constant supply of, which in turn could influence the production negatively. Thus, the implementation of these sustainable technologies has been financially beneficial for case company A, while also promoting environmental sustainability. This positive outcome on productivity could also be argued to be beneficial for the local communities in the form of an improved taxation foundation.

Respondent 1 and 2 from case company A was asked if they feel any social responsibility. In response, for them, local social responsibility involves activities such as recruitment, improving the well-being of coastal communities, and promoting the development of these. This is especially important for them as Smøla, the location they operate from, holds 2,300 inhabitants. At the national or global level, the company has contributed to new methods of innovation and production. Additionally, the company provides food production globally with a focus on minimizing the impact on both the environment and climate.

The fundamental principle of fish farming is according to Respondent 1 that it involves circulation. However, there are limitations to this principle, as not all waste can be repurposed in production. The waste generated in fish farming has significant potential for further improvement. For instance, salmon waste could be utilized to produce salmon feed since salmon can consume this, due to ethical issues, this is not commonly practiced, which implies that it cannot be reintroduced into production in that manner. Other possibility is that fish faeces or waste can be sent to suppliers to use as fertilizer. Due to its

nutritional content, some of the waste can be transformed into animal feed. Therefore, the waste material could become valuable for farming since it continues to be nutritious and holds other useable space.

Perception on sustainability in a supply chain for Case A

When asked what they perceive to be a sustainable supply chain in the fish farming industry, respondent 1 says:

> "*Firstly, I would like to say that fish farming is a sustainable supply chain, as the stockfish produce roe which is in a way the supply chain that everything goes around, since we do not get anything special anymore from nature, that is in a way why we do this type of farming".*

Respondent 1 continued by saying that it does not affect the wild fish population of salmon directly, and that they perceive sustainability as the utilization of the products, i.e., in the form of the residual product of salmon, for example, sludge, feed spills, and that type of thing, could be reused for energy or remanufactured as products. Respondent 2 confirms that they believe that they work in a sustainable manner:

> *"In summary, we feel that what we are working on is sustainable, especially with regards to reusing feed and using our resources for as long as possible".*

Respondent 2 discusses the different aspects of sustainability in their workplace and the prioritization of these. They note that the social aspect is important for better working life and conditions for their employees. With the presence of the facility in the area also plays a role in job creation and the local community. Further on, they acknowledge that the environment is important, as they focus on minimizing the use of harmful chemicals and medicines and avoiding pollution. However, they emphasize that the economy is a critical aspect for them, and necessary for enabling the social and environmental aspects. The prioritization of the various aspects depends on the department and perspective of the individual, however, they share a consensus that it is important to balance the economic, social, and environmental sustainability in their workplace. Nonetheless, as Respondent 1 put it:

"If you don't have the finances in place, then you don't have either the social or the environmental aspect".

7.0 Empirical Findings Case B

7.1 How the Supply Chain Operations are organized within Case Company B

The interaction between the participants of the interviews follows the interview guide, which is accessible in the Appendix. The first batch for Case Company B, Salmon Evolution, was in the autumn of 2022 where 30,000 salmon were sent for processing after 7 months of production at their facility in Indre Harøy (iLaks, 2022). The operation was a success with few losses during the transfer between the case company and its processing partner.

Case Company B owns parts of its the supply chain that is part of the food production process. It starts with a smolt company, Salmon Evolution Dale, located in Dalsbygda, Folkestad. This company buys roe from a supplier, in order to produce smolt. When the smolt is ready, it is transported a short distance between the companies to the main production facility for the grow-out phase at Salmon Evolution. When it comes to the harvesting process, the company must buy slaughtering capacity from Vikenco, despite the fact that Vikenco has part ownership in Salmon Evolution. The company itself is responsible for selling the fish, in other words, Case Company B do have control over several parts of the supply chain. Figure 16 is an illustration of the supply chain that Case Company B have. The company is also developing new approaches and technologies to improve practices within fish farming that will also address concerns regarding the environment. The company plans to eventually expand its operations internationally by establishing themselves in South-Korea, but this is in the long term.

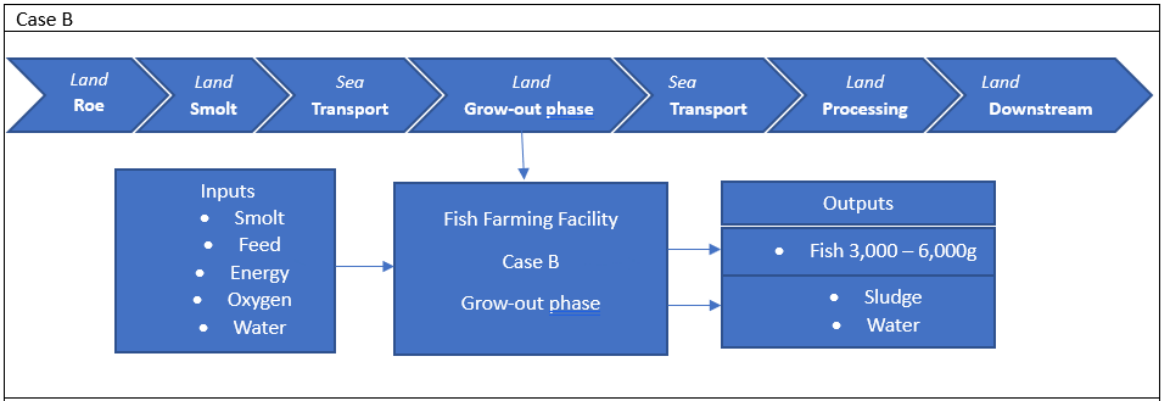

Figure 16: Supply Chain Operations involved within Case B land-based facilities (The authors' elaboration)

When asked why the company does not handle the butchery process, Respondent 4 explains that it is a resource-intensive and complex process. The company has chosen to partner up with a large processing facility on the other side of the fjord named Vikenco, and this partnership is also one of Salmon Evolution`s founders. This decision has allowed the company to avoid the challenges of building a facility to handle this themselves, as the margins are low in this part of the industry according to Respondent 4. It is worth noting that this founder is also a contributing factor to why they are located where they are today.

In March 2022, the first batch of salmon was placed in their tanks, where they stayed and grew until a batch of 30,000 fish was sent for processing in December 2022. The fish are placed in tanks that are 28 meters in diameter and 10 meters deep. Between 30 to 40 percent of the water used is replaced, which is gathered from the sea and goes first through a filter and a UV light before it fills the tanks, as told by Respondent 5:

"There are two intake points for water, which gets divided into 6-7 lines, that further be cleaned before it ends up in the tanks. The water that comes in and out of each individual tank is not shared with the other tanks to avoid disease, as it can quickly spread in the tanks. It would have been too risky and vulnerable".

Currently, the supply of this water comes from a depth of 25 and 95 meters, as this will provide the facility with different degrees of water temperature during different seasons, which in turn will help save costs and energy usage. During the winter there is a higher degree in the depths, and the closer to the surface one goes, the colder it gets, and during the summer, it is the other way around. When sourcing water from the 25 meters depth, there is a risk of lice, however, filters and UV lights are used as redundancy to handle this.

Today they have 12 tanks, but the long-term plan is to have 48 tanks for fish farming. In Figure 17, there is an illustration on how the flow of fish could look like, with the first shipment being a batch of smolt placed in one tank, and at the end this singular batch could end up staying in three to four tanks. Due to the sizes of batches and the growth rate can

vary, we have chosen to use roughly 100,000 inputs of smolt and a 100 days' time period as an example to illustrate how a production line might look like for case company B.

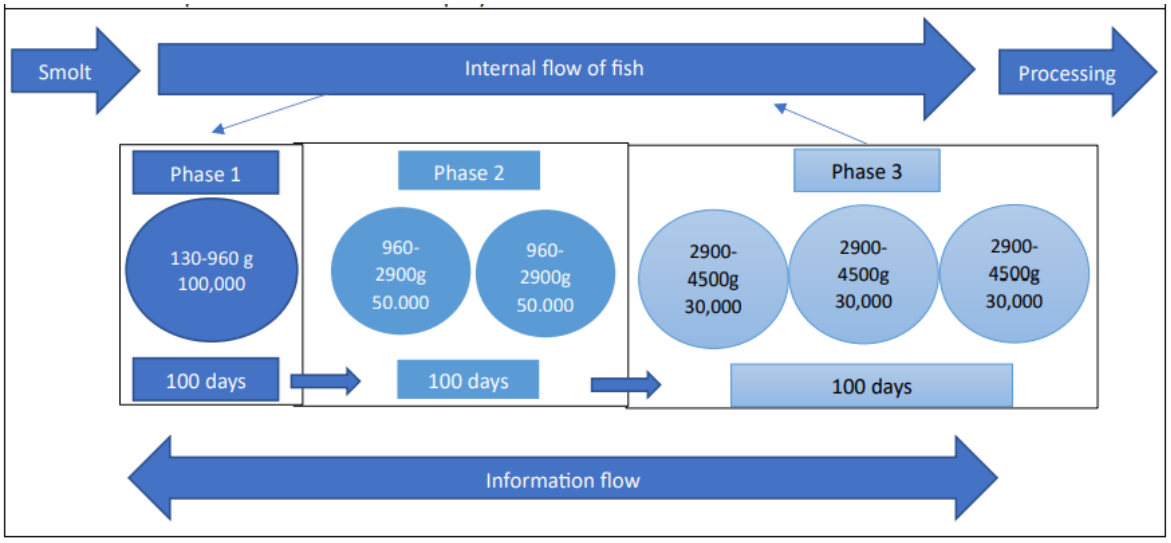

Figure 17: One production line for Case B (the authors' elaboration)

They recorded that their first batch of fish had a high level of fitness and grew quickly, weighing between 3 – 4.5 kg after 7-8 months of breeding. When the smolt arrives at the facility, the batch is placed in a tank where it stays for roughly 100 days before being sorted into two new tanks. This process is repeated until they are spread across three to four tanks. That process is done to maximize space utilization and prevent fish from fighting over food. When mixing the small and large fish in the same tank can result in the smaller ones losing out on the feeding, as they cannot compete with the larger ones, thus hindering the growth of these. The latest batch of fish was very uniform in both growth rate and size, indicating that the feeding system is working well with regard to the even distribution of food among the fish according to Respondent 1.

As the plan is to spread the fish over a total of three to four tanks, this will in turn require extensive planning and logistics, and it is important for them to have empty tanks available so they can sort the fish and utilize the space available. This is where all the technological tools become useful, with the production system known as "*FishTalk"*, which Respondent 5 explains as follows:

"FishTalk is our production system, but we have cameras placed in the tanks where you have the possibility to see when the fish are eating. We also have a detector that is at the

bottom of the tanks that counts how much pellets go through, then we will get an indication of whether we need to increase or decrease the feeding".

7.2 Drivers to sustainability

Optimizing feeding

The feeding system in their fish tanks is automatically operated when distributing feed evenly across all the tanks. The tank in which the feed is stored, is located above the tanks where the fish stays, and once it reaches a certain level, the system give a signal that it is time to feed the fish. This happens once the system registers that the feed in the tank is running low, and it will provide a new batch to the hungry fish. At the bottom of the tank, there is something Respondent 3 calls a "*fish trap*" that collects leftover feed, dead fish, and other debris before the water flows into the drain, as Respondent 5 tells us:

"All feed residues and sludge go down a separate channel at the bottom of the tank and are transported away".

There are cameras that are installed near this "*fish trap*" to count the feed particles, which will provide them with valuable data for fish feeding. If there are for example many particles, then this might tell that the fish are in fact not hungry, or, if it is next to zero particles, then it might be because the fish is famished. It is the case that the feed has its own buoyancy, which means that the feed floats around while the salmon eats, and will according to Respondent 5 be closely monitored:

"If you feed too much, there will obviously be more feed residues in the tank, but since we monitor the tank, we will get much less feed residues. But the feed will not float indefinitely, it will eventually sink to the bottom, this also applies to faeces and various sludges".

As mentioned previously, there are now only 12 out of 48 tanks operational, as construction is still ongoing, there are times that manual feeding is needed, as the digital feeding systems have at times failed. Control of feeding is crucial since it is the most significant input factor in terms of cost and effort, be it in production on land or sea. As mentioned earlier in the paper, feed is the most expensive aspect of fish farming, so, it is

imperative that they have a consistent and reliable feeding system in order. By monitoring their feeding and optimizing this, then they can also reduce the amount of feed used in each batch, which in turn will not only yield economic benefits, but also environmental. This has resulted in a low feed factor as told by Respondent 4:

"A feed factor of 1.10 maybe, but at sea it could be 1.30 or 1.35 because of the mortality".

Respondent 6 explains that technical errors can often occur, but also problems such as clogged hoses. The problem often leads to lost feeding, which in turn leads to lost growth. It is therefore extremely important that the uptime at the feeding facility is 100 percent. By having the best possible spread, the feed is more accessible to a larger proportion of the fish in the cage.

Expanding abroad

According to Respondent 4, there is a possibility in the long term that they will establish a second facility in another country in order to become more international. There is also a sustainable ulterior motive for this, as this minimizes the need for freight by plane, as well as the opportunity to build up infrastructure and communities in other areas.

One of the objectives of this facility as Respondent 3 says, is to develop a technology that can be scaled up for widespread usage. While the principle of the technology is for the most part established, they are still experiencing start-up issues that need to be addressed, such as tuning, tweaking, and optimization of the control, automation, and maintenance systems they use. This technology that is being developed can then be utilized anywhere in the world, allowing for remote control of facilities in for example Asia or the USA from the current location. Now, a significant challenge in implementing this technology is the lack of expertise in the area. It may therefore be necessary to send someone who has the experience and are familiar with fish farming from the current location to assist with the process of implementation.

Handling of undesired output

The company has a discharge permit that they must adhere to, and this permit says that they need to clean the wastewater before it can be released into the sea again, as told by Respondent 5:

"So, in the centre of the tub there is something we call the "center pillar" and inside there the feed residues are collected and taken out. We have such a drum filter where feed residues and sludge are cleaned, and also separated from the remaining water".

The remaining water goes out, while feed residues and sludge remain and that is what we deliver to farmers in the surrounding area, who in turn use it for biogas and fertiliser. There are local farmers that have built bioreactors that can absorb the sludge that the facility produces, and they are hopeful that there will be more bioreactors in close proximity of the facility in the future, as it will eliminate the need to send the waste away elsewhere. It can also be a possible solution to use the waste as fertilizers for the farmers, as told by Respondent 5:

"Here are two local farmers who have a small biogas plant that produces heat, and then they use the dry matter on the fields".

The company is exploring options for sustainable sludge treatment, which includes local projects and biogas reactors, however, they prefer to stick to local options in order to reduce their environmental footprint. Another idea that Respondent 3 mentions is to use the fish that perishes during the production process be used to make animal feed or included it in the sludge that is sent to biogas reactors. However, due to its nutritional value, they hope that it could be more useful as animal feed instead of fuel for a bioreactor. The sludge that is delivered to the local farmers can be used to heat up the drinking water for the cows, as told by Respondent 3:

"The farmers use that energy to heat the drinking water for dairy cows, as it has been proven that the cows that get water at 18 degrees, produce about 15-20% more milk than if they are served cold water".

Certifications

Respondent 5 discusses the importance of transparency and certification in the supply chain and how it can ensure sustainability. By tracing the supply chain from the supplier of feed to the processing, it becomes possible to monitor the process from raw material to the final product. This is emphasized by Respondent 5:

"I believe that the certifications, which are international, both global G.A.P and ASC, the fact that the companies are certified gives us much more confidence that there is sustainability in the various chains".

This transparency can be useful to ensure that the participants in the supply chain is sustainable and meet the requirements of both global G.A.P. and ASC. Due to strict standards and control over suppliers, the certifications will enable and promote sustainable supply chains, as told by Respondent 5:

"On many factors which in turn mean that everything from circular economy to use, reuse, to the environment, all these factors belong to the certification".

Separate biological zone

Case company B is a first mover in utilising the hybrid flow-through system. Through HFS, each individual tank has their own separate biological zone. This minimizes the risks of contagious event spreading, and instead contain this in singular tank. Through the system, they recycle and remove Co2, and since they replace enough water, they do not need a biofilter to remove nitrogen. According to Respondent 4 the technology of a closed-system employed by the Case A aim to improve the production process of the farmed fish.

When asked about experiencing diseases in their tanks, Respondent 3 respond with explain that there are numerous projects on this very topic, being conducted. One of these projects focused on studying bacterial culture in the water and how over the year it may change. However, Respondent 3 clarifies that results may vary from year to year, and if it is sourced from a 25- or 95-meter depth.

Respondent 7 stated that they use clean seawater in their RAS facilities, which can lead to the occurrence of H2S. To prevent this, they continuously work on sludge collection, as a thick layer of sludge can prevent oxygen supply and result in the production of H2S gas. The formation of H2S gas depends on the amount of sulphide present in the seawater. If the system is based on freshwater or has low salt content, the risk of H2S gas formation is lower. Respondents 7 and 8 shared that they had a previous outbreak in one of their tanks,

which resulted in the death of all the fish. However, after identifying the cause of death, they were able to improve the facility, create new procedures and implement better monitoring. The challenge with H2S is that it is difficult to monitor through water samples, as such low gas values can have severe consequences. Therefore, it is crucial to prevent the accumulation of sludge to avoid H2S production.

Optimizing input factors in production

Respondent 3 stated that the company aims to achieve high-quality farmed fish production within a shorter timeframe. This means that the fish are grown at a faster rate without compromising on the quality compared to other production methods. This should be manageable by optimizing input factors such as circulation, feeding, and flow in the tanks and the facility. The circulation of fish is something that is experimented on, so the "losers" can get the opportunity to grow, as told by Respondent 5:

"So as of now, we bring in smolt from our own smolt plant in a tank. When they have reached a certain size, we sort. This is to optimize water quality, feeding, among other things. So that we get increased growth on the slightly smaller fish. Also, it was really an ambition to sort twice, that was the intention".

Respondent 3 told that they have the possibility to change 30-35 percent of the water by using HFS, as the remaining water can be recirculated for further use. The advantage to collect from two different depths is the temperature differences in the water in the summer and winter. In the winter it is warmer at depth, which means that they do not need to heat the water as much, and vice versa in summer where it is warmer at the surface. This will contribute to energy- and cost-saving if they can avoid heating the water more than necessary.

Lice is a frequent problem for the fish farming industry, especially sea-based farming, however, this has not been an issue yet according to Respondent 4. The reason for this can be that they source their water from a depth of 95 meters, which in turn reduces the risk of lice. They are getting water from a depth of 25 meters, so the risk have increase when they began with this. Nonetheless, before the water reaches the tanks the fish lives, it goes through both filters and UV light.

They experience a mortality rate of 6 percent during their first batch, which they explain is from the delays in finishing the tanks, and late delivery of fish, which promptly resulted in the fish staying longer in the hatchery. Respondent 3 notes that the second batch, which has now been in the tanks for roughly 6 months, has experienced a mortality rate of just over 2,2 percent. Respondent 3 compared wild fish, which have a lifespan of 3-5 years and a mortality rate of 70-90% per year, with sea-based farming, where the mortality rate can often range from 5-20%. The company strives for the lowest possible mortality rate, and recognizes the challenges of maintaining water quality and fish health during handling and movement. Therefore, it is crucial to ensure that all production processes are executed correctly to minimize risk. This includes optimizing the supply of feed, water, oxygen, energy, and smolt to ensure top-notch fish quality and welfare.

7.3 Enablers of sustainability

The fact that Case B has a land-based facility, on a ground that has already been used for something else before them, is according to Respondent 3, a good foundation to become circular. To be both circular and sustainable has been the company´s mission from the start. Having a land-based facility allows them to completely avoid the environmental drawbacks of sea-based farming, such as salmon escaping, lice, and other environmentally bad consequences. However, according to Respondent 3, it requires more energy for instance, compared to their sea-based counterparts where they get currents in the sea that replace the water in the cages. In land-based farming, it is an advantage but also a challenge, in terms of controlling the water itself. Each tank circulates one cubic meter of water each second, so they must move a lot of water at the same time.

The local area has many technology suppliers, and most of the facility has in fact been built with suppliers from Møre og Romsdal according to Respondent 4. While there are other suppliers being used, local logistics expertise has been important in the success of the project.

The founders of the company come from the region, and influenced the decision to start up in their local community since they were already familiar with the area according to Respondent 3. The facility was built on a plot of land that had already previously been worked on, so there where not much work regarding the layout and elementary

infrastructure that was required before construction began. This decision has been quite cost-efficient for the company, as it would have been more expensive to establish the facility in other regions, especially if one is to consider the rising electricity costs. This lack of advantage implies that the facility's location has made it more successful if one is to look at it from an environmental point of view, due to the area already being used before the Case Company decided to establish its facility there.

The organization strives to remain at the forefront of its industry, thus it sets significant emphasis on calculating and producing clear target statistics on many parts of its operations. These include things like mortality rates and how much fish oil is used, and the source of this. By working hard to create a good environment for their fish, the company is certain that they will be successful, and this is according to Respondent 4 achieved by maintaining adequate oxygen levels, installing feeding measurement systems, and managing temperature. Overall, the organization feels that a holistic approach to fish farming is required for maximum outcomes. Certifications are a method to achieve this, as explained by Respondent 5:

"We have something called a global G.A.P. in Aquaculture. We have now started the process to be ASC certified. It is a certification that has a main focus on the environment and everything within it, such as circular economy, sustainability, energy, fish welfare, and the whole package".

Systems and technology are something they always want to investigate to become more sustainable, and sustainability has been the company´s mission from the start. This can however be expensive, so they do according to Respondent 5 apply for subsidies for resource efficiency projects, such as energy savings. The company covers many expenses itself, with confident banks and investors that contribute with funding. However, it is still expensive, as told by Respondent 5:

"It requires a lot of funding. Especially a land-based facility, but you can no longer buy a license in the sea, so if the industry is to grow, this is the only option, and it costs a lot to buy a licence".

When asked about the role of the government has in influencing the industry, Respondent 4 respond with:

"As fish farmers, we must adhere to specific requirements as part of our compliance with the authorities who have granted us permission to operate. The Norwegian Food Safety Authority and the government also have a role to play in regulating our operations, but ultimately, it is the state that manages everything".

Regulations from the government may encourage a sustainable fish farming practice for the land-based company by imposing environmental standards, offering incentives, funding research and development, and by promoting best practice.

7.4 Challenges

Costs

In Case Company B, costs have a huge impact on their ability to grow as a company and work towards sustainability. Establishing the necessary infrastructure in order to begin operations are time and resource-consuming, especially if one is to compare the land-based practice with the sea-based one. Respondent 3 gives an example of how this can be compared to sea-based farming:

"It requires a lot of work with a plot of land to have such a facility as ours, but at sea, it's simply put as easy as to place ten rings on the water and anchor them".

Once the infrastructure is in place, then the work on the technical solutions is needed. To ensure that the fish can survive from it arrives as smolt until it is ready to be harvested, then factors such as feeding systems, water supply and quality, batch splitting, energy, oxygen, and others have to be operational.

Being a land-based farmer has its own challenge, in the sense that there are few others that have managed the scalability of such a project. This is something that Case B also experienced, as told by Respondent 5:

"The main factor is that much of the technology we use is known, but it is scaling up that has created challenges along the way, but which we should have managed to resolve".

Once the infrastructure is in place, and the operations can begin, then the company have to consider input factors, especially feed, as it represents a significant portion of the operational costs, as told by Respondent 3:

"Having control over the feeding is extremely important, as it is the biggest input factor, both with us and at sea".

As the fish want feed that have high marine content, and feed made from plants are frequently used in the composition of feed, the company faces a challenge. The marine content is more expensive than plant-based feed, so a balance is therefore needed, as the company have to balance between cost and the welfare of fish.

Fish feed

When asked about the type and quality of feed used for their fish. Respondent 3 stated they decided by themselves what type of feed was used, and it will vary depending on the various stages of the growth of the fish, as the size and content of the pellets used will be adjusted accordingly. However, Respondent 3 mentioned that they have not yet settled on a final composition of feed.

The company has experienced challenges with optimizing the feed they use, due to the difference in needs between sea-based and land-based farming. There is also the fact that there are few suppliers of feed available to them, and this will also have an effect. It can make it difficult for them to find a combination of feed that suits their needs. There are factors that must be accounted for, such as the amount of protein and fat in the pellets.

Further on, Respondent 3 explain that it is not natural for the fish to eat pellets, as they are accustomed to eating live organisms in the wild. It is a lengthy process of producing pellets that will provide the fish with the necessary nutrients. There is also the interest of the firms that influence this, such as the fact that the suppliers would want to prioritize low production costs in order to maximize profits, while the buyer wants to have a feed that will ensure good health and quality for their fish, so there will have to be a balance

between the priorities. As much of the pellets contain a high content of soy, it will also influence the nutrients for the fish, as it may not provide all the necessary ones. therefore, it is important that the feed composition used by the farm balances the costs and health of the fish, so that the growth and quality of the fish will result in a positive turnover.

Supplier constraints

Respondent 3 of the land-based explains that they sometimes are dependent on suppliers in order to improve their operations, as this is a form of constraint for improvements. They acknowledge that while technology suppliers want to think and work sustainably, it can be limited opportunities to do so. It can be difficult to determine which option is more environmentally friendly when choosing between suppliers. It can be useful to document the performance, mortality rates, and feed consumption to appeal to customers, by implementing sustainable practices, and the company is interested in doing so.

Respondent 3 notes that their company has indeed some control over conditions set for their suppliers, but due to a limited number of suppliers will have an effect. Being a small land-based player in the industry that has been shaped by sea-based farming over such a long time means, that they often must ask the suppliers to provide equipment that has not been delivered before. This lack of options can make it challenging for the company to prioritize solutions that are environmentally friendly, therefore, they are more interested in acquiring equipment that will last a long time and is of sufficient quality. This in turn could lead to a dependence on their suppliers, as there are limited options when choosing suppliers.

Economic facts may also influence the choice of suppliers, as Respondent 3 suggests, as there are limited alternatives. There are cases, where the company can choose between only two suppliers, and one may have more experience in dealing with land-based farming. This lack of options results in that one supplier becoming the better option for the company. Further on, Respondent 3 suggests that the larger companies have more leverage to pressure their suppliers, something their company does not have the luxury of doing. Therefore, it is important for them to evaluate the equipment to see if it works properly for them before settling for an option. Overall, while the alternatives to choosing environmentally friendly suppliers are not always present, the company is interested in

improving its solutions to become more sustainable and is optimistic that there will be better alternatives in the times to come.

Technology

Technology is a potential enabler of CE, but it could also pose several challenges as well. As CE seeks to influence goods and systems, it may also require infrastructure that may be both expensive to maintain and acquire. This can be infrastructure that helps remove waste and pollution, such as the tanks used to stockpile the sludge and other undesirable outputs from the production process, or it can be the HFS technology used to recirculate the water inputs. For the land-based fish farming company, the scale has also been proven to be a challenge as told by Respondent 4:

"Another challenge is technology. The technology has been in use for a long time, but the scale is different, it hasn't been done on the kind of scale it is now, so it can be difficult, but it's too early to tell".

To be one of few actors that have begun establishing a land-based fish farming facility of such scale has its challenges, which can for example be the lack of availability of suppliers which is mentioned above. Another challenge is the input water, which is sourced from the nearby sea, as told by Respondent 4:

"Since the facility is located on land, you are dependent on water, which the sea-based facilities have available all the time, so if something were to happen to our intake stations, so that no water comes, it will quickly become challenging".

In order to have redundancy for their water facility, there are two intake lines located at different depths, the first 95 meters and 25 meters deep, which can run independently of each other. Before the water reaches the fish tanks, it will have to go through seven assemblies with pumps, filters, and UV stations that will purify the water, all of which are not needed for daily operations. So, there are redundancies for the redundancy, and as Respondent 4 says:

"In other words, everything has to break at the same time if there is to be a problem, and the probability of that is minimal".

The water is ready to be used when it is sent out of the facility, but since digital tools in the production process are so prevalent, it is also exposed to power outages and computer attacks. The facility is fully automated and can be remotely controlled, with the possibility of manual options available if there were to be an emergency. Nonetheless, the consequences of losing control of the production process can be tremendous.
A facility of this size, where there are many sensors and digital tools to assist the company, can experience difficulties in data management and digitalization of their business, and it is necessary to consider the complexity and costs to ensure that it works efficiently.

7.5 Implications for sustainable fish farming for Case B

Implications

The importance of the three aspects environmental, economic, and social could in any situation be debated, and as an educated economist, Respondent 4 is clear on which of these are the most important to him. However, it is important to accept that all three aspects are important to take into consideration, with certain situations that require one to emphasize one aspect over another.

When considering farming fish on land, then the environment is thought to be quite important, nonetheless, it does not imply that the other two aspects should be underestimated. As mentioned previously, the fact that this is a feat to apply technology and innovation on such a scale, should also reflect positively on the local economy and perhaps contribute to more job opportunities. The company is also in the business of making food for an ever-growing human population, so this will also influence the social and economic aspects of sustainability as well. However, as Respondent 5 told:

"It is clear that we have fish health at the very top of that list here, because if we do not focus on fish health, then we will not run our business either".

Respondent 5 elaborates further by emphasizing that the environment is essential and is one of the reasons why they decided to establish their fish farming practice on land, as they believe they can take care of the environment in a better way. However, the well-being of the fish is crucial for the Case Company. As eloquently said by Respondent 3:

"That's the thing about fish farming, if you want to make money from this, then you depend on good fish welfare, they are so insanely close together".

Respondent 4 also mentions the ripple effect of the production process that goes beyond the actions of the company, suppliers, and employees also an important part. In their tender announcements, it is not specified that local suppliers are preferred, nonetheless, they are often chosen due to their reliability and competence. One example that is mentioned is the supplier of their heat pump, which is manufactured by a local supplier, and here despite their higher costs, produces a piece of equipment that is essential for their farming practices with high quality. Another example Respondent 4 mentions are local suppliers that collect and deliver sludge to nearby farmers, that in turn use this in their biogas reactors.

Respondent 5 believes that in the short run, it is expensive to implement such resource efficiency measures, however over time it will even out or come into balance. By being perceived as a sustainable producer, benefits such as a good reputation can perhaps influence sales and prices, as told by Respondent 5:

"But you profit from running professionally, more than a good reputation. Then you can show that you are working with CE, so maybe you can get more paid for the product at the other end".

With the use of certain certifications, it requires a lot of documentation in order to measure work on sustainability, CE, and social justice. This is something that Respondent 5 believes can contribute to increased sales also.

In short, depending on the situation, the aspects will be prioritized differently, but it is necessary to consider all of them. With the farming of fish on land, all of these play a part, with its ripple-effect, governmental demands, and suppliers being important factors.

Perception of sustainability in a supply chain for Case B

When asked what they perceive to be a sustainable supply chain, Respondent 3 emphasizes the importance of proper feeding practices in fish farming. Ensuring that the fish receive

the right amount and type of feed at the right time, ensures that the production process can proceed smoothly with both good fish welfare and low mortality rates. These factors are essential for any stakeholder that partake in this process. As told by Respondent 4:

"We are quite lucky in that we have a controlled environment, it is a closed facility, so we now have, so to speak, control over water quality, so the fish should not be stressed over. that".

Continuing, Respondent 3 suggests that good fish welfare is critical for profitability in the industry of fish farming. It is not possible to prioritize profits over fish welfare, and the other way around, as both are interconnected. By focusing on the welfare and health of the fish, the quality will improve, and in doing so lead to increased profits. Overall, Respondent 3 believes that a sustainable supply chain involves mainly good fish welfare and proper feeding practices, which is the key to success in the fish farming industry. When Respondent 4 is asked about what he perceived to be a sustainable supply chain, the response was:

"A sustainable supply chain for me is one that is located in Norway, on the coast, and close to other parts of the supply chain".

This involves the other actors of their supply chain, namely the slaughterhouse, feed factories, and other suppliers that are near the facility, with the goal to contribute to the well-being of their respective municipalities and to create job opportunities. The fish that the farming industry produces, is in itself one of the better things to eat, not only because of its sustainable nature, but also its health benefits, as this is a nutritious food that can be enjoyed by all age groups. Respondent 5 believes that transparency is important in making the SC sustainable and is an important reason why they have chosen to implement certifications such as global G.A.P. and ASC.

By focusing on close proximity to the various components of the supply chain, there is a possibility to create a network that will connect people despite great distances. The consequence of these actions could be economic growth and possible prospects through increased employment, as well as contributing to a greater cause. A closer look at the end

product that is offered reveals a product that is healthy, produced in a relatively sustainable environment, that can in turn give the consumer a sense of satisfaction.

8.0 Discussion

This chapter presents a discussion of the findings from the previous two chapters. This discussion is our analysis and is achieved by comparing the literature chapter and the findings and using this to answer the research questions and overall purpose presented in Chapter 1.

8.1 Summary of our Findings

Chapters 6 and 7 feature insightful findings derived from interviews conducted with our respondents. To provide a comprehensive understanding of the similarities and differences observed, we have opted to present a condensed summary of our empirical discoveries. Table 3 aims to offer a concise yet comprehensive overview of our research findings.

Table 3: Summary of Empirical Findings for Case A and Case B (the Authors' elaboration)

	Case A	**Case B**
SCO	▫ Small family run and owned ▫ Land-based smolt-producer ▫ Frequent use of outsourcing	▫ Company listed on the Norwegian Stock Exchange ▫ Land-based farm for grow-out phase ▫ Owns several stages of its supply chain ▫ International ambitions
Challenges in SCO	▫ Cost ▫ Feed ▫ Supplier limitations ▫ Technological issues	▫ Cost ▫ Infrastructure ▫ Feed ▫ Supplier limitations ▫ Technological issues
Drivers for sustainability	▫ Closed-environment ▫ Collaboration ▫ Information flow ▫ Management of waste ▫ Certifications ▫ Input optimization ▫ Fishtalk ▫ RAS	▫ Closed-environment ▫ Collaboration ▫ Information flow ▫ Management of waste ▫ Certifications ▫ Input optimalization ▫ Fishtalk ▫ HFS
Enablers of sustainability	▫ Government regulations ▫ Public subsidies ▫ Certifications ▫ Perception ▫ Technology	▫ Government regulations ▫ Public subsidies ▫ Certifications ▫ Perception ▫ Technology
Circular Economy principles	▫ Reuse of water ▫ Energy-efficient heat pumps	▫ Reuse of water ▫ Energy-efficient heat pumps ▫ Biogas
Implications for sustainable fish farming	▫ Improved Fish welfare ▫ Technological innovation ▫ No escapes ▫ No lice ▫ Control of flow ▫ Higher cost	▫ Improved Fish welfare ▫ Technological innovation ▫ No escapes ▫ No lice ▫ Control of flow ▫ Higher cost

As depicted in Table 3, a notable observation is the abundance of similarities compared to the fewer differences. Subsequently, our thesis delves deeper into the themes presented in the table. In this subsequent analysis, we thoroughly examine the information derived from the findings in light of the relevant theoretical framework.

Case A

The main findings on drivers for Case A are that the company has implemented several sustainable practices in its operations, such as the Recirculating Aquaculture System (RAS) which reuses and recycles water and increases productivity, buying machines of high quality and uses them as long as possible, buys and sells used equipment, as well as other energy-saving measures. Fish welfare is crucial for the company, so a calm environment and adequate space for the fish The company is looking into handling undesired outputs such as sludge in biogas production are emphasized. The fish feed is monitored and balanced, with the use of digital tools like "*FishTalk*" to monitor and manage data during production. The company is involved in extensive coordination and communication between different departments and customers to ensure smooth operations and delivery of high-quality smolt. The company is looking into handling undesired outputs such as sludge in biogas production but has yet to begin to do so. This sludge could be used for biogas production to supply the company with energy or repurposed as fertilizer.

Respondents from Case A state that the primary motivators for implementing sustainability measures are environmental restrictions and public subsidies. They do, however, highlight that some of the measures can be costly and do not always result in increased value for the company right away. The company has begun to investigate biogas production to fulfill environmental regulations, but they acknowledge that producing at sea with equivalent measures can be more challenging, and since they are based on land can be more beneficial. Before implementing any changes, Case A prioritizes statutory environmental measures and undertakes a cost-benefit analysis. Currently, they are working on the Transparency Act, which promotes fair working conditions and basic human rights while also ensuring public transparency of the company's practices.

The main finding for Case A on challenges is cost, and that the company loses a substantial amount of money on projects to implement CE. The most expensive input

element, feed, is one of the key cost drivers for Case A. Another issue Case A experiences are the packaging of roe when it is delivered, and there are no particularly circular solutions available. It is crucial to balance the proper quantity of feed to avoid excess feed and waste, which can lead to poor water quality and other negative implications for the fish. Feed quality and price are critical factors for the company to consider when selecting a feed supplier.

While work on sustainable efforts has increased costs, Case A has implemented profitable technologies, such as RAS and heat pumps, which have increased production and profits while also promoting environmental sustainability. Furthermore, the company feels a local social responsibility to improve the well-being and development of the coastal communities where they practice their business. Fish farming waste has potential for future development, such as being used to make animal feed or fertilizer.

Case B

For Case B the farming facility has an automatic feeding system that distributes feed evenly across the tanks. Based on the feed level in the tank, the system gives a signal when it's time to feed the fish. Leftover debris and feed are collected in a "*fish trap*" at the bottom of the tank, and cameras monitor the feed particles to determine the optimal time for feeding. With a foreign partnership in South Korea, the company seeks to expand abroad by establishing a land-based facility that produces salmon in South Korea. Case B is working on developing technology that can be scaled up for widespread usage, however, issues must be addressed. The company has a discharge license that requires the wastewater to be cleaned before it is released back into the sea. The leftover water is discharged, while the feed wastes and sludge are distributed to nearby farms to produce biogas and fertilizer. Case B also investigates sustainable sludge treatment options, including local biogas projects. The fish that perish during the production can be repurposed as animal feed or used in biogas production with the fish feed and sludge. By optimizing its feeding Case B intends to cut its expenses and decrease the environmental impact through its production.

Case B's decision to start building on already utilized land has made it environmentally successful, as it avoids the negative implications of sea-based farming and is spared the work of exploiting virgin lands to establish their facilities. However, the land-based

facility requires more energy and has challenges in terms of water control. To provide a suitable habitat for its fish, Case B emphasizes the need of keeping proper feeding measurement systems, oxygen levels, and temperature management. To become more sustainable, Case B also focuses on subsidies, certifications, and technology, which can be costly.

For Case B the challenges they face are related to infrastructure, cost, feed, supplier limits, and technological issues. The company experienced difficulties in establishing infrastructure and scaling up the project. Feed is a significant operating expenditure, particularly in creating a balance between cost and the well-being of the fish. Due to restricted possibilities, Case B experiences a market where the suppliers are more tailored towards sea-based rather than land-based fish farming. Technology is viewed as a potential enabler of CE, but Case B has experienced difficulties in finding sustainable technological solutions.

The example of raising fish on land is presented to demonstrate how crucial the three aspects are. Case B emphasizes the importance of fish health and the environment, as well as the possible economic benefits of this approach. Local suppliers are frequently mentioned as a strategy to help the transition towards sustainable practices. Sustainable practices may boost a company's reputation and even increase sales.

8.2 Supply Chain fish farming Operations from the Stakeholder perspective

Organization

In a fish farming supply chain, stakeholders can include suppliers of feed and equipment, government, local communities, employees, competitors, and shareholders, but based on our empirical findings we have found what could be a potential stakeholder in the fish farming industry that is non-human, namely the fish itself. It is paramount that the quality of life is high for the fish to thrive, which in turn will yield increased value, so the success of the fish farmers depends on the well-being of the fish being farmed. However, as stakeholders are considered to be invested in the success of the operations of the company, such as the employees, customers, suppliers, shareholders, and regulatory agencies, then it

could be argued that the fish are not a stakeholder, since it is viewed as a product by the fish farmers and not an individual or group that are in some way interested in how the company is faring. This is visualized by the dotted line towards the fish farmers in figure 18, as the fish influence the industry but won't be recognized as a stakeholder by the fish farmers.

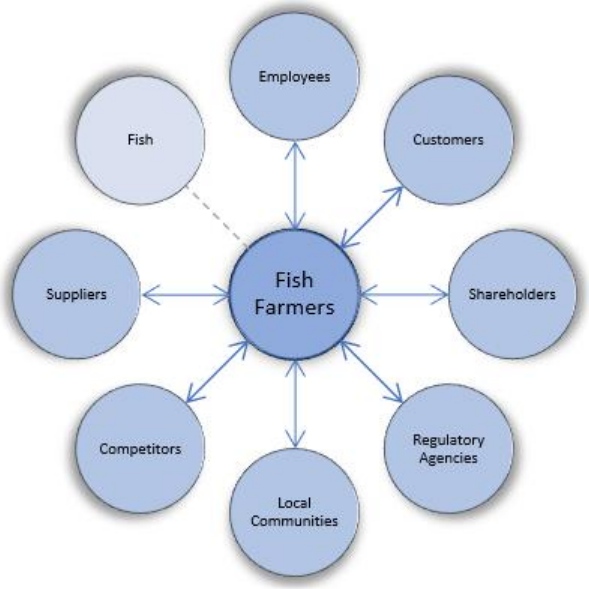

Figure 18: Stakeholders in the fish farming industry (the Authors' elaboration)

There are considerations on the ethical aspect and well-being of the fish, as it is important for the fish farmers to prioritize the health of the fish. Some stakeholders can have a different perspective on the fish compared to the farmers and may be more open to the idea that fish are in fact stakeholders. Nonetheless, the stakeholders influence the Case Companies and can promote implementation of sustainable practices within the organizations.

Organizations have according to Seuring and Müller (2008) strong influence on the product they offer their customers and has therefore an important role in the sustainability within the supply chain from the holistic course from point of origin to consumption. One way that organization can manage its stakeholders is through collaboration.

Close collaboration with different stakeholders is needed to be able to implement sustainable practices within the supply chain (Seuring and Müller, 2008). Collaboration can be useful to share knowledge and best practice between the stakeholders in the supply chain. However, considering multiple priorities from various stakeholders could hinder the

progress on sustainable practices. Companies can according to Seuring and Gold (2013) through collaboration address environmental, social, and economic issues.

Challenges in organizing the supply chains operations

According to the empirical findings, the Respondents decide on the type and grade of feed used in their production processes, and the composition of the used feed varies based on the fish's growth stage. Due to the variations between land-based and sea-based farming, as well as restrictions regarding the availability of feed providers, Case B has experienced issues in optimizing its feeding processes. Since the fish that both Case A and Case B farm are not accustomed to eating pellets, it is critical to balance the health of the fish and the expenses in order to assure optimal quality and development of the company's output. The goal is to create a feed mix that meets requirements regarding expenditures, while also providing the proper nutrition for the fish.

According to our empirical findings, the cost is a recurring challenge that both Case A and Case B experience when organizing their operations and working on sustainable measurements, which confirms what Seuring and Müller (2008) highlighted as one of their barriers to implementing sustainability within a supply chain. Implementing and utilizing technology such as RAS is demanding, as it requires space and can be costly (Bjørndal et al., 2018). Even though a closed containment system can have a positive effect on environmental issues such as escaped fish, lice, and diseases, it can still be expensive to establish and operate, which can lead to a higher production cost, and therefore a higher price for customers (Misund, 2022a).

Companies can sometimes be bound by their suppliers, restricting the opportunities to develop operations in a sustainable manner. Difficulties in evaluating which choice is environmentally sound when comparing the suppliers. In order to attract customers, the Case Companies may want to apply sustainable practices and keep track of mortality rates, feed usage, and performance. However, due to a restricted number of suppliers, it can be difficult to emphasize sustainable solutions, as not all suppliers have dealt with land-based fish farmers, especially considering the scale that Case B operates with. These findings confirm the assumptions made by Lopez et al. (2019) that the market can be underdeveloped in the sense that there is a lack of options in choosing suppliers. Therefore, acquiring equipment with a long lifecycle and appropriate quality can be

another viable option for the Case Companies. While the options to pick suppliers as one sees fit are not always available, the Case Companies are nonetheless confident that there are more available opportunities in the future. Therefore, it could be interesting to investigate the power dynamics between fish farmers and their suppliers, as there are few highly specialized suppliers of feed and roe for example.

The study examines how technology may both facilitate and impede CE activities. Tanks and RAS/HFS systems, for example, are costly to purchase and operate, yet are important for CE. The size of the facilities and their needs is demanding, and the scarcity of potential suppliers, can result in supplier leverage (Lopez et al., 2019). According to Seuring and Müller (2008), complexity can be a challenge when implementing sustainability within a supply chain. This applies to infrastructure as well, as it requires more space and technological solutions before it can begin production when compared to sea-based farming.

Sludge can have significant impacts on the operational aspects of supply chain operations, as it can lead to several negative consequences. If there is a large amount of sludge in the tanks, it can have a detrimental effect on the welfare of the fish, as it affects the water quality, among other things. For those who operate a RAS system with seawater, there is a high risk of H2S gas formation during sludge collection, which can be fatal to the fish in the worst-case scenario. Losing an entire tank of fish leads to lost sales and revenue for the company. Poor routines around sludge collection can greatly impact the company's income. By using HFS, the risk of H2S gas formation is minimized through their cleaning system, which ensures high water quality for the fish (Salmon Evolution, n.d., b). This could imply that the HFS system has not yet been utilized enough in the production process for such a challenge to emerge. Nevertheless, even if the risk of H2S is minimal, Case B should still make efforts to collect sludge to maintain water quality and ensure the well-being of the fish.

Drivers for sustainability

According to our findings, both companies are implementing sustainable practices in their operations, but the approaches and technology vary. Case A emphasizes communication, coordination, reducing emissions and water usage in its operations, promoting sustainable practices among local farmers, monitoring fish feed, and exploring the potential for using

fish waste and sludge for biogas production. Case B is focused on automation, management of sludge and fish wastes, optimizing feeding, local projects, and biogas reactors, and working on expanding abroad, as this will minimize freight by plane, as well as the possibility to establish infrastructure and influence communities in other areas. Both companies are exploring options to utilize their undesired outputs for energy production or other uses. Collective efforts from individuals and communities are emphasized to achieve change and address challenges related to sustainability.

Our findings have revealed that the water used in the production is recycled and heat pumps have been developed to become more energy efficient. These are actions that try to reduce the number of inputs used in the production process and reuse the materials for as long as possible. So, our findings are consistent with the 9R framework on CE strategies presented by Kirchherr, Reike, and Hekkert (2017) in the literature chapter.

The closed containment system according to Misund (2022a) reduces emissions, escaped fish and lice, and by focusing on good feeding practices can influence the environment that the fish live in. With a closed system, the Case firms has been able to improve their operations, as the production system collects waste and have ensured the possibility to improve produce more fish that are healthy. These findings are consistent with authors such as Genovese et al. (2017), Kirchherr, Reike, and Hekkert (2017), Sanguino et al. (2020), that emphasizes that reducing, recycling, and reusing are strategies that can ensure that energy and materials are kept in circulation within the company.

The input factor feed is emphasized as a critical component in the production process of farmed fish. With the usage of digital tools such as "*FishTalk*" the Case Companies are able to monitor and analyse the feeding process and can collect valuable data to generate information used to determine optimal feeding. By focusing on closing the resource loop of feed, the companies have experienced better water quality and lower costs, as the amount of feed particles in the tanks and the usage of feed has been reduced.

According to our findings, both Case Companies are focused on collaborations within their company and external stakeholders, which according to Seuring and Gold (2013) is an important driver to address environmental, social, and economic issues. With good communication and coordination, then the companies can ensure an efficient flow of

information, and therefore efficiently manage flow of capital, and materials (Ansari and Kant, 2017). Our findings are therefore in accordance with Paulraj (2011), which stated that collaboration can contribute to sustainability in a supply chain.

Enablers of sustainability in supply chain operations

The government may help promote sustainable fish farming practices by granting incentives, supporting R&D, establishing environmental requirements, and promoting best practices. Government subsidies have been of great use for the family-owned company, as it has been an important contributor to funding measurements for sustainable practices for Case A. For the larger more international Case B there are more opportunities to finance its projects and operations (Salmon Evolution, 2022.). It is apparent according to our empirical findings, that public regulations and subsidies are important enablers for the two Case Companies and confirm what Ansari and Kant (2017) recognize as one of their crucial enablers, which is governmental regulations. Both Case Companies are working on implementing the Transparency Act which entered into force on 1 July 2022 (Forbrukertilsynet, 2023). This Act's objective is to allow information to be available to stakeholders so they can make more informed choices and to push companies to safeguard their operations, document traceability, and provide food safety.

The involvement of its stakeholders can according to literature, be beneficial for the companies, as it can have an impact on its success (Donaldson and Preston, 1995, Freeman, 2016, Freudenreich et al., 2020, Simon, 2022). The partnership between the company and its stakeholders can influence the creation of value (Donaldson and Preston, 1995). Therefore, it can be necessary to have a good relationship with its stakeholders, which the Case Companies try to achieve by implementing the Transparency Act within its business and supply chain. Good relationships, collaboration, and commitment to stakeholders can create trust and be useful in addressing common issues (Yawar and Seuring, 2017).

A high-quality standard enforced by strict regulations on the welfare and health of the fish, has according to our empirical findings, influenced the farmers to prioritize sustainable practices. The standards that were found in the empirical findings are the global G.A.P. for both Case Companies, and ASC as well as for Case B. These are standards that aim to promote economically, socially, ecologically, and culturally responsible aquaculture, and

can according to Amundsen and Osmundsen (2020) contribute to focus on environmental risks. However, Osmundsen et al. (2020) state that certifications tend to focus on environmental issues and not sustainability as a whole. Certifications can be great in driving and enabling sustainable practices, but it has its limitations when guiding a holistic sustainable effort.

Perception of the fish farmers also has an impact on their approach to becoming more sustainable. Respondents believe that sustainability in the industry of fish farming involves reusing resources, utilizing residual products, proper feeding practices, economic growth, job creation, local presence, fish welfare, and contributing to a greater cause. The fish farmers offer their customers a healthy and nutritious food that can feed an ever-growing human population (FAO, 2022, United Nations, 2022). There is an emphasis on balancing sustainability's economic, environmental, and social aspects. However, depending on the situation, these aspects are prioritized differently, as the economic aspect is crucial for the survival of the companies. Nonetheless, there is a shared consensus that the three aspects play a part in enabling sustainability measures.

According to our empirical findings, both Case Companies are constantly seeking new ways to improve operations, ranging from feed to advanced technology like RAS, energy-efficient heat pumps, remote monitoring, managing data, and automated feeding systems (*FishTalk*). Technology can be an enabler of circular economy principles, as it can according to Kristoffersen et al. (2020) for example be used to schedule operations, predict the health of products, and optimize energy consumption through data analysis. Martins et al. (2010) state that RAS technology can improve environmental sustainability through waste management, water usage reduction, and nutrition recycling. However, it can come at a high cost, which according to Lopez et al. (2019) is a barrier to implementing resource efficiency measures.

Another enabler of sustainability is the financial one, as the chapter above shows, it is crucial to have the economy in place to begin enabling sustainable prospects. It is also a challenge, especially for land-based fish farming, as it is costly to acquire and maintain critical infrastructure. This can also be a barrier for newcomers to enter the market, due to the financial toll it might cause.

8.3 Implications of circular economy on the sustainable aspects

It seems that there is no shared consensus between the stakeholders on what CE involves in the fish farming industry. The Case Companies that have participated in the master´s thesis have been working on making their supply chain operations sustainable. Yet there is no specific definition of what CE is or what it consists of. However, the principles of CE, which according to the Ellen MacArthur Foundation (2013) is to eliminate pollution and waste, circulate materials and products to maintain their value, and regenerate nature by moving from a linear- to a circular economy, are currently something the Case Companies are working towards. Resource efficiency, waste reduction, and innovation are ways the Case Companies are improving their operations, yet the term CE remains vague, and is, therefore, something that could be investigated further.

Based on the findings from the empirical findings, both circular economy principles and sustainability practices are connected since both strive to utilize their resources to the fullest as well as reduce waste, which confirms the assumptions by Merli, Preziosi, and Acampora (2018). The purpose of the circular economy is to have the resources used in operations for as long as possible while at the same time maximizing the value output, and at the end of the good's life cycle, recovering and recycling them (Geissdoerfer et al., 2017). Now, sustainability is concerned with meeting the requirements of today, without jeopardizing the opportunities for future generations to fulfill their own needs (Brundtland and Dahl, 1987). According to our empirical findings, both Case Companies believe that long-term sustainability, incorporating social and environmental actions rather than short-term economic opportunities is important. However, it seems that there is a difficulty in balancing economic, social, and environmental sustainability, as economic performance is crucial to have in order for environmental and social sustainability to be prioritized. Therefore, depending on the situation, the aspects are prioritized differently. Nonetheless, there is a shared opinion that the welfare of the fish is important for the fish farmers.

It is in the interest of the fish farmer that the fish experience a healthy life, as this results in a product of high quality for their customers. This confirms what was presented in Chapter 3 on the stakeholder view that fish welfare is as important as all other relevant stakeholders, as a healthy fish results in monetary gains (Lam, 2016). There is also shared consensus among the Respondents of the Case Companies that the more demanding period

in the production process is the growth phase of the fish, when it needs a great amount of feed and energy over a long period of time.

This influences the decisions on how the operations are conducted, as it is crucial that the fish is not disturbed because this will have implications on the quality of life, and therefore affect the bottom line for the fish farmer practitioners. By having control of the inputs used in their closed environments, the farmers can close the loop of inputs, waste, and emissions, which according to literature is a way supply chains can incorporate CE and become sustainable (Geissdoerfer et al., 2017, Genovese et al., 2017).

According to the empirical findings of both Case A and Case B, there is a sense of local social responsibility, with local recruitment, use of local suppliers, and placement of their facilities being determined by the influence of stakeholders. According to the literature, CE tends to focus on economic profitability, followed by environmental performance, instead of a holistic view of all the aspects of sustainability, with the social aspects mentioned as the creation of jobs (Geissdoerfer et al., 2017). However, our research findings indicate that both Case A and Case B prioritize the reduction of pollution and waste. The empirical analysis demonstrates that the implementation of CE principles in these cases has contributed to the creation of a cleaner environment for stakeholders and facilitates collaboration among businesses, local communities, suppliers, and governmental agencies. This suggests that CE can have the potential to promote collaboration between various stakeholders.

Reducing, reusing, and recycling materials are ways that CE can influence environmental sustainability and can have implications on production. By having a closed environment, the Case Companies can ensure that there are no fish that escapes, lice can quickly be detected, and the general flow of materials can become easier to control. The undesired output, such as sludge and fish remains can be reused as fertilizer, animal feed, and as inputs in biogas production. With a closed system, the fish farmers can according to Nyhus (2014) have more control over fish feed, but this system requires more energy compared to an open system. This dependency on energy can be problematic if the prices are prone to be volatile.

Focus on fish health has resulted in a focus on good quality of life, which involves adequate space, good water quality, and proper feeding. The typical losers are given the opportunity to grow as the batches are split, which in turn allows for more fish to reach acceptable sizes before being sent for processing. The findings on the implications of CE on sustainability has been summarized in table 4 below:

Table 4: Implications of CE on social, environmental, and economic sustainability (the Authors' elaboration)

Aspects of Sustainability:	**CE Implications:**	**Consequence:**
Social	▫ Stakeholder engagement ▫ Local responsibility ▫ Well-being of fish ▫ Job creation	▫ Collaboration between various stakeholders ▫ Involvement in local communities ▫ Fish health influence product quality
Environmental	▫ Closed environment ▫ Control of flow of inputs ▫ Improved resource efficiency ▫ Waste reduction	▫ Improved fish welfare ▫ Closed systems and control of inputs reduces environmental impact ▫ No escapes ▫ No lice ▫ Reusing undesired outputs reduces waste
Economic	▫ Implementation cost ▫ Optimization of resource utilization ▫ Potential revenue streams in undesired outputs	▫ Relatively high initial cost ▫ Increased production output ▫ Resource efficiency can reduce operational expenditures ▫ Sludge and fish waste could be recovered and recycled as fertilizers, feed, etc.

9.0 Conclusion

This is the final overview of the master thesis, and contains the implications for both theory and practice, limitations of the study, and suggestions for further studies.

Research question 1: *How are the supply chain operations organized within the Norwegian fish farming Case A and Case B?*
Specialized in their role in their supply chain of farmed fish, with areas that are beyond this role oftentimes being outsourced to other actors. These actors can be producers in the feed, roe-, smolt-, and grow-out phases as well as transportation, processing, and other operations that occur from point of origin to consumption.

Research question 2: *How do the Norwegian fish farming Case A and Case B make their supply chain operations sustainable, and what are the enablers of this transition?*
Case A focuses on communication and collaboration, emission reduction, reduction of production inputs, and promoting sustainable practices with its stakeholders. Case B emphasises waste management, automation, optimizing feeding, and expansion abroad. The enablers of this transition include government support, stakeholder collaboration, high-quality standards, and the adoption of technology. The perception of fish farmers and financial considerations are regarded as the crucial enablers. There are diverse approaches and enablers of sustainability in the fish farming industry, emphasizing the importance of addressing social, environmental, and economic aspects.

Research question 3: *What are the key challenges faced by Norwegian fish farming Case A and Case B in organizing their supply chain operations?*
The study has revealed that the challenges that Norwegian fish farming Case A and Case B experience when organizing their respective supply chain operations include high costs of implementing technology, complex infrastructure requirements, limited availability of suppliers, balancing expenses and fish health when optimizing feed, and the necessity of proper management of undesired outputs poses significant challenges for their operations. By addressing these challenges, the Case Companies can improve their operations, ensure sustainability, and maintain the crucial fish health and high-quality products they offer their customers.

Research question 4: *How do fish farming Case A and Case B implement Circular Economy principles in their operations, and what impact does this have on their economic, social, and environmental sustainability?*

Case A and Case B are working towards implementing Circular Economy principles, aiming to eliminate pollution and waste, circulate products and materials, and regenerate nature. Both prioritize long-term sustainability by considering the social, environmental, and economic aspects. Through waste reduction, resource efficiency, and innovation, the Case Companies strive to maximize utilization of resources and achieve sustainability. Working with CE principles can contribute to a cleaner environment, collaboration with stakeholders, a focus on fish welfare, and achieving high-quality products. By having a closed environment, the fish farmers can have control over inputs such as water, waste, feed, etc.

Main research purpose: *how circular economy principles contribute to sustainable supply chain operations within the Norwegian fish farming industry.*

Fish welfare is a shared priority, and the growth phase of the fish requires attention to ensure that it receives the necessary care needed to produce high-quality products. Sustainable practices in the fish farming industry are crucial for addressing social, environmental, and economic challenges. The implementation of sustainable practices includes a combination of various strategies such as reusing, reducing, and recycling materials, optimizing inputs, and collaborating with both internal and external stakeholders. Technology and digital tools can improve the efficiency and effectiveness of these sustainable practices. Collaboration from individuals and communities are ways to transition towards sustainability in the fish farming industry of Norway. Working on sustainable practices requires a long-term perspective, as there is no easy quick fix that will ensure short-term gain.

9.1 Implication for theory

This master thesis offers insights into the specific practices and facilitators employed by the fish farming industry. The findings support established theories, including CE strategies such as reuse, recycle, and reduce. Collaboration with stakeholders and the role of government subsidies and regulations as enablers of sustainability are also affirmed.

Moreover, the study emphasises the importance of adopting a holistic long-term perspective on sustainability, which involves the social, environmental, and economic aspects. It points out that a focus on environmental issues and certifications alone are not the way to work towards sustainability. The study has highlighted some supply chain challenges regarding feed optimization, sustainability and cost considerations, a limited option when choosing suppliers, infrastructure and technology issues, and the management of undesired outputs contributes to advancements of theories relevant for supply chain operations in the Norwegian fish farming industry.

In this master thesis, we have applied stakeholder theory as our theoretical lense to assist research and guide the interpretation of data. This decision has allowed us to explore the relationship the Case Companies have with its stakeholders and investigate how this can influence the performance and success of a company. Our findings indicate that stakeholders can play an important role in shaping the supply chain of a company by maintaining good relationships and collaboration, as they can be useful in addressing common issues.

9.2 Implication for practice

The identified sustainable practices and enablers can be valuable as guidance for other fish farmers that seek to make its supply chain sustainable. Effective communication, collaboration, and coordination with stakeholders, be it internal or external, are crucial for addressing issues of sustainability. Governments can by incentivizing, establishing environmental requirements, and promoting best practice be an influential enabler. Technology can contribute to optimization of operations and minimize environmental impacts.

Understanding how CE strategies can be utilized can be useful for other companies that are interested in implementing CE principles into their operations. Our investigation has revealed challenges that practitioners or managers may experience when organizing their supply chain operations. By employing the CE strategies of reducing, reusing, and recycling the fish farmers can influence their operations and performance.

9.3 Suggestions for further research and limitations

This master thesis emphasises the importance of establishing a shared understanding and consensus on the definition and implementation of Circular Economy principles within the fish farming industry. With an absence of a precise Circular Economy definition highlights the importance of a clear framework that can guide practical applications and approaches of CE in this industry. By exploring and investigating further other implementations of CE in the industry can contribute significantly to the development of a theoretical framework that can be useful for the fish farming industry.

Further on, the study emphasises the significance of integrating CE principles into the operations of fish farmers to address social, environmental, and economic issues. The efforts of the Case Companies to improve efficient use of resources, reduction of waste, and innovation can serve as a guide to other fish farmers. Through further studies, one can improve and develop the theoretical framework mentioned above. Theoretical frameworks such as Actor-Network theory, resource-based view, and others to review the interplay between CE and sustainability, as this could reveal ways to make the supply chain sustainable.

The interaction between buyer and supplier could be useful to investigate. If there is a dependency on suppliers, lack of availability, the implication this has sustainable efforts, and if this is experienced by other fish farmers could be interesting to explore.

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Appendix

Appendix 1: Interview Guide

Below are four definitions listed as a tool to understand the questions in the interview guide. We have chosen not to have too many definitions to avoid strong influence that can affect the quality of the interview. If there are any technical terms along the way that you do not understand, we will explain them briefly.

Supply Chain Management:

Supply Chain Management covers all processes related to procurement and transportation of raw materials to production, production of goods, and delivery of finished products to end customers. This means planning, implementation, and control of all activities related to the production and delivery of the product to the consumer.

Operations Management:

Related to the company's main tasks in daily operations.

Sustainability:

Being sustainable contributes to making the world a better place for people who live now, without destroying it for those who come later. In sustainability, the world must work within three areas: Economy, Environment, and Social.

- The economic aspect of sustainability is about ensuring economic security for all. A sustainable economy is fair and lasting so that everyone can afford to meet their needs now and in the future.
- The environmental aspect of sustainability is about taking care of nature and climate. It involves investing in renewable resources, i.e., resources that nature automatically replenishes and that are not used up.
- The social aspect of sustainability is about ensuring that all people have a good and fair foundation for a decent life.

Circular Economy:

Is an economic model that consists of three principles according to MacArthur (n.d.):

- Elimination of waste and emissions by transitioning from a take-make-waste system to a system that keeps resources as long as possible by being maintained, reused, repaired, and recycled to become something new.
- Using circular products and materials for as long as possible, either as products, components, or raw materials. This is done to avoid waste while preserving the value of products and materials.
- Restoring nature by transitioning from a take-make-waste linear economy to a Circular Economy that supports and considers the environment.

Structure of the Interview Guide:

The questions in this interview guide are divided into four categories:

- Introduction of the participant
- Supply Chain and Operations Management
- Sustainability and Circular Economy
- Other Questions

Interview Guide:

In this interview guide, there are many questions to obtain ample details from all participants. Skip the questions that are obviously not directed towards your business, but feel free to answer if you have knowledge of the topic. There are some questions that overlap a bit, so skip questions you have already answered through another if answering in writing.

Introduction:

1. Name
2. What is your position in the company?
3. Can you provide us with a job description?
4. How long have you been in this industry/had this job?

Supply Chain Management and Operations Management

Supply Chain

1. Can you briefly explain the supply chain you have today?

2. Has the supply chain experienced any changes in recent years?
    1. If yes: Elaborate on changes.
    2. If no: Explain why, is there a reason for this?

2. Which parts of the supply chain are managed by yourselves, and which are left to other actors?
    1. If other actors: Are there reasons why you do not control this part of the supply chain yourself?
    2. How many actors are involved in these links?
    3. Can you mention the number of actors involved in the supply chain?

3. Which part of the supply chain is resource-intensive?

Operations Management

1. Can you briefly explain the internal flow of fish in you company?
    1. Are there any challenges in keeping the fish alive?
    2. What measures do you use to minimize stress on the fish?
    3. Transport of live fish (internal and external)
        1. How does this work in practice?
        2. What kind of equipment do you use? (Pipes, wellboats, nets, etc.)
        3. What are the challenges with this?
2. Have you experience any challenges with fish farming?
    1. Broodstock, spawning, and hatching
    2. Fry, parr, and smolt
    3. Transfer to sea, growth in sea (smoltification)
    4. Land-based facilities
    5. Slaughter and processing
    6. Other
3. What happens to the broodstock after spawning?
4. Can you briefly explain the internal flow of information?
    1. What will this information flow cover? (Feed, medicine, water temperature, etc.)
    2. Do you experience any form of silo effect in your business?
    3. Do you use digital tools to keep track of the flow of fish?
5. What routines do you have for maintenance of nets/fish farming facilities?

1. What happens to the nets after use?
    2. Are the nets treated with chemicals to prolong their lifespan? Are these chemicals harmful to the environment?
    3. Are chemicals used to clean/maintain land-based facilities harmful to the environment?
6. What measures are taken to prevent fish from escaping from a net?
    1. What are the consequences of escaped fish?
    2. Do you have any statistics on this? Not needed if confidential.
7. Are cleaner fish used in each production cycle?
    1. What type of cleaner fish do you use?
    2. Are cleaner fish caught locally or purchased from suppliers (fish farms)?
    3. What percentage of cleaner fish is used in each production cycle with farmed fish?
    4. Do you have any statistics on cleaner fish? Not needed if confidential.
    5. Can cleaner fish be used for anything else «after use»?
    6. Are a lot of resources used for cleaner fish?
    7. Other challenges with cleaner fish?
8. Are other measures than cleaner fish used against lice?
9. Are there major challenges with diseases in the nets/facilities?
    1. Please mention the names of these
    2. What measures are taken to keep the fish healthy?
10. Feeding of fish
    1. Do the fish receive different feed throughout their life cycle?
    2. Have there been any changes in fish feed over the years?
    3. Have you experienced any challenges with feeding the fish?
11. Feces / Food residue on the seabed / facility
    1. Are there any challenges with this?
    2. Are there any measures taken to control and/or reduce the discharge?
    3. Where does this discharge go?

Sustainability

1. What do you perceive as a sustainable supply chain in fish farming?

2. Do you consider the three aspects (economic, environmental, and social) of sustainability as equally important, or is there an imbalance?
3. When did it become relevant to work on sustainable solutions for your company?
4. Have incentives been used in the transition to a sustainable supply chain?
    1. What incentives?
    2. Internally with employees and managers
    3. Externally with suppliers, competitors, customers, authorities, etc.
5. What measures are being taken to achieve a more sustainable supply chain?
6. Have any measures been taken in the following processes to make them more sustainable?
    - Broodstock, spawning, and hatching
    - Fry, parr, and smolt
    - Transfer to the sea, growth in the sea
    - Slaughter and processing
    - Something else?

    1. This can be related to feeding, health issues, transportation, distribution, storage, etc.

Circular Economy (If one have implemented / is about to)

1. Has the company implemented a circular economy?
2. How do you perceive circular economy within fish farming?
3. What incentives have been used to implement circular economy?
    1. Internally with employees and managers
    2. Externally with suppliers, competitors, customers, authorities, etc.
4. Have there been any challenges in implementing circular economy principles in the following processes?
    1. Broodstock, spawning, and hatching
    2. Fry, parr, and smolt,
    3. Transfer to sea, growth in sea
    4. Slaughter and processing
    5. Any other parts of the value-chain
5. How has circular economy affected the economic aspect of the business?
    1. Impact on costs

2. Impact on profits

6. How has circular economy affected the environmental aspect of the business?
    1. Has the result been positive or negative? Explain
7. How has circular economy affected the social aspect of the business?
    1. What do you think fish farming can contribute to your local community?
    2. What can your product offer to your customers?
8. What is your relationship to social responsibility?
    1. Do you feel any responsibility?
    2. How do you practice social responsibility?
    3. What is the result of this work?
9. Is there a prioritization between the economic, environmental, or social perspective?
    1. What is the threshold for balance/prioritization, for example: How much money can we lose before we chose to not prioritize environmental measures?
10. How do circular economy and sustainability practices relate to your supply chain?

Other

1. Is there anything else you think might be interesting to add that has not been mentioned previously?
2. Is it possible for you to share internal information with us?
3. Is it possible to contact you again if necessary?

Sources:

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