Master's degree thesis

LOG950 Logistics

Circular economy principles and sustainable development of SCM: a single case of fish farming in Norway

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Number of pages including this page: 108

Molde, 02/06/2020

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In loving memory of my mom.

“If I know what love is, it´s because of you. Thankyou!”

Acknowledgment

This research is submitted as the final requirement part of the condition to achieve a Master of Science Degree in Logistics at Molde University College in the year 2020. It was a great experience to write this master thesis alone within the field of sustainable supply chain management and circular economy.

This investigation research was a journey and made me grew up as a journalist. It was challenging to write alone by using multiple sources of data collection. However, it has also been highly instructive.

First, I give thanks to the Lord Almighty for making this research success. Secondly, I would like to thank my supervisor Antonina Tsvetkova for her professional insight and guidance on this master's thesis. She continuously encouraged and was always willing and enthusiastic to assist in any way she could throughout this master thesis: the Norwegian fish farm and Norwegian research institute for their heartfelt assistance. Your guidance and supervision throughout the thesis are highly appreciated.

Thirdly, my beloved father for his prayer, my uncle Abdul for his advice and encouragement, my brothers Mody, Juma, Ommy for continuously checking up on me, my sisters Yasmin and Shamim for their warm words and last but not least for my friends Zelda, Lorita, Benta, Caro and Husna for being there for me whenever I needed them.

Molde 02nd June 2020

Leila Omari Mahmoud

Abstract

Sustainable Supply Chain Management (SCM) has gained increased attention from many researchers in parallel circular economy has been developed as part of the environmental sustainability that focuses on three principles: reduction, reuse, and recycling. The purpose of this master´s thesis is to explore how circular economy principles contribute to the sustainable development of SCM. This investigation implies a single case study approach. The empirical case presents a Norwegian fish farm located in Smøla island that applied circular economy principles to the existing practice of fish growing and production, as well as (SCM). The data collection is based on multiple sources, including four interviews, personal observation, and secondary data, i.e., companies report, overviews, and official website.

The findings show that the implementation of circular economy principles has helped the case fish farm to improve all three aspects- environmental, economic, and social for sustainability. Further, the findings show challenges on the sustainable SCM, especially on the empirical case fish farming live fish transportation, i.e. to ensure the quality of fish is maintained throughout the process. Furthermore, the findings have revealed several implications of how it is important to find a balance between circular economy and sustainability that is still a debate in literature and a challenge in practice.

The originality of this investigation is that my findings align circular economy principles to sustainable SCM that previous research has almost neglected. This master thesis suggests other researchers more on empirical studies on how circular economy principles can contribute to sustainable SCM within different contextual settings.

Keywords *Sustainability, Circular economy, Sustainable supply chain management, Social sustainability, Value creation, Aquaculture, Case study*

Terms and definitions

Sustainability: "*meeting today´s needs without compromising the future generation needs" (Brundtland 1987).*

Supply Chain Management: "*the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three aspects of sustainable development, i.e. economic, environmental and social, into account which are derived from customer and stakeholder requirements" Seuring and Müller (2008a, p.1700).*

Sustainable Supply Chain: "*the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" Carter and Rogers (2008, p.368).*

Circular Economy: "*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, system, and, within this, business models*" *MacArthur (2013, p.7).*

List of abbreviations, tables and figures

Abbreviations

SCM – Supply Chain Management

WHO – World Health Organisation

WEF – World Economic Forum

UN – United Nation

FAO – Food Agriculture Organization

UNEP – United Nations Environment Programme

OECD – Organisation for Economic Cooperation and Development

UNDSD – United Nation Division of Sustainable Development

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CHAPTER 1. INTRODUCTION

This chapter contains a brief overview of the study by starting with the background for the research. After that, the presentation of the overall purpose and research questions presented. And finally, there is a presentation of the structure of this master thesis.

1.1. Background for the research

Supply chain management (SCM) has been developed for the last decade in industries for the following up of goods or services from the point of production to final product to deliver customer satisfaction of goods or services (Seuring and Müller 2008a). For the last two decades, sustainable SCM has gained increased attention from many researchers, although it is doubtful to say this concept has fully taken consideration of all three aspects. These practices have expanded the SCM scope from the traditional focus on profit maximization and customer satisfaction (Stock and Boyer 2009) to the environmental and social impact of value creation (Pagell and Wu 2009; Cetinkaya et al., 2011; Bapuji et al., 2018).

The concept of sustainability has defined as meeting today´s needs without compromising the future generation needs. It is the most frequently quoted definition from *our common future*, also known as the Brundtland report (1987), that integrates economic, environmental, and social responsibilities. It is worth noting that sustainability requires the balancing equally of these three essential aspects. Value is being increasingly created within supply chains by linkage in different process through production. Value in the form of products and services, therefore, the environmental and social aspects of products and services as much as their economic perspective needs to be tracked across the entire supply chain and in the whole product life cycle (Seliger 2012).

While the intensity of the SCM research about the environmental aspect of sustainability has recently more than tripled (Gurtu et al., 2015), the social element has received extremely limited attention. This was pointed out by many researchers like Suring and Müller (2008a), Wu and Pagell (2011), Hammervoll et al., (2012), Sarkis (2012, Neely et al. (2015), Ahi and Searcy (2015a), Mani et al., (2016), Tsvetkova (2020). The lack of equal attention to all three aspects of sustainability may create difficulty in making existing SCM practices more sustainable (Davidson 2011).

Circular economy has been developed in parallel to sustainability, mainly in the concept of sustainable and green SCM practices (MacArthur 2015a). The notion of circular economy looks beyond the take-make-waste extractive industrial model through the implementation of three ´R´ principles, which are reduction, reuse, and recycling. Circular economy has pushed the environmental aspect of sustainability by emphasizing the idea of transforming products so that there are workable relationships between ecological systems and economic growth (Francas and Minner 2009). Circular economy is not just concerned with the reduction of the use of the environment as a sink of residuals but rather with the creation of self-sustaining production systems in which materials are used over and over again (Genovese et al., 2017). I believe that circular economy has changed the existing practices and made companies put new technologies in the production process and transportation.

So, finding ways to align sustainable supply chain strategies to circular economy principles has become important but remains unexplored on how the boundaries of environmental sustainability have to be pushed further. Circular economy is primarily concerned with material flows in economic systems, this paradigm neglects other important issues such as there is a lack of understanding of how environmental impacts i.e. related to energy usage, carbon emissions and how the implications of these impacts can be resolved (Genovese et al., 2017).

There has been a lack of studies within the field of understanding of how circular economy fish farming can contribute to environmental perspective and societal values. Further, the literature has paid little attention to how circular economy has been implemented in fish farming, the industry that affects the natural environment.

1.2. Overall purpose and research questions

Being motivated by the shortcomings described above, **the overall purpose of this master´s thesis is to explore how circular economy principles contribute to the sustainable development of SCM.**

In doing so, this master thesis presents an empirical case of a fish farm located in Norwegian island, Smøla. The selected fish farm implemented circular economy principles into the process of fish growing and production since 1996 and changed the existing practice completely.

Fish farming in Norway is a traditionally essential industry for the Norwegian economy. Since the 1970s, the industry has experienced tremendous growth. Fish farming is prolific mostly along the Norwegian coastline and produces more than 1.2 million tonnes per year, 95% of the whole fish production is exported (Dyrevern 2019). Fish farming meets the demands for seafood, and it is beneficial to local communities. At the same time, fish farming activities affect the natural environment through the emission of marine animals from aquaculture facilities into the ecosystem. The effect on the natural environment affects not only other fish but also results in nutrient pollution.

The selected empirical case illustrates how the fish farm implemented circular economy principles into its fish growing and production, as well as the consequences of circular economy principles. The case also discloses the specificity of live fish transportation that faces many challenges and requires additional efforts. It is time consuming and very demanding that the live fish does not receive stress and die or lose its quality as a product during transportation, as well as during loading/offloading operation in/out the hold of a specialized vessel.
So, the selected case helps find answers to the four research questions and reveal the overall purpose of this master´s thesis.

The investigation process in the present master thesis is based on providing deeper insight into four research questions:

1. ***"How has circular economy evolved in fish farming in Norway?"*** This question helps to reveal how circular economy principles have been implemented by the fish farm and to understand the reasons for implementing a circular economy into the fish growing and production. This will allows comparing the previous practice before the implementation of circular economy and the existing practice after this implementation.

2. ***"How is the transportation of live fish managed?"*** This question helps to understand how circular economy principles have been implemented in SCM and created a new practice of transportation of live fish, as well as to identify the challenges fish farming faces when managing logistics operations, fish stress and fish transportation.

3. ***"How does fish farming based on circular economy principles, contribute to the environmental aspect of sustainability?"*** A recent literature review has identified that a circular economy is based on principles of designing out waste and pollution, keeping products and material in use, and regenerating natural systems (MacArthur 2015c). This question aims to identify how a case fish farm changed its existing practice to stop environmental pollution and therefore contributed to a safer use of the environmental resources in fish production.

4. ***"How does fish farming based on circular economy principles contribute to social aspects and societal values?"*** Social sustainability has received very limited attention in the literature that was emphasized by many scholars (Seuring and Müller 2008a; Wu and Pagell 2011; Sarkis 2012). This question helps to reveal how a case fish farm based on circular economy principles has contributed to social sustainability in the existing practice of fish production towards local communities.

1.3. Structure of the thesis

This master´s thesis comprises of six chapters in total and organized as follows:

Chapter 1. This chapter is a general introduction that provides the background behind the chosen topic, the presentation of the overall purpose and research questions, and finally, the presentation of the structure of this master thesis.

Chapter 2. This chapter gives a brief description of the theoretical framework of Sustainable supply chain management with three aspects, circular economy concepts, principles. In the end, a circular economy toward sustainable SCM relationship reviewed.

Chapter 3. This chapter introduces and explains the methodology used in detail. Based on the research purpose and the nature of this thesis, a case study selected as a research strategy and the qualitative methods used to analyze it. The sections of this chapter are such as philosophical position, research design, the process of data collection (primary and secondary data), and data analysis were described. As well the research quality (validity & reliability and generalization) and finally the ethical issues have been mentioned.

Chapter 4. This chapter gives a brief description of the development of fish farming in Norway. The requirement to operate a fish farm, Government regulations, and the technology required for the operation of fish farming.

Chapter 5. In this chapter, the empirical case presented. Reasons for how circular economy has evolved in the case of a fish farm mentioned and the integration between circular economy and sustainability in fish farming discussed. Then management of transportation of live fish with its challenges and characteristics is analyzed. And finally, the effect of circular economy in fish farming on the environmental aspect, social aspect, and for the societal value discussed.

Chapter 6. In this chapter, the main research findings presented, and research questions discussed.

Chapter 7. This chapter concludes with the final overview of the research findings and presents implications for theory and implications for practitioners and decision makers. This chapter also discusses the limitations of this master´s thesis and provides suggestions for future research.

CHAPTER 2. THEORETICAL FRAMEWORK

This chapter presents the theoretical basis to conduct this investigation. The concepts of sustainable SCM, three aspects of sustainability, and circular economy considered through the state-of-the-art literature. The focus of this chapter is to find a theoretical gap in the current knowledge of these concepts.

2.1 Sustainable Supply Chain Management

SCM is the management of all the supply chain assets and flows (financial, information, and product/materials) and should have as a primary goal of the maximization of the supply chain surplus Chopra and Meindl (2010). Another useful definition is provided by Levi et al. (2003):

> *"supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements"(p.1).*

Sustainable SCM has gained increased attention among a great number of researches Ansari and Kant (2017). Sustainability was adopted in SCM due to the growing concern among society, government and non-government organizations on the environmental issues (Luthra and Mangla (2018). Brundtland Report is the first to adopt the concept of sustainability and gave it the widespread recognition it enjoys today, which refers to sustainability as meeting today´s needs without compromising the future generations´ needs Brundtland (1987).

Gupta and Palsule-Desai (2011, p. 235) defined sustainable SCM as a set of managerial practices that include all of the following: environmental impact as an imperative consideration of all stages across the entire value chain for each product and a multi-disciplinary perspective, encompassing the entire product lifecycle. The most cited definition of sustainable SCM is by Carter and Rogers (2008), who defined sustainability in SCM as:

> "*the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" (p. 368).*

Several researchers have pointed out that the notion that sustainable SCM in the organization, supply chains, environment, and society is not separate entities, but rather is mutually dependent. So, businesses cannot merely seek short-term profitability for shareholders at the expenses of environmental damage and adverse social effects (Paulraj, 2011; Wolf, 2011). That is why researchers and practitioners are increasingly concerned with the need to link the sustainable development concept with SCM and overall business strategies (Pirachicán et al., 2014).

Further, sustainable SCM has become a strategic process enabling firms to create competitive advantage (Sivaprakasam et al., 2015). So understanding the three distinct aspects, namely economic, environmental, and social, and their inter-relationship is crucial (Elkington 1999; Pagell and Wu 2009; Gallego-Álvarez et al., 2015). Sustainability aims to satisfy all three aspects of sustainability and to be considered equally on the entire SCM. Hammervoll et al. (2012) suggested that environmental and social proactivity, top management support for SCM strategy, long term social and environmental cooperative relationship with suppliers and customers, and environmental and social monitoring. Once these organizational antecedents are in place, companies become the micro-foundations of processes and routines that support the sustainable SCM (Eisenhardt and Martin 2000; Hammervoll et al., 2012). These antecedents observed in companies engaged in sustainable SCM, and so once these practices are functioning, those companies can be said to become truly proactive and creative, both of which characterize companies involved in sustainable SCM strategy (Hammervoll et al., 2012).

Table 2.1.1 shows the evolution of the sustainable supply chain concept adopted from (Bouzon et al., 2012) events from the 1960s to 2010s on how companies/businesses used to perceive the sustainable supply chain.

Table 2.1. 1: Evolution of the Sustainable Supply chain concept (Bouzon et al., 2012).

Decade	Events
1960's and 1970's	Companies said they did not cause negative impacts to the environment (Georgiadis and Besiou 2008)
	Proliferation of corporate social responsibility (especially in the 1970's) (Carroll 1999)
1980's	Beginning of attention on environmental issues related to logistics and evolution of this emphasis only in transportation (Chunguang et al. 2008)
	Publication of the Brundtland Report (WCED, 1987)
	Change from local optimization to chain optimization (Linton et al. 2007)
1990's	Environmental impact drives green logistics (Chunguang et al. 2008)
	The concept of Green SC is defined (Srivastava 2007 and Zhou 2009)
	CLM publishes its first definition of reverse logistics (Brito and Dekker 2003)
2000's	Logistics is seen as a competitive tool (Rutner and Langley Jr 2000)
	Early work is published from 2002 covering the triple bottom line sustainability in SC (Seuring and Müller 2008)
2010's	Sustainability is included into business management (Wittstruck and Teuteberg 2010)
	Research works are published on the integration and management of the SSC. The concept of risk management is included in the SSC (Wolf 2011)

Table 2.1.1 illustrates that the development of sustainability has gone through several stages. Early years in the 1960s, sustainability perceived as corporate social responsibility, and now the tendency is more into business management, including concepts such as risk management being included in the sustainable supply chain et cetera.

Several researchers have pointed out that most organization move toward sustainability and engage in sustainable SCM practices mainly to react to pressure and incentives from their environment, namely governments, NGOs, and other various stakeholders, or to influence their environment (Seuring and Müller, 2008b; Gold et al., 2010a). Other researchers have emphasized that the successful implementation of sustainable SCM can require the support of top managers Gold et al. (2010b). The installation of cross-functional teams Chen and Paulraj (2004) and enhanced communication for the pursuit of win-win situations for all included partners (Seuring and Müller 2008b).

To turn a supply chain into a sustainable supply chain, cooperation and integration needed at all stages as explain from product i.e., raw materials purchase to end customers and consumptions, which can be feasible through a partnership based on trust (Seuring and Müller 2008a).

Pagell and Wu (2009) have suggested five components for studying sustainable SCM: *Integration,* innovation, *supply base continuity*, *economically viable supply chain*, and internal and external *reward and incentives.* Combining all these components make it possible to achieve a high level of sustainability outcomes by embracing all three aspects. This notion was as well supported by (Tsvetkova 2011; Slivestre 2015), emphasizing that a sustainable supply chain can occur only through learning, change, and innovative solutions, and becoming a sustainable supply chain is not a destination but rather a journey.

Chacón and Mantilla (2014) have suggested that the incorporation of sustainability in supply chains is complex and challenging, and there is no universal formula exists for doing so. However, signals that can act as guides do exist, such as the need to develop distinctive organizational capabilities. The literature can help understand these signals, allowing managers to incorporate more information into their decision making.

Further, Pagell and Wu (2009) have examined ten empirical cases to learn the elements necessary to create a sustainable supply chain. They have found that the company's ability to be innovative promotes to be more sustainable. Thus, it assumed that an organization's capability to innovate is a precursor to the successful implementation of sustainable SCM practice. That can contribute to value creation if organizations are proactive and align both the environmental, economic, and social aspects. It was also confirmed by Tsvetkova (2011) that to develop a sustainable supply chain (including all the three aspects of sustainability), companies have to operate within a realistic financial structure, as well as contribute to society. In other words, the supply chain becomes sustainable when it is realistically financed, and all the operations within it meet all the three aspects of sustainability, economic, environmental, and social (Cetinkaya et al., 2011; Tsvetkova, 2020). Furthermore, Büyüközkan and Berkol (2011) have added that a sustainable supply chain only achieved if supply chain partners meet basic needs targeted by the aspects of sustainability. These are economic (total cost, financial benefit, equity use, and inventory management), environmental (fuel usage, emissions, and waste created) and social (health and security, laws, and regulations).

The combination of three aspects of sustainability can allow achieving the creation of a sustainable system (Glavič and Lukman 2007).

2.1.1 Environmental aspects

The environmental aspect denominates those terms that describe environmental performance to minimize the use of hazardous or toxic substances, resources, and energy. These terms are *renewable resources, resource minimization, resource reduction, recycling, reuse, repair, regeneration, recovery, remanufacturing*, among others (Glavič and Lukman 2007). The environmental aspect of sustainability has been widely investigated compared to other aspects (Gurtu et al., 2015). Companies may decide for a short-term strategy to stress one aspect, i.e., the environmental one more than others. Still, it should be kept in mind that nowadays, the urgency to include the three aspects for sustainability for long-tern industrial strategy is becoming more imperative to stay in business Arena et al., (2009).

According to Min and Galle (1997), practice environmental considerations in SCM can lead to achieve the goal of sustainability. Arena et al., (2009) analyzed the literature. They identified nine main sub-aspects of environmental sustainability from an industrial operational point of view: materials, energy, water, biodiversity, emissions, waste, product services, and compliance, and transport. The tool for implementing these aspects differs from company operating in different sectors like issues related to waste more relevant for a manufacturing firm than for a knowledge-based service company.

Wastes and emissions in supply cause many negative issues to the environment. Gupta (1995) claims that controlling and recycling both wastes and emissions in the production processes can be regarded as the most effective way to handle environmental issues. At the same time, Ülkü (2012) has pointed out that shipment consolidation reduces cost and environmental damage. The supply chain design for delivery products and materials, as well as logistics operations considerably, effect the environment. New methods of calculating of carbon dioxide emissions due to the intensive movement of different types of vehicles are needed (Ülkü 2012).

Several previous researches have focused on the development of ´green supply chain management.´ The objective of a green supply chain is to eliminate or minimize negative environmental impacts (air, water, and land pollution) and waste of resources (energy, materials, products) from the extraction or acquisition of materials up to final use and disposal of products (Hervani et al., 2005). Other researchers have focused on the effects of environmental management on firm performance by addressing the following metrics for sustainable SCM, “solid wastes,” “energy used,” “buying environmentally friendly materials,” “process innovation” and others (Zhu et al., 2008).

Many scholars have proposed several effective ways to reduce negative environmental impacts. Among others, being “closed-loop supply chains” for an effective control of waste through monitoring and fed back into the system has seemed to be an effective way of reducing waste to the environment (Gurtu et al., 2015).

2.1.2 Economic aspects

The economic aspect has traditionally been a focus of previous SCM research. Concerning cost minimization, profit maximization and optimization of firm performance (Lamming et al., 1999; Bouzon et al., 2012; Taticchi et al., 2013; Luthra et al., 2014; Schaltegger et al., 2014).

The essential objective for a company is to make maximum profit for the company and related stakeholders. This argument was acknowledged by Setthasakko (2009), who pointed out that “the narrow focus of economic performance is a shortcoming in the creation of environmentally responsible organization and green supply chain management”. But with the development of globalization and international business implementation, the concept of sustainability has become more and more indispensable for organizations (Huatuco et al., 2013b).

Some indicators describe implementing sustainability into the supply chain, and the stakeholder is an important component to achieve sustainable development and can lead to commercial success (Zailan et al., 2012). Helfat et al., (2007) pointed out that the company become more economical sustainable and competitive by economic value created such as excellent service or good environmentally friendly products.

2.1.3 Social aspect and societal values

The social aspect and society values have received much less attention in the literature than the environmental aspect. Many researchers have also emphasized that the omission of the social aspect makes the possibility of sustainable development doubtful (Beske et al., 2008; Seuring and Müller, 2008a; Pagell and Wu 2009; Wu and Pagell, 2011; Hammervol et al., 2012; Sarkis, 2012; Neely et al., 2015; Ahi and Searcy 2015a; Tsvetkova, 2020). The triple-bottom-line concept call for the equal consideration of all three aspects of sustainable development, namely economic, social and environmental development.

According to the UN global compact (2020), social sustainability is about identifying and managing business impacts, both positive and negative, on people. Directly or indirectly, companies affect employees, workers in the value chain, customers, and local communities. Social and environmental issues go beyond the border of one organization, and they need to be taken into account along the whole supply chain because the material and information flow moves across various organizations (Suring and Müller, 2008b; Gunasekaran et al., 2014). Thus, social sustainability in SCM can be understood by addressing social issues not only inside internal operations but also concerning suppliers and stakeholders such as the local community, society, and consumers (Mani et al., 2015). Klassen and Vereecke (2012), have identified three points that should be taken into account to manage social sustainability in the supply chain. Those points are who (i.e., which stakeholders are considered), what (i.e., what social issues are considered), and how (i.e., what actions should be taken in the supply chain).

It is worth noticing that many researchers have studied and understood the social aspect differently. Leire and Mont (2010) have identified social issues like protection of employees´ health and safety, prevention of social exclusion, ensuring equal treatment, and reduction in unemployment. These researchers have also shown how these aspects can be allied and incorporated into the supply chain as well as how the social criteria could be used to monitor the supplies and ensure their compliance. Others have viewed the social aspect through concepts like equity, safety, health, philanthropy, housing, education, wages, and their relationship with the social sustainability of the organization (Gopalakrishnan et al., 2012; Mani et al., 2015a; Mani et al., 2015b).

Langella et al., (2011) have shown how the adoption of better human resource measures can affect sustainability in the supply chain. At the same time, Hollos et al. (2012) have focused on the drivers and outcomes of social sustainability practices on firm performance and found that a strategic orientation within purchasing and supply management promotes closer supplier cooperation on sustainability and the adoption of social responsibility practices. Further, ethics is one of the important social aspects of corporate sustainability (Lu et al., 2012).

In addition, some researchers have found that social sustainability can be influenced by parameters like the requirements of customers, stakeholders, and employees, as well as the economic status of an organization that can make social sustainability more effective. Several previous research have found that governmental regulation and pressure are significant drivers for companies to behaving socially responsible (Tate et al., 2010). Only a few studies have shown how the development of social responsibly practices in SCM contributes to local communities and the increase of social values (Tsvetkova 2020).

Tsvetkova (2020) implies that the firm should not only look into how social issues are managed but also to whom the solution of those social issues is targeted, such as incorporating the social responsibility principles into existing of supply chain practices.

Further, several researchers have identified various barriers to the non-adoption of social sustainability. Dillard et al. (2008) have found four factors that result in a relative disregard of social sustainability by organizations. First, the organizations' economic goals are commonly aimed at increasing the wealth of various shareholders. Secondly, many contemporary social issues are due to negative environmental impacts and adverse environments. Thus, social sustainability has been often considered in the literature as a side effect of studying the environmental aspect of sustainability, e.g., concerning a level of health due to the air and water pollution. Thirdly, the social aspect of sustainability has been often viewed as to be the responsibility of the state and/or society. Finally, the lack of research and thereby understanding of social sustainability is expected to bring more negative outcomes for future sustainable development in comparison with the other aspects (Dillard et al., 2008; Tsvetkova, 2020). Change on how we perceive the operation or overall context of the supply chain and make changes on the strategy of implementation or formulation that may, in turn, change the link between all supply chain players, including local communities, is required as implied by (Tsvetkova and Gammelgaard 2018).

2.2. Circular Economy

In parallel to the development of sustainable and green SCM practices, circular economy discourse has been propagated in the industrial ecology literature and practice for a long time. A circular economy is characterized as an economy that is regenerative by design, with the aim to retain as much value as possible of products, parts and materials (MacArthur 2015b).

A circular economy is not an entirely new concept. It took off during the Second World War in industrialized countries. It was characterized by the fact that managers maintained the value and utility of goods stocks for a longer period of time MacArthur (2013). Today this concept has gained increased attention in practice as it expresses an inspiration to get higher value from the usage of resources and to waste less, especially if there is pressure such as price-driven, political or environmental.

The product discard at the end of product life characterizes the linear socioeconomic system; this is one of the main causes of natural depletion. Since the industrial revolution, economic growth was based on a pattern of "take-make-consume and dispose," beginning with constant use of raw resources and ending with constantly growing level of waste and large amounts of embedded materials, energy, and labor (Michelini et al., 2017). However, it is not easy task to change the linear economic model and it would entail a transformation of our current production and consumption pattern. So, the introduction of circular economy has brought innovative transformational technologies. Such as digital and engineering, in combination with creative thinking, will drive fundamental changes across entire value chain that are not restricted to specific sectors or materials and would in turn entail significant impacts for the economy, the environment and the society (Accentrure, 2014; Bicket et al., 2014; Acsinte et al., 2015).

Scholars have suggested several definitions of circular economy MacArthur (2017) defined circular economy as looking beyond the take-make-waste extractive industrial model. A circular economy aims to redefine growth by focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite sources and designing waste out of the system. Underpinned by a transition to renewable energy sources, circular model builds economic, natural, and social capital. In early research, MacArthur (2013) which describe circular economy as:

"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, system, and , within this, business models" (p.7).

The overall objective is to enable effective flows of materials, energy, labor, and information so that natural and social capital can be rebuilt MacArthur (2013). At the same time, the European Commission (EC 2015) define circular economy as an economy:

"…where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized" (p.2).

The European Commission (2015) considers that this transition towards circular economy can contribute to the development of a sustainable, low-carbon, resource-efficient, and competitive economy. Also, Sauvé et al. (2016) have suggested that circular economy refers to:

"*production and consumption of goods through closed-loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)" (p.49).*

According to Sauvé et al. (2016), circular economy primary focus is the reduction of resource consumption, pollution, and waste in each step of the product´s life cycle.

Circular economy aims at transforming waste into resources and bridging production and consumption activities (EC 2015; Witjes and Lozano 2016; Sauvé et al.,2016). Circular economic is all about managing resources and using products/components more efficiently throughout their lifecycle. It aims to keep resources in the lifecycle as long as possible by reducing raw material and energy consumption, emissions and waste to a minimum, and reusing the same product several times (MacArthur 2015a).

Several researchers have pointed out that circular economy aims to reduce the use of the environment as a sink of residual and at creating self-sustaining production systems in which materials are used repeatedly (Genovese et al., 2017).

At the same time, circular economy has received some criticism from several researchers who identified circularity as one archetype of sustainable business and viewed it as one of the several options to foster the sustainability of the system and among other economic models (Bocken et al., 2014; Evans et al., 2009; Allwood et al., 2012).

Also, circular economy has been criticized for its disregard of the social issues like gender, racial, and financial equality, inter and intra-generational equity and equality of social opportunities (Murray et al., 2017).

In additional Cristoni and Tonelli (2018), based on their study of Italian companies, have found that there is still low consciousness of circular economy potential across industries and even lower levels of maturity, especially by small, medium-sized enterprises. Despite the growing evidence of sustained competitive advantage achieved by pioneering companies moving away from a linear form of production towards the development of new core competencies, many companies still perceive circular economy as something not applicable to them or too costly and risky to implement.

Further, Sanguino et al. (2020) have studied sustainable development and energy management based on circular economy principles and found out that the implementation of circular economy principles into practice faces a lot of challenges but simultaneously creates opportunities to generate economic, environmental and societal benefits.

2.2.1 Circular Economy Principles

To be able to change the linear economy to circular economy, there is need to ensure maximum efficiency from each process in the life cycle of a product or service. The waste management become one of the most priority areas (McKinsey 2016).

The “3R” principles which, are reduction, reuse, and recycling of materials and energy, have become the only acceptable ways to dispose of waste in practice (Yong 2007; Mudd et al., 2011; Samiha 2013; Ahmadi 2017; Huang et al., 2018). Andersen (2007) has pointed out that the successful application of circular economy principles in companies is closely related to the profitability of circular resource use.

Table 2.2.1. 1: Reduce-Re-use-Recycle principles, goals and methods, adapted from McKinsey Centre for Business and Environment (2016).

Principles	Goals	Methods
Reduce	Control and balance of renewable re-sources allow to save and to increase the natural capital.	Recycling; virtualization; sharing; re-newal; renewable and finite resources inventory management.
Reuse	Looping processes and more efficient use of the goods, materials, and their separate components to optimize the production resources.	Reuse or sharing, optimization, looping. Four looping cycles: at the consumer level (sharing), at the service provider level (reuse), at the producer level (re-covery and repair), at the component level (recycling).
Recycle	Identification and disposal of harmful tools and processes	Minimization of systematic losses and negative consequences of the economic activity.

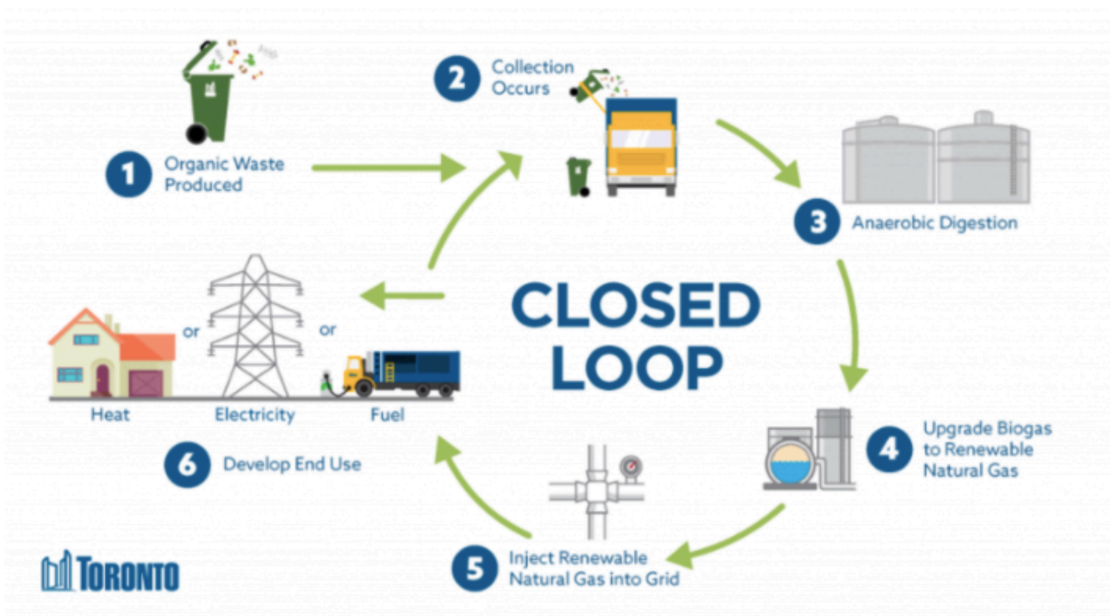
Based on the “3R” principles (see Table 2.2.1.1), it is also necessary to establish short chains between producers and consumers, create shared networks, and exchange data among various participants in the economic process (McKinsey 2016).

2.2.2 Circular Economy toward sustainable SCM

Circular economy and sustainability are interrelated, and circular contributes to sustainability. Bakker et al., (2014) imply that circularity is necessary for a sustainable economy to maintain sustainable economic growth. Other researchers have highlighted circular strategies as a tool for reusing and remanufacturing that can benefit toward sustainability (Garetti et al., 2012; Seliger 2007; Läpple 2007; Webster 2015).

Circular economy has been applied first of all to improve the environmental aspect of sustainability. Several researchers have assessed the environmental impacts of circular economy or resources efficiency. The main focused on specific processes have fall within circular economy´s scope i.e., recycling, reduction of waste (Rizos et al., 2017). The concept of circular economy has gained momentum because it gives a clear angle of attack to help to solve environmental problems (Sauvé et al., 2016).

One of the interconnected ideas for circularity is the ′closed-loop’ system, which has been considered necessary for the sustainable economy. The closed-loop material flow in the whole economic system through the restorative design aims to keep product, components and materials at their highest utility and value, at all times (MacArthur, 2013; Webster, 2015). The closed-loop system is associated with efforts like managing production residues (by-products and waste) in such a way as to minimize the level of waste transferred to landfills or incinerators (Szmelter, 2016). Figure 2.2.2.1 illustrates how circular model works, showing waste can ultimately be used to create green energy. Organic waste is collected and moved to anaerobic digestion whereby, microorganisms are break down into biodegradable material in the absence of oxygen. Then upgrade to biogas to renewable natural gas that can be developed to different usage i.e., heat, electricity, or fuel (WEF 2019).



Circular model showing how waste can ultimately be used to create green energy.

Figure 2.2.2. 1: Illustration of the closed-loop system on the management of waste to create green energy (adopted from(WEF 2019).

Circular economy toward sustainability has received some criticism. Andersen (2007), for example, describes that not only the potential benefits brought by the implementation of circular economy on SCM but also the costs of circular systems that must be balanced to avoid the creation of negative value. Allwood (2014) has suggested a range of problems that circular economy brings with it. The technical impossibility of a closed loop in combination with growing demand or issues with the energy required to recycle materials.

CHAPTER 3. METHODOLOGY

This chapter provides an overview of the research methods used in this master´s thesis. The philosophical position is based on social constructivism. Then, it is described how the design of the research is and the data collection methods are presented, the quality of the research and ethical issues followed during the research for this thesis.

3.1 Philosophical position

The philosophical assumptions of this master´s thesis is based on social constructivism. Social constructivism emphasizes the importance of culture and context in understanding what occurs in society and constructing knowledge based on this understanding. Social constructivism is based on specific assumptions about reality, knowledge and learning (Kim 2001).

The reality is constructed through human activity, knowledge is through a human product i.e. individuals create meaning through their interactions with each other and with the environment they live in and social constructivists view learning as social process. Meaningful learning occurs when individuals are engaged in social activities (Kim 2001).

3.2. Research design

This master´s thesis presents a qualitative research design. The qualitative research design helped reveal the contextual settings and internal processes to reach the study´s purpose. This methodology provides a tool to study the case phenomena within its contexts (Baxter and Jack 2008).

This master´s thesis written in both an explorative and descriptive manner. The exploratory way of this research design helped reveal how circular economy principles contribute to the sustainable development of SCM. The descriptive way allows the intervention of the real-life context in which circular economy occurred on the fish farm (Yin 2003).

The thesis was designed to focus on learning the meaning that the respondents (expertise) hold about the case to explore the case and get a more detailed understanding of the issue (Creswell and Poth 2016).

There are two common alternative way of relating theory to reality, which are *inductive* and *deductive* approach. The *deductive and inductive* approach can be described as:

> "…*deductive* approach is *a theory testing process which starts with an established theory or generalization and seeks to test if the theory matches to specific instances while inductive reasoning is a theory building process which starts with observations of instance and aims at establishing generalization" Hyde (2000, p.83).*

This master's thesis focused on a combination of the deductive and inductive approach. The case study analysis based on the deductive approach where "testing theory" was done, and the inductive approach used the "theory building" when circular economy principles affect the existing practice.

3.3. Case study

This master's thesis applied a single case-study approach based on the fish farm in Norway. Fish farming in Norway is the traditional essential industry for the Norwegian economy. Norway is the largest producer of farmed salmon that contributes to the country's health, economic, and environmental impact. It was interesting as a field of study to understand how circular economy in fish farming can contribute to the three aspects of sustainability.

The case study approach helped to learn the phenomenon in real practice, disclose the contextual settings, internal processes to reach the study purpose of this master thesis (Baxter and Jack 2008).

Yin (2003) defines the case study approach in the following two citations:

> *"A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident* "(p.13).

3.4. Data collection

3.4.1 Primary data

The primary data for this master thesis collected through face to face semi-structured interview. Other primary data collection was through personal observation and using the internet for primary research (Hox and Boeije 2005).

Face-to-face interviews

In total, four semi-structured face-to-face interviews conducted in February-March 2020. Three interviews conducted during my visit to the selected fish farm located in island Smøla. One interview conducted at the Norwegian Research Institute situated in Tingvoll.

According to Kreiner et al. (2005), semi-structured interviews helped reveal how respondents created meanings of their day-to-day routines and gave interpretations of the legal procedures they had to follow. Analytical elements during the interviews allowed the creation of deeper mutual knowledge between the author and the informant.

All the interviews were conducted in English, recorded with the respondents' concern, hand-written, and transcribed afterward. Data were collected and analysed concurrently through standardizing questions prepared for the target interview on the information required for the study. An open hand questions prepared for conducting the semi-structured face to face interviews which was done in February 2020. The interviews digitally recorded via an MP3, and their length varied from 45 to 90 mins. To gather the data precisely, besides recording the interviews, field note taking also followed.

The selection of the respondents was based on their long experience in the fish farming industry. As well the questions consisted of a series of questions that allows some divergence broader answers developed adopted from (Wisker et al., 2008). They perform their daily operations within fish farming, manage and control tools and technology, make decisions, plan, and forecast activities. The respondents for the data collection are the Managing director, Senior advisor, Quality manager, and Scientist (See Table 3.4.1.1).

The real names of the respondents were not used because of ethical issues. Before the formal interview, interview guidelines with questions were sent to all my respondents (see Appendix 1). So, that they had time to look through and comprehend the questions in advance. The follow-up questions were done via e-mail and phone calls, as recommended by (Walliman 2011).

The data collection was limited due to the coronavirus pandemic, but at the same time, the empirical data collected was rich enough to enhance this study.

Table 3.4.1. 1: Overview of the interviews, respondent titles, date, duration, location and topic of interview discussed.

No.	Respondent(s)	Date	Duration	Location	Topic of Interview
1.	**Managing Director**	20.02.2020	1hr	Smøla	♦ General questions ♦ Operation and Logistics ♦ Sustainability and Circular economy ♦ Others.
2.	**Senior Advisor**	20.02.2020	1hr	Smøla	♦ General questions ♦ Operation and Logistics ♦ Sustainability and Circular economy ♦ Others.
3.	**Quality Manager**	20.02.2020	45mins	Smøla	♦ General questions ♦ Operation and Logistics ♦ Sustainability and Circular economy ♦ Others.
4.	**Scientist**	04.03.2020	45mins	Tingvoll	♦ Waste (sludges) ♦ Transportation of waste-sludges ♦ Fish feed ♦ Sustainability and Circular economy

Personal observation

A huge amount of the empirical data collected while visiting the fish farm located in Norwegian island Smøla on 20th February 2020. I watched by my own eyes at the smolt plant on the production process of salmon from roe to mature salmon. I saw a fish vaccination system, the recirculating water system, transportation of salmon from freshwater to seawater, and transportation of live fish for processing. I stood on the cage at sea and participated in feeding the fish. During my visit, I observe how employees and senior managers collaborate on their daily activities. Personal observations helped me understand how to fish growing, and production organized.

Triangulation

This research applied different source of data and thereby ensured triangulation of the data. Fink (2003) has claimed that:

> *"Triangulation focuses on the collection of data from different sources like field notes, interviews et cetera or from different surveyors in different places, thus the credibility of the data collected is highly enhanced with the use of multiple sources as the information produces similar results."*

The triangulation has helped to collect multiple data from different sources for this master thesis, made this case compelling and credible. Triangulation is one of the best validation strategies, in a qualitative approach (Jonsen and Jehn 2009).

3.4.2 Secondary data

The secondary data used for this master's thesis mostly based on scientific articles and journals found through the school database by searching for the specific topic on circular economy and sustainable SCM. The secondary sources of the empirical data were also based on archival documents, press releases, reports of business companies, official websites. The secondary data collected has helped to improve the understanding of this case study.

Curwin and Slater (2007) have argued that it is very difficult to imagine any type of research that does not benefit from secondary data analysis. Secondary data may already have been used in previous research, making it easier to carry out further research.

3.5. Data analysis

The empirical data presented as storytelling consisted of fragmented parts of the respondents' talks. Data analysis based on comparing the existing knowledge about circular economy

principles and sustainable SCM with my observations and interview to reveal what is unique for the management of fish farming in Norway (Miles and Huberman 1994).
The interviews transcribed in the English language transcriptions were read and compared with the recorded interviews to ensure that the participants´ words had been captured correctly. An analysis of the expert's opinions from the fishing farm and Norwegian research institute in circular economy sphere regarding the essential issues are reflected in this thesis.

3.6. Research quality

The quality of the empirical data throughout the master's thesis had to be secured with high validity and reliability. The empirical data was partly collected from the interviews and personal observations. The other part of the empirical data was gathered from information already available, like scientific journals, press releases, and official websites. It was also important to determine in which degree the findings of the case study could be generalized for other organizations and practices (Biggam 2015).

3.6.1 Validity and Reliability

The validity in this master's thesis refers to establishing the domain to which a study's findings can be generalized, when doing a case study (Yin 2003, p.34). In qualitative research, validity means the quality. Winter (2000) identifies validity as:

> *"…rather a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies and projects"* (p.1).

Validity can be defined as choosing the correct and appropriate methods for doing the research (Biggam 2015).

Reliability refers to discuss whether the research is reliable and trusted (Biggam 2015). The concept is of generating good quality research Stenbacka (2001) define that the purpose of reliability is for "generating understanding" (p. 551).

The interviews were conducted for approximately 1 hour, and the transcription of the interviews was made into paper. The respondents were also given the questions a couple of days before the interview to be able to prepare for the interview in the best possible way.

The interviewers were reliable on the follow-up questions through e-mail, nevertheless, the answers from interviews might have some errors because different interviewees had owned subjective opinions due to different personal experiences. As a result, it will lead to negative impacts on the reliability of the research. In order to improve the research reliability, the comparison with the internal documentation was done and asked further questions with each interviewee through e-mail. The internal documents as secondary data were received from the case fish firm and secure website, so to be considered reliable.

All research activities in this study included in selecting the research strategy of a single-case study, reviewing scientific literature, collecting primary and secondary data based on the interviews, and internal documentation that can ensure the validity of the research and keep the correct direction to follow.

3.6.2 Generalization

The generalization of the case study design has often been criticized, and many researchers have viewed the case study design as unscientific. Another common misunderstanding about case-study research is that "one cannot generalize from a single case; therefore, the single-case study cannot contribute to scientific development." Flyvbjerg (2006) corrects this misunderstanding by pointed out that:

> *"One can often generalize based on a single case, and the case study may be central to scientific development via generalization as a supplement or alternative to other methods. But formal generalization is overvalued as a source of scientific development, whereas "the force of example" is underestimated" (p. 228).*

According to Yin (2003), there are two categories of generalizing results from a case study to theory; analytic generalization and statistical generalization. Analytical generalization relies on case studies (as with experiments) where previously developed theory is used as a template with which to compare empirical results of the case study. In analytical generalization the investigator is striving to generalize a particular set of results into some broader theory. The statistical generalization, on the other hand, relies on research based on an investigation where a conclusion is made about research on the basis of empirical data collected from a case.

The findings in this master’s thesis were generalized through analytic generalization as the most common case study approach. Previous research was compared with the findings received from the case study.

3.7. Ethical issues

The Molde University College approved the research, and the Norsk Senter for Forskningsdata (NSD) consent form was approved by 30th January 2020. The research in the master´s thesis was written, and oral information was provided in line with the three persons from Norwegian fish farm, and one person from Norway Research Institute. Accordingly, informed consent was obtained from all the members involved in the interview before observations and actual interviews.

The respondents were informed about the purpose of research and the data collecting procedures to ensure privacy (see Appendix 2). Participants were assured that participating in the study was voluntary and that they could cancel proceedings at any time.
The interviews were recorded with the participants' consent, and the interview's location was a quiet place with privacy and comfort. Before the interview, participants declared their approval by signing a written consent.

CHAPTER 4. FISH FARMING IN NORWY: CONTEXT DESCRIPTION

This chapter presents a short overview of the historical development of fish farming in Norway. Then, the empirical findings presented according to the four research questions of this master's thesis.

4.1. Development of fish farming in Norway

The aquaculture industry has been one of the long traditional sector in Norway, but the real growth in the industry started in the1970´s. New technologies led the industry to grow Atlantic salmon (Salmon salar) and rainbow trout in seawater-cages, and since then, the industry has seen tremendous growth (FAO 2020a). The aquaculture industry is the third-largest export industry in Norway, after the oil and gas and metal industry.

The Food and Agriculture Organization of the United Nations (FAO, 1998) has introduced a definition of aquaculture as:

> "*farming of aquatic organisms, including fish, molluscs, crustaceans, and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licenses, are the harvest of fisheries*".

Norway is the third largest seafood exporter in the world after oil/gas and metals. The country´s geographical characteristics, a long coastline, and climatic factors have made the country extremely well suited for this industry. The equivalent of 37 million meals fetched from Norwegian waters is consumed worldwide each day (worldfinshing.net 2015). Aquaculture is one of Norway´s most important responses to the challenge faced by the world today, to produce sufficient, healthy food for a rapidly growing population.

Through many decades, Norway has tried to be at the forefront when it comes to developing good fisheries and aquaculture management and continuing to preserve sustainable sea life through regulations and incentives in cooperation with the scientific communities. The fishing industry has contributed to a 0.4% share of GDP and accounts for 4.6% of the total Norwegian export value, (worldfinshing.net 2015, Eurofish 2017). The Norwegian seafood exports top to NOK 107 billion in 2019, which is (NOK 8.3 billion) increase in value, compared to 2018 (NSC 2019).

The EU is by far the most important market, the largest export market being France for Norwegian Salmon and Norwegian Fjord Trout, followed by Russia and Poland. In 2009, the number of jobs created by aquaculture totaled 22,7000 (NSF 2011). Figure 4.1.1 shows areas of aquaculture at sea in Norway.

Intensive salmon farming is by far an essential activity, accounting for more than 80 percent of the total Norwegian aquaculture production. Production volume in 2003 exceeded 600, 000 tonnes, with a value of US$ 1,350 million between 1972 and 1975 (FAO 2020a), production from Norwegian aquaculture increased by 40 percent annually (NSF 2011). In the first way back to 1850, aquaculture in Norway was the first brown trout (Salmo trutta trutta) hatched.

An increase in interest was shown after World War II, followed by a breakthrough in the early 1960s when the first-time rainbow trout was successfully transferred to seawater. Then the first successful on growing of salmon also took place during the same period. A technological breakthrough came around 1970 when the first cage constructed. Ongrowing in cages proved to be safer and provide much better environmental conditions than onshore tanks or the various enclosures that had been used earlier, particularly with regard to salmon farming (FAO 2020a).

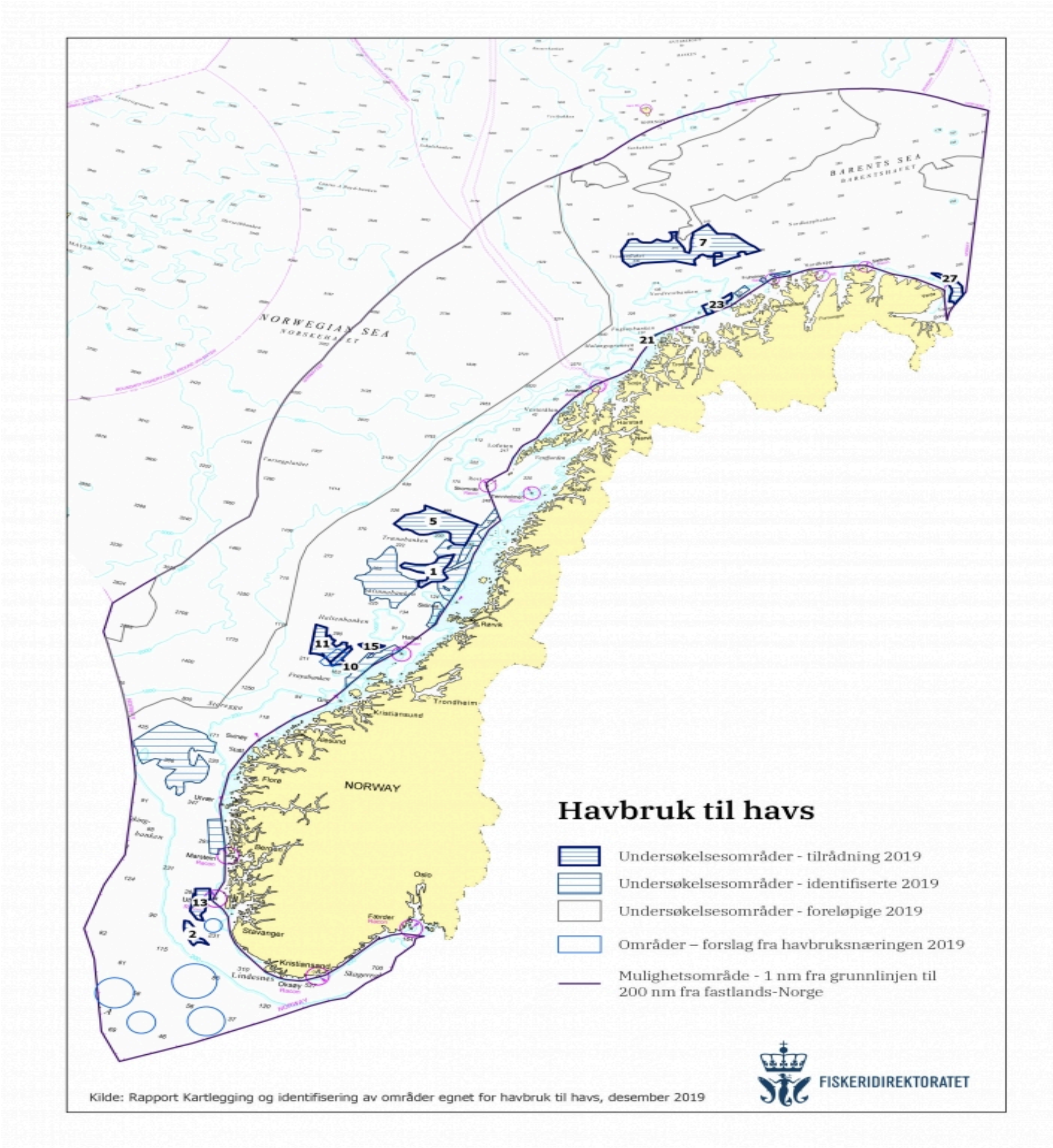


Figure 4.1. 1: Overview map: identified areas for aquaculture at sea (Fiskeridirektoratet 2019)

The long and sheltered coastline of Norway, with its thousands of islands and inlets, as well as the Gulf stream providing a reliable and stable temperature, has been proven to provide excellent opportunities for this kind of intensive fish farming today, salmon farming has developed into a major business along the majority of the Norwegian coast (FAO 2020a).

As a result of the high Labour cost in Norway, fish farming operations become highly rationalized. Since 1995 salmon production doubled while the number of employees employed in primary production reduced from 4500 in 1995 to 3 300 in 2003 (FAO 2020a). The same pattern was seen in the slaughtering and processing sector, while employment relating to other species has increased.

The service and supply sectors are also very important, since feed costs are responsible for more than 50 percent of total production costs. The industry had become a significant contributor to *employment*, as have suppliers of technical equipment, services, and logistics. The employment in production has been declining over recent years. It has not been the case with the administration and service sector to the industry where a major change from an unskilled to a skilled labor force has occurred, and the number of employees with academic qualifications has increased (FAO 2020a).

Shortly after the development of intensive salmon farming, severe problems with bacterial diseases (vibriosis, cold water vibriosis, furunculosis et cetera) emerged, the diseases were treated unsuccessfully with antibiotics. The problem continues to increase by 1987; antibiotic use reached a peak with close to 50 tonnes administered during the year. A major review of the industry was then undertaken, including better environmental practices and the development of fish vaccines. This development was extremely successful, and antibiotic use in salmon has remained at less than 1 000 kg a year since 1996, (FAO 2020a). The levels of salmon lice on farmed salmon are currently low and do not pose a problem for farmed salmon itself. However, because of the high number of farmed salmon in the cages, fish farms may be a source of salmon lice that can affect wild salmon and, particularly, in areas with a lot of fish farms. The greatest disease losses are due to viral infections such as pancreas disease (PD), heart and skeletal muscle inflammation (HSMI) and infectious pancreatic necrosis (IPN), which have no treatment but none of these viruses can affect humans (Government.no 2019).

Norwegian aquaculture has developed through a close cooperation between industry and research institutions. The main research administration body is the *Research Council of Norway*, supported by another governmental agency called *Innovation Norway,* which deals more with business development programs. Aquaculture research and academic teaching undertaken by almost all Norwegian universities as well as several public research institutes in aquaculture research. The most important being the Institute of Fisheries and Aquaculture

Research, the Institute of Marine Research, SINTEF Fisheries and Aquaculture, and the Institute of Aquaculture Research (AKVAFORSK) (FAO 2020a).

Several cultured species used for aquaculture for several years, but the research of this master thesis, only salmon, has been analyzed. Salmon is the common name for several species of fish of the family Salmonidae (e.g., Atlantic salmon, Pacific salmon) (SFIH 2019). *Salmon* is native Norwegian waters, where spawning and smoltification has taken place in the country´s rivers since the last glacial period followed by an on growing period at sea. Wild stocks of salmon have been caught since ancient times, both in rivers and in the open sea, along with the halibut, salmon has probably been the most valued fish species of all by people living along the coast.

By far, salmon is the most important species in Norwegian aquaculture, account for more than 80 percent of total production. Farming of Salmon takes place along the entire coast from Agder in the south to Finnmark in the north. The cage systems based on either square steel platform constructions linked together or circular plastic rings (FAO 2020a). Figure 4.1.2 shows the increase in total and per capita fish supply. The World Bank developed a scenario analysis in their report Fish to 2030 (2013) predicting that aquaculture will continue to fill the supply-demand gap, and that by 2030, 62% of fish for human consumption will come from aquaculture (SFIH 2019).

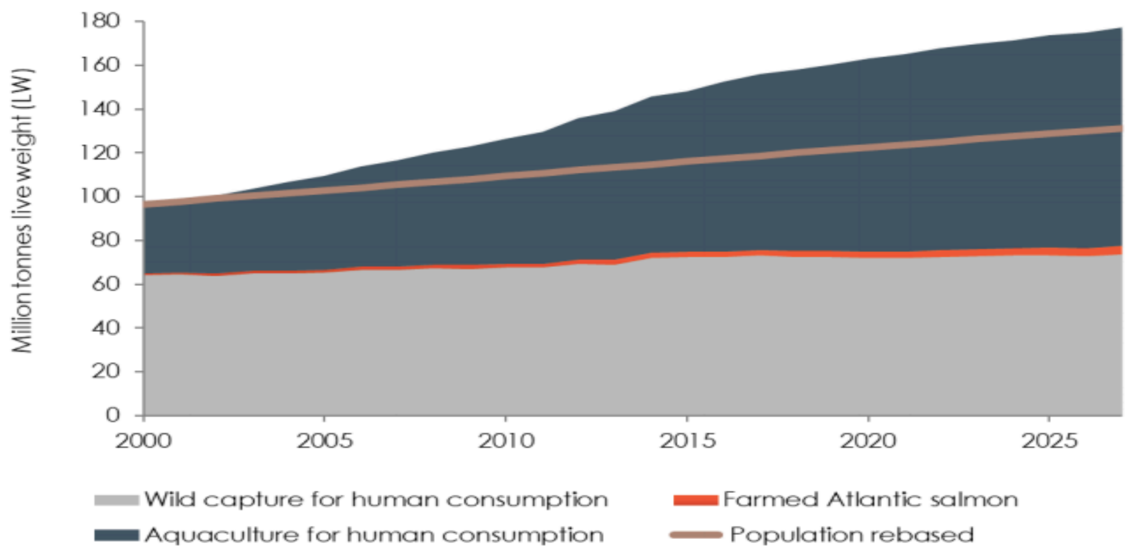


Figure 4.1. 2: Position of Salmon, stagnating wild catch-growing aquaculture source: SFIH (2019).

Although the figure above shows the salmon is relatively small in harvest volume compared to other species, it is a distinct product in many markets due to industrialization. Figure 4.1.3 shows the supply of farmed and wild salmonids in 2018; almost 2,500 thousand tonnes of GWT of farmed salmonids were supplied compared to only 9,000 thousand tonnes of wild salmon. That shows there is a vast market demand for salmon than wild salmon couldn´t satisfy.

Figure 4.1. 3:Supply of farmed and wild Salmonids from year 2009 to 2018 per thousand tonnes (GWT), source: SFIH (2019).

A healthy product

Salmon is rich in long-chain omega-3, EPA and DHA, which reduce the risk of cardiovascular disease. The World Health Organisation advises eating oily fish like salmon at least twice a week, because it's a rich source protein especially the fatty acids known as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) which are essential to the human diet. This nutrition's are imperative, and our bodies cannot make these fats on their own, yet they are crucial for healthy metabolism and good health (Eric et al.,2019).

Salmon is nutritious, rich in micronutrients, minerals, marine omega-3 fatty acids, high-quality protein, and several vitamins, and represents an important part of a varied and healthy diet (SFIH 2019). FAO highlight that "fish is a food of excellent nutritional value, providing high-quality protein and a wide variety of vitamins and minerals, including vitamins A and D, phosphorus, magnesium, selenium and iodine in marine fish."

4.2. Requirements for fish farming

In all salmon production regions, the relevant authorities have a licensing regime in place. The license is a key prerequisite, and it restricts the maximum production for each company and the industry as a whole. The license regime varies across jurisdictions (NSF (2011).

Most of the Norwegian aquaculture is based on anadromous fish (salmonids). It needs to be both freshwater and seawater stage of the production cycle. The oxygen content, temperature, and salt content of the seawater at the fish farm must be monitored closely because it affects the health and welfare of the fish (NSF 2011). Prevention of many diseases is achieved through vaccination at an early stage while salmon are in freshwater. From July 1, 2020, the Norwegian food safety authority (FSA) reported that all fish exposed to feed and broodstock from Taskneset in the south to Langoya at Kvaloya (Somna) in the north are to be vaccinated against pancreatic disease (PD) (ucn 2020).

If the fish farm wants to grow more salmon, they must comply with a strict environmental standard. Those conditions were: A) below 0,1 lice every counting for 2016 and 2017 and B) Maximum of one treatment during the last cycle of production. For sites meeting this standard, a maximum of 6% growth was offered, regardless of the general situation in the different production areas (SFIH 2018).

The cages' location requires good water flow, although the industry has grown, the number of sites fell by 40 percent from 2000 to 2010 (NSF 2011). The cage systems used have fundamentally changed a little from those first produced a moored, floating, and square, hexagonal or circular unit with a closed net hanging down below it. While the first cages were wooden, with a net volume of 3,400m^3, today's pens are either very robust steel square platforms or circular plastic rings with net capacity varying from 3,000 to 40, 000m^3 consists of buoyancy element on the surface and net bag in which the fish swim. Each cage usually has a surface area varying from 400m^2 to 1,100 m^2, and the nets can be from 20 to 50 meters deep. Regulations allow a total cage surface area of approximately 2,800m^3 per license, but the entire area demand will be much larger when mooring systems are included (FAO 2020a). The cage should allow 2.5% of fish out of 97.5% water on a pen. Circular plastic cages require more space than steel platforms (NSF 2011). Figure 4.2.1 photo below shows the open net cage pen.

Figure 4.2. 1: Large floating open net cage pens, photo taken during the visit to the fish farm on Smøla (Source made by the Author of the master's thesis during personal observations)

There are regulations relating to sea lice. The diseased fish is not allowed to enter the food chain. The fish farmer must report to the number of sea lice on the fish weekly, and the report is monitored via the website Lusedata in Norwegian. To ensure that only approved veterinary medicinal products are used, and they are used correctly, only authorized veterinary prescriptions for use to treat fish. There are also regulations for specifying the length of time that must elapse between medication and slaughter (withdrawal time), to make sure that the fish is safe to eat (Government.no 2019).

Government regulations

Since 1975 production has been regulated by government licensing. By the end of 2003, 832 licenses for on-growing seawater and 242 onshore hatchery/smolt production licenses were in operation (FAO 2020a). Under normal conditions, several licenses are operated together, either within the same company or through cooperation between companies. In addition to the licenses, farmers must also have permission to utilize specific sites for production. These production sites are required to operate on a single-year class basis. Once the smolt put into a site in any particular year, the farmer is not allowed to stock new smolt into the same place before the original fish have been grown and all the fish harvested out. Then the site should be left empty or fallow for at least two months before new smolts can be transferred into the sites available for the seabed environment and to reduce any infection pressure in the area (NSF 2011). When farmers apply for new sites, or permission to expand existing sites, the authorities require an environmental survey of seabed conditions at the site. The farmers are also obliged to carry out on-going monitoring of how operations affect the seabed. After six months of production at the site, all installation above and below water must be removed (NSF 2011).

The Directorate of Fisheries is the authority granting all fish farm licenses, as well as having management and enforcement powers. It is responsible for the aquaculture industry's public management, which is an executive administrative body within the Ministry of Fisheries. This agency is assigned the responsibility for coordination, administration, and execution of surveillance and control (FAO 2020a).

In 2005, a new aquaculture law was issued. The focus shifted towards sustainable production and growth in the sector (Norges Sjømatråd 2016). As of 2013, among the regulations a salmon farm must follow is the total number of salmon allowed per cage, which is restricted to 200,000 salmon. They have to remain under the total allowed biomass per concession, which is 780 tons (945 tons in the northernmost counties Troms and Finnmark). For the aquaculture of freshwater salmon allowed biomass is up to 325 tonnes (laksefakta 2018).

Moreover, to control the sea lice problem, fish farm has to regularly count the number of lice per salmon and take action if the number of adult female sea lice per fish is above 0,2 on average in week 16-22 (the migration period for wild smolts).

Directorate of Fisheries, the Norwegian Food Safety Authority, the Norwegian Coastal Administration, the County Governor, and NVE have supervisory tasks regarding the environment and the environmental impacts of a fish farm. Also, through the Internal Control Regulations, the aquaculture industry is required to carry out its own risk assessment in relation to, among other things, the environmental impact, and to have its own monitoring of various environmental conditions in further detail in the various regulations and permits that apply to operations (laksefakta 2018).

Requirements for the technology

Fish farming technology is necessary to ensure quality salmon produced and prevent any environmental and social impact, salmon escape, waste management, et cetera, and ensure all necessary measures are in place.

The systems and technology used in aquaculture have developed rapidly. The system/technology varies from simple facilities (e.g., family ponds for domestic consumption in tropical countries) to high technology systems (e.g., intensive closed systems). Much of the technology used in aquaculture is relatively simple. It is often based on small modifications that improve the growth and survival rates of the target species, e.g., improving feeds, feeding, oxygen levels, and protection from predators (FAO 2020b).

Closed systems isolate the aquaculture systems from natural aquatic systems, thus minimizing the risk of disease or genetic impacts on the external systems.

Significant progress has also been made in the aquafeeds technology, combining many ingredients into tiny pellets (FAO 2020b).

4.3. Production Process

The fish farm has two smolt plants for smolt production, with the total annual production of 3.5-4 million smolts annually. The 75% of the volume sold externally on contracts or spots. The smolt produced from the plants has a size of 150-500 grams before being launched. There are two types of transportation of live fish in the production process. The first one is when the salmon are smolts then are either transported to the sea by truck or well boats depending on the location of the production facility. The second transportation occurs when the salmon is matured enough from 4-6kg, then live fish is transported to the slaughter facility by the well boats.

The fish farm received the license for the development of floating closed fish farming facilities in 2011. The production of large post-smolt at sea begins from 200g to 1kg, and in 2016, the firm developed a concrete cage with the possibility of collecting sludge and feed spill. The production process is divided into five phases, as follows:

Phase 1: Roe

The salmon lives start on land, in a broodstock facility. By using advanced technology, the broodfish characteristics analyzed, and the breeding season manipulated. In this way, the quality of the fish expanded in the seasonal range of production. The fertilization of the roe took place in freshwater and kept at a constant temperature for around 80 days before hatching.

Phase 2: Fry

After hatching, the salmon is called fry. It has a sac on its stomach that it uses to feed itself; two to six weeks after hatching, the fry begins to eat feed and transferred to larger freshwater tanks. Figure 4.3.1 shows fry production with the sac on its stomach.

Figure 4.3. 1: Fry with sac on the stomach (Source made by the Author of the master's thesis during her visit to the fish farm at Smøla).

Phase 3: Smolt

After 10-16 months in freshwater, the salmon are now ready to be placed into the sea. At this stage, each fish weighs less than 60-100 grams, but it has gone through a significant change known as smoltification. This change enables salmon to live in saltwater, and it is now called smolt. The transportation of smolt from freshwater to seawater is done by trucks, or the boat depends on the location of the fish farm's production facility.

Phase 4: Mature salmon

The salmon is now rear in aqua farms (cages) in the sea for 14-22 months. In the pens, fish starts with a healthy diet that offers the same nutrients that wild fish receive at sea. The pallets consist of about 70% vegetable raw material and 30% marine raw material. With high technology cameras and videos, the fish are monitored and promote healthy fish growth and food safety at every step.

Phase 5: Processing

After the fish has reached a weight of 4-6kg, it's ready to be processed. It takes approximately 6-8 hours from sea to shipment; live salmon is brought from the feeding pen to the waiting pens by well boats. Then they are transported into the processing plant where the fish are stun before slaughtering them as quickly as possible to ensure the minimum amount of stress. The transportation of live fish on this stage is done by well boats.

Furthermore, the shipping company gutted and sorted the salmon into size and quality, superior, ordinary, or production. Then packed with ice or sent to filleting before being distributed to more than 100 countries worldwide. Figure 4.3.2 below shows the summary of the fish production cycle.

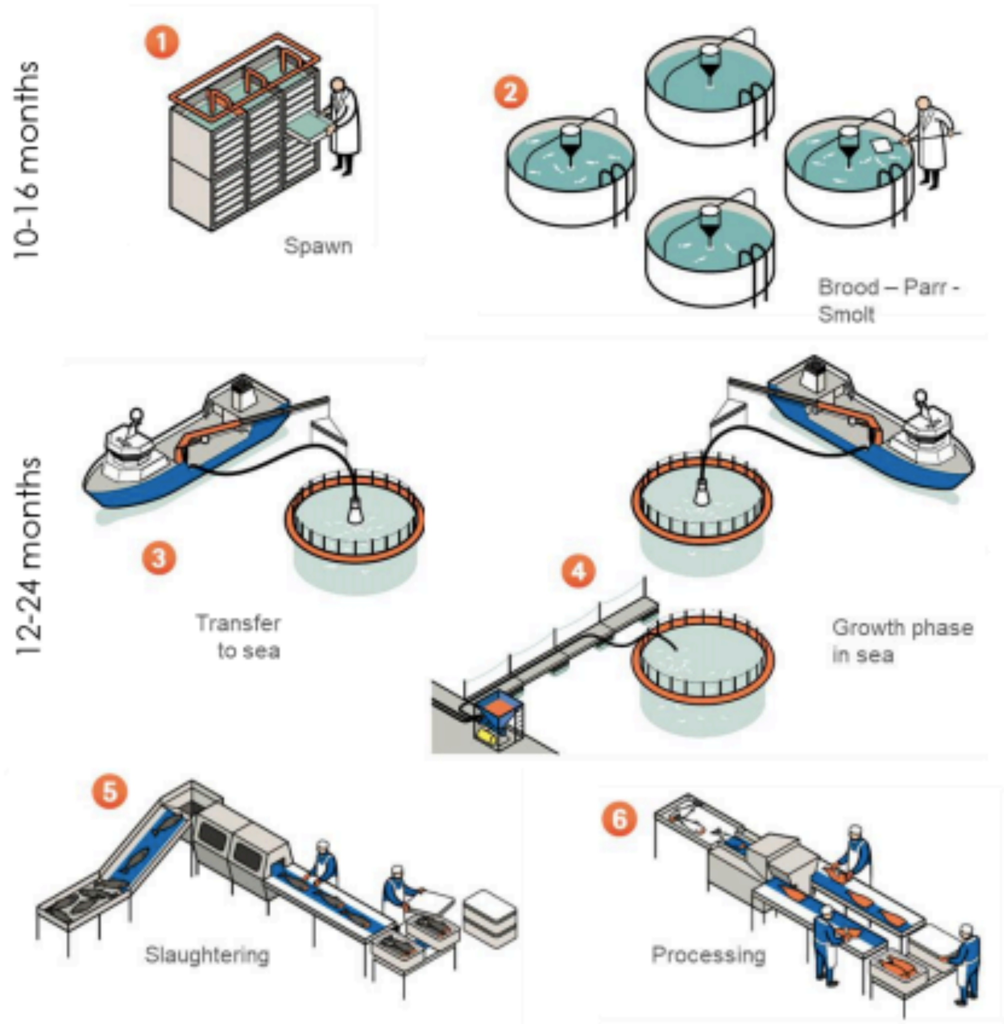


Figure 4.3. 2: Summary of the salmon production cycle, source: SFIH (2019).

When harvesting, the fish are transported *live* from the farms to slaughter facilities in well boats, capable of carrying loads of between 20 to 200 tonnes of fish. The harvesting stations are designed and have operating practices in place to ensure the best possible levels of animal welfare as well as end-product quality. All offals produced during the process channeled into the fish meal production industry, and there is no discharge back to the sea (NSF 2011).

The 70 percents of Norwegian farmed salmon exported chilled on ice, gutted with head-on, and the remainder is processed in a variety of ways (fillets, smoked salmon, et cetera.) or frozen. Farmed cod and halibut have been very well accepted on both domestic and export markets, as has the blue mussel, these species are all sold fresh, chilled on ice (NSF 2011).

CHAPTER 5. CASE PRESENTATION

This chapter consists of a brief description of the case, the past practice of the fish farm production process before integrating circular economy principles. The core part of this chapter is the management of live fish transportation and how circular economy principles in the selected fish farms have affected the environmental and social aspects of sustainability.

5.1. Empirical case presentation

The case fish farm is located on island Smøla in Møre og Romsdal country. It has been performing fish farming for the last 50 years with a tremendous experience in fish farming challenges and technology with more than 12 sites. The fish farm currently has 60 employees.

The case fish farm believes that dialogue between business to business, politicians, and citizens is essential when developing the next generation of aquaculture. The firm is happy to collaborate and share their knowledge with others.
Figure 5.1.1 shows one of the indoor fish farming facilities.

Figure 5.1. 1: Indoor fish farming facility (Source made by the Author of the master's thesis during her visit to the fish farm at Smøla).

The fish farm teaches and recruiting local labor and work with several research institutes to give the best education on aquaculture education in the environment where the values created. The case fish farm also has the latest and foremost in technology and has several own research projects in progress.

For the contribution of the sustainable development of the aquaculture industry, the firm has the GlobalG.A.P. certification. The certification is an international standard for food safety and is a voluntary certification for anyone involved in food production in the world. The main requirement for being certified through GlobalG.A.P. includes the following: low environmental impact in fish farm operations, reduced use of chemicals, a responsible approach to employee health and safety, and reduced use of chemicals. The case fish farm also has the label rouge. This Norwegian Label Rouge means that salmon produced following the French standard LA 31/50. The label rouge owned by the French Ministry of Agriculture and Fisheries and is the oldest official quality mark to be obtained. Manufacturers of Label Rouge are subjects to strict monitoring and control requirements. For example, the entire supply chain from roe to finished products and feed is continuously monitored and audited by CertiPaq Paris. Furthermore, central to the concept is that Label Rouge should be the best in taste, so taste is regularly tested through sensory analyzes and tasting panel of experts and ordinary consumers. Other concepts are better fish welfare, slower growth, and high marine content in the feed (50-70%).

The case fish farm has two licenses for the production of food fish: the viewing license and a Green C license. The aquaculture operator manages the viewing license, this license is under the condition that it made possible for the public to see and learn more about the Norwegian aquaculture industry, both on land and at sea. An operator is allowed to produce a certain amount of fish, which in the professional language is called the maximum allowable biomass (MTB). The case fish farm is authorized to produce a maximum of 780 tonnes of salmon at any given time.

The case fish farm is certified to produce quality, world-class salmon placed in niche markets around Europe.

Figure 5.1.2 below is the fish vaccination machine installed at the case fish farm's land facility.

Figure 5.1. 2: Salmon vaccination machine (Source made by the Author of the master's thesis during her visit to the fish farm at Smøla).

The case fish farm is experiencing some *challenges* during the production process; the operations are not always smooth; some of the challenges being; fish feeds and feeding, wild disease, fish dying, and weather challenge.

Vaccination of fish is mandatory to protect fish against common diseases. The vaccine helps fish against bacteria, so antibiotics are not used. Since 2015, Norway has cut antibiotic use in salmon, which has led to a flourishing industry and a reduction in the risk of antibiotics resistance in humans (regjeringen.no 2015). Although the fish farm *marine biologist and quality manager* argue that:

> ".. *there are fish diseases such as bacteria that fish can get from land and sea that have no vaccine, and only antibiotics can help the fish to get health, people perceive that it is a bad reputation, but it is good for the fish*."

When the fish are at maturity at the hatching stage (when it is an egg), usually died because of fungus, deformities are between 2-4%. Another step being critical is the feeding. If the fish doesn't eat at a particular time frame, then it becomes too thin, and even if it east, later on, it doesn't matter, it dies. So, the case fish farm makes sure all fish eat at the right amount and right water quality all the time. From the first feeding process, usually, there is a loss of 8% of the entire production. The quality manager pointed out that:

> "*... even if you do everything right to control it, you still have a mortality rate of more or less 8% even if the fish don't get sick.*"

Another critical stage is moving the fish to the sea. The first few months are critical to make sure the fish can tolerate seawater. If a change of adoption to seawater on the fish is not completed or not started at all, it may cause death. Death rate is between 1% loss, so for 1mil fish volume production, it is quite a challenge to make sure all can tolerate seawater. After fish reach 16-18 months in the sea, deaths are usually caused by mechanical handling, the case fish farm uses automated methods to reduce sea lice when fish are 4-5kg, so the technique is essential to keep sea lice low. The Norwegian regulations specify that there are must be fewer than 0.5 adult female lice per fish on average in a facility (barentwatch.no 2016).

Feeding is another challenge, especially at sea, when it is winter or storm, the case fish farm calls it, "winter feeding days." The feeding days usually are once a day when there is enough light; they typically perform the feeding at 10 o'clock or 12 o'clock and try to feed as much as possible. The fish meal pallet consists of vegetarian raw material and marine raw material contents. Feed producers have started to produce a fish meal with more plants like soy, grains, et cetera rather than marine raw materials, which seems to be more sustainable to use feed made from the plant. FAO (2009) did a researched the use of wild fish as aquaculture feed and its effects on income and food for the poor and the undernourished, in Europe. The poor and undernourished in Europe are few but mainly in the eastern part. Although some carp cultures were carried out in those regions, and modern farms include some fishmeal in the fish feeds used, feed fisheries cannot be said to have any measurable impact on Eastern Europe's poor people or food insecurity. Neither the fishmeal plants had any significant impacts in the areas of Western Europe where they are located. In 2005, the Veterinary Institute discovered an epic of intestinal cancer with metastasis in the liver and other organs among farmed salmon. They found out that the common thing was the feed, plant feed to be more specific (NMF, 2011).

The challenge is that the fish feed with high marine content is more expensive than the feed made of plants. The case fish farm tries to balance the feeding by providing the fish with the high marine content, which they call it health feed for few days, and then go back to the plant-based feed to balance the cost and as well to keep the fish health.

5.2. Evolvement of circular economy in the case fish farm

The case fish farm started as low capital (family business). The idea of implementing circular economy principles came as idealism to make something valuable for the community, and the case fish farm itself initiated it. The previous practice based on, open system of farming, waste discharge to the ocean, chemical usage on killing sea lice, antibiotics usage to cure some fish disease, which wasn't right for the environment and people.

The case fish farm implemented all three circular economy principles, such as reduction, re-use, and recycling on their operation-to-end product, which is farmed salmon fish, first, through the creation of the closed system of fish production.

The technology of *a closed-system* as a means of production implemented by the case fish farm in 2013 aims to improve the fish growing processes. A closed system is one of the systems that consider to be the low-risk system. Closed system, or closed containment farming methods, use a barrier to control the exchange between farms and the natural environment. The significantly reduces pollution, fish escapes, negative wildlife interaction, and parasite and disease transfer from farms to marine and freshwater ecosystems (seachoice.org 2020).

This technology of the closed system is the better performing resources, the closed system cage, or as they call it open-net pens acts as a barrier to control the exchange between farmed salmon and wild salmon as well, it manages the natural environment. The cage helps to control parasite and disease, so salmon can be treated on the cage without transferring the disease or parasite to wild salmon, control pollution, and ensures high control for fish not to escape. The pens are designed to collect waste as well from the feed and the dead fish.

Norway´s broad areas of marine and coastal waters are rich in resources and support a wide variety of species and habitats. The growing human activity and climate changes are growing threats to the biodiversity of these areas. Therefore, Norway developed an integrated marine management system involving cooperation between authorities in several sectors (environment.no 2018). The fishing vessels and well boats are the ones causing the water pressure at sea, which may result in habitat destruction. The case fish farm has limited the transportation of the fish for at least twice per year; the fish are transported one time from land to sea and as well during transport to the slaughtering facility.

Besides the closed system, the case fish farm has implemented the "Recirculation Aquaculture System (RAS)" and the renewable heat system for its production. The recirculation of water is achieved by employing water treatment, re-aeration, mechanical filtration is done, and biological treatment used to make sure the water is as fresh as possible for the production. In brief RAS system, the water receives treatment for the removal of solids, then ammonia is removed, and finally, the water is oxygenated, and it can be reused (Figure 5.2.1).

Recirculation systems filter and clean the water for recycling back through the fish culture tanks. At least 90% of water is recyclable to freshwater to be used for fish growing, so only 10% of clean water is added to make up the water loss due to splash out and evaporation during flush out fish waste materials to storage tanks. The quality Manager at case fish farm pointed out that:

> *"It is more sustainable at the land compared to the sea, as there is much control of the waste, fewer risks for possible accidents, no disease, and no sea lice. Although the operation is expensive compared to the sea as you need more energy and pump the water which at sea is free".*

The Senior Advisor also emphasized the advantage of the recyclable water:

> *"By using the recyclable water at the plant, we produce two mil smolt per year compare to when we were not, and we were only producing 200 thousand smolts a year".*

The recirculation system has low water requirements, small land requirements, and easy to control water temperature and quality. Also, fish production indoor the farmer not limited by weather conditions whereby sudden storm could wipe out one-year production of fish at sea.

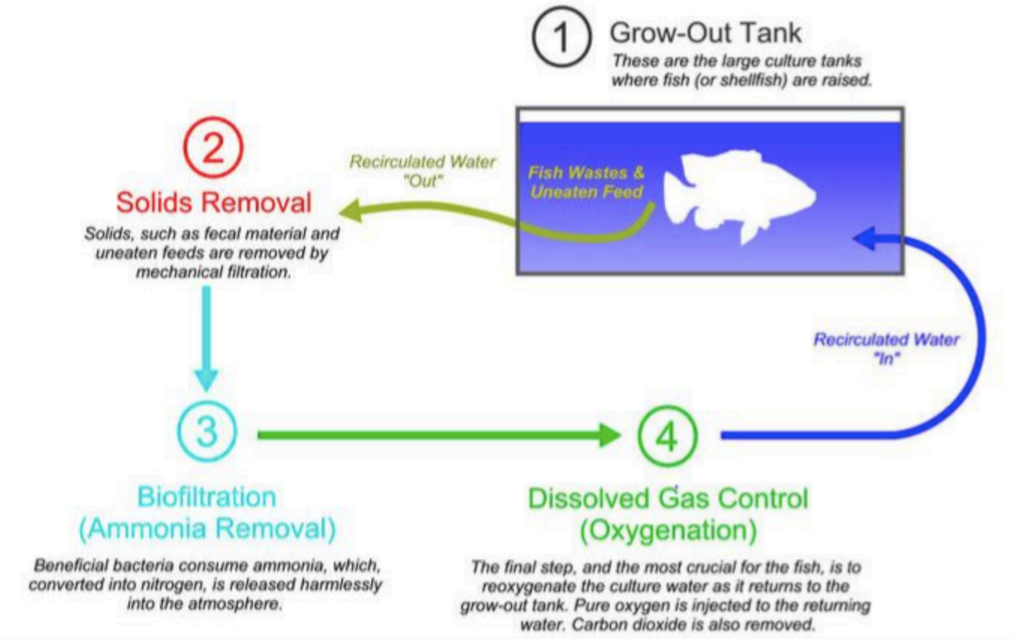


Figure 5.2. 1: An example of a flow diagram for Recirculating Aquaculture System (RAS). Source: http://www.blueridgeaquaculture.com/recirculatingaquaculture.cfm

According to Figure 5.2.1, the process starts with the grow-out tanks where the smolt raised, and then sludge is produced. Then the solids are removed, such as fecal materials and uneaten foods by filters. The third step is biofiltration, or ammonia removal, where beneficial bacteria are realized and converted from ammonia into nitrogen. The fourth step is the oxygenation of water and the removal of carbon dioxide (CO_2), which allows for water recirculation.

The *waste collected* from fish sludges and fish faeces is used on the biogas plants to produce heat. The remaining waste of dead fish sold to other industries where they use the waste to manufacture fertilizer. The scientist from the Norwegian research institute told that:

> *"The advantage of biogas is that it gives out liquid as digest product, which is a very good fertilizer. Also, it can be used to produce feed for feeding micro-ology; besides, it generates sustainable energy and other output from the biogas process, for example, if the biogas is converted by a generator to electricity or compost."*

Figure 5.2.2 illustrates the whole biogas production chain starting with the substrate input and ending the biogas output of diesel and fertilizer.

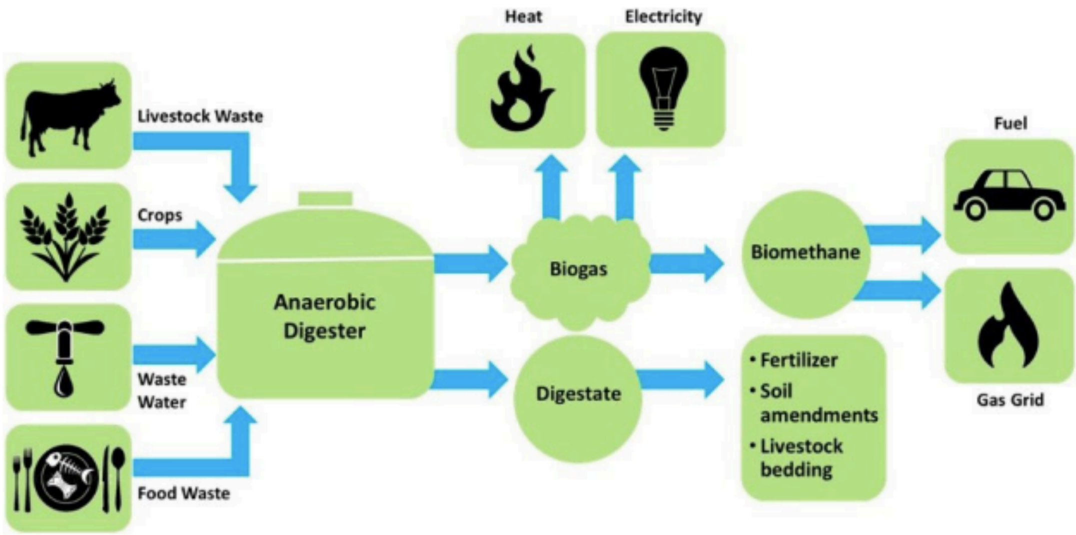


Figure 5.2. 2: Illustration of the biogas value process chain, source: (publications.lib.chalmers.se 2018)

Biogas production is a fragile process that can be inhibited by an imbalance between the microorganisms performing the different steps. The process is influenced by the temperature composition of the substrate and the timing of feeding the reactor with the substrate (Vangdal et al., (2014).

The case fish farm doesn´t use any chemicals on the production to make sure the salmon produced are of good quality for human health. For removing sea lice, the delousing system is used to flash and clean the fish removing the sea lice and using a fish cleaner (wrasse), which eat sea lice on the salmon. The case fish farm pays local fisheries to catch the cleaner fish, there is a massive demand for the wrasses, and even official guidelines are in place on how to fish, handling, and transportation of wrasse. Eurofish magazine (2020) reported at least 15 million wrasses would currently be necessary to meet the Norwegian salmon industry´s requirement. The ration of two to three wrasses are required for 100 salmon production.

5.3. Interactions between circular economy and sustainability in fish farming

Fish feed

Most aquatic feed producer globally is used for carp as this is the predominant fish species. Feed for salmonids only accounts for 10% of the total production of aquatic feed. Feed is considered a perishable product with a shelf life normally up to a maximum of one year. Historically, the two most essential ingredients in fish feed have been fish meal and fish oil. The use of these two marine raw materials in feed production has been reduced and replaced with ingredients such as soy, sunflower, wheat, corn, beans, peas, and rapeseed oil. This substitution is mainly due to substantial constraints on the availability of fish meal and fish oil and for the sustainable feed sources (SFIH 2018).

Salmon have specific nutrient requirements for amino acids, fatty acids, vitamins, minerals, and other lipid and water-soluble components. These essential nutrients can, in principle, be provided by the range of different raw materials listed above. Fish meal and other raw materials of animal origin have a complete amino acid profile and generally have a higher protein concentration compared to proteins of vegetable origin. As long as the fish receives the amino acid, it needs it will grow and be healthy, and the composition of its muscle protein is the same irrespective of the feed protein source (SFIH 2018).

Feed wastage, and pollutant loadings are much higher in the open-sea cage on the culture systems where trash fish used as feed. According to the UN, 7 million tonnes of wild catches are destroyed or discarded as non-commercial harvest annually by commercial fisheries for feeding farmed salmonids (SFIH 2019).

A potential shortfall in the supply of fish meal and fish oil, concerns have recently been raised regarding the sustainability and ethical arguments for utilizing fish species that could be used directly as food for humans in animal feeds. Over the last five years, many studies have investigated a range of fish oil substitutes in a wide range of species. However, all of these earlier studies fed the experimental diets for only a small part of the growth cycle for each species, usually only for 8–20 weeks (Bell and Waagbø 2008).

The fish farm marine biologist and quality manager argues that:

> "*.. fish are predictors, and fish get more health when the feed has more marine raw materials. Although circular economy sustainability has been developed now, this new food made from plants has been recognized as "sustainable," but the health and quality of fish become poor. It has been a challenge to balance the quality and health of fish and still to be sustainable.*"

The Senior Advisor of the case fish farm added that:

> "*the marine feed used by our firm is from sources not suitable for human consumption, derived from secondary fish products (waste cuts, heads, central bones, skin) and pelagic species that are not so commonly used for human consumption. These species die after one year if left compare to plant feeds, which are usually from Brazil and transported around the world, which is not sustainable at all. We want to be sustainable but still to provide salmon with enough nutrients for human consumption, so it has been a challenge to balance this.*"

Sustainable fish farming demands sustainable feeds, but findings show that sustainability is not a prior good. The fish feeds made from plant, although it has been labelled "sustainable" but doesn´t provide the fish with enough nutrients to grow and to be healthy and quality for human consumptions. The balance between feeding fish with traditional food and more "sustainable" food is still a challenge for the case fish farm to balance the need of the fish and to be sustainable.

Fish cleaner (wrasse)

The use of cleaner fish by Norwegian salmon farming has increased in recent years. The fish cleaner has been considered a "sustainable" way of cleaning sea lice on the salmon and keep lice numbers down. The use of wrasse as `cleaner` fish is part of a long-term plan to replace chemical usage on killing sea lice on salmon. But this exploitation of wrasse is raising concern. The wrasse that has finished cleaning lice are killed and discarded. There is a fear that the wild wrasse populations are shrinking severely. However, some aquaculture companies now have fishing wrasses and lumpfish out of cages for reuse (sciencenorway 2020).

The count shows that four out of ten cleaner fish die during a single round of salmon production of a year. Salmon and cleaner fish have different needs in terms of the environment in which they live. Nevertheless, they are expected to handle living in the same cage with salmon. The cleaner fish need enough food, oxygen, and protected areas where they can hide and rest, which are usually not provided by all fish farms. In the natural world, wrasse can live for at least 7-8 years (sciencenorway 2020).

The introduction of new regulation of fewer than 0.5 lice per salmon, have made the demand for wrasse to increase. If there more than one-half mature louse per salmon, fish farms must slaughter all the salmon. Although this way of keeping low sea lice on the salmon seems sustainable, there are still challenges in keeping these wrasse populations from shrinkage.

Other being hunger as one of the reasons for mortality, cleaner fish eat only lice as a snack and need their feed, which is different from that of salmon. Some fish farmers only occasionally fed cleaner fish, or only feed them little overtime to increase their appetite for lice. The temperature of water at the sea, oxygen, and shelter for cleaner fish is different compare to salmon (sciencenorway 2020). The case fish farm Senior advisor pointed out that:

> *"Our farm has been certified by Marine institute due to the best sustainable way of controlling sea lice on the salmon by using the cleaner fish that eat sea lice from the skin of the fish. However, it has been a challenge to manage these species, especially at the sea cage, and provide them with what is needed."*

Although the fish cleaner has been considered the most "sustainable" way of cleaning sea lice based on circular economy principle as an alternative way of chemicals, there is still concern about the usage of these species. Other specialists have pointed out the shrinkage of these living species due to the high demand and worse management that will lead to the disappearance of these living species in the near future. The balance between being sustainable on using these species for removing the sea lice and keeping these species alive in the next years is required.

Wild salmon and farmed salmon

These sectors provide different social, economic and cultural benefits to society, but also face many problems and challenges. They have different interests, practices, traditions and audiences, and are also administered by different authorities and regulated under varying management regimes and legislations. These two sectors complement each other in terms of product supply, employment creation and income on the other hand, they face conflicts over management objectives and strategies.

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These two sectors intersect closely in production, especially since the environmental effects brought about by salmon aquaculture, such as escapees and sea lice infection on wild salmon stocks, have intensified with the rapid expansion of salmon aquaculture. The significant adverse environmental and biological effects associated with farmed salmon include disease and parasite transfer and spread, particularly sea lice infestation and interbreeding. Studies show that interbreeding between farmed and wild salmon causes changes in genotypes and the loss of genetic variations in wild salmon populations (Liu et al., 2011). The concern being the repeated intrusion of escapees may potentially wipe out wild salmon populations, which is caused by open cage farming. In the long run, this may be a worry for the aquaculture sector since the farmed salmon broodstock originated from wild stocks that are selected from the various salmon rivers. Broodstock fish chosen can be used for ten generations, and a new selection cycle starts again.

During the visit the Norwegian Research Institute, the scientist emphasized this issue:

> *"...I´m very critical with fish farming, especially salmon, I believe we should do more to protect wild salmon and to encourage the protection of wild salmon habitat. For example, in the United States (Alaska), salmon farming is strictly forbidden because wild salmon is very important for the economy. The focus should be on the regenerating wild salmon habitat and wild salmon population and do more to find alternative feed ingredients for salmon farming. Like using the waste from (gamma rides) by adding organic materials through modern agriculture and integrating food production. A new*

technology of fish growing like aquaponics can contribute to a more regenerative system..."

It has been an extensive discussion regarding the issue of wild salmon and farmed salmon on which way of production is more sustainable. A lot of concern has pointed out on the farmed salmon regarding the escapee and interbreeding, which changes the genetic variation of the wild salmon. And feeding wild salmon to farmed salmon, on the other hand, farmed salmon still depends on the wild salmon for the salmon broodstock that is required for the production of salmon. The question between which one of the productions is "sustainable" is still a debate in the literature that is not the purpose of this master thesis and remains for other research.

Further, improved logistics systems made possible by fish farming will also help develop the culture of other species in competition with capture fisheries. What is also seen today is integration between the traditional fishing and aquaculture. ´Capture-based aquaculture´ is now creating quite an interest, where fish is caught and brought ashore *alive*, graded, held in pens, fed if necessary, and harvested in response to market demand (FAO 2020a).

5.4. Management of live fish transportation

Transport of live fish has always been associated with a high risk of spreading contagious diseases. Norwegian competent authorities have a long tradition concerning regulating such transports, and despite the development in technology and improved regulations, the risk of spreading diseases is still high (NFSA 2019). The fish kept alive for as long as possible until they reach the processing plant. The aim is to keep the fish fresh and of good quality for as long as possible (FAO 1995).

There are no exact statistics for transportation of farmed fish, but fish is at least transported twice during their lifetime first, from hatchery to growing sites and, secondly, to slaughter stations. The number of transported fish is increasing mainly due to increased production and to the centralization of the slaughter facility. In Norway, well boats are the most common way to transport fish, but trucks are also used for the transportation of fingerlings and smolt. The transportation of live fish by air is less common for economic reasons (VKM 2008).

There are two basic transportation systems for live fish, the closed system and the open system. Recently, regulations and restrictions due to the occurrence of infectious diseases have, to some extent, required that more live fish have to be transported in closed systems and should be as short as possible (NFSA 2019). Transportation in closed systems requires treatment, as well as systems for observation of fish and monitoring of water quality. Consequently, well-trained crew and skills to handle emergencies are needed. But the advantage of closed transport might be associated with the sedative effect of mil carbon dioxide exposure, given sufficient oxygen and slow cooling system (NFSA 2019).

5.4.1 Challenges for live fish transportation

The welfare of fish is an essential criterion, such as freedom from severe (long-lasting) stress, suffering, and pain. Several researchers pointed out that physical disturbances during the transportation and slaughter of fish have the potential to induce stress responses that affect meat quality (VKM 2008). The case fish farm tried to control the transportation of live to twice. When salmon matured to smolts are transported to sea either by truck or well boat depended on the location of the facility and to the slaughtering facility. VKM (2008) outlines the factor that leads to stress in fish, including handling, crowding, temperature, and water quality;

1. Handling

Transport and handling procedure consist of several potential stressors, such as capture, on loading, transport, and unloading. Handling of fish during transportation has a significant effect on the fish (Barton and Iwama 1991) pointed out that the stress of capture and handling has a profound impact on the blood chemistry and stimulated gonadotropin, androgen, and the stress hormone cortisol.

2. Crowding

There is a difference between loading and density, while loading is defined as the weight of fish per unit of flow (kg/l/min); density refers to the weight of fish per unit space (kg/m3). So, when the system is static, the fish have a decreased volume for water exchange, potentially affecting water quality and related stress responses. This stress is often associated with high stocking densities leading to crowding stress (VKM 2008). Short term crowding stress occurs commonly in aquaculture practices; possess characteristics of acute as well as chronic stress with long-term compromised immune systems resulting in disease or death Portz et al., 2006 . So optimal densities at loading and in transport tanks should always be taken care of regardless of profitability or convenience (Portz et al., 2006). The case fish farm has pointed out that this is the most risk procedure on the transportation of live fish, the quality manager emphasized that:

> *"The sea cage is huge, so you need to crowd the fish before pumping them on the well boat for transportation. Crowding is the most risk procedure because crowding fish too tight or the water too warm at sea, and low oxygen may damage the fish. It is like a work of art; you need to know what you are doing. It has a lot of potential to go wrong than mechanical. It also involves a lot of professional people in the process."*

3. *Temperature*

Fish are poikilotherms, and an increase in ambient temperature will increase their metabolic rate. Thermal stress occurs when the water temperature exceeds the optimal temperature range, with energy demanding stress responses and a potential decrease in individual survivorship (Portz et al., 2006). Most fish can gradually acclimate to regular temperature changes. Still, rapid changes in temperature, as may happen under fish loading, offloading and transportation, may result in thermal stresses or lethal conditions (Portz et al., 2006). Measure to reduce this stress is reducing feed intakes and growth, reduce swimming behavior. Others are reducing sudden or erratic movement, which may cause a possible collision with the tank wall or with other fishes, increased regurgitation, defecation, and gill ventilation measured to be taken (VKM 2008). According to Portz et al., 2006 , state that state that the temperature should be similar to the source, to avoid thermal shock when the fish transferred to the holding system, the temperature for tropical fish ranging from 18 to 28 degrees Celsius, the ideal temperature is 21 to 25 degrees Celsius.

4. *Water quality*

The most common water quality parameters include temperature, dissolve oxygen, ammonia, nitrite, nitrate, salinity, pH, carbon dioxide, alkalinity and hardness in relation to aluminium and iron species that affect physiological stress (Stefansson et al., 2007).

All transportation of fish will, to some extent induce stress, related to factors like changes in water chemistry, pH, temperature, foaming, loading and unloading, transportation time, and biomass that needs to be controlled as explained above.

In Norway, transportation of live fish is monitored, and vessels need to be approved, and the list can be found on the mattilsynet.no website. The record shows that there are currently 304 approved vessels for live fish transport (Mattilsynet 2019).

The fish's metabolism will influence the water chemistry and, thus, the welfare of the fish during transportation. Except for young fish (larvae), all fish starved for three to five days before transportation. In this closed system of transportation, the concentration of CO_2 should be below 20 mg/L. During transportation of fish for slaughter with chilled water, the light sedation due to accumulation of CO_2 is considered beneficial i.e., up to 30 mg could be accepted (VKM 2008). These as well depend on biomass, temperature, and duration of transportation.

Closed transportation should be as short as possible, both in distance and time. The extended transportations can be performed with reduced biomasses. By adding seawater to reach a salinity of 1‰, then the buffer capacity in freshwater will increase, and the risk of accumulation of CO_2 and mixing of different water qualities will, to some extent, be reduced but as well necessarily treatment of the seawater must be followed. For Atlantic salmon, the transportation temperature should not aim to be below 6 ^{0}C (VKM 2008). A lower water temperature during transportation can reduce the impact of several factors on fish physiology and welfare.

In the regulation (Mattilsynet 2019), the well boats, pumps, and pipes are defined as the transport system, which also includes water oxygenation equipment. The regulation consists of specific rules for approval, washing, and disinfection of transport systems. Both trucks and well boats will usually supply extra oxygen to the fish during loading, transport, and unloading, and several methods for oxygen supply used. The opening of the valves can control the water exchange in most well boats, the speed of the vessel, or large circulation pumps while in trucks, water exchange must be carried out by water tapping and refilling. Cooling of the transport water reduces the metabolism of the fish, thereby delaying the deterioration of the transport water in closed systems (VKM 2008).

5.4.2 Characteristics of live fish transportation

The fish farm currently uses two characteristics of transportation to transport live fish, which are trucks and well boats. The land fish farm facility located far from the sea farming and the slaughtering facility so, it is necessary to transport live fish.

The transportation of live fish performed twice. The case fish firm received the roe from other companies for the production of salmon through trucks. Once the smolts reach, 10-16 months are ready to be transported to the seawater. The transportation is done by trucks or well boat depending on the location of the facility. Once the salmon matured at the weight of 4-6kg are transported by well boat to the slaughtering facility.

The truck fleets

All transport vehicles meant for transport of live fish destined for aquaculture purposes must be approved by the Norwegian Food Safety Authority (NFSA). The approval is valid only for five years from the date of issuing. A standard size of the fish containers on a truck is 1-5 m^3. There are several fish containers, and total transport volume on a truck with trailer is often 20-30 m^3 (VKM 2008; NFSA 2019).

The *Managing director* of case fish farm stated that:

> *"…the oxygen is very important to keep an eye on the water temperature; if 200 to 230 kg fish in each tank during truck transportation, it won´t take more than 5 minutes when the water temperature is 13-14 degrees so fish could die".*

Other challenges being the weather and narrow shape road for transportation of live fish by road.

The well boat fleets

The first Norwegian well boats were originally fishing vessels used for live transport of saithe (*Pollchius virens*) and cod. In the 70´ties, well boats came into common use in transportation of farmed salmonids. Since 2002 another 29,500 m^3 capacity was added to the Norwegian fleet. The vessels technical standard contributes to the risk associated with the transport of fish in general and specifically for transport on a closed system (VKM 2008).

The managing director of the fishing firm pointed out about the process of the new technology well boat that uses a completely closed system for the transportation of the live fish that they use. He emphasized:

> *"… the technical solution for this system focuses on the well-being of the fish, hygiene and quality".*

The entire process of loading the fish, unloading the fish, and getting ready for the new cargo works as follows:

The fish swim into the cargo hold by creating a negative pressure in the well, passing counting devices to keep the numbers of fish. As long as there are fish in the tanks, the water is continuously recycled, adding oxygen in the process and carbon dioxide removed by aeration. The water cleaned by skimmers removing the proteins, which consists of bacteria and waste matter, this waste or protein foam is heat treated before being released back into the sea. The water and its fish can be cooled down to the desired temperature by Refrigerated Seawater (RSW). And for the well-being of fish, water cooled by 1.5 degrees Celsius per hour to maintain the quality of the fish. Unloading is carried out by vacuum pumps or by pressurizing the tanks to make the fish swim back out. The fish are pushed toward the pipe inlet by a sliding door inside the tank. The unloaded water is continuously being pumped back into the tank; transportation water is disposed of at the prescribed area after the operation. Tanks piping and all other equipment are cleaned and disinfected prior to a new operation.

The process is the same for the transportation of smolt to the ocean cage. Sensors and video cameras survey the entire process, and all the significant parameters such as H_2O, CO_2, O_3, pH and temperature monitored. The closed well boat concept used as well for the controlling of the parasite treatment for the large quantity of fish and as well as sorting the fish by size and weight. It can delouse 20 to 50 metric of fish per hour per line, depending on fish size and fish health, and remove 90 to 95 percent of sea lice from the fish. The well boat keeps the water on board and release it back to a safe area at sea at the end of the transport by pumping oxygen into the water and removing carbon dioxide. The well boat can run more prolonged operations on closed valves without affecting the fish.

The water cooling is done throughout the operation to maintain fish quality and as well to keep the fish calm and extend fresh fish shelf life. The well boat also reduces the contamination, so higher quality fish kept throughout the operation. Figure 5.4.2.1 below illustrate how the well boat closed system works.

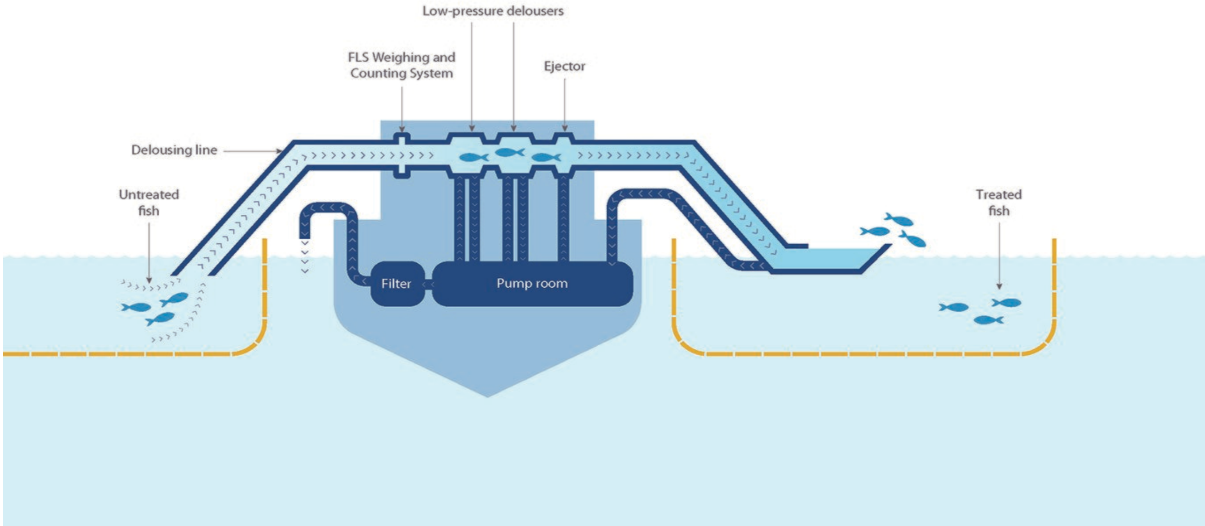

Figure 5.4.2. 1: Illustration of the delousing system and how it works, source: (TheExplorer 2020)

In Figure 5.4.2.1, the FLS Delouser flushes the fish through a vacuumed pipeline with seawater at the seawater temperature. The pressure is kept very low in the pipeline, resulting in fewer injuries and low mortality rates. The FLS Delouser removes the fish from a net-pen and release them straight into a net-pen after treatment. In this way, the fish are not exposed to the air, fluctuating temperature, or harsh weather.

5.5. Effects of circular economy in fish farming on the environmental aspect

The potential of farm salmon considered to be growing, but at the same time, sectors in the Norwegian society are concerned due to practices implemented in salmon farming. These groups of society are the professional fishers, sport fishers, conservationists, and recreational groups, which demand the increase in production to stop due to the harm caused to the ecosystem (Hersoug 2015). Today most marine aquaculture facilities are located in fjords or along the coastline. Waste feed, feces, fish escapes, and high concentrations of parasites have negative impacts on both the local environment and wild fish stocks. Skogen et al., 2009, imply that the location of the fish farms was of more importance for the environmentally friendly, the best localization of the fish farms found to be near the mouth of the fjord where the water exchange with the coast is the largest and preserve environmental effect. The statement was decline by (Carroll et al., 2003) on the analysis of data from than 80 active sites in Norway. The report shows that neither depth nor current speed alone are good predictors for the sedimentary environment's environmental quality. Instead, the study gives a strong indication that the management practice of periodic abandonment of sites to allow recovery (fallowing) is one of the best management tools for sustainable fish farming.

Fish production from marine aquaculture sites generates considerable amounts of effluent, including nutrients, waste feed and feces, and by products such as medications and pesticides. These effluents can have undesirable impacts on the local environment, depending on the amounts released the time-scale over which the releases take place, and the assimilation capacity and flushing ability of the local recipient water body (Kelly et al., 1996; TheExplorer 2019). The case fish farm pointed out that they are not using chemicals at all, only in one condition. The quality manager pointed out that:

> *"Chemicals used only to disinfect well boats before transportation of live fish. The well boats can be a source of sea lice transportation due to traveling from site to site, so we use the chemicals to make sure the well boats are clean and disinfected from bacteria..."*

The Green Warriors of Norway (NMF 2011) reported on the environmental impact of North Atlantic Salmon farming in Norway. The report shows at least five effects of salmon farming in Norway, which are; escapes that threaten the wild salmon, large quantities of waste directly into the sea, aquaculture feed to wild fish, and spreading of disease, and as well farmed fish mistreated.

The report well supported by (Taranger et al., 2015) on the risk assessment of the environmental impact of Norwegian Atlantic salmon farming. The research reported on the risk assessment of the farmed escaped salmon between the year 2010 to 2012 were moderate to high risk experiencing genetic changes due to introgression of farmed salmon. The number of salmon lice infections year 2010-2013 estimated at a total of 109 stations covering relevant areas of the Norwegian coastline with the high frequency of the viral disease outbreak, i.e., PD, IPN, heart and skeletal muscle inflammation and CMS in salmon on the same years' rate (Tanger et al., 2015). The escapes of farm salmon infected with sea lice considered dangerous because the sea lice can exterminate wild salmon. Hydropower plants threaten wild salmon smolt in Norway because the water damming reduces the water flow and elevates water temperature, which gives a lethal kidney disease to the salmon (Sterud et al., 2007).

Svåsand et al., 2016, pointed out on the impacts of the level of the nitrogen concentrations that are increasing in the oceans. Although not considered a significant impact on the environment with production level in most locations, in areas with high fish productivity and pour water flow, such as the deep fjords, it can be a problem. The same impact was pointed out on the increased loads of organic materials in the ocean due to the waste discharged from fish farming (Svåsand et al., 2016).

Other environmental impacts include greenhouse emissions, acidification, reduced biological diversity, eutrophication, ecotoxicity, and visual disturbance (Ellingsen et al., 2009).

Fish feed is also another concern of the environmental impacts, mainly the current feed, which made of plants; for example, the substantial amount of soy imported for use in dry fish feed, which impacts local ecosystems. The aquaculture industry must find methods of maintaining nutritional quality while sparing the environment, (TheExplorer 2019). Some companies now have developed some environmentally friendly fish feed. Such as copepods, which are zooplanktons found in abundance in all the world's oceans their natural prey organisms for wild marine fish and prawn larvae, their fed with CO_2 absorbing algae, ensuring positive carbon production. The Norwegian Research Institute *scientist* mentioned the new alternative fish feed currently still under testing, which made of small tiny shrimps that live in title zone. He pointed out that:

> *"The new feed will be alternative source of omega 3 oil and protein for fish feed and as well human consumption. The advantage of this feed is that shrimps have pink color (astaxanthin), which is natural color while during fish farming, the color is added to the feed to give salmon the pink color which is synthetic. The feed will also be environmentally friendly..."*

Sea lice are one of the most pressing challenges facing the aquaculture industry. These parasites release their eggs into the water. The eggs develop into larvae that attach themselves to fish, retarding their growth, disrupting their salt balance, and making them vulnerable to disease and predation. Norwegian companies have been using their creativity to come up with the prevention of this pest from attacking fish and as well without harming the environment. One of the technologies is the use of electrical pulses to inactivate sea lice before they attach to the fish. This method stops infestation within the cage and further spreads to the surrounding environment without any damage to the fish (TheExplorer 2019). Another technology is the laser's use to shoot down sea lice by scanning each fish for parasites and then destroying the sea lice one by one with a laser. The method doesn't require handling or moving the fish. It used to remove and control sea lice on a continuous and preventive basis. Another technique is the preventive method through discover sea lice at an early stage. This method has been an effective way of monitoring fish and counting of sea lice and preventing sea lice entering the cage in the first place (TheExplorer 2019). It is a system that acts like a mosquito trap, luring in sea lice through a combination of attractors and then containing them (TheExplorer 2019).

The case fish farm uses a sustainable closed system aquaculture, which is one way of solving environmental challenges associated with marine aquaculture along the coastline, that is, enclosing the fish farms. The closed system facilities prevent fish escapes, eliminating risk to wild fish stocks and allow waste to be collected instead of being released to the sea or ocean. The closed-loop system as well significantly reduces the risk of sea lice outbreaks.

The Norway fisheries authorities suggested four new reforms that all contribute to the greening of the Norwegian salmon production. In 2013 Ministry of Fisheries and Coastal Affairs came up with the idea of introducing a new license under much stricter conditions that fixed the limit of a maximum of 0.5 sea lice per fish. One year later, a new conservative/right government taken over and finalize the allocation of green licenses. The new proposal to use an average maximum allowable biomass (MTB) over the year, proposing each existing farmer should be able to increase its MTB volume by five percent under new and very strict regulations regarding sea lice. The mister also initiated a more predictable, long-term growth, under which the growth parameters were fixed and transparent, and the new proposal presented for the public year 2014. And lastly, a new green management policy was developed whereby the Norwegian Food Safety Authority (Mattilsynet) has to do the counting of sea lice in all sea pens at all farms every week. The Norwegian Food Safety Authority as well demanded the slaughter of all or some of the salmon at the farm if found to have more than required sea lice (Hersoug, 2015).

5.6. Effects of circular economy in fish farming on social aspect and societal values

The impact of aquaculture on the social aspect and societal values varies tremendously. Aquaculture is also making substantial contributions, freshwater aquaculture, in particular, to the availability of nutritious food to both farming households and broader society. Inland fisheries contribute significantly to food security and economic security by providing primary sources of animal protein, essential nutrients, and income (Welcomme et al., 2010). The food and income benefits provided by inland capture fisheries and aquaculture can offer opportunities for empowering individuals where opportunities in other sectors are limited. Over 90% of global inland capture fisheries production used for human consumption, most of which is in the developing world (Welcomme et al., 2010). As well fishes provide protein such as omega-3, fatty acids, vitamin D, calcium, B vitamins, vitamin A, iron, zinc, and lysine to those where other nutritional sources are not available or are cost-prohibitive (Youn et al., 2014).

Neiland et al., (1991), identified the possible social and economic benefits of aquaculture in Europe, such as increased fish supply, fish price reduction, export earnings, employment creation, conservation of social structure, and improved infrastructure in rural areas. Aquaculture can, however, cause unwanted societal effects when it produces boom and bust cycles or otherwise collapses, for example, due to disease outbreak, food safety recalls, or natural disasters (Slater 2017). Resource conflicts can rapidly arise when traditional users feel that aquaculture is encroaching on their "path" Orchard et al., (2015). However, most of these defined disturbances to traditional societies are typical for fast-expanding industries, not aquaculture alone.

Aquaculture offers significant societal benefits in terms of access to food, contribute to infrastructure development, education, and healthcare. Many aquaculture industries in developed nations suffer from low availability of high paying jobs combined with a lack of appropriately trained staff willing to work in menial positions for low wages (Slater 2017).

The World Health Organization recommends eating oily fish like salmon at least twice a week because it´s a rich source of protein and one of the best sources of omega-3 fatty acids. In the human body, omega-3 fatty acids are involved in several vital metabolic functions, which on a more significant level, promote healthy heart function, preventing disease and strokes (Eric et al., 2019).

The strong linkage between aquaculture and human culture can result in fish becoming a cultural icon with community importance that extends beyond food value. For example, Murray Cod (Maccullochella peelii peelii) in southeastern Australia serve as unifying symbols of regional identity. The sense of identification for fishing communities has been described as having fishing "in the blood" (Smith et al., 2003), which can foster environmental stewardship.

The case fish farm pointed out that the farm has brought new job opportunities to the community i.e., any service required for the farm, such as maintenance, electrician is acquired locally. The local fisheries as well get extra income through fishing sea lice for the farm during fish growing.

CHAPTER 6. DISCUSSION

This chapter represents the analysis of the case fish farm's empirical findings and the discussion performed by comparing the findings and the literature review from chapter two.

6.1. Analyses of the empirical findings

The implementation of circular economy principles in the fish production process and SCM practices have helped the case fish farm to receive positive outcomes on the environmental, social and add society values of the local community at Smøla. Table 6.1.1 below illustrates the summary outcomes of the implementation of circular economy principles on the case fish farm.

Table 6.1. 1: Implementation of circular economy principles in the fish farming process

No.	Principles	Fish farming process	Outcome
1.	***Reduction***	- Closed system - No chemical usage	- Reduced pollution - Reduced fish escape - No interaction with wildlife - No parasite and disease transfer from farm to marine.
2.	***Re-use***	- Collection of waste from feed and feces	- No waste to sea and landfill hence no environmental impact. - Production of biogas, manure (fertilizer).
3.	***Recycling***	- Recirculation of water - Heat is renewable for the entire production system (Biogas)	- 95% of water is recyclable (preserve water). - Less land requirement - Easy to control water temperature and quality. - Freshwater ecosystem

Table 6.1.1 shows the research findings of the implementation of circular economy principles into the case fish farm at Smøla. These three circular economy principles have been elaborated on the case fish farm, first of all, through the installation of the closed system in 2013.
The closed system supported the fish farm to reduce the fish escape, reduce the interaction with wildlife, and reduce the disease transfer to wildlife. The collection of waste from feed and feces and re-use them to produce biogas and manure (fertilizer) has brought a considerable advantage for the fish farm; hence no waste is disposed to land or sea, which has led to the environmentally friendly production. And last but not least, the recirculation of water led to

preserve of water. At the same time, heat is renewable through biogas made it convenient to control the water temperature and quality throughout the production process.

Compared to the previous practice where the case fish farm had challenges maintaining the environmentally friendly production and operation of fish growing, the implementation of circular economy principles on the case fish farm had a significant impact on tackling those challenges.

The findings have shown circular economy principles implemented through stages of fish growing from roe to matured salmon on the case fish farm. The findings revealed many challenges the case farm faces on the fish growing and production with circular economy principles introduced. The transportation of live fish requires the management of stress, crowding, temperature, and water quality to ensure the salmon is of the best quality as a finished product. The conclusive about fish feeding, a balance should be forced in traditional feed labeled "sustainable," the findings have revealed in the challenging about balancing circular economy and sustainability in the fish feed. Also, the management and balancing of fish cleaner in a more sustainable way advised. The findings showed that balance is required between a circular economy principle and sustainability to align with each other to make them sustainable.

It is as well crucial for all the three aspects of sustainability to be balanced equally. The findings have revealed the contribution of circular economy principle implementation to the three elements of sustainability. The application of new technology of farming has contributed to the control of the environmental impact, i.e., no waste, chemicals disposed to the environment.
Implementation of circular economy principles has contributed to the new job creation, new infrastructure development in Smøla island. Producing health salmon with enough nutrition for human consumption and, hence, gaining extra benefits for the whole fish farming.

6.2. Discussion

The development of circular economy principles on the existing SCM practice of the Norwegian fish farm emerged as a consequence of several environmental impacts. The previous method based on, open system of farming, waste discharge to the ocean, chemical usage on killing sea lice, antibiotics usage to cure fish disease, which wasn´t right for the environment and people. The decision was a company idealism to make something valuable for the community. The Norwegian fish farm then implemented a closed system of fish farming in 2013. This strategic action made it possible for the fish farm to improve the environment, add value to the community, and keep salmon of high quality as a final product. The new innovative SCM practices, such as the recirculation of water and renewable energy for the entire production system, encouraged the fish farm to collect waste from the sea farm and land to produce more and health salmon. These findings are consistent with (Yong 2007; Mudd et al., 2011; Samiha 2013; Ahmadi 2017; Huang et al., 2018), who emphasized that the "3R" principles have become the only acceptable ways to dispose of waste in practice.

Further, the findings have indicated various collaborations between the case fish farm, slaughter facility, and local fishery. The partnership with the local fishing on fishing the cleaner fish have brought benefits to the local fisheries on gaining extra income. The supply chain between fish farm and slaughter facility has improved the quality of the salmon as well. This finding is consistent with McKinsey (2016), report, who has implied that it is essential to establish collaboration between stakeholders within a supply chain to add value and create a shared network for economic benefits.

The development of supply chain operations based on three aspects of sustainability through the implementation of circular economy principles, has ensured the fish farm further step towards sustainability. This finding is consistent with the findings by Bakker et al., (2014), who imply that a circular economy and sustainability are interrelated, and circular contribute to sustainability. Table 6.2.1 below shows circular economy implication on the three aspects, i.e., social and societal value, environmental and economic.

Table 6.2. 1: Circular economy implication on the aspects of sustainability

No.	Aspects	Circular economy implications	Outcome
1.	***Social and Societal value***	- Collaboration with local fisheries. - Collaboration with slaughter facility. - Collaboration with local community (Trainings). - High technology	- Development of rural area - Job creation - Improved infrastructure - Nutrition food (protein) & food security - Increase fish supply reduction in fish price - Conservation of social structure

			- Education - Health care
2.	***Environmental***	- Waste collection - Water recirculation - Reduced usage of chemical - Alternative feed - Reduced escapes - Removal of sea lice	- No waste to landfill - Reduce water consumption - Preserve nature and environment - Reduce transfer of diseases and sea lice - Allowing site recovery
3.	***Economic***	- Challengeable to predict	- Extra benefits for the whole fish farming

Table 6.2.1 shows the implication of circular economy principles that have contributed to social needs through providing jobs, providing health salmon for the community, et cetera. The case fish farm collaborates with the fishery at Smøla on providing the cleaner fish (wrasse) for extra income. It offers free training for the community for anybody willing to learn about the production of the salmon and the process performed by the case fish farm. Due to this strategy, the case fish farm has built a trust with the community of Smøla and receive support from them.

Now the development of supply chain operations within the case fish farm has been based on the environmental, economic, social, and as well add society value to the community toward sustainable development. These findings are consistent with assumptions by Glavič and Lukman (2007), who have assisted that the combination of three aspects of sustainability can contribute to achieving a sustainable system.

The startup of the case fish farm at Smøla has brought the development of this island. Currently, 60 people employed at the case fish farm, which has led to the development of education and health care, supermarkets, and speed boat trips for people and vehicles between the island and other locations.

The findings show the positive outcomes of circular economy principles on these aspects on the journey toward sustainability. It was also essential to show how circular economy implemented throughout the stages of fish growth, sustainability, and the outcome for sustainability (see Table 6.2.2).

Table 6.2. 2: Circular economy toward sustainability in fish farming

No.	Stages of fish growing	Circular economy	Sustainability	Outcome for sustainability
1.	***Roe***	- Advanced technology used for broodfish and breeding manipulated.	- The quality of Salmon is expanded in the seasonal range.	- Seasonal range of quality salmon
2.	***Fry***	- Not identified	- Not identified	- Not identified
3.	***Smolt***	- Recirculation of water - Heat is renewable for the entire production - Smoltification process - Vaccination	- 95% of water is recyclable -- Less land requirement - Salmon are able to live in salt-water	- Preserve water - Preserve land - Easy manipulation of salmon from freshwater to seawater.
4.	***Mature salmon***	- Feed waste and feces are collected - Alternative feed (vegetable + marine raw material) - Technology cameras and videos.	- Biogas is produced through collected waste. - Salmon received health diet - The follow up is done on feeding and counting dead Salmon for removal.	- Renewable energy - Food safety - Health Salmon as product

5.	***Transportation***	- High technology well boat.	- The Oxygen, Carbon dioxide and PH of water is controlled while salmon are transported alive. - Stress is controlled to salmon during transportation.	- The quality of salmon as a product is kept at maximum

Through the implementation of the closed system 2013, the case fish farm was able to improve the environment as explained above. The closed system collects waste and re-use to produce energy. The system uses a recirculation water system which preserves water. The installed cage at sea reduced the salmon escapee and hence reduced the transfer of disease from farmed salmon to wild salmon. High technology well boat is used on the transportation of live salmon from land farm to sea cage and as well during transportation to the slaughter facility. The new technology well boats designed to flush the salmon through a vacuumed pipeline where the sea lice removed during this process. These findings have emphasized that the implementation of circular economy pushes companies on the installation or application of new technology on the production or method that would, in turn, entail significant impacts for the economy, the environment and the society. These findings are consistent with several researchers from theoretical review. These researchers are such as Accentrure, (2014); Bicket et al., 2014; Acsinte et al., 2015).

Furthermore, circular economy interaction with sustainability has brought a lot of benefits and some drawbacks. Table 6.2.3 illustrate the interaction between circular economy and sustainability in the case fish farm.

Table 6.2. 3: Benefits and drawbacks of the interaction between circular economy and sustainable in fish farming.

No.	Category	Benefits	Drawbacks
1.	***Fish feed***	- Alternative feed (from plants) seems sustainable with ingredients of soy, sunflower, wheat, corn, beans, peas and rapeseed oil. - No feeding fish with fish meal (reduce killing of wild salmon).	- Un sufficient nutrients - Conserve nature - Utilizing fish species that could be used directly as food for humans.
2.	***Fish cleaner (wrasse)***	- Sustainable way of cleaning sea lice on the salmon - Reduce the use of chemical which could harm salmon as product and health of people. - Fish farm can reach the regulation of 0.5 louse per salmon	- The wrasse that have finished cleaning are discarded. - The wild wrasse population are shrinking - Four out of ten wrasse die during single round of salmon production. - Management of wrasse i.e. feeding, water temperature, oxygen, shelter
3.	***Wild salmon and farmed salmon***	- Salmon farming has satisfied the demand gap that wild salmon couldn't.	- Transfer of disease and parasite from farmed salmon to wild salmon (sea lice). - Changes in genotypes and loss of genetic variation in wild salmon population due to intrusion of escapees (interbreeding). - Repeated intrusion of escapees may wipe out wild salmon population.

This study has revealed one more distinctive benefits and drawbacks to implementing the principles of circular economy for sustainability (Table 6.2.3). The findings have shown three categories are still in discussion between balancing circular economy principles and sustainability within the case fish farm. These categories are fish feed, fish cleaner and wild salmon versus farmed salmon.

There is still a massive debate regarding wild salmon and farmed salmon on the sustainability, which is not the purpose of this master thesis. However, the study shows the vast demand for salmon on the market that wild salmon alone couldn´t satisfy.
Further, the alternative fish feed seems sustainable due to being made of plants but doesn’t provide salmon with enough nutrients to grow to offer required proteins to humans. It has brought the argument on delivering the right amount of nutrients to salmon through fish meal, which does not seem to be a sustainable way. This master thesis has pointed out the alternative fish feeds suggested by scientists from the Norwegian Research Institute and other researchers as an alternative feed for an environmentally friendly and sustainable future.

Furthermore, the fish cleaner has been one of the benefits of cleaning sea lice from salmon fish without using any chemicals. The argument being the management of the usage of these fish cleaner and discarded after usage, which may lead to the shrinkage population of these fish cleaner. Management of these wrasse requires feeding, water temperature, shelter, and oxygen separate from salmon, making it difficult to manage them at sea cages. The study has suggested the fishing wrasses and lumpfish out of cages for reuse, providing the right environment for these wrasses to survive and as well separate feeding.

CHAPTER 7. CONCLUSIONS, LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEACH.

This chapter concludes with the final overview of this master thesis findings and presents implications for theory and practitioners and decision-makers. This chapter also discusses the limitations of this master´s thesis and provides suggestions for future research.

7.1. Conclusions

The overall purpose of this master thesis is to explore how circular economy principles contribute to the sustainable development of SCM: a single case of Norwegian fish farming. This master thesis presents an empirical case of fish farm located in Norwegian island, Smøla. The selected fish farm implemented circular economy principles into the process of fish growing and production and thereby changed completely the existing practices of fish growing, production, operation, and SCM. Fish farming meets the demands for food, and it is beneficial to the local communities at the same time fish farming activities affect the natural environment. The empirical case helps to find answers to the four research questions to reveal the overall purpose of this master thesis.

To answer the first research question, on how circular economy evolved in fish farming in Norway. The findings reveal that the case fish farm changed the previous practice through the implementation of circular economy principles on the existing practice of fish production, operation, and SCM. The principles helped the case fish farm to improve the overall process and production of the fish growing at farm and to produce healthy fish as the final product for consumption.

Regarding answering the second research question, the investigation illustrates that fish production and management of the transportation of live fish is also a challenge for the case fish farm and will always imply some risk of implementing circular economy principles in the existing practice. The quality of fish has a significant impact on the risks associated with transportation. For example, sick fish should not be transported, and a lot of care should be taken to minimize and handle stress before and during the transportation of live fish. There were also many challenges to the collaboration of circular economy principles and sustainability, consequently, well-trained crew and skills to handle emergencies required throughout the live fish's transportation process.

To answer the third research question. The case fish farm changed its existing practice to stop environmental pollution like the discharge of waste to the sea or land, no longer use chemicals to kill sea lice, which has contributed to the safer use of the environmental resources in fish production.

Further, to answer the third and fourth research questions, the investigation has revealed how a circular economy contributes to social and societal value. My research provides more in-depth insight into the lack of understanding of how environmental impact and social influence are affected by a circular economy. These findings may be beneficial to other sectors as well on finding ways to collaborate circular economy principles on the social and societal value on their SCM for gaining economic and environmental benefits on their business.

7.2. Implications for theory

This master thesis looks into finding ways to align sustainable supply chain strategies to circular economy principles. The findings show all three aspects are equally important for the contribution of the sustainable development of SCM. The investigation has revealed some gap such as lack of social impact which has received minimal attention as pointed out by Suring and Müller (2008a), Wu and Pagell (2011), Hammervoll et al., (2012), Sarkis (2012, Neely et al. (2015), Ahi and Searcy (2015a), Mani et al., (2016), Tsvetkova (2020). We need to balance both circular economy principles and their effect aspects and sustainability. Further, the findings agree that a sustainable supply chain can occur only through learning, change, and innovative solutions. The case fish farm is not one hundred percent sustainable and still experiences challenges on the implementation of circular economy principles. Yet, it has created opportunities to generate economic, environmental, and societal benefits. The journey for sustainability is still ongoing (Tsvetkova 2011; Slivestre 2015).

The existing literature on sustainable SCM, Gold et al. (2010b) emphasized that for successful implementation of sustainable SCM, require the support of top managers. In the case of fish farms, however, it wasn't the case. Instead, it was through learning their past practice and learning through practicing innovative solutions to make something valuable for the community, which is in line with (Tsvetkova 2011; Slivestre 2015). The path through reaching sustainability requires the initiative of all stakeholders within the SCM, in and outside the company. This thesis also argues on the fish feed that comes from a plant that is labeled "sustainable" there are still a lot of complications on balancing this feed as sustainable. Further suggestions are analyzed on this thesis for a better ecosystem in the future.

Further, the findings highlight that the building of a sustainable supply chain can longer be ignored in the fish farming, as it is one of the essential ways for further industrial and social development. It is reflecting on the past practice of the case fish farm´s past practices, which wasn´t good for the environment before developing new SCM practices. Through implementing the three principles of circular economy, which change on how the case fish farm perceive the operation and overall context of the supply chain and make changes on the strategic implementation that in turn, change the link between all supply chain players, including local communities (Tsvetkova and Gammelgaard 2018). The application of circular economy principles has proved to replace the existing practices and make the case fish farm put new technologies in the production process and transportation (MacArthur 2015c).

7.3. Implications for practice

This section is for practitioners and decision makers to practice this part of the theory. The findings generated from this thesis can be advantageous for managers who want to implement a circular economy in fish farming. Other practitioners will see how circular economy used on the existing practice on the manufacturing system. The empirical case of the fish farm shows the implementation of the “3R” as per the literature review. The application of circular economy principles on the existing SCM of the case fish farm has made the fish farm to change the overall performance, operation, and production process.

Managers from different conceptual settings can learn how to implement a closed system. The closed system, which was performed by the case fish farm, had many advantages. Such as helping the case fish farm to control the parasite and disease transmitted to the wild salmon and highly control of salmon escape. The cage at sea designed to collect waste from feed, dead salmon, and feces, which are re-used as biogas fuel to produce heat.

The managers or practitioners can take advantage of the implementation of technology such as the recirculation of water, which is performed per the case fish farm and can reserve at least 90% of water recyclable to freshwater to be used for fish production. The recirculation system is an easy way to control water temperature and quality of water for fish farming.

Further, the managers or practitioners can learn how to discard the use of chemicals or the discharge of chemicals or waste to sea or land. These can lead to preserve the environment by creating added value procedures to the fish growing process for the benefit of the community and environment, which may lead to economic value in the long run.

7.4. Limitations and suggestions for future research

This master thesis applies a single case study approach. The case findings are based only on fish farming. This master thesis presents contextual investigation based on two concepts, circular economy and sustainability.

Further studies on how sustainability and circular economy align with each other within different contextual settings are required. I suggest future research to apply theoretical lenses like resource-based theory, institutional theory, and others to review how circular economy and sustainability interact with each other through new perspectives. There are still fundamental issues that future research needs to address to explore how to create supply chains more sustainable, and how to find a balance in the interaction between circular economy and sustainability issues in the SCM practice.

REFRENCES

Internet webpages

barentwatch.no. (2016). "Salmon lice."   Retrieved 20.04.2020, 2020, from https://www.barentswatch.no/en/articles/Salmon-lice/.

Eric Stavney Mukiteo, W. (2019). "Is farmed salmon safe and healthy?"   Retrieved 11.05.2020, 2020, from https://www.norwegianamerican.com/farmed-salmon-safe-healthy/.

Eurofish. (2017). "Overview of the Norwegian fisheries and aquaculture sector."   Retrieved 22.11.2019, 2019, from https://www.eurofish.dk/norway.

Eurofish. (2020). "Fighting salmon lice with "cleaner fish"."   Retrieved 9.05.2020, 2020, from https://www.eurofishmagazine.com/sections/aquaculture/item/236-fighting-salmon-lice-with-cleaner-fish.

FAO. (1995, 20.04.2020). "Quality and quality changes in fresh fish."   Retrieved 20.04.2020, 2020, from http://www.fao.org/3/V7180E/V7180E00.HTM#Contents.

FAO. (1998). "Rural Aquaculture: Overview and Framework for Country Reviews." from http://www.fao.org/3/x6941e/x6941e00.htm#Contents.

FAO. (2020a). "National Aquaculture Sector Overview: Norway."   Retrieved 18.04.2020, 2020, from http://www.fao.org/fishery/countrysector/naso_norway/en.

FAO. (2020b). "Aquaculture technology: variety of technologies."   Retrieved 15.05.2020, 2020, from http://www.fao.org/fishery/technology/aquaculture/en.

Fiskeridirektoratet. (2019, 20.12.2019). "Aquaculture at sea."   Retrieved 18.04.2020, 2020, from https://www.fiskeridir.no/Akvakultur/Tema/Havbruk-til-havs.

Government.no. (2019, 18.11.2019). "Fish health/Salmon lice."   Retrieved 18.04.2020, 2020, from https://www.regjeringen.no/en/topics/food-fisheries-and-agriculture/fishing-and-aquaculture/1/farmed-salmon/fish-healthsalmon-lice/id607091/.

laksefakta. (2018). "Norwegian rules for environment and aquaculture."   Retrieved 16.05.2020, 2020, from https://laksefakta.no/laks-og-miljo/norske-regler-for-miljo-og-oppdrett/.

Mattilsynet. (2019). "ATP approved means of transport."   Retrieved 20.04.2020, 2020, from https://mattilsynet.no/om_mattilsynet/godkjente_produkter_og_virksomheter/?kategori=1001&liste=10001#godkjenninger.

sciencenorway. (2020). "Every year, 50 million cleaner fish die in Norwegian fish farms." Retrieved 16.05.2020, 2020, from https://sciencenorway.no/animal-welfare-fish-farming-salmon-industry/every-year-50-million-cleaner-fish-die-in-norwegian-fish-farms/1631228.

seachoice.org. (2020). "Aquaculture methods." Retrieved 20.04.2020, 2020, from https://www.seachoice.org/info-centre/aquaculture/aquaculture-methods/.

TheExplorer. (2019). "Norwegian technology for sustainable aquaculture." Retrieved 09.05.2020, 2020, from https://www.theexplorer.no/stories/ocean/norwegian-technology-for-sustainable-aquaculture/?gclid=CjwKCAjwqdn1BRBREiwAEbZcR_WhUfwLddhFOa4csOjocQP9MuURbNvqFYSImqGIcsxbQKRfjhWbphoC21MQAvD_BwE.

TheExplorer. (2020). "Delousing with seawater at seawater temperature." Retrieved 20.04.2020, 2020, from https://www.theexplorer.no/solutions/delousing-with-seawater-at-seawater-temperature/.

ucn. (2020). "Norway launches vaccines, action plan against salmon pancreatic disease." Retrieved 15.05.2020, 2020, from https://www.undercurrentnews.com/2020/02/04/norway-launches-vaccines-action-plan-against-salmon-pancreatic-disease/.

unglobalcompact.org. (2020). "Social Sustainability." Retrieved 20.03.2020, 2020, from https://www.unglobalcompact.org/what-is-gc/our-work/social.

WEF. (2019). "Toronto wants to power its trash trucks with food waste." Retrieved 13.05.2020, 2020, from https://www.weforum.org/agenda/2019/11/toronto-food-waste-fuel-truck-closed-loop-recycling/.

worldfinshing.net. (2015). "World fishing and aquaculture." Retrieved 22.11.2019, 2019, from https://www.worldfishing.net/news101/regional-focus/a-model-industry.

Others

Accenture (2014). "Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limit to Growth." 23.

Acsinte, S., A. Verbeek, J. Byström, L. Goovaerts and M. Francini (2015). "Assessment of access-to-finance conditions for projects supporting Circular Economy."

Ahi, P. and C. Searcy (2015a). "An analysis of metrics used to measure performance in green and sustainable supply chains." Journal of Cleaner Production **86**: 360-377.

Ahmadi, M. (2017). "Evaluating the Performance of 3Rs Waste Practices: Case Study-Region One Municipality of Tehran." Adv Recycling Waste Manag **2**(130): 2.

Allwood, J. M. (2014). Squaring the circular economy: the role of recycling within a hierarchy of material management strategies. Handbook of recycling, Elsevier**:** 445-477.

Andersen, M. S. (2007). "An introductory note on the environmental economics of the circular economy." Sustainability science **2**(1): 133-140.

Ansari, Z. N. and R. Kant (2017). "A state-of-art literature review reflecting 15 years of focus on sustainable supply chain management." Journal of cleaner production **142**: 2524-2543.

Arena, M., N. D. Ciceri, S. Terzi, I. Bengo, G. Azzone and M. Garetti (2009). "A state-of-the-art of industrial sustainability: definitions, tools and metrics." International Journal of Product Lifecycle Management **4**(1-3): 207-251.

Bakker, C., M. den Hollander, E. Van Hinte and Y. Zljlstra (2014). Products that last: Product design for circular business models, TU Delft Library.

Bapuji, H., B. W. Husted, J. Lu and R. Mir (2018). "Value creation, appropriation, and distribution: How firms contribute to societal economic inequality." Business & Society **57**(6): 983-1009.

Barton, B. A. and G. K. Iwama (1991). "Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids." Annual Review of fish diseases **1**: 3-26.

Baxter, P. and S. Jack (2008). "Qualitative case study methodology: Study design and implementation for novice researchers." The qualitative report **13**(4): 544-559.

Bell, J. G. and R. Waagbø (2008). Safe and nutritious aquaculture produce: benefits and risks of alternative sustainable aquafeeds. Aquaculture in the Ecosystem, Springer**:** 185-225.

Bicket, M., S. Guilcher, M. Hestin, C. Hudson, P. Razzini, A. Tan, P. Ten Brink, E. Van Dijl, R. Vanner and E. Watkins (2014). "Scoping study to identify potential circular economy actions, priority sectors, material flows and value chains."

Biggam, J. (2015). Succeeding with your master's dissertation: a step-by-step handbook, McGraw-Hill Education (UK).

Bocken, N. M., S. W. Short, P. Rana and S. Evans (2014). "A literature and practice review to develop sustainable business model archetypes." Journal of cleaner production **65**: 42-56.

Bouzon, M., F. H. Staudt, C. Rodriguez and J. Ferreira (2012). "A framework towards a sustainable development in supply chain." 9es Recontres Internaitonales de la Recherche en Logistique, Association Interantionale de Recherche en Logistique, Montreal.

Brundtland, G. H. (1987). "What is sustainable development." Our common future **8**(9).
Büyüközkan, G. and Ç. Berkol (2011). "Designing a sustainable supply chain using an integrated analytic network process and goal programming approach in quality function deployment." Expert Systems with Applications **38**(11): 13731-13748.

Carroll, M. L., S. Cochrane, R. Fieler, R. Velvin and P. White (2003). "Organic enrichment of sediments from salmon farming in Norway: environmental factors, management practices, and monitoring techniques." Aquaculture **226**(1-4): 165-180.

Carter, C. R. and D. S. Rogers (2008). "A framework of sustainable supply chain management: moving toward new theory." International journal of physical distribution & logistics management.

Cetinkaya, B., R. Cuthbertson, G. Ewer, T. Klaas-Wissing, W. Piotrowicz and C. Tyssen (2011). Sustainable supply chain management: practical ideas for moving towards best practice, Springer Science & Business Media.

Chacón Vargas, J. R. and C. E. Moreno Mantilla (2014). "Sustainable supply chain management capabilities: a review from the resource-based view, the dynamic capabilities and stakeholder theories." Latin American Journal of Management for Sustainable Development **1**(4): 323-343.

Chen, I. J. and A. Paulraj (2004). "Towards a theory of supply chain management: the constructs and measurements." Journal of operations management **22**(2): 119-150.

Chopra, S. and P. Meindl (2010). Supply Chain Management: Strategy, Planning, and Operation, Prentice Hall.

Creswell, J. W. and C. N. Poth (2016). Qualitative inquiry and research design: Choosing among five approaches, Sage publications.

Cristoni, N. and M. Tonelli (2018). "Perceptions of Firms Participating in a Circular Economy." European Journal of Sustainable Development **7**(4): 105-105.

Curwin, J. and R. Slater (2007). Quantitative methods for business decisions, Cengage Learning EMEA.

Dao, V., I. Langella and J. Carbo (2011). "From green to sustainability: Information Technology and an integrated sustainability framework." The Journal of Strategic Information Systems **20**(1): 63-79.

Davidson, K. M. (2011). "Reporting systems for sustainability: what are they measuring?" Social indicators research **100**(2): 351-365.

Dillard, J., V. Dujon and M. C. King (2008). Understanding the social dimension of sustainability, Routledge.

EC (2015). "Closing the loop—An EU action plan for the circular economy." Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions, Brussels, Belgium.

Eisenhardt, K. M. and J. A. Martin (2000). "Dynamic capabilities: what are they?" Strategic management journal **21**(10-11): 1105-1121.

Elkington, J. (1999). The link between accountability and sustainability–theory put into practice. Conference on the Practice of Social Reporting for Business, ISEA.

Ellingsen, H., J. Olaussen and I. Utne (2009). "Environmental analysis of the Norwegian fishery and aquaculture industry—A preliminary study focusing on farmed salmon." Marine Policy **33**(3): 479-488.

Evans, S., M. Gregory, C. Ryan, M. N. Bergendahl and A. Tan (2009). Towards a sustainable industrial system: With recommendations for education, research, industry and policy, University of Cambridge, Institute for Manufacturing.

Fink, A. (2003). "Appropriate Survey Analysis." Fink, A. The Survey Handbook. Thousand Oaks: Sage Publications.

Flyvbjerg, B. (2006). "Five misunderstandings about case-study research." Qualitative inquiry **12**(2): 219-245.

Francas, D. and S. Minner (2009). "Manufacturing network configuration in supply chains with product recovery." Omega **37**(4): 757-769.

Gallego-Álvarez, I., M. P. Galindo-Villardón and M. Rodríguez-Rosa (2015). "Evolution of sustainability indicator worldwide: A study from the economic perspective based on the X-STATICO method." Ecological Indicators **58**: 139-151.

Garetti, M. and M. Taisch (2012). "Sustainable manufacturing: trends and research challenges." Production planning & control **23**(2-3): 83-104.

Genovese, A., A. A. Acquaye, A. Figueroa and S. L. Koh (2017). "Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications." Omega **66**: 344-357.

Glavič, P. and R. Lukman (2007). "Review of sustainability terms and their definitions." Journal of cleaner production **15**(18): 1875-1885.

Gold, S., S. Seuring and P. Beske (2010a). "The constructs of sustainable supply chain management–a content analysis based on published case studies." Progress in Industrial Ecology, an International Journal **7**(2): 114-137.

Gold, S., S. Seuring and P. Beske (2010b). "Sustainable supply chain management and inter-organizational resources: a literature review." Corporate social responsibility and environmental management **17**(4): 230-245.

Gopalakrishnan, K., Y. Y. Yusuf, A. Musa, T. Abubakar and H. M. Ambursa (2012). "Sustainable supply chain management: A case study of British Aerospace (BAe) Systems." International Journal of Production Economics **140**(1): 193-203.

Gunasekaran, A., Z. Irani and T. Papadopoulos (2014). "Modelling and analysis of sustainable operations management: certain investigations for research and applications." Journal of the Operational Research Society **65**(6): 806-823.

Gupta, M. C. (1995). "Environmental management and its impact on the operations function." International Journal of Operations & Production Management.

Gupta, S. and O. D. Palsule-Desai (2011). "Sustainable supply chain management: Review and research opportunities." IIMB Management Review **23**(4): 234-245.

Gurtu, A., C. Searcy and M. Jaber (2015). "An analysis of keywords used in the literature on green supply chain management." Management Research Review.

Hammervoll, T., L.-M. Jensen and P. Beske (2012). "Dynamic capabilities and sustainable supply chain management." International journal of physical distribution & logistics management.

Helfat, C., S. Finkelstein, W. Mitchell, M. Peteraf, H. Singh, D. Teece and S. Winter (2007). "Dynamic Capabilities. Understanding Strategic Change in Organizations. Blackwell Publishing: Malden, MA."

Hersoug, B. (2015). "The greening of Norwegian salmon production." Maritime studies **14**(1): 16.

Hervani, A. A., M. M. Helms and J. Sarkis (2005). "Performance measurement for green supply chain management." Benchmarking: An international journal.

Hollos, D., C. Blome and K. Foerstl (2012). "Does sustainable supplier co-operation affect performance? Examining implications for the triple bottom line." International Journal of Production Research **50**(11): 2968-2986.

Hox, J. J. and H. R. Boeije (2005). "Data collection, primary versus secondary."

Huang, B., X. Wang, H. Kua, Y. Geng, R. Bleischwitz and J. Ren (2018). "Construction and demolition waste management in China through the 3R principle." Resources, Conservation and Recycling **129**: 36-44.

Huatuco, L. D. H., J. R. Montoya-Torres, N. Shaw, A. Calinescu, Z. Wang and J. Sarkis (2013b). "Investigating the relationship of sustainable supply chain management with corporate financial performance." International Journal of Productivity and Performance Management.

Hyde, K. F. (2000). "Recognising deductive processes in qualitative research." Qualitative market research: An international journal.

Jonsen, K. and K. A. Jehn (2009). "Using triangulation to validate themes in qualitative studies." Qualitative Research in Organizations and Management: An International Journal.

Kelly, L., J. Stellwagen and A. Bergheim (1996). "WASTE LOADINGS FROM A FRESHWATER ATLANTIC SALMON FARM IN SCOTLAND 1." JAWRA Journal of the American Water Resources Association **32**(5): 1017-1025.

Kim, B. (2001). "Social constructivism." Emerging perspectives on learning, teaching, and technology **1**(1): 16.

Klassen, R. D. and A. Vereecke (2012). "Social issues in supply chains: Capabilities link responsibility, risk (opportunity), and performance." International Journal of production economics **140**(1): 103-115.

Kreiner, K., J. Mouritsen, A. Edström, E. Häckner, R. J. Boland Jr and S. Jönsson (2005). "The analytical interview. Relevance beyond reflexivity 153." PART ONE: THE ROLE OF THE RESEARCHER 17: 10.

Lamming, R., A. Faruk and P. Cousins (1999). "Environmental soundness: a pragmatic alternative to expectations of sustainable development in business strategy." Business Strategy and the Environment **8**(3): 177-188.

Läpple, F. (2007). Abfall-und Kreislaufwirtschaftlicher Transformationsprozess in Deutschland und in China: Analyse-Vergleich-Übertragbarkeit.

Leire, C. and O. Mont (2010). "The implementation of socially responsible purchasing." Corporate Social Responsibility and Environmental Management **17**(1): 27-39.

Levi, D. S., P. Kaminsky and E. S. Levi (2003). Designing and managing the supply chain: Concepts, strategies, and case studies, McGraw-Hill.

Liu, Y., J. O. Olaussen and A. Skonhoft (2011). "Wild and farmed salmon in Norway—A review." Marine Policy **35**(3): 413-418.

Lu, R. X., P. K. Lee and T. Cheng (2012). "Socially responsible supplier development: Construct development and measurement validation." International Journal of Production Economics **140**(1): 160-167.

Luthra, S., D. Garg and A. Haleem (2014). "Empirical analysis of green supply chain management practices in Indian automobile industry." Journal of The Institution of Engineers (India): Series C **95**(2): 119-126.

Luthra, S. and S. K. Mangla (2018). "When strategies matter: adoption of sustainable supply chain management practices in an emerging economy's context." Resources, Conservation and Recycling **138**: 194-206.

MacArthur, E. (2013). Toward the Circular Economy: Economic and business rationale for an accelerated transition. **Volume 1.:** 98.

MacArthur, E. (2015a). Towards a Circular Economy: Business rationale for an accelerated transition**:** 20.

MacArthur, E. (2015b). Delivering the circular economy: A toolkit for policymakers, Ellen MacArthur Foundation.

MacArthur, E. (2015c). Rethinking value creation. **1A**.

MacArthur, E. (2017). "Concept: What is a circular economy? A framework for an economy that is restorative and regenerative by design." Retrieved 10.03.2020, 2020, from https://www.ellenmacarthurfoundation.org/circular-economy/concept.

Mani, V., R. Agarwal, A. Gunasekaran, T. Papadopoulos, R. Dubey and S. J. Childe (2016). "Social sustainability in the supply chain: Construct development and measurement validation." Ecological Indicators **71**: 270-279.

Mani, V., R. Agrawal and V. Sharma (2015a). "Social sustainability in the supply chain: analysis of enablers." Management Research Review.

Mani, V., R. Agrawal and V. Sharma (2015b). "Social sustainability practices in the supply chain of Indian manufacturing industries." International Journal of Automation and Logistics **1**(3): 211-233.

McKinsey (2016). The circular economy: Moving from theory to practice. **Special edition:** 36.

Michelini, G., R. N. Moraes, R. N. Cunha, J. M. Costa and A. R. Ometto (2017). "From linear to circular economy: PSS conducting the transition." Procedia CIRP **64**: 2-6.

Miles, M. B. and A. M. Huberman (1994). Qualitative data analysis: An expanded sourcebook, sage.

Min, H. and W. P. Galle (1997). "Green purchasing strategies: trends and implications." International Journal of Purchasing and Materials Management **33**(2): 10-17.

Murray, A., K. Skene and K. Haynes (2017). "The circular economy: an interdisciplinary exploration of the concept and application in a global context." Journal of business ethics **140**(3): 369-380.

Neely, A., R. Edgeman, J. Eskildsen, P. Ahi and C. Searcy (2015). "Measuring social issues in sustainable supply chains." Measuring Business Excellence.

Neiland, A., S. Shaw and D. Bailly (1991). "The social and economic impact of aquaculture: a European review." Aquaculture and the environment(16): 469-482.

NFSA (2019). Regulation of transport of fish in Norway**:** 14.

NMF (2011). Report on the Enviromental Impact of farming of North Atlantic Salmon in Norway**:** 60.

NSC. (2019, 07.01.2020). "Norwegian seafood exports top NOK107 billion in 2019." Retrieved 18.04.2020, 2020, from file:///Users/leyla/Downloads/Norwegian_seafood_exports_top_NOK_107_billion_in_2019.pdf.

NSF (2011). Aquaculture in Norway**:** 29.

Orchard, S. E., L. C. Stringer and C. H. Quinn (2015). "Impacts of aquaculture on social networks in the mangrove systems of northern Vietnam." Ocean & Coastal Management **114**: 1-10.

Pagell, M. and Z. Wu (2009). "Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars." Journal of supply chain management **45**(2): 37-56.

Paulraj, A. (2011). "Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability." Journal of Supply Chain Management **47**(1): 19-37.

Pirachicán-Mayorga, C., J. R. Montoya-Torres, J. Jarrín and A. X. Halabi Echeverry (2014). "Modelling reverse logistics practices: a case study of recycled tyres in Colombia." Latin American Journal of Management for Sustainable Development **1**(1): 58-72.

Portz, D. E., C. M. Woodley and J. J. Cech (2006). "Stress-associated impacts of short-term holding on fishes." Reviews in Fish Biology and Fisheries **16**(2): 125-170.
regjeringen.no (2015). National Strategy against Antibiotic Resistance 2015-2020**:** 33.

Samiha, B. (2013). "The importance of the 3R principle of municipal solid waste management for achieving sustainable development." Mediterranean Journal of Social Sciences **4**(3): 129-129.

Sanguino, R., A. Barroso, S. Fernández-Rodríguez and M. I. Sánchez-Hernández (2020). Current trends in economy, sustainable development, and energy: a circular economy view, Springer.

Sarkis, J. (2012). "Models for compassionate operations." International Journal of Production Economics **139**(2): 359-365.

Sauvé, S., S. Bernard and P. Sloan (2016). "Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research." Environmental Development **17**: 48-56.

Schaltegger, S., R. Burritt, M. Varsei, C. Soosay, B. Fahimnia and J. Sarkis (2014). "Framing sustainability performance of supply chains with multidimensional indicators." Supply Chain Management: An International Journal.

Seliger, G. (2007). "Sustainability in manufacturing." Recovery of Resources in Product and Material Cycles.

Seliger, G. (2012). Sustainable Manufacturing: Shaping Global Value Creation, Springer**:** 400.

Setthasakko, W. (2009). "Barriers to implementing corporate environmental responsibility in Thailand: A qualitative approach." International journal of organizational analysis **17**(3): 169-183.

Seuring, S. and M. Müller (2008a). "From a literature review to a conceptual framework for sustainable supply chain management." Journal of cleaner production **16**(15): 1699-1710.

Seuring, S. and M. Müller (2008b). "Core issues in sustainable supply chain management–a Delphi study." Business strategy and the environment **17**(8): 455-466.

SFIH (2018). Salmon Farming Industry Handbook**:** 113.

SFIH (2019). "Salmon Farming Industry Handbook." 114.

Sivaprakasam, R., V. Selladurai and P. Sasikumar (2015). "Implementation of interpretive structural modelling methodology as a strategic decision making tool in a Green Supply Chain Context." Annals of Operations Research **233**(1): 423-448.

Skogen, M. D., M. Eknes, L. C. Asplin and A. D. Sandvik (2009). "Modelling the environmental effects of fish farming in a Norwegian fjord." Aquaculture **298**(1-2): 70-75.

Slater, M. J. (2017). "Societal and economic impacts of aquaculture." Journal of the World Aquaculture Society **48**(4): 539-541.

Smith, S., S. Jacob, M. Jepson and G. Israel (2003). "After the Florida net ban: the impacts on commercial fishing families." Society &Natural Resources **16**(1): 39-59.

Stefansson, S., G. Bæverfjord, R. Nigel Finn, B. Finstad, S. Fivelstad, S. Handeland, T. Kristensen, F. Kroglund, B. Rosseland and T. Rosten (2007). "Water quality–Salmonids." Aquaculture research: from cage to consumption. Norwegian Research Council, Oslo: 101-119.

Stenbacka, C. (2001). "Qualitative research requires quality concepts of its own." Management decision.

Sterud, E., T. Forseth, O. Ugedal, T. T. Poppe, A. Jørgensen, T. Bruheim, H.-P. Fjeldstad and T. A. Mo (2007). "Severe mortality in wild Atlantic salmon Salmo salar due to proliferative kidney disease (PKD) caused by Tetracapsuloides bryosalmonae (Myxozoa)." Diseases of aquatic organisms **77**(3): 191-198.

Stock, J. R. and S. L. Boyer (2009). "Developing a consensus definition of supply chain management: a qualitative study." International Journal of Physical Distribution & Logistics Management **39**(8): 690-711.

Svåsand, T., Ø. Karlsen, B. O. Kvamme, L. H. Stien, G. L. Taranger and K. K. Boxaspen (2016). "Risikovurdering norsk fiskeoppdrett 2016."

Taranger, G. L., Ø. Karlsen, R. J. Bannister, K. A. Glover, V. Husa, E. Karlsbakk, B. O. Kvamme, K. K. Boxaspen, P. A. Bjørn and B. Finstad (2015). "Risk assessment of the environmental impact of Norwegian Atlantic salmon farming." ICES Journal of Marine Science **72**(3): 997-1021.

Tate, W. L., L. M. Ellram and J. F. Kirchoff (2010). "Corporate social responsibility reports: a thematic analysis related to supply chain management." Journal of supply chain management **46**(1): 19-44.

Taticchi, P., F. Tonelli and R. Pasqualino (2013). "Performance measurement of sustainable supply chains: A literature review and a research agenda." International Journal of Productivity and Performance Management **62**(8): 782-804.

Tsvetkova, A. (2011). "Innovations for Sustainability of Maritime Operations in the Arctic." Maritime Logistics in the Global Economy: Current Trends and Approaches **5**: 205.

Tsvetkova, A. (2020). Social responsibility practice of the evolving nature in the sustainable development of Arctic maritime operations. Arctic Marine Sustainability, Springer**:** 119-143.

Tsvetkova, A. and B. Gammelgaard (2018). "The idea of transport independence in the Russian Arctic: a Scandinavian institutional approach to understanding supply chain strategy." International Journal of Physical Distribution and Logistics Management **48**(9): 913-930.

Ülkü, M. A. (2012). "Dare to care: Shipment consolidation reduces not only costs, but also environmental damage." International Journal of Production Economics **139**(2): 438-446.
unglobalcompact.org. (2020). "Social Sustainability." Retrieved 20.03.2020, 2020, from https://www.unglobalcompact.org/what-is-gc/our-work/social.

Vangdal, E., K. Kvamm-Lichtenfeld, R. Sørheim and Ø. Svalheim (2014). "Fiskeslam frå oppdrettsanlegg. Gjødsel til planter eller råstoff for biogass." Bioforsk Rapport.

VKM (2008). Opinion of the Panel on Animal Health and Welfare of the Norwegian Scientific Committee for Food Safety. Transportation of fish within a closed system. **VKM Report 2008: 23:** 63.

Walliman, N. (2011). Your research project: Designing and planning your work, Sage Publications.
Webster, K. (2015). The Circular Economy: A Wealth of Flows. Ellen MacArthur Foundation, Isle of Wight. P. 16.

Welcomme, R. L., I. G. Cowx, D. Coates, C. Béné, S. Funge-Smith, A. Halls and K. Lorenzen (2010). "Inland capture fisheries." Philosophical Transactions of the Royal Society B: Biological Sciences **365**(1554): 2881-2896.

Winter, G. (2000). "A comparative discussion of the notion of validity in qualitative and quantitative research." The qualitative report **4**(3): 1-14.
Witjes, S. and R. Lozano (2016). "Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models." Resources, Conservation and Recycling **112**: 37-44.

Wolf, J. (2011). "Sustainable supply chain management integration: a qualitative analysis of the German manufacturing industry." Journal of Business Ethics **102**(2): 221-235.
worldfinshing.net. (2015). "World fishing and aquaculture." Retrieved 22.11.2019, 2019, from https://www.worldfishing.net/news101/regional-focus/a-model-industry.

Wu, Z. and M. Pagell (2011). "Balancing priorities: Decision-making in sustainable supply chain management." Journal of operations management **29**(6): 577-590.

Yellishetty, M., G. M. Mudd, P. G. Ranjith and A. Tharumarajah (2011). "Environmental life-cycle comparisons of steel production and recycling: sustainability issues, problems and prospects." Environmental science & policy **14**(6): 650-663.

Yin, R. K. (2003). "Case study research design and methods third edition." Applied social research methods series **5**.

Yong, R. (2007). "The circular economy in China." Journal of material cycles and waste management **9**(2): 121-129.

Youn, S.-J., W. W. Taylor, A. J. Lynch, I. G. Cowx, T. D. Beard Jr, D. Bartley and F. Wu (2014). "Inland capture fishery contributions to global food security and threats to their future." Global Food Security **3**(3-4): 142-148.

Zailani, S., K. Jeyaraman, G. Vengadasan and R. Premkumar (2012). "Sustainable supply chain management (SSCM) in Malaysia: A survey." International journal of production economics **140**(1): 330-340.

Zhu, Q., J. Sarkis and K.-h. Lai (2008). "Confirmation of a measurement model for green supply chain management practices implementation." International journal of production economics **111**(2): 261-273.

APPENDIXES

Appendix 1: Interview guidelines for the respondents

General Questions:

1. Please give a brief presentation of your position in the company (project).
2. What is it your duties about your position?
3. How long have you worked in this position or project?
4. What is it you enjoy most about your job or position?
5. How old are you?

Operations and Logistics:

1. How is the production system or operation is organized?
2. Does your company (project) have an adequate knowledge regarding fish farming processing? E.g. experience, technology competence etc.
3. How do you acquire the sample for fish production?
4. When did your company or project start thinking on environment issues?
5. At what stage in the production system is dangerous to the environmental aspect?
6. What do you do to eliminate this danger to the environment?
7. How does internal logistic operation occur within the company (project)? i.e. Storage, Transport
8. At what condition/temperature does the fish are kept during production and storage?
9. How is the fish packaged for transportation?

Sustainability and circular economy:

1. What has been your role in the implementation process of circular economy?
2. Why did you decide to use the concept of circular economy?
3. How is the circular economy organized and formulated in your system?
4. How is the circular economy happen in your system?
5. In which parts of the (processes, product etc.) has circular economy been applied?
6. Did you used any specific tools to implement circular economy approach? If yes, which ones did you use? (e.g. Cradle to cradle, eco-efficiency, product-service system)?
7. Was the Government initiate for circular economy? If yes, When?

8. Did the implementation of the circular economy concept provide you with sufficient return on investment (revenue, cost reduction, employee motivation etc.) or do you expect it in the future?
9. How do you feel fish farming contribute to the society?
10. What societal value you can think about that fish farming brought to the society? E.g. Health eating...
11. How can you produce fish as pure/clean product for people health?
12. Do you cooperate with other domestic firms? If yes, how? E.g. other firms in the same / other segment. If No, why not?
13. Do you think that when circular economy is fully implemented, it does lead towards sustainability?

Others;

1. How circular economy help to make fishing industry such as fish production more social, environmental and economical?
2. What could your company do to increase the competitiveness in the Norwegian fishing industry?
3. Is there anything else that you think would be important for us to know?

Appendix 2: Consent letter

Are you interested in taking part in the research project?

” Circular economy principles and sustainable development of SCM: a single Case Study”

This is an inquiry about participation in a research project where the main purpose is to provide deeper insight into how a circular economy affects the sustainable development of Supply Chain Management. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

This is the master´s thesis research as part of the requirement to fulfil the master's degree program in Logistics and Supply Chain Management at Molde University College as a final assessment. The research purpose is to explore how the circular economy can contribute to the sustainable development of Supply chain management in Norwegian fish farming.

From our literature review, we have found that circular economy focuses on the creation of self-sustaining production systems, but it does not concern with the reduction of the use of the environment as a sink of residual like sustainable supply chain strategies. So, it still remains underexplored how the boundaries of environmental sustainability can be pushed by the circular economy. Further, there is a lack of understanding of how the circular economy principles can affect the social aspect of sustainability and societal values.

The research is based on a single-case study about fish farming in Norway. The case is interesting for the research purpose because fish farming challenges both the environmental aspect and societal values.

Who is responsible for the research project?

Molde University College is the institution responsible for the project.

Why are you being asked to participate?

The data collection will be done through in-depth face-to-face interviews with open-ended questions. Semi-structured questions were prepared for the on the information required for the study.

All personal data will be presented in the research anonymously. All ethical issues will be respected.
It is assumed at this initial stage of the research to conduct face-to-face interviews with at least five persons on different positions from three companies. The selection was made on the basis of their involvement and experience of working in fish farming production based on the circular economy principles.
The contact details of the companies have been shared with me by my Supervisor and as well signatory of this consent form.

What does participation involve for you?
The method which will be used for data collection is through face-to-face interviews and personal observations if it is possible to do during the interviews. The type of information that will be collected is the general information of the interviewer, operations and logistics performance, sustainability and circular economy performance and the information will be recorded electronically (a sound record) only with the consent of each interviewee to be transcribed later. Then each interviewee will receive drafts of interview protocols and transcripts via email to ensure the validity of descriptions and interpretations.

- "If you chose to take part in the research, this will involve that you will be interviewed face-to-face with semi-structured open-ended questions. It will take approx. 60 minutes. But we respect the respondents' time and are flexible when conducting the interview. The interview guide includes questions about how fish farming production is based on the circular economy and how this practice can contribute to the three aspects of sustainability – economic, environmental, and social. Your answers will be hand-written during the interview and recorded only with your consent".

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All personal information about you and your company will be presented only anonymous in the research. There will be no negative consequences for you if you chose to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

- Molde University college as the institution responsible for the project, student and supervisor will have access to the personal data.
- The collected personal information will be stored on the data on a research server, locked away or encrypted.
- The participants will be recognizable in the research publications and the information such as name, age, and occupation will be published on the research thesis document.

What will happen to your personal data at the end of the research project?

The project is scheduled to end 11th June 2020.

The collected personal information will be anonymised during and at the end of the project and for the purpose of future research and follow up studies, the Molde University college will have access to it as by 11th June 2020 and will be archived indefinitely for the follow-up studies.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with Molde University College, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- Molde University College via *[Supervisor: Antonina Tsvetkova via, antonina.tsvetkova@himolde.no]*.
- Our Data Protection Officer: *[Data protection officer at Molde University College via personvernombud@himolde.no]*
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader

Student

(Supervisor)

Consent form

I have received and understood information about the research on implication of circular economy on sustainable supply chain management and have been given the opportunity to ask questions. I give consent:

☐ to participate in an interview

I give consent for my personal data to be processed until the end date of the project, approx. 11.06.2020.

(Signed by participant, date)