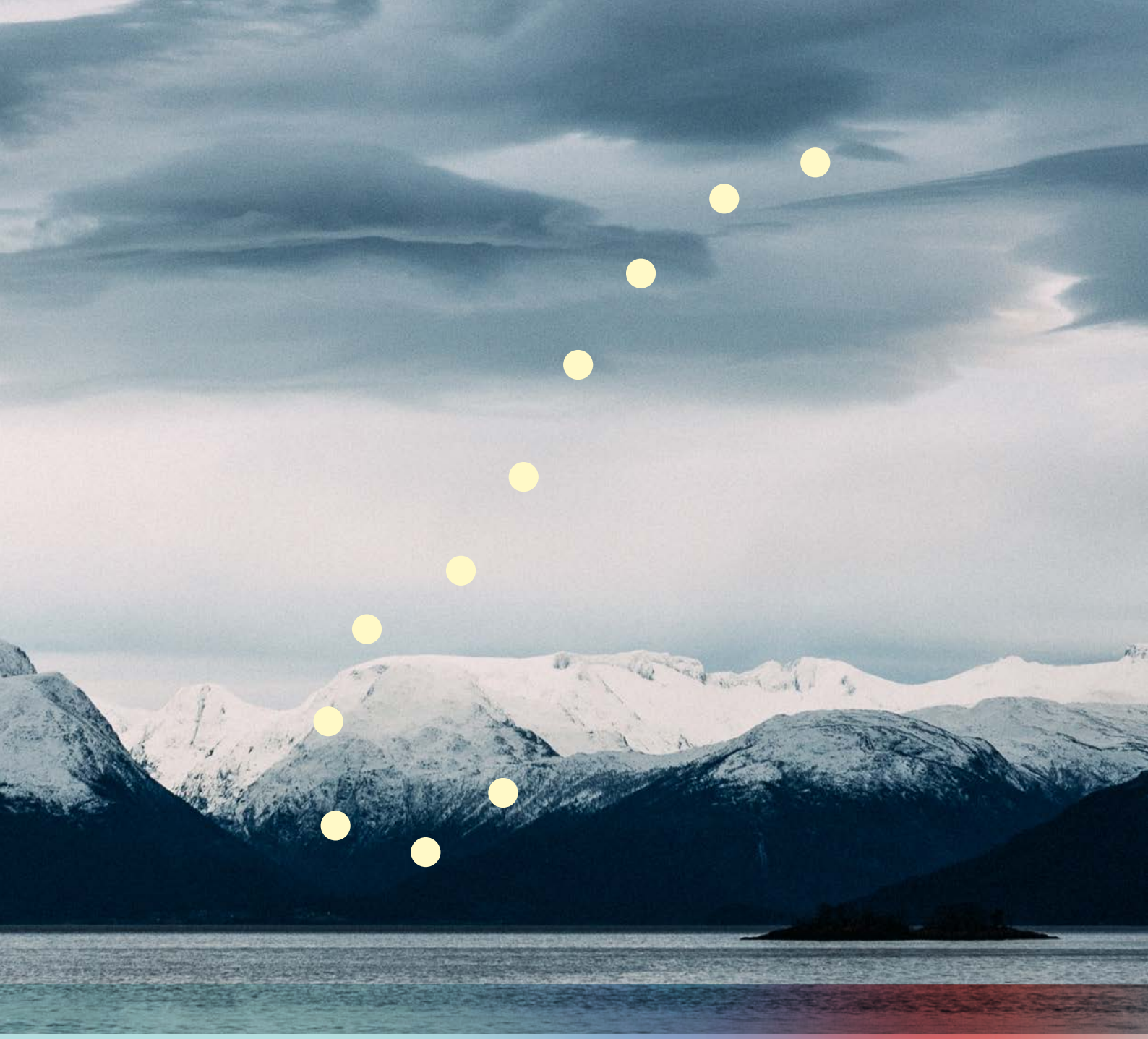


SALMON GROUP

Sustainable farming
of salmon and trout
– what is that?

Feasibility study 2018

SALMON
GROUP

Developed and published by: Salmon Group AS ©
Bergen, Norway, 2018-11-13

Contents

1 Sustainability as a Driver

Awareness of human impact on the environment and climate has changed many lines of business industry, and the challenges related to resource use and exhaustion of the Earth's resources have become clearer. Today, all sectors and industries place sustainability issues high on their agenda, and currently this is perhaps the most important driver for business and product development. This focus has also led to changed consumption patterns, which often precede the ability of trade and industry to adjust. Everyone wants to be and to be perceived as sustainable, and is eager to promote their strategy to achieve this. Is this greenwashing or actual change?

We need a shared set of guidelines against which we can make real measurements, which will clarify challenges and how close you are to defining your own product and business strategies in accordance with sustainability criteria.

Our goal is therefore that the indicators used to define sustainability in aquaculture, and through them the criteria that are developed, should be knowledge-based, and dare to be clear and strive towards honesty. Our point of departure is based on a holistic approach founded on the production stage. We see that the reputation of the industry and its end product depends on all parts of the production chain having a shared understanding of and framework for defining the industry as sustainable.

We now know that fish farming ranks among the type of industrial 'meat' production with the smallest environmental footprint. We see that increased focus on the environmental footprint of all types of food production helps promote food from the sea. This will lead to a positive response to changed patterns of consumption and ever increasing awareness of and demands from consumers for healthy, clean and environmentally friendly food production.

The industry depends on a fresh and clean ocean to produce good, healthy fish, and it is both natural and right to take a critical approach to the sector's combined activities.

In the absence of clear criteria, one may nevertheless immediately take on some of the challenges. There is, for instance, a political wish to make the industry fossil-free by 2025, which may also be understood and argued for based on the definition of sustainability. The industry has already made changes, and a transition is underway, for instance in fleet electrification. This is an important step in the right direction, measured in direct emission reductions.

Marine pollution is another issue. The industry depends on a fresh and clean ocean to produce good, healthy fish, and it is both natural and right to take a critical approach to the sector's combined activities. To a great extent, this is about awareness, and all agents in the industry need to ask themselves which parts of the process and in which ways they can make changes now. For instance: What can we do to stop microplastic pollution? To what extent can we make clearer demands to the subcontractors in this area? The time is ripe to ask all participants in the industry some questions, such as: Why are feed tubes and hiding places for cleaner fish at fish farms made of plastic? Is it possible that these, with usage, release microplastics into the sea? What consequences could this have for the marine ecosystem in the ocean? Or another and closely related environmental aspect: How can we optimise feeding, so that the feed comes through the feeding tube in the right condition instead of disintegrating and falling to the bottom? And what about sludge? Can sludge be handled in a way that is better for the marine environment, and also provides added value when refined? Who can use sludge as a resource, and can this also be used in other industries as well?

To what extent should the use of chemicals be allowed and how should this be managed to ensure that the marine environment is not affected in any way? What can be done to eliminate the use of chemicals and choose other solutions?

These are only a few examples of issues and questions that should be asked in this project. This will be a prerequisite for all parts of the industry in a sustainable future.

It must be a clear and defined goal that the sustainability criteria should address the practical issues the aquaculture industry faces today. With increased awareness in the industry itself, fish farmers will increasingly challenge their suppliers with clearer requirements that involve demands for sustainability, than what is the case today.

Feed is the most important specific challenge for the aquaculture industry. It will be paramount to focus, to a greater extent, on quality, composition, access to raw materials, quality of the feed, and knowledge about nutrition, handling and transportation. There are many challenges in this part of the industry from a sustainability perspective, and this is probably the area under the highest pressure due to access to raw materials.

The Earth's capacity is limited, and it has been determined that we have not only reached it, but exceeded it. For a long time we have harvested its resources all the way to the limit, and it requires rapid changes in all industries to adjust our course and create a planet with healthy sustainability. This is defined in the Paris Agreement and in the UN's 17 Sustainable Development Goals. 175 countries signed the Paris Agreement in 2015 and have committed themselves to identifying and coordinating measures to fulfil internationally determined development goals related to the climate and environment. The UN's 14th Sustainable Development Goal concerns life below water, and is also the basis for this feasibility study.

The fish farming is a part of the aquaculture and fisheries industry, and takes the sea as a point of departure for its business. There is a significant social responsibility in managing natural resources and the industry must consider the inherent obligations in this. This requires all parts of the industry to work together towards shared goals, and not in a fragmented manner, as is largely the case in the industry today. This requires a far more open, transparent and honest industry than what we see in aquaculture today.

We should not only point to the challenges that lie straight ahead of us, but identify in detail the current status within aquaculture, on a national and global level. Based on these status descriptions, concrete, shared criteria should be defined and joint standards and certifications should be developed which will ensure that protection and growth goes hand in hand. The industry is both expected to, and needs to grow, and a healthy business development must be ensured, also within related industries.

The primary goal of a sustainable aquaculture industry will lead to significant gains that extend far beyond the industry itself. It will help achieve sustainability goals in other industries and sectors, and it will contribute significantly to strengthening and taking the aquaculture industry to the next generation. The added value for the industry comes in terms of an increased understanding of the economic value it brings to coastal communities throughout Norway, which also plays an important role in people's perception of the industry.

Today, the fish farming industry has some work to do regarding its reputation, and this needs to be addressed by the industry. In this case, the different parties in the industry need to join together and bring out the best in each other, by taking the necessary steps to lift the industry and secure an altogether professional and transparent sector with a focus on control, security and traceability.

2 Introduction

Sustainable fish farming is not new. The entrepreneurs and pioneers of the aquaculture industry have engaged in sustainable fish farming for three or four generations, from the time when the fishing industry began exploring the other opportunities the sea had to offer. What is new is the understanding of the term 'sustainable', and new and increasingly strict industry requirements. The latter is a natural consequence of a growing industry. All industries mature and undergo processes that shape and lead to stricter requirements regarding the way it operates. Sustainability requirements are now being included at all stages of production, to enable the industry to sustain further growth.

More food needs to come from the ocean in the future and consumers demand good food that is produced in a way that does not put too much strain on the Earth. For the Earth is under pressure. It has reached its environmental limits, and all industries must make an effort to use less of the Earth's resources than we do today. 'Sustainability' is a term that sets the upper limit before something cannot sustain or maintain itself. 'Critical limit' is another term. The Earth has reached its carrying capacity or environmental limit, which was exceeded on 1 August this year. This day is called Earth Overshoot Day, and in 2018 alone the world's population used resources equivalent to 1.7 Earths. In 2014, WWF estimated that within few years we would need 3 Earths if we continued our resource use at the same rate.

'Sustainability' is a term that sets the upper limit before something cannot sustain or maintain itself. 'Critical limit' is another term. All future businesses must relate to sustainability and critical limits.

In September 2015, the UN adopted the Sustainable Development Goals to ensure a sustainable planet by 2050. In December the same year, the Paris Agreement was adopted at the United Nations Climate Change Conference in Paris. The UN's efforts to promote a sustainable development seeks to lead and act as a catalyst for action by promoting and coordinating the implementation of

internationally agreed development goals, including seventeen sustainability goals. The Paris Agreement contains provisions for – among other things – reductions in greenhouse gases, climate change adaptation and support for developing countries, and was signed by 175 countries.

Salmon Group (SG) is committed to a healthy industry development and aims to be a catalyst within its field and be at the forefront of sustainable development of aquaculture. As entrepreneurs and pioneers in the industry, the SG's shareholders consider it highly relevant to take action and lead the way towards shared goals for sustainable aquaculture.

SG is a network of small and medium-sized fish farmers of salmon and trout. On their own, they would be considered small, but together the fish farmers represented by the Salmon Group are the third largest market player in Norway (with a total production volume of 12 % of the total volume in Norway). One by one they contribute to building this industry, stone by stone, and always driven by a goal of development and improvement. The economic motivation behind this is guided by a social and environmental motivation that focuses on the protection of the coastal zone and coastal culture, good fish health and animal welfare and a healthy marine ecosystem. This can be combined with and converted into the UN's Sustainability Goals, which are natural and necessary to adopt as guiding principles for the further development of the industry.

To approach the main project of creating a sustainability manual, one must necessarily question the practices of the aquaculture industry today. There are many details that need to be checked thoroughly, and this will likely uncover operations and methods that can be simplified or improved to achieve higher efficiency, safer and more accurate operations and a smarter approach to the industry as a whole.

Salmon Group places sustainability high on the agenda in all its work. We seek to identify future solutions that can provide the industry with smart interfaces and ensure growth with precision. New technology gives new opportunities, and this may have a democratic effect, as fish health is maintained and one is able to respond to a rapidly increasing demand for food from the ocean.

2.1 A Sustainable Future in the Aquaculture Industry

On 25 September 2015 the UN General Assembly adopted an agenda for sustainable development: 'Transforming our world: the 2030 Agenda for Sustainable Development'. This is a global action plan for people, the planet and development, which recognises poverty in all forms and dimensions as one of the biggest challenges of our time. As part of the action plan, the UN's 17 Sustainable Development Goals were launched to identify the complex challenges the world faces in its goal of creating a sustainable planet by 2030.

The UN's Sustainable Development Goals are accepted by all countries and apply to all, considering different national realities, capacities and levels of development, and respect national policies and priorities. These are universal goals that involve the entire world, developed and developing countries alike. The goals are ambitious, but at the same time represent a need for rapid and comprehensive change.

Salmon Group (SG) places sustainability high on the agenda in all its work. We seek to identify future solutions that can provide the industry with smart interfaces and ensure growth with precision. New technology gives new opportunities, and this may have a democratic effect, as fish health is maintained and one is able to respond to a rapidly increasing demand for food from the ocean.

SG sees the need for tools and measurable indicators in the transition to sustainable fish farming and aquaculture, and wants to develop and implement documentable sustainability requirements in the aquaculture industry. This will require comprehensive restructuring, which will go through many stages and where different reactions may arise, depending on each industry player's situation, role and reality.

A reorganisation of the aquaculture industry to a documentable, sustainable business arena at all stages will likely involve a significant and, for many, dramatic change of the entire sector. Changes will be introduced in major parts of the entire value chain and most production and operating methods in the life cycle will have to be reviewed and readjusted. A simplified Life Cycle Assessment (LCA) will be able to demonstrate this and the market players will likely need to go through mental, cultural, professional, business-related and organisational changes. This will largely involve concrete, quantifiable relations.

3 Objectives for the Work – Complete, Concrete and Practical

The aquaculture industry as a whole has extensive and long food and value chains. The industry harvests from many areas and levels of the world's and our shared natural resources, and also affects these. Consequently, it is important to highlight and clarify these connections. One way to do this is to carry out a *simplified Life Cycle Assessment* (LCA) based on familiar methods and evaluate it against the UN's Sustainable Development Goals.

One of several key elements in understanding and quantifying the different footprints of the aquaculture industry, is the direct and indirect energy flow in the entire food and value chains. This applies to energy use in the ecosystems as well as energy for e.g. daily operations.

SG wants to develop a complete, concrete, documentable and practical manual for environmental, economic and social sustainability in aquaculture. The manual will be based on the UN's 17 Sustainable Development Goals, which are to be reached by 2030. The approach to sustainability is based on a fundamental understanding and practice of how the relevant ecosystems work, as a prerequisite for the development of the entire aquaculture industry.

The feed and production stages in the value chain are given first priority, but the entire value chain and the 17 goals are to be rendered concrete and discussed in the main project. This is to show the complexity of each stage and each role in connection with the changes that need to be made.

This document is a feasibility study description that aims suggest a way to continue working, a general outline for further work on the main project. This document is not in itself scientific research.

3.1 Neutral Project Management

To succeed in this work we consider it very important to organise and carry out the main project in a way that leave competent actors without connections to the aquaculture industry in charge of the central project. The coordination and academic responsibility for the project should lie with an

impartial agent. SG may play a role throughout the entire process, but one should avoid an organisational model that binds the organisation to the work in ways that in hindsight may prove to undermine the results.

By 'impartial agent' we mean knowledge environments that can deliver technical and professional input that can contribute to the project without interfering with the integrity of either party.

3.2 Project Goals: A Sustainability Manual for the Industry

A constructive view and offensive approach to this situation, is that the ambition of the work and its concrete content could become practical and thus in effect the main business tool that takes Norwegian aquaculture from what many consider to be a controversial start-up-phase to a modern, realistic and future-oriented second generation phase with renewed confidence and new opportunities. The feasibility study seeks to identify measurable indicators that can form the basis of the main project, which will develop a sustainability manual for Norwegian fish farming. A lot of work has been done to highlight challenges and goals, but no management tools have been created that define sustainability in the industry. SG therefore sees the need to create this.

The fundamental part of the work will be to develop and implement the actual content of the sustainability manual itself. This will be gradually distributed across all parts of the LCA processes, measured against the UN's 17 Sustainable Development Goals. This in itself is a process that will take years to complete, organised as a main project in which some fundamental themes are described in this feasibility study. However, the work is initially limited to the feed production in the industry's LCA, measured against a selection of the UN's Sustainable Development Goals.

We intend this feasibility study to be followed by a main project from which the results and conclusions form a manual for how fish farmers can run their business in a sustainable manner. The manual should be a practical 'guidebook' with clear guidelines and instructions. The manual will address three levels of sustainability: environmental, social and economic sustainability. And it will define the key drivers of the future, and the terms and framework for protection and growth. It would therefore be natural to assume that such a manual could be used as a manual for all operators in the industry, and not just the shareholders in the SG network.

4 Background

Salmon and trout farming in Norway has developed from its humble beginnings in the 1960s through a desire to provide a supplemental income for rural areas in the 1970s and 1980s, to becoming one of Norway's major export industries in the past decade. This means, among other things, that the supplementary industry now has become a quite extensive system of industrial food production, which largely uses marine ecosystems as its production site.

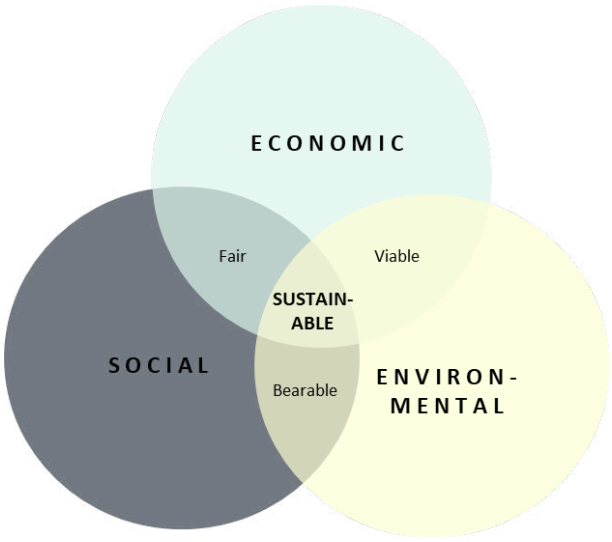
One of the consequences of the extensive growth in volume in a relatively short time period, is increased environmental challenges, especially in the production units and the ecosystems surrounding them, and the environmental, economic and reputational consequences of this. How is this compatible with sustainable operations and to what extent does it impact a sustainable reputation for the industry?

4.1 Initial Definition of the Term 'Sustainable Development'

The term 'sustainable development' was first used in the Brundtland Commission's 1987 UN report *Our Common Future*. In it, the term is defined as follows:

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable development concerns three areas of society and the areas where they intersect: economic, social, and environmental relations. These must work together to be able to achieve a social development that does take place at the expense of the Earth's limits, and keeps a safe distance to the critical limits in the different areas. In this way we can use the Earth's resources without spending the resources of the next generation and without exhausting natural resources.



Ill.: Sustainable development in different areas.

4.2 The FAO's Definition of Sustainability

The UN's Food and Agricultural Organisation (FAO) definition of sustainable development is based on the UN's 'Convention on the Law of the Sea' (UNCLOS) which concerns the protection of marine ecosystems from harmful activity, and sustainable use of marine resources, which again are based on the Brundtland Commission's original definition.

With regard to food production, the FAO has defined sustainable development as follows:

The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

4.3 The Precautionary Principle

The FAO states that the *precautionary principle* is a key element in the understanding of sustainability. The principle was met with international support following the 1992 Rio Declaration. In the year 2000 the EU published a major report on the principle. It states that:

The precautionary principle is used where scientific evidence is incomplete or uncertain, or where research results are without conclusion and scientific assessment give reasonable cause for concern that potential harm to the environment, human, plant and animal health may be incompatible with the EU's high standards of protection.

So far the most thorough review of the precautionary principle in an international forum is found in the report *The Precautionary Principle*, published by UNESCO's World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) in 2005. COMEST defines the precautionary principle as follows:

When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm. Morally unacceptable harm refers to harm to humans or the environment that is

- *threatening to human life or health, or*
- *serious and effectively irreversible, or*
- *inequitable to present or future generations, or*
- *imposed without adequate consideration of the human rights of those affected.*

The judgement of plausibility should be grounded in scientific analysis. Analysis should be on-going so that chosen actions are subject to review. Uncertainty may apply to, but need not be limited to, causality or the bounds of the possible harm. Actions should be chosen that are proportional to the seriousness of the potential harm, with consideration of their positive and negative consequences, and with an assessment of the moral implications of both action and inaction.

The main project needs to address the precautionary principle and discuss and clarify how this can be used as part of the effort to transform the industry into a sustainable form of fish farming.

4.4 How Do We Ensure Sustainable Farming of Salmon and Trout

Through the sustainability manual, SG aims to draw up concrete standards, indicators, documentation and operating procedures, measurement and reporting systems, training and other specific themes and descriptions of measures to answer some key questions:

- *What is sustainable farming of salmon and trout?*
- *How should the aquaculture industry be run in order to be defined as sustainable?*

- *What methods and tools are needed to establish, develop and use a verified sustainability system?*
- *How does fish farming today affect the marine ecosystem?*
- *To what extent are fish health and food safety taken into account in a sustainability perspective?*
- *To what extent are demands made for suppliers to deliver sustainable products and production methods when it comes to feed, equipment, technology, digitisation, AI and energy?*
- *In what ways do economic drivers play a role in the development of a sustainable industry?*
- *To what extent does institutional framework conditions play a role in sustainable fish farming?*
- *To what extent is the development of sustainable fish farming socially and culturally dependent?*
- *To what extent can communication that takes on the narrator/educational role contribute to a sustainable reputation?*

4.5 Framework Conditions and Clarification of Terms

The feasibility study is based mainly on the environmental aspect of the concept of sustainability, but also touches upon the other two main elements: economic and social sustainability.

In order to understand the specific content of the concept of sustainability, one needs to review some ecological framework conditions and key concepts and render them concrete. These key terms include: ecosystem, trophic level, energy, stock resource, renewable resource, monoculture/natural diversity, food chain, biosphere, biological production, protein accounting, cowboy economics/spaceship economy (circular economy), etc. Some of these terms are mentioned in this feasibility study description, while others will form part of a clarification of terms in the main project.

The term ‘sustainable’ is used in various contexts, with different content and interpretations. Sometimes it is concrete and measurable; at other times it is used as a positive concept without a defined content, which contributes to the greenwashing of real environmental problems. This applies to the aquaculture industry, as to all other industries, and it is necessary to take this into account in its sustainability efforts.

5 The Scope of the Project

This chapter gives an overview of the most important areas for further work. The chapter raises some main problems for discussion. Discussions and clarifications of these will help make the issues more concrete and thus establish and implement the transition to a sustainable aquaculture industry.

5.1 Ethical Considerations and Ecosystem Understanding

There will always be ethical considerations and issues related to any form of food production that involves ecosystems – aquaculture as well as agriculture. In this work, it will for instance be vital to consider and understand some basic ecological connections to the aquaculture industry. These must be considered in light of economic, social and environmental conditions and assessed against ethical dilemmas and the extent to which they should describe or define sustainable salmon and trout farming.

Some basic considerations may be:

- *How does an ecosystem work, in principle?*
- *How are its main function(s) measured?*
- *Where and how do salmon and trout farming affect (important parts of) ecosystems?*
- *Is this related to sustainability in the aquaculture industry?*
- *Is this related to ethics in the aquaculture industry?*
- *And if so, how?*

5.2 Solar Energy Flow in Aquaculture

Farming of salmon and trout is, in principle, the utilisation of various forms of radiated solar energy for many of the Earth's ecosystems. All other human activity is based on the same principle.

It may be interesting to look into how the global community manages the total radiated solar energy on Earth, both to make the most of the solar energy for the good of mankind (ecosystem services) and at the same time preserving the natural qualities needed to maintain intact ecosystems for future generations. What is the aquaculture industry's total use of solar energy and how might this be related to ethics? Solar energy is a prerequisite for creating growing conditions for all life. In this context it is relevant to consider how the sun as an energy source in marine ecosystems can best be utilised to feed the Earth's population with food harvested from the sea.

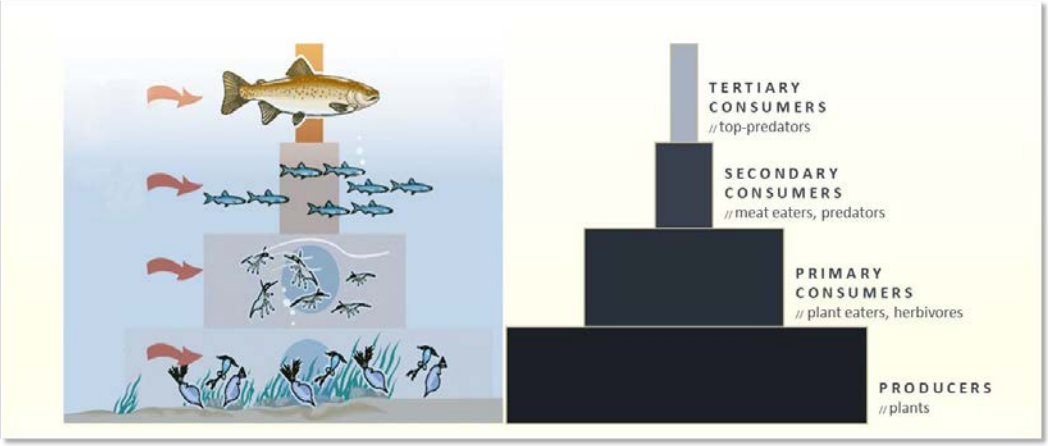
5.2.1 Aquaculture, Food Chains and Trophic Levels

A simplified life cycle assessment (LCA) of the aquaculture industry will show, among other things, how the different forms of solar energy are used and where in the food chain this occurs. A general definition of the terms 'food chain' and 'trophic level' may be summarised as follows,

A food chain is an overview of the being that lives off the previous one and each organism is located at a trophic level. The amount of energy and biomass decreases upwards in the food chain by approx. 90 % for each trophic level/link. Therefore, there are generally no more than five trophic levels in an ecosystem, and often only four levels, as there is not enough energy for more trophic levels.

After a maximum of five trophic levels, all the energy originally radiated by the Sun has been used by the organisms of the Earth, and passed on up the food chain until finally it is spent.

For the aquaculture industry this can be illustrated by the following two figures:



Ill.: Examples of food chain and use of solar energy at four trophic levels. 90 % of the solar energy disappears at each level of the food chain.

In theory, the figures show the energy flow from the Sun and in a marine example:

Ill.: A solar energy flow diagram.

Primary producers, or the green photosynthetic organisms, are on the first level, while the different consumers are assigned numbers according to the number of links there are between them and the photosynthetic plant. At each link 90 % of the energy disappears. This is usually called the chain of decreasing efficiency and can be described as follows:

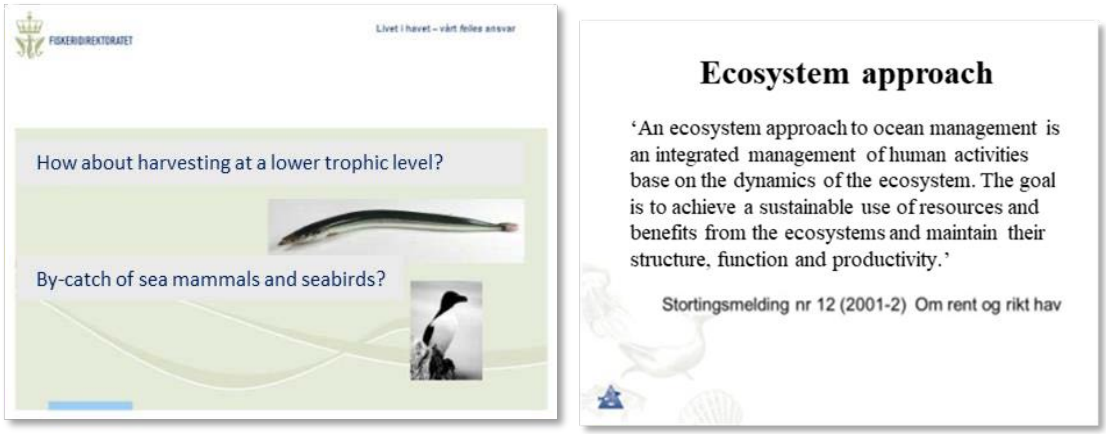
If we divide the mass of organisms at one level with the next, we get a ratio of 5 to 15 for most ecosystems. If the plants produce 1000 kg and we use a ratio of 10, the plant eaters be able to utilise (1000: 10) kg = 100 kg. Secondary consumers get a net profit of (100: 10) kg = 10 kg, and tertiary consumers get (10: 10) kg = 1 kg.

Based on this example, we see that a farmed salmon as a tertiary consumer can only make use of one thousandth of the radiated solar energy. This makes it reasonable to ask what is the most appropriate way of producing salmon/trout when it is at the top trophic level in the food chain(s).

Put differently, we may also ask how salmon/trout farming can be defended in a sustainability perspective, and relevant follow-up questions to this may be:

- *Is there a limit to the amount of farmed fish at this trophic level in the food chain and what is it?*
- *How is it measured and documented?*
- *Would it be a more optimal use of ecosystem energy to produce at one step lower in the food chain (low trophic level) instead of running this energy through an extra trophic level and thereby losing 90 % of the energy?*

Ecosystem approaches have been discussed and attempts have been made to actualise them by various industry actors, also in Norway. The illustration shows an example of this, from the Norwegian Directorate of Fisheries and the Institute of Marine Research.



Ill.: Examples of ecosystem approaches in managing marine resources.

As we can see, the Institute of Marine Research's ecosystem quote is taken from report no. 12 to the Storting, *Protecting the Riches of the Seas* (Stortingsmelding nr. 12 (2001–2002), 'Om rent og rikt hav'). In the 16 years that have passed since this report was adopted, the industry has developed and the effects and impact human activities have on ecosystems are increasingly evident.

In Norwegian waters we have, for instance, seen good seasons in spawning cod, mackerel and herring fisheries, harvested at high trophic levels. We have also witnessed the collapse of a number of seabird populations during this period, and recently, plastic contamination of the oceans and pollution of coastal nature has become an issue on the global agenda.

How does this relate to the development of the aquaculture industry, seen in the light of the changes in the ecosystems? In Norway the industry has increased in volume from 422,000 tonnes in 2002 to over one million tonnes in 2017, almost tripling the total volume.

These fundamental ecological conditions form a main framework for understanding the entire concept of sustainability and its specific content in SG's further work. It will therefore be crucial question, discuss and concretise this theme thoroughly in the main project.

5.3 Carrying Capacity and Environmental Limit

In the 30 + years that have passed since the concept of sustainability was introduced, various agents in society have made their own interpretations of the term. The very basis of the term's content is the objective principle that different activities cannot be operated by using natural resources beyond certain defined and documented environmental limits. This fundamental relation is both concrete and objective. If the tolerance limits are exceeded, the activities come into conflict with the second part of the sustainability definition, that is, 'without destroying the opportunities for future generations to meet their needs.'

At the same time, the fundamental principle of sustainability, in purely ideological terms, is the complete opposite of the basis for the concept of growth economy, or everlasting economic growth. In this type of context, you get a more ideological approach to and adaptation of the concept of sustainability, where different agents in society seek to adapt the term to suit their own ideology.

This type of discussion of the sustainability concept and the conclusions that are drawn will be key to the success of SG's sustainability project. The main project should therefore include a thorough review of these relationships. One of several approaches could be to define the contradiction between the current economic models, where the world's natural resources are viewed as an open, unrestricted system – and, on the other hand, the ecological knowledge humanity possesses that shows that our planet and its ecosystems are closed and limited systems with distinct carrying capacities.

Given the original definition of sustainability, it is important to help quantify the content of the term within the industry's areas of activity, making it possible to provide measurable sustainability results.

5.3.1 Contradictions in Economic Models

Sustainability efforts should be based on the natural laws of the ecosystems and use these as a guide when different measurement units, methods of quantification, tools and documentation systems are established and put into use. One of several fundamental questions is how these can be concretised and help provide guidelines in the transition towards sustainable fish farming.

Given the original definition of sustainability, it is important to help quantify the content of the term within the industry's areas of activity, making it possible to provide measurable sustainability results.

As early as in 1964, Professor Kenneth Boulding, launched the concept of 'spaceship economy' as a contrast to the prevailing economic theory, which was named 'cowboy economy'. The term 'spaceship economy' was based on the then-recently-established spacecraft technology, where from the very beginning it was understood and decisions were made based on the realities of a spacecraft: that limited resources were available for the journey into space and that these must be kept and treated inside the ship during storage, use and after they have become waste. Today, the term 'spaceship economy' has largely been replaced by the term 'circular economy'.

The term 'cowboy economy' was derived from the cattle and sheep farming of The Wild West, where cowboys moved their flock to the next green valley when the previous one was overgrazed and emptied of resources. This was considered a relevant description in the 1960s and 70s because it highlighted a characteristic attitude towards operations – that the participants in such a system failed to consider the natural resources and the areas' carrying capacity, but kept on expanding in spite of diminishing and often over-consumed natural resources. Other examples of cowboy economic thought and methods of operation, especially in Western economical values, are the slaughter of the North American bison, and from Norwegian history: whaling in the Antarctic Ocean 100 years ago, when species such as the blue whale were almost eradicated.

5.3.2 Shallow and Deep Ecology

In developing and implementing a documentable sustainability system, there will be a number of views on definitions, practical content, direction, speed, scope, accuracy, methods, etc. Experiences from environmental work in land-based industries in Norway and abroad, especially since the 1980s, show that different industries and individual businesses' reactions follow largely identical patterns:

a) At first, they denied all kinds of emissions and other types of pollution, on a local, national and international level.

b) Phase two was that businesses and corporations eventually accepted that they were the cause of various types of environmental impact...

c) Phase three happened as a consequence of phase two, where businesses e.g. started to clean up, either voluntarily or because the government eventually introduced laws and regulations that could impose various depollution measures. In Norway the Pollution Control Act was put into effect at this time, for the same reason.

The largest single issue in the 1980s was the destruction of the ozone layer around the Earth. The case was dramatic, but the international community solved it in record time, and the rapid changes and efforts made culminated in the 1987 Montreal Protocol and international follow-up of the protocol.

Many will argue that key actors in the aquaculture industry are still in phase one. Others point out that the industry spends major resources on taking responsibility for its environmental impact and that it is almost trendy to call your business sustainable. To define itself as sustainable by 2030, according to the UN's sustainability goals, one must comply with sustainability criteria in practice.

SG's sustainability project has high ambitions. The project is prepared to face objections at a 'greenwashing level', which is only natural, given the three phases in the reaction patterns described above.

The concepts of 'shallow ecology' and 'deep ecology' are underlying key elements for the UN's sustainability concept. There is no room for a thorough discussion of the terms here, but they are included in the feasibility study to give the concept of sustainability a value dimension and a corresponding foundation. The starting point is philosopher Arne Næss's establishment of deep ecology and ecophilosophy in the 1970s. In an excerpt from an article by philosophers Trygve Lavik and Jørgen Pedersen, some of this can be formulated as follows,

Shallow ecology sees man as distinct from nature. Man is seen as the crucial part of nature, and everything else gains value depending on whether it is valuable to man. Shallow ecology attributes an instrumental value to nature, i.e. nature only has value as a means (an instrument) to the extent that it can promote human goals. Shallow ecology is also oriented towards preserving nature, but based on an argument that it has value to humans, and not because nature has value in yourself. This is an anthropocentric view. Deep ecology, on the other hand, claims that human beings are part of nature and that everything in nature has value in itself.

Shallow ecology accepts the dominant economic idea of economic growth as a goal that is not to be questioned. It can therefore criticise prevailing economic policies, but without asking fundamental questions about the financial system and the way it works. Nor does it question whether the nation state is fit to solve the ecological problems facing the planet. Deep ecology, on the other hand, replaces growth economics with the idea of sustainable development.

So how does this relate to SG's sustainability project? Any transition aims to change something for the better, and in that case it would be sensible to have an understanding of sustainability against which both the current situation and future changes can be understood and measured.

The main project should elaborate on the different levels of ecology that form the basis of the idea of sustainability. This is the foundation for further work and becomes part of training and skills development, as well as the project work itself.

5.3.3 The UN's 17 Sustainable Development Goals

In the autumn of 2015, the UN member states adopted 17 goals for sustainable development towards 2030. Below you will find an overview of the goals:

Ill.: The UN's Sustainable Development Goals. Source: FN - https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Based on the three main areas where sustainability initiatives should take place – environmental, social and economic sustainability – SG has defined the future drivers of the aquaculture industry as follows:

- *society and value creation*
- *environment and sustainability*
- *economy and technology*

By systematising and considering these drivers against the UN Sustainable Development Goals, this can be illustrated as follows,

Ill.: The future drivers of aquaculture applied to the UN's Sustainable Development Goals.

At present we consider no. 2, 3, 12 and 14 of the UN goals to be most relevant to SG's sustainability initiatives. Nevertheless, it is important that the sustainability efforts embody all 17 sustainability goals. This feasibility study is based on and attempts to illuminate the perhaps most relevant goal for the aquaculture industry, that is Sustainable Development Goal no. 14: *Conserve and sustainably use the oceans, seas and marine resources for sustainable development.*

5.3.4 The UN's Plan to Implement Goal No. 14

Sustainable Development Goal no. 14 concerns life below water, and describes its short-term goals and overall changes point by point. The UN's 14th Sustainable Development Goal is formulated as follows:

14.1 *By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution*

14.2 *By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans*

14.3 *Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels*

14.4 *By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics*

14.5 *By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information*

14.6 *By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation16*

14.7 *By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism*

14.a *Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of*

marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries

***14.b** Provide access for small-scale artisanal fishers to marine resources and markets*

***14.c** Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of 'The future we want'*

5.4 Relevant Concretisations – What Does This Mean in Practice?

This type of work requires an overview that shows the status of the environmental aspects one wants to define within the target goals. The status is then compared to the specific goals one wants to achieve within a certain time frame. The discrepancies between the status and the goals are then formulated and constitute the main parts of the concrete areas and measures to be improved, changed, initiated, terminated/cancelled, etc. Initially, this is a gap analysis method.

The aquaculture industry is affected by many of the objectives shown above, both directly and indirectly. Particularly sections 14.2 and 14.5 (directly), which deal with ocean ecosystems and marine and coastal management, and section 14.4 (indirectly), which concerns the implementation of an action plan. Using these three sections as a starting point, this feasibility study will attempt to elucidate some conditions that we consider relevant to the Norwegian aquaculture industry.

A common feature of the UN formulations on goal attainment is the concrete and short timeframes for implementation. Two years have already passed since the Sustainable Development Goals were adopted and a fundamental question concerns the extent to which, in Norway and in other coastal states, measures have been taken to implement the UN plans by 2020, as given in UN's time frame?

Some questions that may be raised in this regard include the following:

- *Have we prepared a state of the environment document on Norwegian fjords, coasts and waters which show the overall and concrete environmental challenges that need to be solved?*
- *Are the solutions and measures clearly defined, unified and coordinated?*
- *Have they received funding? Are there available financial resources in the government budget and in the business sector?*

- *Who is in charge of the implementation?*
- *Who is involved?*
- *How is the work distributed?*
- *How is the work carried out and reported?*
- *Etc.*

Issues in this area should be addressed in the further work on the main project.

6 Important Factors

If we begin with section 14.2, a number of relevant resolutions and plans for management, protection and use of Norwegian fjords, coasts and waters have been adopted since autumn 2015 and are therefore widely known. We also know that a number of public and private actors are involved in this complex situation in different ways and at different levels.

It must be possible to prove that the management of resources harvested from the sea is in line with the ecological systems' carrying capacity. The use of marine resources must always go hand in hand with demand for raw materials in the aquaculture industry, without compromising the limits of the ecological systems.

Some examples of concrete conflicts that arise due to a lack of a definition of carrying capacity and clear management parameters for the industry can be:

- Division of waters into fish farming areas with traffic light systems, where Hordaland and Sogn og Fjordane are located in the so-called red zone
- Osterøy municipality's decision on closed fish farms

Examples of environmental sustainability:

- environmental limits for use of raw materials for fish feed
- environmental limits for the use of chemicals and medicine
- energy consumption and energy carriers
- lice and problems with disease
- collapsing seabird populations
- location ratings
- point loads for emissions versus accumulated emissions
- animal welfare

This overview needs to be expanded and each of these points rendered concrete in the main project. One example might be collapses in seabird populations.

In recent decades, a dramatic decline and collapse in many seabird populations have been reported around the North Sea, the northeast Atlantic and the Arctic. In the complex ecological situation where this is observed, there are a number of factors that need to be considered. One general ecological factor is the reduction and loss of nutrition/food for the various seabird species at critical stages of annual life cycles. Sand eel is one ecological key species in the sea, and for many seabird species. Loss of this type of key species can cause major negative consequences for seabirds, especially during the breeding season. In that case, is this sustainable?

Examples of social sustainability:

- conflicts about area use between fish farming interests and other social values and groups
- media coverage
- reputation
- ethics and transparency
- local value as a workplace/pillar of society
- protection of and growth in the coastal zone

Examples of economic sustainability:

- tolerance limits for fish mortality and other types of waste
- quality standards
- access to feed
- energy sources and consumption
- footprint
- long-term strategy and perspective

Defining acceptable tolerance limits for fish mortality and biomass waste is imperative to avoid overuse of resources.

Some relevant questions need to be asked regarding the limits and carrying capacity associated with environmental, social and economic sustainability. Which sustainability indicators should be used to set the limit for all aspects of aquaculture? How can we facilitate seamless management that takes care of this aspect?

It must be possible to prove that the management of resources harvested from the sea is in line with the ecological systems' carrying capacity. The use of marine resources must always go hand in hand with demand for raw materials in the aquaculture industry, without compromising the limits of the ecological systems.

6.1 Current Management Regimes

In its 2004 vision document, '*Scenario Havbruk 2020 – en ny næringsnøytralitet*' ('Scenario Aquaculture 2020 – A New Industrial Neutrality') published by the Research Council of Norway, the Council discusses new, expected framework conditions and success factors for what is now called the Norwegian aquaculture industry. The document includes:

The aquaculture industry throughout the EEA is governed by functional environmental, health, ethics, environmental requirements, etc., but the detailed, specific and descriptive regulations that characterised the industry when it was young have been discontinued. The industry actors compete and everyone has the right to establish a business if and where they wish to, as long as they can prove that the functional requirements defined in the legislation are fulfilled. The free market forces are at work, for instance in the sense that the licensing policy is gone. Tariff barriers have also been lifted. European companies have the right to establish businesses, and in the marine area Norway is an attractive host country, not least due to the advanced knowledge environments located here, and based on the economic conditions that apply to foreign establishments in Norway.

The first part of these formulations indicates a generation change in the management regimes and hence the framework conditions for further development of the aquaculture industry, where sustainability elements are emphasised as success criteria. This coincides with current perceptions of innovation and development of many areas of society, including salmon and trout farming, as stated by e.g. Innovation Norway in this document.

Today, the industry faces a fragmented public management regime. Laws and regulations that the industry must relate to are enforced by different administrative bodies at different levels of

management. New laws and regulations are underway and management is expected to become more coordinated and uniform, especially in terms of sustainability indicators for the industry.

Administrative framework conditions will become an important theme in the main project. The main project should also provide an overview of all administrative bodies and national and international responsibilities, in addition to national and international laws, regulations, plans, etc.

Based on the aquaculture industry's position in a management regime and SG's desire to facilitate measurable sustainability, there are also other questions that should be asked:

- *Are the relevant administrative bodies and procedures organised according to defined sustainability criteria?*
- *Which administrative bodies does this apply to?*
- *And if so, which sustainability criteria are taken into account?*
- *Does Norway have a comprehensive overall management of the ecosystems along the Norwegian coast?*
- *And if so, which administrative bodies and laws/regulations provide this comprehensive, ecosystem-based management and how does public management implement such a regime?*

If you consider individual decisions made in individual cases that concern the aquaculture industry's role in utilising and having an impact on the nature along the Norwegian coast and fjords and study their verdicts against a closely defined ecosystem model, the administrative bodies still appear to have one dominant management regime: handling cases individually.

Some will immediately argue that such an assertion is incorrect and base their opinion on the fact that there are a variety of planning systems at different levels that cover the whole and that various individual cases are then incorporated into this whole. Yet the main question remains:

- *Are relevant administrative bodies and litigation procedures organised according to defined sustainability criteria?*

Let us briefly consider an example – the mining waste disposal site in Førdefjorden – an management case that involves the aquaculture industry.

The starting point is the decision to allow a mining company to dump large amounts of waste in Førdefjorden in Sogn og Fjordane over several decades. Many actors and institutions have protested, one of them being the local aquaculture industry, which fears reduced environmental quality and associated challenges in its own production areas.

Many parties in the case have also used available Norwegian and international appeal bodies, but no one has been heard. One of these bodies is EFTA's Surveillance Authority, ESA. ESA is responsible for ensuring that Norway complies with the EEA Agreement's requirements in managing environmental laws and regulations in Norway and the EU. One of the approaches has been made through the EU's Water Framework Directive. The EU itself refers to this to as the strictest environmental law introduced by the EU. Nevertheless, none of the appellants' claims have been upheld by the ESA, although a list of reports may be presented showing breaches of the Water Framework Directive and other relevant environmental laws and regulations in Norway and the EU.

This may be perceived as inconsistent enforcement of regulations. Both Norway and the EU's environmental laws and regulations that provide clear grounds to make concretisations in a sustainability perspective, are set up in such a way that it seems as if socio-economic benefits can be defined as generally positive at the expense of the generally negative environmental impact.

This means that the concerns of local fish farmers about ecological changes that may affect the production base are not considered as a weighty argument.

This case is one of many examples of how two industries operate in a shared ecosystem, in this case, Førdefjorden, and the struggle for its shared resource base. At the same time, society has defined the fjord as a National salmon fjord, a confirmation of its unique natural values.

Although the aquaculture industry has operated in the fjord for decades, the industry has worked to maintain access to its production base and competitive edge in a basically intact ecosystem.

As the aquaculture industry's value creation in the area is well known, the authorities chose to define the added economic value from mining as socio-economically more important than the aquaculture industry's precautionary attitude.

This corresponds to the very basis of the Brundtland Commission's definition of the concept of sustainability: *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

One may therefore question whether relevant administrative bodies and litigation procedures today are organised according to defined sustainability criteria.

6.1.1 The EU's Water and Ocean Directives – Central Management Documents

There are two directives that provide a fundamental basis for the EU's efforts concerning sustainable aquaculture: the EU Water Directive and the Marine Directive.

The purpose of the EU's Water Directive can be summarised as follows:

The main goal of the Water Directive is to ensure the protection and sustainable use of the aquatic environment and, if necessary, implement preventive or improved environmental measures to ensure the environmental status of freshwater, groundwater and coastal waters. Environmental goals must be set which must be concrete and measurable. Water management should be considered as a whole, from mountain to fjord, and coordinated across sectors, systematic, knowledge-based, and enabling broad participation. The water directive entered into force in the EU on 22 December 2000.

A corresponding directive is also available for our oceans, the Marine Directive:

A comprehensive report on the basis needed to ensure sustainable aquaculture has been completed for the European Commission. The Cefas report has been used as a basis for developing EU guidance on the subject. Several Norwegian representatives have contributed in the workshops and the process. The report also has a number of examples and references to Norwegian aquaculture, including best practices in Europe in this area, and potential good environmental solutions in future fish farming.

These two directives are being implemented in the Norwegian administration and will become key management documents in the future. It is expected that sustainability indicators will be determined in the wake of this process.

6.2 Animal Welfare

Animals have intrinsic value regardless of their utility value for humans. All animals should be treated well and protected from the risk of unnecessary stress and strain. It is therefore crucial in a sustainability perspective that animals, in this case the fish from the breeding stage, from roe to smolt to edible fish and to slaughter, are handled according to principles and procedures that uphold the Animal Welfare Act and sustainability criteria.

In the further work on this project, sustainability criteria must therefore be established that safeguard animal welfare. The criteria must form the basis of the breeding guidelines and methods.

The procedures must be based on reducing handling of the fish and making the necessary handling as gentle as possible. The procedures must be defined based on sustainable criteria in order to limit stress, injury, outbreak and spread of disease after treatment.

All equipment, treatments and medication must undergo risk assessments, documentation and a gradual trial demonstrating that animal health is safeguarded and that it is in accordance with the precautionary principle. All production facilities must document that their operating criteria uphold sustainability criteria. This also applies to land-based facilities such as RAS and corresponding facilities. The use of chemicals must necessarily take place in accordance with strict, specific criteria. The same applies to medicine and vaccines.

Feed is very important in the production of fish, and it is therefore essential to achieving the goals outlined above. All additives to the feed should be defined in terms of a comprehensive sustainability assessment.

Mortality is an indicator that requires definition of measures: in this case, a tolerance limit must be defined. The purpose of this is to promote good animal welfare and healthy, high-quality fish.

6.3 The Value Chain

Without going into the definitions and methods of LCA processes, the following includes a simple sketch of the main parts of a preliminary and simplified LCA chain:

Marine arena as entrance:

Fishing/ catching marine feed materials → transportation → processing/ production of feed → transportation → feeding on site → (feed) waste → product handling → product transportation → final handling → reuse/ destruction of handling materials

Terrestrial arena as entrance:

Production and harvesting marine feed materials → transportation → processing/ feed production → transportation → feeding on site → (feed) waste → product handling → product transportation → final handling → reuse/ destruction of handling materials

All parts of the chains involve a variety of different actors with different tasks and interests. One natural part of the main project will be to establish a comprehensive overview of the actors and their

documented behaviour in relation to the environment, economy and social aspects.

6.3.1 Energy as a Shared Environmental Aspect

Each part of a simplified LCA chain usually has several specific environmental aspects that need to be defined. The environmental aspects are usually both direct and indirect.

One of the vital frameworks in this work is the energy needs and consumption of the aquaculture industry throughout the value chain. In this context, energy refers to biological/ecological energy (radiated solar energy) in the ecosystem where the industry's activities take place, as well as physical energy needed to operate various mechanical and other operating systems in the industry's life cycle.

It may be tempting to suggest using energy as a common denominator as a basis and unit of measurement in preparing what will become quantifiable, documented units of measurement for sustainability in the aquaculture industry. This is, however, a demanding job that needs to be defined, structured and implemented, to the extent that it is possible, but challenges are also likely to arise during the process. Perhaps there already exists an environmentally responsible basis and quantifiable measurements in the various parts of the LCA chain that may serve as a starting point for this development work.

Based on this simple and preliminary introduction to a simplified LCA assessment, one may start by formulating some key questions to ask a selection of actors in the industry's value chain.

In the main project it will be crucial to define, analyse and quantify the energy quantities in all parts of the industry and use these as a point of departure for developing quantifiable units that form the basis for further documentable sustainability work.

Pedagogically speaking, this can be based on simple, concrete and applied understanding of terms of the type 1m = 1m, 1l = 1l, 1 kwh = 1kwh, 1joule = 1joule, etc., and define, develop and incorporate corresponding energy concepts as units of measurement in the aquaculture industry.

6.3.2 From LCA chain to Circular Economy

The circular economy is a modelling of natural cycles in an economical perspective with an approach based on LCA. Using this as a point of departure, one may ask the following questions:

- *How can each link in an LCA chain continue to develop its own activities/procedures from linear relationships to a circular economic model, including an energy-efficient platform?*
- *Is this desirable and possible and, if so, could it provide a basis for establishing sustainability indicators?*

This is one of several possible approaches the main project can and should discuss and use as a foundation for further efforts to concretise sustainability work.

6.4 Feed

It will be natural to consider the connections between the resource base, production of and access to feed, and the actual production of salmon/trout when formulating the concrete sustainability criteria. Feed production and fish farming are two industries that are closely linked, but are not directly dependent on each other.

If we begin with the feed industry and define all its value and food chains, we see that this is an industry that is subject to other sustainability indicators, including agriculture and aquaculture. This is what we call an indirect sustainability arena for the aquaculture industry.

Based on this, the direct sustainability arena is the actual production stage in the aquaculture industry. This production arena includes both the land-based stage (fry) and the sea stage (edible fish) of the value chain and until the fish is harvested.

In line with the feasibility study's sketch of a simplified LCA-approach to sustainability, we will show some of the environmental standard work undertaken at the two LCA levels of feed and production, which some of the industry actors themselves describe as sustainable. In addition, we will propose how this can be developed further in the main project.

The main project should develop a separate chapter on feed and available resources in the ecosystems. One approach may be to find the total available biomass of marine raw materials and the distribution of this, and the corresponding total available biomass of terrestrial raw materials and distribution of this, produced according to sustainability criteria, for aquaculture and agriculture respectively.

A general perspective in this context can be based on the total solar energy needed in the form of biomass in some ecosystems and a sustainable distribution of this to the Earth's population.

6.4.1 The Marine Component of the Feed

At an early stage of salmon and trout farming in Norway, all feed production was based on marine resources/ raw materials. At one point in the industry's growth, it reached the maximum limit for the use of marine proteins for feed production based on ocean fisheries. This led to the introduction of vegetable resources to feed production.

There are several interesting perspectives in this field, such as:

- *What is the global annual catch limit for marine species used for all types of feed production?*
- *How much of this is spent on salmon/trout farming?*
- *How does this relate to trophic levels in the ecosystems?*
- *Which industries other than farmed salmon/trout use marine resources in their feed production?*
- *What is the distribution of marine feed resources between these industries?*

The questions above are interesting in order to establish an understanding of the use of resources with regard to carrying capacity and environmental limits.

6.4.2 Other Feed Production Factors

It is important that all production factors used to make feed for farmed salmon/trout, both marine and terrestrial raw materials, are subject to similar sustainability assessments.

It will become more important to find alternate raw materials in the time to come, which can largely replace or compliment the feed in a way that ensures fish welfare, provides a high-quality end product and, at the same time, utilises the Earth's resources according to sustainable criteria.

Other production factors are: minerals, vitamins, pigments, antioxidants, alternate protein sources, alternate marine sources and other processed additives.

6.4.3 Sustainability Information from Feed Supplier BioMar

BioMar is one relevant producer of salmon/trout feed. The company states that 2017 marks the 10-year anniversary of its sustainability work, BioSustain.

Its 2016 sustainability report provides interesting information about how the company thinks and works with its definition of sustainability. For example, BioMar shows the distribution of raw materials used in its feed production:

The raw materials can be divided into two groups, cuttings and caught. Fishmeal and fish oil from waste cuttings make up a total of 4 % of the raw materials in the feed, while the corresponding proportion of caught raw material amounts to 20 %. In total, it is stated that 24 % of the feed is based on marine raw materials. The rest, that is 76 % of the raw materials, is vegetable-based.

6.4.4 Sustainability Information from Feed Supplier Skretting

Skretting is another relevant producer of feed for salmon/trout. In its June 2018 sustainability report the company presents its sustainability strategy and programmes to implement it.

Compared to the raw material distribution at BioMar, Skretting states that 24.62 % of its feed production is based on marine raw materials (oils and fishmeal) and 75.38 % of the total feed production is based on vegetable raw materials. The distribution of raw materials is almost identical to BioMar.

There are no quantifications of the production factors used per produced feed unit in Skretting's report, but the company presents summaries of the various approval and certification schemes they are part of. It is assumed that quantifiable entities are to be found in this material.

Skretting also refers to the competition for raw materials that exist between different categories and industries in feed production. This is an important relationship in a sustainability context. Skretting also strives to be energy efficient in all parts of its production systems. By energy, Skretting means energy spent on different production and transportation systems in the value chain.

6.4.5 The Salmon Group Feed

The Salmon Group (SG) feed, or SG feed, is a recipe that feed suppliers produce for SG. The SG feed contains 30 % fishmeal and 10 % fish oil, and waste cuttings are estimated at 12 % of the raw materials.

SG makes strict requirements for all added factors in the feed, especially in terms of food safety and sustainability, and this is documented through certificates.

6.4.6 Energy in an Ecosystem Context

It does not seem possible to trace different types of environmental impact of harvesting wild fish in the ecosystem of the North Sea in neither BioMar nor Skretting's sustainability reports. This type of information and/or issues will be interesting to highlight in the main project.

Neither BioMar nor Skretting seem to be using the fundamental natural law in the overall energy account of the ecosystems, namely the law of decreasing efficiency. It is in this type of energy context that a number of fundamental sustainability issues, especially when it comes to social and environmental sustainability, will have to be formulated, discussed and addressed in the main project.

In the main project, it would be desirable to place the feed production process into an LCA model. In the feasibility study this cannot be addressed in more detail, but it is desirable, for instance, to use energy as a unit of measurement in the various stages of the value and food chain in feed production. In this context energy means the flow of solar energy through the ecosystem's trophic levels as well as energy spent on production, transportation, etc.

6.5 The Indirect Sustainability Arena – Examples of Existing Standards

There are a variety of eco-labels and certification schemes, in Norway and abroad. Eco-label schemes are basically tools for product labelling. Environmental/energy and other certification schemes are methods used to improve the environmental behaviour of companies/groups, and they often use continuous, measurable improvement in behaviour in the certification areas as a method.

The various standards are based on different functions. Some involve purchases, others production and some address the consumer level. All certification schemes have their own set of criteria, but some of their areas overlap in many of the standards.

Some of the standards are developed specifically for fisheries. These are relevant to the marine part of access to feed resources, as shown in the feasibility study's simplified LCA model: the indirect sustainability arena. It is important to have an overview of these and to be aware of how they can be used in an overall sustainability assessment. We can distinguish between the standard of the production factors and the standard of the end product.

We must demand that the different standards be based on the same understanding of the criteria and that the standards are 'standardised' and harmonised. The owners of the standards should join together and agree on shared, formalised requirements and guidelines so that they can build on each other. This must be based on a mutual understanding of the sustainability criteria.

An overview of relevant information on eco-labelling schemes for fish is available, for instance in the following two reports:

- *Nofimarapport 34/2009: Hva menes med bærekraftig sjømat? (Pleym, Honkanen, Toften),* http://www.fhf.no/media/28669/rapport_1_hva_menes_med_b_rekraftig_sj_mat-12082010.pdf
- *Nofimarapport 40/2009: Miljømerking av fisk og norsk fangstmønster (Karlsen og Dreyer)*, https://www.nofima.no/filearchive/Rapport%2040-2009.pdf

It might be useful to study known labelling systems within fisheries such as the Marine Stewardship Council (MSC), KRAV, BRC Food Certificate and Friends of the Sea, regarding the specific arenas, already in the feasibility study.

6.5.1 Marine Stewardship Council (MSC)

The Marine Stewardship Council (MSC) certifies fishing for shrimp, saithe, cod and haddock as sustainable species. This is the world's leading and most recognised independent certification and eco-certification programme for harvesting wild fish. The MSC fisheries certification programme and eco-label for seafood certify and reward sustainable fishing. MSC is a global organisation that works with fisheries, seafood companies, researchers, environmental groups and the public to promote the most environmentally friendly seafood. It does so by identifying and creating market motivation for well-managed and sustainable fisheries.

There are three principles that all fisheries must fulfil:

1. **Sustainable fish stocks**
   Fishing must be at a level that is sustainable for the fish stocks. Certified fishing ensures sustainability and avoids exploitation of natural resources.
2. **Minimising environmental impact**
   The fishing activity must be managed carefully so that the structure, productivity and diversity of the ecosystem are maintained.
3. **Effective fisheries management**
   Fishing must comply with all local, national and international laws. A management system must be in place to respond to changes in the environment and maintain sustainability.

6.5.2 KRAV

Fishing for cod, haddock, saithe and deep-sea prawn in the Norwegian Sea and the Barents Sea have been approved by KRAV. KRAV is Sweden's most famous eco-label for organic food. The certification means that there are sustainable stocks and that fishing is carried out with tools that limit by-catch and catching fish below the minimum size.

6.5.3 BRC Food Certificates

BRC Food is one of the world's leading suppliers of standards for seafood manufacturers of all sizes that wish to clarify best practices and accountability. It takes care of the entire food chain, and delivers standards related to traceability, within the production line and sales and distribution.

6.5.4 Friends of the Sea

Friends of the Sea is an international certificate for products from sustainable fisheries. Fishing for deep-sea prawns in the Northeast Atlantic has been approved as sustainable. The approval means that the stock is not overfished, leads to no by-catch of endangered species, no damage to the seabed and that fishing takes place within current regulations.

6.5.5 Certification Schemes for Agriculture

There are also certification schemes for agriculture. The most relevant today relate to the indirect sustainability arena for feed production, and are ProTerra, RTRS and RSPO.

The main project must review all relevant standards for feed production and fish farming, both to gain an overview of the current status, but also to be able to utilise the standards as a basis for further work.

6.5.6 Market Reactions to Eco-labelling of Fish

Within SG's ambitions for sustainable aquaculture it is relevant to investigate the extent to which sustainable fish farming systems produce some kind of effect on the market, and if so, what kind of effect this is.

Nofima has investigated this [1] and in the following summary it appears that in 2011, there was little or no effect of eco-labelling of fish caught in the UK and France.

The goal of this survey was to identify and analyse consumer perceptions, understanding of and knowledge about the sustainability concept, focusing on the Marine Stewardship Council. One part of this goal was to investigate the importance of sustainability as a purchase criterion and to estimate recognition and use of the MSC logo when buying fish. This report presents descriptive results from focus group surveys (N = 80) and a web survey (N = 2036) in the UK and France.

A more current (2016) perception of sustainability as a competitive advantage is found the following statement from Innovation Norway by Inger Solberg, Division Director, Department of Technology and Society – Green Growth:

Companies that work with sustainable solutions within their own business areas develop new products and services faster for their customers.

It is important to get up-to-date information in this area to match the focus in the industry itself, while responding to international challenges through the UN's Sustainable Development Goals. In this regard it would be relevant to cooperate with the Norwegian Seafood Council, which operates close to the markets.

Our starting point in this feasibility study is the following: SG aims to be a driving force in developing indicators and a standard that sustainability can be measured against. In this way we will contribute to establishing a new and documentable sustainability standard that can also help achieve greater market shares in a competitive supplier market.

6.6 The Direct Sustainability Arena – Eco-labelling the Production Stage

There are currently some standards for certification of fish farms. The most relevant are GlobalG.A.P, Best Aquaculture Practicis (BAP) and Aquaculture Stewardship Council (ASC). It is important to acknowledge that these certification schemes are not based on joint standards, and the industry should require the owners of these certification schemes to develop shared standards that can build upon each other, based on a shared understanding of the sustainability criteria.

6.6.1 ASC – A Global Standard for Environmentally Certified Aquaculture

The WWF was one of the initiators of the environmental certification for a number of aquaculture species, and the ASC was founded in 2009. ASC is an abbreviation for the Aquaculture Stewardship Council, and is an independent, non-profit certification body for responsible aquaculture. Products with the ASC label have met the requirements of the ASC environmental standard. The eco-label shows that the seafood comes from aquaculture that minimises its impact on the environment and society.

The environmental standards used in the ASC were developed through the Aquaculture Dialogues, which were coordinated by the WWF. The ASC is an independent certification body that certifies aquaculture facilities through open process, and it is an approved certification body that carries out certifications. All certification documents are posted on the ASC website (www.asc-aqua.org) and organisations as well as individuals can provide input to the certification of a facility as part of the process.

Tiliapia was the first aquaculture product that was certified according to the ASC standard in 2012. Since then, salmon, pangasius, freshwater trout, tropical prawns and mussels (including blue

mussels, scallops and oysters) have also been ASC certified. 46 nations have aquaculture facilities that are certified according to the ASC standard. The ASC standard is not adopted once and for all, but is a dynamic standard that is revised every three years.

In Norway, farmed salmon is currently the only ASC-certified aquaculture product. The Salmon Standard was completed in 2012 and developed through the Salmon Aquaculture Dialogue, an inclusive process with over 500 contributors.

By late 2015 there were over 200 ASC-certified farms worldwide. Salmon is the largest product group and had 84 ASC-certified plants worldwide at the time, most of which were located in Norway. Pangasius and tropical prawns are other species that are certified through the ASC.

The ASC fish farming scheme complements the MSC system for wild fish, and both set sustainability requirements based on their own criteria. Today, seafood from aquaculture accounts for more than half of all seafood consumed worldwide, and with a global growth in the aquaculture industry, sustainability in fish farming becomes increasingly important to minimise its impact on the environment and society.

The introduction of the ASC for aquaculture products is an important step towards making consumers aware that all seafood has the potential to be sustainable and come from responsible suppliers. Three years after the first ASC logo was introduced, there were more than 4 000 ASC-certified seafood products worldwide. More and more consumers acknowledge the ASC as a guarantor for food safety and associate its eco-label with something positive.

6.6.2 Industry Input

One important relationship in the kind of development work this feasibility study initiates is to study the factors the industry is already using in this field. This should be done to highlight important, established knowledge and working methods, as well as to illustrate the industry's understanding of sustainability today.

In Nordland there is one SG shareholder and producer of organic ASC-certified fish, who might be a relevant candidate in constructing this type of approach. Information and documentation from this company can be used as an example of a point of departure/basis for further concretisations in the main project, if the company is interested.

It may also be useful to make a survey of a selection of Norwegian fish farms, concerning the companies' practices and documentation systems and their understanding of sustainability today.

This can be carried out simply through document/process reviews. Experience has shown that one may then find that some of the procedures and results have already been established, but perhaps to different extents, and without being defined as sustainability elements.

The SG has already initiated various activities aimed at strengthening the network's overall environmental behaviour. Through these initiatives, the lack of clear common indicators and standards for sustainable fish farming, on a national and global level become evident.

How do we ensure that the technological development also solves challenges in a sustainability perspective? Is today's technological development firmly based on sustainability criteria? Is the development driven by immediate challenges or by economic interests alone?

6.7 Technology

Increased focus on sustainability has led to increased technological innovation. There are far more drivers for development that need to be considered today and the whole situation has become more complex. Beside the development of the industry and the major global changes in society, one must relate to the great paradigm shift centred on digitisation and the sharing economy. The technological shift is part of the shift towards a green economy. This is a welcome change in the world economy, but it is unfamiliar to the business community and there are many considerations that need to be made at the same time. It requires a great ability and willingness to adjust, and when you need to make many expensive investments at the same time, you need to be sure about the direction you choose.

It is important that the shift to a green aquaculture industry is carried out in a way that includes the entire industry, and is based on the same guidelines. It is easy to take a false step, and therefore the industry should act jointly to point out the direction and improve the industry together. In the main project it will be crucial to define and clarify the term 'det grønne skiftet' (the 'green shift' towards a green economy) for the industry.

Regardless of the approach, it is a fact that new technologies in the aquaculture industry are still being developed and implemented. This is a crucial factor in turning the industry in the right direction. But how do we ensure that the technological development also solves challenges in a sustainability perspective? Is today's technological development firmly based on sustainability criteria? Is the development driven by immediate challenges or by economic interests alone?

It will be vital to formulate and analyse these and other issues in the field of technology in the main project. Similarly, the main project should prepare an overview and a review of relevant new technologies for the industry.

There are several on-going projects aimed at clarifying sustainability for the industry. To the extent that one is able to develop the ideas surrounding them and identify indicators, this is interesting for the industry as a whole. It is therefore important to follow other initiatives and collaborate to refine the final sustainability criteria.

6.7.1 Examples of Similar Sustainability Projects

The project *Bærekraftsindikatorer i norsk havbruk* ('Sustainability Indicators in Norwegian Aquaculture'), commissioned by The Norwegian Seafood Research Fund (FHF) is currently underway. Nofima and SINTEF are responsible for its execution. Information about the project can be found through the following links:

https://nofima.no/prosjekt/bkb/
http://www.fhf.no/prosjektdetaljer/?projectNumber=901255

It will be natural to follow this FHF project into the main project, as it may contain factors that may be developed further, which therefore would be important to consider in the main project.

6.7.2 A Technological Example – Electrification of Vessels and Feeding Stations

It may be useful, in the further work on the project, to use examples to explain and show reorganisation in a sustainability context. One example that is concrete, practical, familiar, realistic and feasible is the electrification of vessels and feeding stations. This change is already underway, but it requires an overall strategy for the provision of infrastructure and charging capacity for the coastal fleet as a whole.

This type of infrastructure project requires different actors (power/network suppliers, etc.) and technology suppliers, business sectors (shipping, the Norwegian Coastal Administration, etc.) to cooperate to achieve a fossil-free fish farming industry.

6.8 Transportation

Transportation is defined as one of the main areas for reductions in greenhouse gases in the Paris Agreement and in following up the agreement on a national level. Transportation is a major contributor to greenhouse gas emissions, and although it does not have its own goal in the UN's Sustainable Development Goals, it is integrated into many of the 17 goals: the goal concerning sustainable cities and infrastructure and the ones concerning food safety, health and energy are closely linked.

For a large and growing industry like aquaculture, public opinion of the industry also relates to the choices it makes in transporting raw materials and finished products to and from the production site. It is therefore important to take action to solve this challenge to meet the goal of reducing greenhouse gas emissions.

The main project must describe the overall transportation situation and the associated climate accounts. Transportation will be a significant area for development and implementation of sustainability indicators and future procedures in this field.

7 Summary

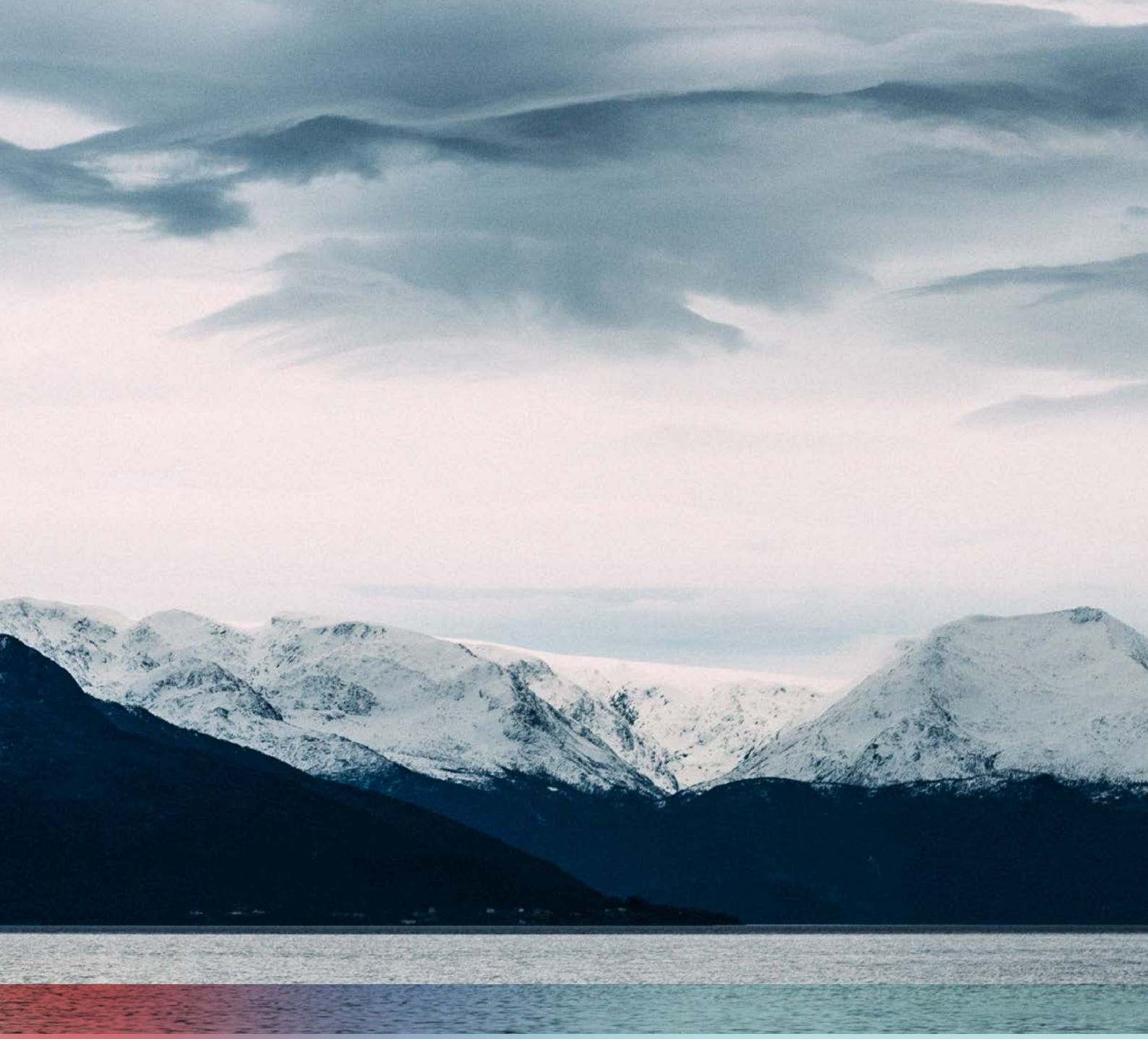
This feasibility study describes important aspects of fish farming and aquaculture, seen in light of sustainability as a driver of development. It describes the status of the industry today, and outlines some of the challenges and opportunities it faces, while pointing out aspects that are not well-integrated into the continuous transformation towards sustainable farming, as seen in e.g. the UN's Sustainable Development Goals. This is probably due to the fact that there are currently no defined indicators for sustainable fish farming that guide global practice. Once such indicators are in place, it will be possible to define concrete criteria that can measure the degree of sustainability.

Our goal is that this feasibility study should lead to a main project that defines indicators and through them, criteria that can be established as a global standard and will guide global practice. Salmon GroupG wishes to develop a comprehensive and concrete manual as part of the main project, where this type of global standard concerning all aspects of and concerning the industry form part of the sustainability accounts.

Our goal is therefore that the indicators that underlie the definition of sustainability in aquaculture, and thus the criteria that are developed, should be knowledge-based and dare to be clear and honest. Our point of departure is based on a holistic approach founded on the production stage. We see that the reputation of the industry and its end product depends on all parts of the production chain having a shared understanding of and framework to define the industry as sustainable.

Photo: Lingalaks

SALMON
GROUP



Salmongroup.no

/salmongroup