MASTER THESIS

Grete Thuv Tjønndal
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Upscaling macroalgae aquaculture production: Sustainable innovation principles applied by Norwegian stakeholders

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Forord

Denne masteroppgaven markerer slutten på min grad, Master i Biovitenskap - Akvakultur. Masteren er gjennomført ved fakultetet for biovitenskap og akvakultur ved Nord universitet i Bodø. Oppgaven omfatter 30 studiepoeng.

Gjennom et masterløp som har vært sterkt preget av koronapandemi og nedstenging er det en overveldende glede å endelig få levere min avsluttende oppgave. Jeg har opparbeidet meg mye ny kunnskap etter intenst arbeid over flere måneder, innenfor et interdisiplinært felt jeg engasjerer meg for.

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Bodø, 16.05.2022

Grete Thuv Tjønndal

Abstract

The macroalgae industry is a promising addition to the production of renewable resources in European countries. By presenting an alternative to terrestrial biomass production or fish aquaculture, macroalgae aquaculture contributes to the dimensions of sustainability; environmental, societal, and economical. Considering European macroalgae production is still in its infancy, facing challenges related to further development and profitability, initiatives toward sustainable development, supported by innovation, are encouraged. This thesis identified challenges and opportunities associated with sustainable development in this novel industry in Norway.

More specifically, the study aimed to identify the intentions and actions taken by stakeholders representing the macroalgae industry by generating empirical data through a qualitative methodological approach using semi-structured interviews. An extensive literature review supported the study's theoretical foundation and provided the background for the interviews. Through interviews, the study achieved insight and knowledge from five industry stakeholders associated with the macroalgae industry in Norway. The interviews explored the stakeholders' ambitions and awareness of sustainability and economic growth to understand how these concepts promote sustainability initiatives in small organizations that are sensitive to changing conditions.

Theory about sustainable innovation through responsibility and stakeholder engagement initiatives was applied to explore the thesis statement. The industry representatives identified flexibility toward change, openness, and inclusion of community and industry stakeholders in their endeavours as part of their contribution toward sustainable development. All informants agreed that taking responsibility for sustainable production on nature's terms entails knowledge about the risks and impact of production. Further, the informants were aware that the production of macroalgae benefits livelihood in coastal communities through employment and value creation. To facilitate innovative solutions leading to industry growth, the production of macroalgae requires further collaborative work between various fields of research, including both internal and external stakeholders, to provide successful innovations that facilitate beneficial interaction with the dimensions of sustainability.

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1 Introduction

1.1 Background for the thesis

By 2050 the world's population is estimated to exceed 9 billion, increasing the demand for resources to accommodate the requirements of the growing population (UN, 2022b). Resource scarcity, including a predicted doubling of global food requirements from 2013 to 2050 (FAO, 2017), along with climate change and destruction of ecosystems, necessitates more sustainable production based on renewable resources. To solve these challenges, we need to do things differently, calling for a change from business as usual to new business structures by creating new knowledge and innovation (Boons et al., 2013).

The oceans have the potential to supply the demand of the world's growing population for food in the years to come through an increase in the production of renewable resources (Hoegh-Guldberg et al., 2019). Moreover, the marine sector provides great prospects for innovation and economic growth (OECD, 2016). Biomass production in the marine environment has gained interest, in particular the cultivation of food resources from lower trophic levels than today (Olsen, 2011). A future increase in marine production must entail knowledge and risks associated with large-scale production in this environment to sustain resources and minimize impact through sustainable management and regulations (Campbell et al., 2019). Salmon aquaculture is a well-established and expanding industry, producing fish biomass for the growing population, but it is also associated with infamous regard to environmental impact and animal welfare (Sommerset et al., 2022). The potential for other emerging biomass productions in the ocean is imminent, and growing the macroalgae aquaculture industry could largely contribute to sustainable resources and food security.

The EU Bioeconomy Strategy aims to strengthen biomass-producing sectors' sustainable development and growth (Araújo et al., 2021). Further, this has increased interest in pursuing industrialized macroalgae production as it is considered a significant and unexploited marine resource in European waters (Campbell et al., 2019; Skjermo et al., 2014). The development of a macroalgae industry in Europe is still in its infancy, with small-scale producers and limited knowledge of production methods, biomass processing, and concerns related to environmental impact. Pursuing sustainable industry development entails innovation that supports the environmental, societal, and economic dimensions of sustainability and could facilitate further growth in the macroalgae industry.

1.2 Research question

This thesis explores macroalgae farmers' awareness, understanding, and attitudes by examining how they perceive sustainability and how their perception connects to the innovation for economic growth in the macroalgae sector. Further, this involves an investigation of the informant's intention and actions through responsibility and collaboration with stakeholders. The overall research question was:

How do macroalgae producers work with sustainable innovation to ensure continued growth and economic viability in a novel industry?

More specifically, I asked:

- How do macroalgae farmers perceive sustainability?
- What do macroalgae farmers view as their responsibility in achieving sustainability?

As sustainable development is a global concept directed at interactions and outcomes on a macro level in the larger Earth system, this thesis seeks a deeper understanding of the current situation for small-scale macroalgae producers. Accordingly, this entails uncovering their ambitions for sustainable and economic growth and their perception of how they work with these concepts to promote sustainable development on an organizational micro level.

1.3 Limitations

The term macroalgae refer to all species of red, green, and brown algae with macroscopic multicellular life cycle stages.

Measuring the impact of sustainability initiatives includes identifying indicators for further monitoring and evaluation. This thesis does not seek to identify such indicators but instead provides insight into the work organizations are engaged in and how they create new solutions as responses to change.

This thesis frequently mentions the sustainability dimensions, a combination of the environmental, societal, and economic dimensions. These dimensions are not exclusive in their reach. Some theorists include the dimensions of governance and culture to gain a better understanding of the entire system. However, to limit this thesis, I chose to include the dimensions of sustainability that are compatible with the business model Triple Bottom Line – environment, society, and economy.

1.4 Structure of the thesis

The outline of the thesis made up of six chapters. The first chapter describes the background for the choice of topic and the research questions of this thesis. Chapter 2 presents the conceptual setting and theoretical framework, while chapter 3 delivers the methodological approach used for the study. Chapters 4 and 5 present the analysis results and the discussion of these results, respectively. In chapter 6, the main findings and concluding remarks are presented.

2 Context and theoretical framework

Chapter 2 provides background on macroalgae aquaculture and the global status before closing in on the Norwegian industry, elaborating on production processes and challenges and opportunities in this emerging sector. Further, the main theoretical concepts of sustainable development and innovation for sustainability are described based on the provided context.

2.1 Macroalgae aquaculture

2.1.1 Wild macroalgae

Macroalgae are macroscopic species of red, green, or brown algae growing in the marine environment around the globe (FAO, 2018). They support intertidal and shallow subtidal coastal ecosystems, providing marine species with habitat and protecting exposed communities along the coast (Barbier et al., 2019). The distribution is species-specific and depends on light conditions, wave exposure, temperature, and available nutrients (Kerrison et al., 2015). They are characterized as photoautotrophs as they gain energy from the sun and absorb available nutrients from their environment (Grebe et al., 2019; Skjermo et al., 2014).

Macroalgae have been harvested for centuries and are used for food and feed in coastal communities (FAO, 2018). In the previous century, natural macroalgae forests were progressively harvested to meet the increasing interest as a source of alginate in the expanding production of additives for food (Skjermo et al., 2014). Today macroalgae biomass is a multipurpose product used various of industries such as medicine, fertilizer, cosmetics, biofuel, bioproducts, feed, and food (FAO, 2018). Harvesting wild macroalgae is detrimental to the marine environment and ecosystems, as overexploitation and damaging and invasive mechanical harvesting methods are practiced using trawlers (Araújo et al., 2021). Therefore, macroalgae cultivation has gained interest as a more stable and sustainable way of producing macroalgae biomass (FAO, 2017).

Macroalgae aquaculture provides great opportunities to produce biomass in coastal areas worldwide, additionally described as a relevant contribution to sustainable development (Barbier et al., 2019). Macroalgae do not require feeding, fertilizers, or extended use of freshwater to grow in aquaculture facilities (Skjermo et al., 2014), as opposed to fish aquaculture, where feed and medical treatments increase production costs and are limited by supply (FAO, 2018). However, for the industry to meet the future requirements, the production must increase, which will raise not only opportunities but also challenges to remain sustainable. While these challenges may partly hinder rapid growth and development,

they can also be a driver for innovation of a novel industry concerning technology, research, and management strategies (Skjermo et al., 2014).

2.1.2 Current status

Today the global production of macroalgae is supplied by about fifty countries, with industrialized production led by countries in East and South-East Asia, such as China, Indonesia, the Republic of Korea, and the Philippines (FAO, 2018). Since 2000, production has tripled worldwide, from 10.6 mill tons to 32.4 mill tons in 2018, with cultivated macroalgae making up 97 % of the volume (FAO, 2020). Temperate and tropical species dominate the production, mainly cultured in efficient and labour-intensive growing systems, as the industry leader, China, grows predominantly kelp species (FAO, 2017; FAO, 2020; Campbell et al., 2019).

The production of farmed macroalgae in Europe is increasing to accommodate the European bio-economy goals and as a step towards sustainably developing new biomass resources. Today, macroalgae biomass is mainly used for food ingredients (51%), feed (10%), and cosmetics (17%), with only a small portion of other biobased products or services (Araújo et al., 2021). Thus, macroalgae cultivation is a growing industry in 13 countries around Europe. Currently, about 30% of the macroalgae biomass harvested in Europe comes from aquaculture (Araújo et al., 2021). The cultivation of macroalgae is rising, with sugar kelp, Saccharina *latissima*, being the main species grown in temperate and cold waters of the Atlantic (FAO, 2020). With a high carbohydrate content and fast-growing nature, the biomass yield is attractive and creates possibilities for diverse utilization for industrial purposes (Araújo et al., 2021; Skjermo et al., 2014).

While the European macroalgae industry aims to reach an industrialized scale (Barbier et al., 2019), it is still juvenile and decentralized. It faces multiple challenges before realizing up-scaling as a possibility (Araújo et al., 2021). Additionally, environmental impact and risks associated with production must be assessed to ensure beneficial outcomes (Campbell et al., 2019). Barriers in the supply chain related to building a stable production cycle, mechanical advances in seedling and harvesting technology, and species-specific knowledge for management and market accessibility must be solved (Campbell et al., 2019; Araújo et al., 2021). Hence, further investments in research and development are required to develop a sustainable industry outside of Asia (Barbier et al., 2019).

Currently, Norway is the largest producer of harvested wild macroalgae and represents the European country with the most registered macroalgae aquaculture companies (over 500 permits) (Stévant et al., 2017; Fiskeridirektoratet, 2022). Its long coastline and nutritious waters, with stable temperatures and light conditions, facilitate a potential macroalgae production of 70-200 tons per ha (Hancke et al., 2021). Kelp, primarily sugar kelp (*Saccharina latissima*) and winged kelp (*Alaria esculenta*), are currently the most cultivated species in Norway (Norderhaug et al., 2020). However, as of 2020, the registered cultivated production for the entire country is 336 tons a year (248 tons S.*latissima* and 88 tons A.*esculenta*) (Fiskeridirektoratet, 2022) (figure 1). Therefore, the potential exceeds the reported harvest by far because the majority of the producers are start-ups with research-based farming in small-scale facilities (Hancke et al., 2021; Stévant et al., 2017).

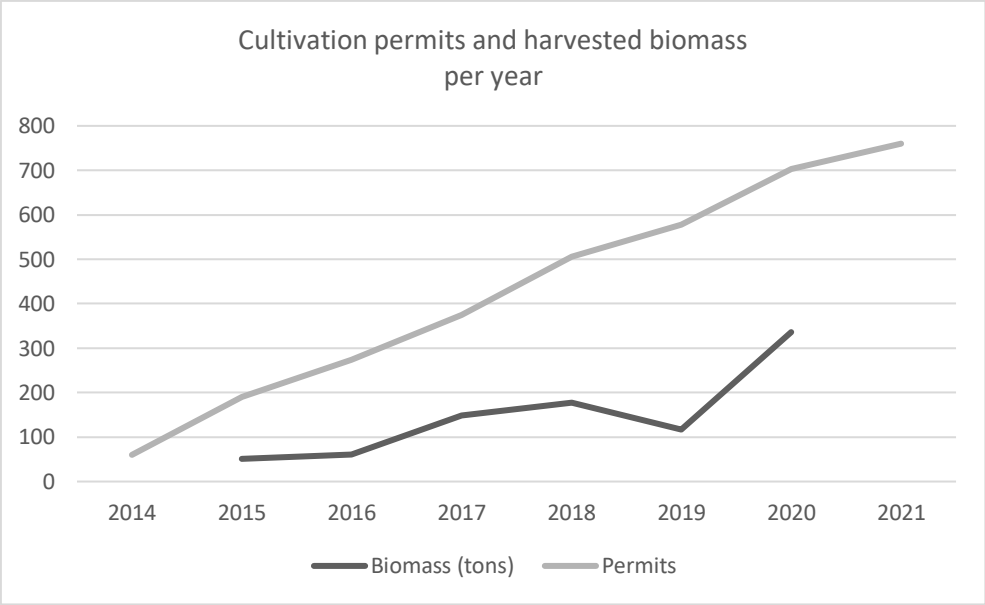

Figure 1. *Cultivation permits provided by the Norwegian Directorate of Fisheries the period 2014-2021 and the registered harvested biomass from macroalgae aquaculture (Fiskeridirektoratet, 2022).*

The initial cultivation of macroalgae in Norway was introduced due to the possible application for bioenergy purposes (Skjermo et al., 2014). However, due to insufficient delivery of stable biomass, and limited technology advancements to accompany such production, producers were challenged in multiple steps of the supply chain (Stévant et al., 2017). The market access is yet limited, as the commercialization of products for new markets must develop (Skjermo et al., 2014). For future prospects, using a broader range of species with different nutritional properties better suited for food or high-value products could be possible. Although having the conditions for a potential macroalgae industry, the production

sites are currently limited and scattered along the coast, remaining not operational for large-scale production (Stévant et al., 2017).

In Norway, the agenda for building and encouraging biobased industries is a part of the bioeconomy and sustainability goals (Meld. St. 20 (2019–2020)). To ensure management and regulations in accordance with these goals, cooperation between stakeholders is vital, especially between governmental organizations, producers and industry, and research institutions, to guarantee the development of standards and strategies for best practice (Stévant et al., 2017), while also accounting for the ecosystem as a stakeholder. Such cooperation builds the foundation of the Norwegian Seaweed Association. It aims to be an arena for collaboration between stakeholders linked to the macroalgae sector while managing the interests of these stakeholders towards the regulatory sector (NSA, 2022).

2.1.3 Stakeholders and practices in the value chain

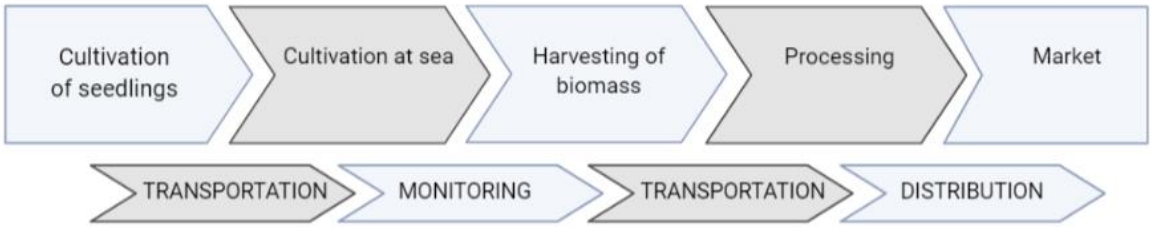

Figure 2. *Describes a generalized supply chain applicable to macroalgae aquaculture.*

Currently, the macroalgae sector calls for optimizing the entire supply chain to ensure efficient use of resources and reduce production costs. The improvements are essential for value creation in all steps of the organization's operations (Holweg & Helo, 2014). Further, stakeholder involvement is needed to manage the variety of interests and perspectives for development to balance the potential conflict between suppliers, vendors, and farmers (Laplume et al., 2008). Profitability requires the farmers to compensate for the high investments needed in technology development and operational expansion, by reducing costs elsewhere in the supply chain. A significant concern is that the current production methods in Europe resemble the ones established in Asian countries but at a much higher labour cost (FAO, 2017).

Site selection is not a part of the supply chain but is a prerequisite to establishing a farm and includes multiple external stakeholders. The regulative sector facilitates areas for production, policies, and management. Spatial plans and interdisciplinary evaluation processes are

essential to balance the interests of various sectors (Stévant et al., 2017; Broch et al., 2016). Further, the species-specific growth depends on suitable environmental conditions such as salinity, temperature, light, and nutrients (Kerrison et al., 2015; Campbell et al., 2019). Such evaluations must be included in the placement assessment for farms.

A common strategy for cultivating seedlings is to collect mature sporophytes from their natural habitat (Forbord et al., 2018). Further, the spores and gametophytes are grown on land controlled with artificial lighting (Stévant et al., 2017; Norderhaug et al., 2020). Breeding efforts aim to develop robust, disease-resistant seedlings, with predictable production, and adapted to the applied cultivation systems (Norderhaug et al., 2020). However, it is also important to use native species and populations in cultivar production to preserve the genetic diversity of wild populations (Grebe et al., 2019).

The growth substrates for kelp sporophytes are typically ropes, nets, or textiles, which allows for the transfer to ropes or other structures at sea. A standard method uses long-lines with seedlings suspended with moorings in surface structures (Kerrison et al., 2015; FAO, 2018). The deployment timing depends on seasonal varieties, although late fall and winter is regular practice (Broch et al., 2019). A challenge is to optimize the biomass density and timing of deployment to ensure the highest return of product while maintaining a cost-efficient production (Campbell et al., 2019). The harvesting period is often limited by the growth of fouling organisms on the kelp in spring or early summer, while the composition of valuable components in the macroalgae degrades as nutrient access decreases during the season (Norderhaug et al., 2020). Additionally, the loss of biomass due to deterioration or weather conditions impacting the surrounding environment can be avoided if the harvest is precisely monitored (Grebe et al., 2019). As the harvesting process is intensive and time-consuming, with an extended need for workforce and equipment, automated solutions are in development for European applications (Campbell et al., 2019; Stévant et al., 2017).

Processing refers to the handling of the biomass after the harvesting, and the product must be stabilized rapidly after landing. Various methods, including drying and freezing, are used to preserve the biomass, ensuring a stable product delivery year-round (Skjermo et al., 2014). Logistical challenges throughout the supply chain, due to long-distance transport, require stabilized biomass (Stévant et al., 2017).

2.2 Conceptualizing sustainable innovation

2.2.1 Definition of sustainability

The term *sustainable development* has gained momentum since the report *Our Common Future* from 1987, delivered by the World Commission on Environment and Development (WCED). The report defined sustainable development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987, p. 43). That is the most used definition of sustainability because it acknowledges of the privilege of all people, present and future. The triple bottom line – comprises ecological sustainability, economic opportunity, and social equity – as the three dimensions of sustainability (Elkington, 1998), and is commonly used to express business contribution to sustainability. However, due to the field's interdisciplinary nature, there is no consistent concept or terminology to describe sustainable development (Bocken et al., 2019).

Due to the severe impact of human activity and development on global ecosystems, we have entered a new era of Earth's history referred to as a new geological epoch, the Anthropocene (Robertson, 2021). The Earth's systems are drastically destabilized by biophysical processes referred to as the nine planetary boundaries, including climate change, biosphere integrity, ocean acidification, freshwater use, land system change, biochemical flows, atmospheric aerosol loading, stratospheric ozone depletion, and novel entities (Steffen et al., 2015). The boundaries are interconnected, and thresholds are identified as critical values that must not be exceeded. For instance, the threshold for loss of genetic diversity is surpassed, leading to uncertainty and increased risk of devastating outcomes such as sudden or permanent changes to the global environment (Rockström et al., 2009).

Carrying capacity is a term used to describe the limits of ecological systems' capability to maintain a set number of individuals, as the availability of resources is finite (Del Monte-Luna et al., 2004). Thus, for people to lead healthy and secure lives, the carrying capacity of ecosystems must be considered, along with the social capital – a community's capacity for cohesive effort – to ensure sustainable development (Paldam, 2000; Robertson, 2021). System transformation is required to safeguard the health of ecosystems by making sure that resources are exhausted no faster than they can reload, and that pollution is not released faster than it is absorbed, accompanied by circularity in production and waste management. This calls for quality solutions without quantitative expansion in consumption (Robertson, 2021).

Complex adaptive systems

The Earth system is comprised of complex webs interacting with each other, characterized as complex adaptive systems. These systems are self-organizing and interdependent, using feedback and links for controlling the systems' basic properties, meaning changes in one part of a system could generate beneficial or adverse changes in other parts (Ritala, 2019). The dimensions of sustainability – environment, economy, and society – operate on multiple scales within the Earth systems and subsystems, which are fundamentally interlinked (Robertson, 2021). Therefore, the whole system is always more than the sum of its parts, as one system cannot be realized at an individual scale, requiring a holistic approach to the study of sustainable development.

The United Nations sustainable development goals

In 2015, the United Nations (UN) formalized the main challenges facing humanity globally. These challenges are aimed to be solved through 17 sustainable development goals (SDGs) to reach before 2030 (UN, 2022a). These goals facilitate a normative framework for the global community to work together for climate actions to secure food, clean water and sanitation, and equality for the Earth's population in the future (Bocken et al., 2019). The various SDGs cover multiple scales and are interconnected, meaning that addressing one goal might resolve issues related to another (UNDP, 2018). Approaching the goals involves encouraging innovation and sustainable consumption, as radical change is required to recognize the power of small-scale actors' and industries' contributions to the larger system (Leach et al., 2012).

Figure 3. *Outlines the 17 sustainable development goals from the United Nations (FN, 2022).*

2.2.2 Sustainability initiatives

Organizations have various reasons for pursuing sustainability initiatives in their operations. Building the initiatives on "because it is the right thing to do" or on the fear of monetary or legal liability is a weak motivation. However, organizations generally experience that implementing new strategies toward sustainability yields positive outcomes (Bocken et al., 2019). Energy-saving initiatives reduce production costs, while efforts responding to customer demand impact the market share, as the company differentiates itself from its competitors. Accordingly, the implementation of sustainability initiatives can be profitable (Robertson, 2021).

Prioritizing sustainable initiatives in the organization also entails assessing associated opportunities and risks. However, the priorities depend on governance systems within the company and how they consider proposals from their employees or stakeholders. Traditional management models are based on linear hierarchical systems, where employees are considered assembly-line workers who do not need additional organizational knowledge to do their job (Skorstad, 2021). Instead, when management is built on non-linear systems, employees are encouraged to participate in processes within the organization (Skorstad, 2021). These systems are often compared to complex adaptive systems, as they evolve and self-organize in the face of change while employees take part in the shared development of goals and strategies (Robertson, 2021). Further, initiatives for sustainability support innovation and demand active participation from employees and stakeholders to uncover solutions benefiting the triple bottom line.

The path of implementing sustainability initiatives in the company can take various directions. As the task is extensive and continuously changing, the company must establish a baseline for assessing the current conditions. Therefore, several frameworks have been designed to guide companies in their process of implementing sustainability initiatives and measuring indicators for performance, like the global reporting initiative (GRI) and triple bottom line (TBL) (Robertson, 2021). These frameworks facilitate the progress through planning and prioritizing projects, which are further monitored and evaluated to assess the improvement of sustainability work (Robertson, 2021).

However, the level and scale of sustainability initiatives must be established before initiating the process (Robertson, 2021). Whether the process is top-down or bottom-up could either limit or enhance the progress. Scale-dependency requires oversight to identify challenges

across multiple scales. Working with individual scale actions involves initiatives such as eating meat-free diets, with minor impacts unless many individuals participate in presenting a powerful message. These individual acts are a good starting point for further actions, but solutions to more considerable challenges are not feasible. “Systemic problems require systemic solutions,” and as such, the company must decide at what level the work should start (Robertson, 2021).

According to Robertson (2021), the systematic process of initiating sustainability work starts with producing a vision statement that clearly identifies sustainability aspects transferrable to reality. The statement gives future projections on where the organization wants to be, steering the transformation process (Leach et al., 2012). Further, it creates a roadmap going backward to the present state while recognizing milestones. These milestones indicate measurable performance goals achieved through strategies aligned with the vision statement. Specific projects, also described as tactics, are instigated to support the implementation of strategies with the guidance of organizational policies to progress toward sustainability. However, to adjust the course and enable learning through this process, it is essential to identify performance indicators, which are relevant and significant to the context, as they calculate impacts and recognize trade-offs to facilitate management decisions (Dale et al., 2015).

Knowledge and collaboration

As sustainability work is collaborative work, it builds on interdisciplinary teams, combining different functions and departments, and varied positions of responsibility (Robertson, 2021). Thus, openness toward different needs and views of the world creates greater diversity and promotes innovative solutions (Leach et al., 2012). Networks display emergent properties as people collaborate on projects and generate outcomes that exceed the possibilities of the organizational system itself. Collaboration also recognizes the need for knowledge-sharing practices, which, in turn, fosters trust and innovation (Wang & Noe, 2010), and provides competitive advantages by transferring specific knowledge through collaboration.

Corporate social responsibility

The concept of Corporate Social Responsibility connects ethics to organizational policies (Vărzaru et al., 2021) through four levels of responsibilities, including economic, legal, ethical, and philanthropical (figure 4) (Carroll, 2016). Following the Paris Agreement and the launch of the UN’s 2030 Agenda, the application of CSR has been strongly linked to its

application to the SDGs (Latapí Agudelo et al., 2019). This expansion of CSR includes a broader commitment for companies to take action for their environmental impact while accounting for societal aspects and seeking transparency in their practices as a strategic approach. Furthermore, their corporate responsibility is demonstrated through their principles and performance that align with stakeholders' expectations and demands (Vărzaru et al., 2021). Thus, companies include environmental and social aspects as part of their economic value creation (Bocken et al., 2019), making CSR a prominent initiative for companies today.

Companies address their corporate responsibility beyond the financial interest, and they approach what many believe to be the primary obligation for corporations, creating shared value (Latapí Agudelo et al., 2019). Focusing on recognizing the relation between economic and societal progress, the concept of shared value supports global growth (Porter & Kramer, 2011). Accordingly, accounting for societal well-being in the company's business model and fulfilling the internal and external stakeholders' requirements (Vărzaru et al., 2021). However, critics argue that CSR is limited by the conflicts between seeking profit, and social and environmental challenges (Ritala, 2019), as the concept does not grasp the interconnectedness of these dimensions.

Figure 4. *Illustrates the four levels of corporate social responsibility: economic, legal, ethical and philanthropic (Carroll, 2016).*

2.3 Innovation for sustainability

Innovation is regarded as a multidisciplinary concept without any consistent definition (Bocken et al., 2019), as various disciplines use definitions that align with their respective field. Innovation is often initiated as a response to changes caused by alterations concerning the organization's assets, capacity, policies, and obligations (Baregheh et al., 2009). Innovations are characterized as emerging from either process or outcome perspectives (Quintane et al., 2011; Baregheh et al. (2009)):

- The form or nature of innovation, as something new or improved.
- The type of innovation, as the resulting product or service.
- The stages of innovation processes.
- The social context.
- The means of innovation, including technical, creative, or financial resources needed.
- The aim of innovation that underlying all activities undertaken in the innovation process.

However, the primary outcome of innovation processes in organizations' initiatives is the development of new knowledge (Quintane et al., 2011).

Traditionally, innovation processes emphasize the expected economic growth and assess developmental risks, not accounting for social and environmental perspectives (Silvestre & Ţîrcă, 2019). In more recent developments, the perspective of sustainable innovations has emerged as an inclusive and holistic approach to sustainable development, as it balances economic, environmental, and societal aspects, not maximizing opportunities but yielding reasonable solutions (Boons et al., 2013; Silvestre & Ţîrcă, 2019). However, the organization's intentions to proceed with sustainable innovations could negatively affect the larger system, as it is challenging for parts (organization) within a complex adaptive system to assess the outcome of their actions (Ritala, 2019). Initiating sustainable innovations does, therefore, require thoughtful planning to be able to evaluate and trace possible impacts, as is essential to all sustainability work (Bocken et al., 2019).

To pursue sustainable innovations within an organization, there is no clear and defined recipe, and researchers are divided in their opinions on the approach (Bocken et al., 2019). It is

argued that established companies initiate this as a purposeful *change* to their principles and practices to generate environmental and social value while supporting the economic yield (Adams et al., 2016). Entrepreneurial companies and start-ups initiate sustainable innovations as a purposeful *design* to establish their environmental and social value (Bocken et al., 2019), and create competitive advantages. Aspects that must be considered in sustainable innovation practices are direction, diversity, and distribution (Leach et al., 2012), which involves environmental feedback in complex adaptive systems, diverse approaches to innovation through knowledge-sharing and collaboration, and a fair share of available resources within the Earth system (Leach et al., 2012).

To face the call for sustainable development, gradual changes will not be sufficient, and systemic change in the organization entails disruptive transformations toward new standards and markets (Hall & Vredenburg, 2003). As the organization's foundation is realized through the business model, it is essential to employ systemic changes. Further, it guides in assessing the interactions between the dimensions of sustainability (Boons et al., 2013). Initiating such significant changes can be challenging for one organization alone, and therefore collaboration with stakeholders is essential (Williams et al., 2017). Accordingly, this relates to managing relationships with external stakeholders and openness toward integrating their values and needs in the approach to sustainable innovation (Cillo et al., 2019). Also, research on the connection between the organization's financial success and sustainable innovation is marginal, as fundamental data about the organizational approaches vary, and no causality is discovered (Cillo et al., 2019).

3 Methodology

3.1 Scientific position

Through my thesis, I wish to understand better my experience of reality based on my scientific position. The position is decided from the thesis statement the researcher pursues. The position further influences the thoughts and evaluations of the data collected through analysis and presentation of the project.

From my previous studies, I have taken on a position of positivism, seeing knowledge as something obtained through observable and measurable facts. However, this is not easily compatible with research within the field of interpretive social sciences, where a founding principle is that one does not have an objective perception of the world, as often required in studies based on an individual's perception of the context, but also how individuals give meaning to this context (Johannessen et al., 2010). Thus, I turned my attention to the individual's perception of sustainable innovation, as this is the focus of my thesis. I wish to explore the meaning people give to this context and their perceptions.

The glasses we see the world through can be dual. One pair sees the philosophical basis of our reality, and the other examines the world with theoretical knowledge we have previously obtained. My glasses position me within the epistemological perspective of social constructivism, interpreting reality based on social factors, and believing that knowledge is a social construct continuously shaped by interactions (Tjora, 2021, p. 295). Through ontology, I try to grasp the range of how knowledge is obtained and how we can interpret reality to know what is true based on our experiences (Johannessen et al., 2010).

This study explores and analyzes the individual's meaning and perception of sustainable innovation and how it is operationalized in their organization, which involves interpreting the socially constructed reality based on the informants' sensitivity. The study does not, with high probability, provide the objective reality but rather a baseline of insight into various interpretations of the complex phenomena that is sustainable development (Johannessen et al., 2010). The thesis statement of this study is:

How do macroalgae producers work with sustainable innovation to ensure continued growth and economic viability in a novel industry?

3.2 Research design

The study's research design describes the research process from start to finish and describes how the researcher plans to achieve the project's objectives. It is further accompanied by

descriptions of *what* phenomenon the study centers around, *who* the participating subjects are, *where* the study is conducted, and how it is performed (Thagaard, 2018, p. 50).

To answer the thesis statement, it would be appropriate to consider the possibility of adapting the plan along the way (Thagaard, 2018, p. 50), as I seek a deeper insight into the phenomenon by approaching this openly to explore distinctions. This design allows for flexibility in considering unpredicted discoveries (Johannessen et al., 2010). Initial thoughts and ideas about the aspects that would be significant were not leading in the process as I also explored and highlighted new and central elements observed throughout the study. The research question also aims to receive descriptions of attitudes toward responsibility and positions on accountability to understand the value of sustainable innovations. I am also gaining insightful explanations of *how* sustainability initiatives and the process related to implementation (Thagaard, 2018).

3.2.1 Research approach

Deductive and inductive reasoning are the divides when choosing a research approach. The approach is inductive if the researcher develops a theory based on empirical findings without conscious assumptions (Thagaard, 2018, p. 172). Using a deductive approach, the researcher sets out assumptions built on existing theory to gather empirical data to confirm or refute those assumptions (Johannessen et al., 2010). Researching my thesis, I discovered that my approach is a combination of the two, as I go back and forth between established theory and my empirical study. Therefore, the approach is abductive, formed by the empirical findings while based on theories and perspectives beforehand or during the research process (Tjora, 2021, p. 247). Therefore, the data were achieved through interviews built on established theory from literature reviews, and further, I used the collected data to refine and edit the theoretical framework for the thesis. However, it can be challenging to fuse the empirical findings with the theoretical framework when the theoretical foundation is a concept, such as sustainable innovation. Therefore, a pragmatical approach to the empirical data collection is the best to answer the thesis statement (Johannessen et al., 2010).

3.2.2 Empirical context

The thesis work is based on my background and interest in aquaculture, mainly salmon aquaculture. I have previously studied various interpretations of the concept of sustainability, in addition to innovation, within a utopian universe, which I found to be very interesting to pursue further for my thesis work on macroalgae aquaculture. With this previously acquired

knowledge, I defined my thesis statement and decided on some initial considerations about a company or industry's approach to sustainable innovation in their operations. The presumptions made colour the subsequent phases of the thesis work, but I have been conscious of this and made adjustments when needed. Still, regardless of these presumptions, I have made an effort to refute instead of verifying to increase the strength of the study. With that, even if the glasses I see the world through limit me in my research, I believe that they also guide the direction of my attention.

I have chosen to investigate a phenomenon within a limited population of stakeholders, consisting of producers, entrepreneurs, researchers, and managers, all connected to the same network in a growing industry. This has left me with some challenges regarding ethical considerations of their anonymity (see 3.6). Further, combining two research fields, social and natural sciences, I have encountered various challenges. This influences the language used in the thesis. I have been observing an industry with a solid biological foundation, interacting with marine ecosystems, and understanding their practices and operations in connection with their perception of sustainable innovation. This has proven to be a brave choice, and balancing the various aspects and sustainability dimensions have required compromise.

3.2.3 The scope and time frame of the study

The scope of the research is limited by the time, resources, and knowledge available. Therefore, this study sets out to examine a phenomenon in-depth, studying several variables to gain a holistic understanding. Given the specific context presented in this thesis, the limited number of informants could offer hands-on knowledge and five rich and detailed descriptions of the phenomenon being examined (Jacobsen, 2005). The timeframe and resources available limit data collection to one specific period, supplying insight into the phenomenon at that given time. Although, it would be interesting to examine the process of sustainable innovation within the macroalgae industry over a longer period and include additional stakeholders to comprehend the development as the industry progress.

3.3 Research strategy

Research strategy depends on the study's purpose, position, and design, choosing a qualitative or quantitative methodological approach. To distinguish between the methods, the divide is seen in how the researcher accumulates data and the level of how this data is organized (Johannessen et al., 2010). With the chosen scientific positioning and the phrasing of the thesis statement, I have decided to apply a qualitative methodological approach to data

collection. The qualitative method aims to comprehend perception and understand underlying reasons or opinions of people related to a phenomenon (Dalland, 2017, p. 52). Traditionally this approach is associated with the researcher and subjects' relation, where verbal and visual communication is analyzed (Thagaard, 2018). This approach will support the insight into how sustainability is interpreted due to the informants' social construction of reality and limit the scope as the research process develops (Tjora, 2021).

A qualitative methodology approach provides various paths to exploring the thesis statement. Phenomenology pursues the subjective perception of the informants under the assumption of social constructivism. Therefore, in-depth interviews are often the basis of empirical data collection and analysis. The researcher attempts to learn how the informants see their world by exploring nuances in their experiences (Tjora, 2021, p. 31). Interviews can be structured, unstructured, or semi-structured. The latter provides a middle ground with higher flexibility founded on the interview guide with the possibility of varying the sequence of questions and themes, and is the choice applied for this study (Johannessen et al., 2010).

3.3.3 Literature review

The initial literature search was conducted using search engines like Oria and Google Scholar to gain an insight into the industry, including the current status, to place my scope and establish a foundation for the theoretical framework, using search words related to "macroalgae", "seaweed", "kelp", "aquaculture", "sustainable development" and "innovation" and combinations of these or similar creations. As sustainability is widely discussed and used extensively in the literature, I had to decide on an approach and definition for this thesis, as described in chapter 2. Further, my investigations led me into new research areas, snowballing the process using references from articles to identify substantial literature on the topics of interest. Relevant literature from the university library at Nord university was also included. I have searched for recognized, peer-reviewed articles cited in other pertinent work to the best of my ability. After some back and forth, this process narrowed my search field significantly until I landed on the theoretical framework presented in chapter 2.

Exploring literature related to the research question, ideas began to form on the presentation of the interview guide and which questions were interesting to achieve more information about the phenomenon researched. As I intend to examine the subjective perception of sustainable innovation, I decided to focus on the participant's insight on three different levels;

business level, industry level, and future ambitions in R&D, which was supported by the theoretical framework.

3.3.2 Qualitative semi-structured interviews

Qualitative semi-structured interviews were applied to collect empirical data to answer the thesis statement. Generating data using this approach can be described as intersubjective. The relationship between the researcher and participant depends on dialogue and trust to achieve the reflections and attitudes specific to this encounter and setting, which is why transparency is essential (Tjora, 2021).

My supervisor's network initiated the strategic selection process by establishing contact with potential participants. He had knowledge of and access to potential informants that would fit in with my thesis statement. At this stage, one aspect relating to the thesis was to examine industry representatives in Northern Norway with complex knowledge of the macroalgae industry represented by researchers, producers, and managers. Although, due to scheduling issues, this was not possible to follow through, and alternative participants were contacted. Hence, leading to a broader representation of producers in Norway, widening the scope of the data collection, which, in retrospect, elaborates on the common challenges experienced by the informants and gives greater insight to research the thesis statement. The selected informants are connected through the network arena for macroalgae stakeholders and represent farmers, researchers, and managers, working with facilitating cultivation, cultivation processes and macroalgae products, and alternative production methods. This strategy provides a variety of subjective perspectives, making the process more inclusive and representative of the whole industry. In this context, the informants are chosen to represent themselves in their connection to macroalgae production and to reflect and elaborate on their experiences and insight into questions asked to answer the thesis statement, making them a strategic selection of informants (Tjora, 2021).

Table 1. *Provides an overview of the informants, their role and information about the interview and transcription.*

Informants	Role	Length of interview	Words in transcription
1	Manager	50 min	3100 words
2	Owner	50 min	4200 words
3	Manager	30 min	2200 words
4	Owner	40 min	3200 words
5	Owner	40 min	2700 words

The interviews were conducted digitally, due to the ongoing pandemic and travel restrictions, during February and March 2022 with five industry representatives from various companies. Beforehand, I had performed a trial interview with a fellow master's student to determine if the interview guide was adequate and reasonable for obtaining the objectives I was seeking.

Using semi-structured interviews allowed me to address questions that were natural to initiate throughout the interview, which also identified themes and questions not set in the interview guide (Tjora, 2021). This provided the framework for the interview, and I intended to create an open conversation with the informant.

The interviews were recorded using an audio recorder as an alternative to detailed notetaking and provided me with the opportunity to interact with the participant while focusing on the flow of the conversation and non-verbal cues. Given that the interviews were digital, body language and other expressions are lost through video, as there is a "distance" between the researcher and participant contrary to face-to-face meetings. Although, throughout the interviews, I used both visual and verbal encouragements, like nodding and agreeing, in between asking questions leading the conversation forward, and letting them know they had my attention. Thus, these reassurances could be a way of establishing trust between the participant and me and lead them based on what information they want to share with me.

The transcription process started shortly after the interviews were concluded, usually within a day. It is challenging to translate verbal communication to written text, particularly when the informants speak various dialects. Transcribing the interviews marked a continuation of the analysis process, which began during the interviews as I thought about the meaning of their answers, and why they gave the answers they did. During the transcribing, I gained a deeper

understanding of the material and the data I had collected, further providing ideas on how to categorize and code during the data analysis.

3.4 Data analysis

During the literature review, the researcher will start to reflect on possibilities for the analysis process. As the data collection proceeds with interviews of relevant informants, the empirical material for the analysis grows. Comprised of detailed descriptions of the informants' interpretations and understanding of their experience with the phenomenon, the transcribed material is elaborate and time-consuming. To support the further analysis work, it was essential to facilitate the compilation and simplification of the material. It can be challenging to uncover connections within the material. Still, it is essential to organize and structure the material to identify patterns and characteristics (Klemp, 2014, p. 119).

The first step of the analysis process is coding to extract the essence of the empirical material, reduce the volume of material, and facilitate creative thinking. This method is based on the aspects of inductive reasoning, meaning that the researcher explores the empirical data to construct generalizations (Tjora, 2021, p. 218). For this purpose, I chose to apply software designed for qualitative data analysis to assist my work. NVivo is a CAQDAS (Computer Assisted Qualitative Data Analysis Software), which is supportive of the methodological transparency needed to deliver reliable results (Tjora, 2021, p. 24). This provided me with initial insight into the transcribed material. I used predetermined and theory-based codes to categorize the interviews and added more relevant codes as the analysis progressed. However, due to technical difficulties with the software, I had to manually process the material using coloured markers and printed versions of the transcripts. I went through every interview thoroughly and categorized the content into natural entities, so I did not overlook relevant data and was left with many categories. These were further processed into fewer and more detailed categories until patterns and connections of the informants' perceptions of sustainability and innovation were visible.

Although the analysis process is subjective to the researcher's position, the primary purpose of presenting the analysed data is to facilitate the reader's understanding of the data material in the research project (Tjora, 2021, p. 216). This is done by delivering the findings as credible and consistent with the empirical data gathered for this study (Nilssen, 2014, p. 141). Therefore, the presentation of the results is provided through the structure of the interview guide, in the order in which the informants were asked questions. Also, for the reader to better

understand the context, I chose to include findings related to the informants' daily operations and organizational structure. Further, the results are presented to accommodate the theoretical framework and categorized to enhance the connection to the phenomenon, such as the informants' responsibility towards the environmental aspects of their production and how they ensure sustainable operations on nature's terms.

3.5 Reliability and validity

Validity ensures that the project's methodological approach and research design explore what is described as the purpose (Johannessen et al., 2010). For this study, the informants were notified about the line of questions they would be asked to prepare and reflect on concepts of sustainability and innovation concerning their organization and the industry. The questions they were asked were produced to answer the thesis statement, and the informants had the possibility of withdrawing their consent at any time. These informants were chosen because I believed they could provide the research project with attitudes and insight not obtainable elsewhere. Thus, considering the relevance of the empirical data collected to be in line with the theoretical framework. This is because discoveries that are not based on a theoretical framework can easily be isolated descriptions of a single phenomenon with limited value and no real insight into understanding the researched socially constructed phenomena (Johannessen et al., 2010). To safeguard further validity in the project, the researcher must ensure objectivity and not be influenced by personal factors. However, in performing qualitative semi-structured interviews and literature reviews, one must assume some of the researcher's subjectivity shines through, even if the researcher is aware (Tjora, 2021, p. 294).

Reliability relates to the transferrable properties of the study and how the findings can be replicated in an alternative setting (Tjora, 2021, p. 264). Establishing the researcher's position and prior knowledge is also crucial for the reliability of the study (Johannessen et al., 2010). Due to its inductive reasoning, this study will not be easily transferrable because of the subjective position of the researcher during the analysis process and the relationship established between researcher and informant during the data collection. The information and data obtained in the interviews result from the situation in which the interview is set. Therefore, it is essential to ensure transparency throughout the research process to provide the reader with insight into the choices and decisions made in pursuit of knowledge into the phenomenon and how these are presented as findings. Another aspect to consider is if the generalization provided represents the macroalgae industry in Norway. By selecting five informants, one cannot define their views as representative. Still, the strategic selection offers

the opportunity to explore common perceptions of the phenomenon, supported by the subjective insight of the informants. However, I cannot establish that my exploration of the phenomenon is accurate. Still, I can atone that I can subtly explore relevant matters, respect my informants, and be open to assessment and criticism.

3.6 Ethical considerations

Ethical considerations related to the data collected through qualitative interviews are focused on the interview situation and the representation of data. As the project entails collecting and storing of personal data that can identify the informants, I had to get it registered and approved by the Norwegian Centre for Research Data (NSD) (NSD, 2022). They also provided guidelines for obtaining consent from the informants. The selected informants were informed about the purpose of the study, what their participation would involve, what they were consenting to, and their right to withdraw their consent at any time. All informants obtained an information letter and a voluntary consent form before the interview process started. Further, the data collected were stored in the cloud, password protected with access limitations. The audio recordings were transcribed and deleted, as the rest of the personal data will be upon completion of the study.

During the analysis process, it was challenging to ensure the anonymity of the informants while presenting the findings as reliable and understandable to the reader. I was also aware of the close connections between the informants and other stakeholders and therefore anonymized the data to the extent regarded throughout this thesis. It is essential that the informant trusts the researcher with their personal data, and that the researcher complies with the agreed-upon consent. Quotation check was relevant in this setting as the informants could be recognized based on their responses, as is the case when the selection is small and connected to the same network of companies (Tjora, 2021).

4 Results

This chapter presents the main findings from the empirical data collection using several semi-structured interviews with informants from the macroalgae sector in Norway. The chapter is divided into three subsections, as those were the main categories of questions asked in the interviews. First, section 4.1 presents the business level, focusing on the informants' perception of sustainability and how they work with it daily. Second, section 4.2 presents the industry level, focusing on the informants' insight into sustainability challenges and opportunities for the macroalgae sector. Last, section 4.3 presents the innovation and development level, focusing on how the informants perceive and pursue progress in the sustainability direction.

4.1 Business level

Organizational structure and daily operations

The organizational structures vary amongst producers in the macroalgae sector. However, most of them are small companies with one or a few employees. The managers are often the sole employee responsible for a broad range of tasks, from seeking investments to keeping up with research advances to production planning and mopping floors. Several informants pointed out that since they started their company, they have gained knowledge and developed methods and practices, along with equipment to produce macroalgae. This has been the starting point for many in the sector. Today, their experience facilitates the development of new solutions that address their challenges, as the producers have implemented large parts of the supply chain into their organization. Also, informant 3 describes how its company's involvement with macroalgae has "*been a hobby until recently*," while informant 5 has "*worked with development in the sector for over a decade*." However, the informants unanimously agree that profitability is a prerequisite for further expansion as "*a company cannot run on hopes and dreams"* (4).

Sustainability perception and sustainable production

The sustainability dimensions, including environmental, social, and economic aspects, are the underlying motivation for the informants and the foundation that makes their activities possible. The environmental dimension is the predominant concern when producing biomass in a vulnerable marine environment, as the farmers wish to "*produce on nature's terms*" (1 and 5) and "*ensure that the interaction between nature and society is compatible, without compromising one or the other*" (1). Working with sustainability, the informants recognize

the necessity of knowledge related to new research and development in their sector and related to similar production fields, such as agriculture and fish aquaculture. They are determined to learn about natural processes in vulnerable environments and how they "*best can interact with their surroundings*" (5).

However, informant 5 emphasized that sustainability is not ambitious enough in their operations. Especially focusing on the environmental dimension, as they seek to assess their production's broader impact on the sustainability dimensions and, therefore, require more knowledge about risk and consequences before increasing the production. Informant 4, on the other hand, focuses more on the company's economic sustainability, stating that the "*economy is the most essential, as future activities are dependent on investments*."

Taking responsibility

All informants recognized macroalgae aquaculture as a promising sector to produce biomass sustainably, mainly because there are no requirements for input factors like feed and fertilizer, as in terrestrial agriculture or fish aquaculture. But as informant 1 states, "*there is the question of who has access to the resources we have available, and how these are to be managed in the best way*," emphasizing that responsible production and creating beneficial outcomes for their surroundings are essential. Further, several informants pointed out that their production of macroalgae can potentially compensate or reverse the damage done by other industries over the years, specifically referring to the salmon aquaculture and wild harvesting of macroalgae biomass. Customer demand has also increased with the focus on "*food produced in a way that does not destroy the planet*" (2), which further generates future possibilities for value creation.

The macroalgae farmers have high ambitions to develop a new marine sector in the Norwegian economy by taking responsibility for sustainable production. As Norway is mainly a long coastline with small coastal communities, several informants actively work to involve the community and people influenced by production, and their stakeholders, in their endeavours by creating awareness and immaterial ownership in society (5). Further, this supports the livelihood and creates value for the community by enabling new opportunities and employment and decreasing relocation (2). Informant 1 points out the importance of building the supply chain in Norway to secure jobs and sustain the ownership and influence in the community where the production is located. This, in turn, creates strong communities through private industries (2).

Sustainability initiatives

As the macroalgae sector predominantly consists of small companies, they are not legally bound to produce sustainability reports. Still, several informants have included sustainability goals as a central part of their business model. Informant 5 explained that their organizational operations are based on circularity and have implemented the concept of "cradle-to-cradle," recognizing upcycling and recycling of materials as essential properties. Informant 4 stated that sustainability is continuous work, and described how their company's operations must be flexible and referred to their sustainability goals as "fluid goals, to facilitate quick changes." However, the informant further pointed out that small initiatives, like waste management, are implemented early on to ensure they build viable systems for when and if they grow and to ensure the attitudes evolve with the business. Also, minimizing the environmental impact is the primary focus for larger-scale initiatives because the organization's activities occur in a vulnerable environment. Accordingly, informant 3 stated that they "*actively work with monitoring and documenting the ecological factors through collaborative projects with research institutions*." In contrast, informant 1 accentuates the importance of maintaining the genetic diversity in the ecosystem by cultivating native species, therefore, the collect spores close to the production sites. However, larger initiatives must identify quality indicators that are significant to the organization's work, and, as informant 5 elaborated, they "*need to develop systems for implementation*."

4.2 Industry level

Challenges

As a growing sector, the macroalgae industry faces challenges related to economic sustainability and securing investments for further progress. Informant 3 mentioned that the industry struggles with profitability due to too high production costs. This is in large part related to equipment acquisition and employee wages. Further, informant 4 emphasized that the industrial focus on environmental stability is vital. Still, they are limited because basic features such as production technology and market accessibility are not effectively established. Post-harvest processes pose considerable challenges for the farmers. This is mainly due to stabilizing the macroalgae biomass before further processing and distribution (2). Also, macroalgae are not regulated as seafood or included in The Norwegian Seafood Councils' activities regarding the regulation of seafood export today (3). Even though this would benefit the marketing of algae products by creating marketplaces and facilitating the

design of product declarations supported by standard descriptions for quality and food safety parameters for the product (1). Informant 4 described how they currently must navigate and search for documentation to standardize the product for potential consumers. However, they further stated that since the industry is underdeveloped, they do not seek new regulations at this point as it might limit the progress. Additionally, they wish "*to contribute to the development through a bottom-up approach rather than the usual top-down*." It is also a point to be made that further growth in the industry entails challenges they are unaware of today and that these must be assessed to regulate the sector further (1).

Opportunities

Growth also implies opportunities for the macroalgae sector. Informant 2 described the possibility of contributing to the larger goal to provide sustainably cultivated food for a growing population, meanwhile being frontrunners and paving the way for sustainable development in this industry. In its infancy, the sector did not have any clear directions. Therefore, producers initiated collaboration with the regulatory sector to establish ground rules that allow the development of the industry in a sustainable direction (5). Collaboration with researchers and regulatory authorities has proven beneficial. Some informants point out the need for basic research and openness to resolving issues in the supply chain and market access. Pending an expansion of the sector, stakeholders from research, governmental, and other industries invest, even after years of lacking profitability. This encourages informant 4 to keep going because others see the potential that is worth investing in. Even though growth requires profit, today the surplus is mainly used to develop the existing production (2). Macroalgae production creates possibilities for better resource utilization in marine areas unsuitable for other industries and makes a possible addition or competitor to terrestrial resources (4). According to informant 5, this can be done by producing a more comprehensive range of species and using various production methods to decrease the risk and vulnerability of the production. They further elaborated that up-scaling will not happen before they have detailed the potential risks and ensured profitability in the current production.

4.3 Development and innovations

Direction and drivers

Providing direction to changes is necessary. Several informants identified interest from external sources, both publicly and politically, encouraging and facilitating a drive towards sustainable solutions, emphasizing the focus on blue growth and development of sustainable

productions (4). Further, informant 1 expects that "*the direction of the sector will be developed by combining local and public capital investments*." The societal demands for sustainable development depend on customers, suppliers, research, and governance (1). Moreover, informant 5 considers the macroalgae producers to be the drivers for change, as they work with developing standards and setting the premisses for development as an internal force for change. Assuming that progress depends on both internal and external stakeholders, focus areas are identified to balance the interests of the parties involved. However, this is a question of scale as to what degree of influence and risk are distributed amongst the stakeholders based on profitability in the supply chain (1).

Innovation and collaboration

As drivers of change are identified, most of the informants accentuated that the work they do is depends on innovation and finding solutions to defined challenges (1). Informant 2 described that product development is a large part of the work and that it is a continuous process. Members of its organization always think ahead to define the next step. However, informant 4 stated that being a small producer is challenging as they face problem-solving on many levels. Accordingly, they focus on their areas of expertise and collaborate with others to block out further bottlenecks in the supply chain. Informant 5 recognized that the implementation of innovation in the business model, emphasizing their collaborative work and function within the community, facilitates transformation initiatives. Informant 1 perceives "*increasing competence through knowledge-sharing and experience"* to be an essential foundation for their innovative activities, as openness enables trust between stakeholders.

Limited by resources and profitability, initiating sustainable innovations is challenging for small companies. Informant 2 emphasized that most macroalgae producers handle the entire supply chain themselves, which increases the economic risk for the company and further acknowledges the benefit of collaboration with networks and open communication with other producers about everyday experiences. However, there is an understanding that everyone involved must participate, to the best of their ability, because otherwise, discovering collaborative solutions will be difficult (5). Active participation and stakeholder collaboration are required (3). However, informant 4 believed that only a few individuals will have the drive and capacity to lead initiatives and that their discoveries will benefit others when licensed and shared.

Several of the informants emphasized the need for industry and research to work together in developing sustainable solutions. Informant 3 further accentuated that research initiatives should be industry-directed to ensure relevance and application that alleviates common issues and, in turn, facilitates innovation and the creation of new ideas. Moreover, this requires identification of the benefits for producers provided by the research projects (4).
Collaboration between industry and research also entails conflicting interests because the organization's priority is to grow a business, not produce research material (2). Therefore, informant 2 presented the importance of meeting halfway and respecting the various interests, even if they do not always align. Macroalgae producers benefit from research results, as their means and capacities limit their ability to carry out projects alone (3). Informant 4 stated that they also experience research institutions proactively identifying areas of interest.

5 Discussion

When asked about the future of the macroalgae sector in Norway, all the informants answered that they see a sustainable production interacting with the environment and society beneficially and further that the industry will have to grow to accommodate the increasing demand for food and biomass with the awareness of pending challenges related to up-scaling.

5.1 Perception of sustainability

The stakeholder's perception of sustainability provides direction for initiatives, as internal or external expectations drive the understanding and implementation of sustainability goals. In the organization, they require flexibility to adjust to changes. Therefore, overarching goals and visions to grow an industry based on sustainable development are founded in their operations, but strategies and short-term goals might be the object of adaption. However, contribution to better resource use and biomass production are some of the goals emphasized by the informants, aligning with some of the UN's sustainable development goals. Thus, a limited perception of sustainability and how to connect it to the organizational work and industry context might entail that the practice of the organizations is not in line with the goals. On the contrary, some producers have included sustainability as a foundation of their work through the business model, accentuating the importance of the three dimensions of sustainability provided by the Triple Bottom Line.

Being an interdisciplinary sector, macroalgae producers need knowledge of biological and economic aspects to run profitable companies and social factors, including collaboration with stakeholders and the local community. Given the diverse backgrounds of the stakeholders involved, their perceptions of sustainability vary, as some have research backgrounds in natural sciences while others are economists. Some focus more on the environmental dimension, while others focus on the economy. Still, as it has been established, sustainability work is based on balancing the environment, society, and economy (Boons et al., 2013). This entails a deeper understanding of how the operations and organizational work impact the larger system, discovering connections between economic and social aspects, or environmental and social aspects, as these dimensions are interconnected (Silvestre & Ţîrcă, 2019). Increasing production will potentially negatively affect the environment but could provide a more stable economy for the farmers. They are balancing the negative outcomes against the positive synergies. Currently, systems for evaluation are not provided, but macroalgae producers are aware of their responsibility toward the environment they produce in and continuously account for the potential risks.

5.1.1 Perception of responsibility

Through the interviews, informants accentuated their goal to produce sustainable food for the growing population, to supplement and alleviate the strain on terrestrial food production systems. This entails safeguarding future generations' access to nutritious food and shows how the macroalgae sector takes responsibility as part of the solution for sustainable development (Latapí Agudelo et al., 2019). Further, they work hard to involve stakeholders and the community to create jobs and values that benefit small communities. The detrimental effect of agriculture and finfish aquaculture on the marine environment is also essential for the informants, as their production methods could compensate for some of the damages by upcycling nutrients. Accounting for ethical and social obligations toward the society they are part of (Carroll, 2016). However, conflicts and trade-offs between the responsibilities appear, and companies should, therefore, strive to increase their moral obligation to the environment and society through their practices (Robertson, 2021). Taking responsibility for past mistakes and a wish to do better also entails being held accountable for potential negative effects, and for this reason, risk distribution is essential. Macroalgae producers with small organizations have managerial, legal, and fiduciary responsibilities to their stakeholders without much return. Including corporate social responsibility could provide direction for their work, and as it aligns with sustainability perspectives, an essential aspect of sustainability initiatives is to take responsibility.

5.2 Challenges and opportunities

The informants provided insight into the various challenges they are experiencing and the future opportunities they envision for the macroalgae sector in Norway. The informants widely agreed on the issues and envisioned potential ways to discover solutions. Even though real solutions are not commercialized, some are in the research stages, and investments have been obtained to explore these further (Barbier et al., 2019). Differing opinions about possible possibilities could stimulate creative ideas and be the foundation that progress opportunities for the sector in the years to come. However, since many producers are in the same position, being small-scale and entrepreneurial producers could present a trial when facing future challenges due to the limited experience. The current production methods are low-risk, but an imposing increase in production volume will entail scale-dependent challenges and further balancing the environmental risk factors with beneficial outcomes provided by macroalgae aquaculture (Campbell et al., 2019). Also, knowledge about how the production impacts sustainability will necessitate continuous surveillance and evaluation of indicators,

emphasizing environmental monitoring as changes in production methods may impact genetic variations, distribution of disease, and ecosystem properties (Hoegh-Guldberg et al., 2019).

5.2.1 Environmental sustainability

The anticipated developments in all aspects of the macroalgae supply chain raise questions about the impact on the environment in which the production is situated. This requires evaluation of all stages of the production but, in particular, the direct effects of cultivation on the surrounding ecosystem, including the introduction of invasive species and diseases that could pose severe threats to native biodiversity (Barbier et al., 2019). According to the informants, the industry should develop a broader range of species in cultivation, create more diversity minimize risk. However, designing numerous production systems and technology is not the focus now, as mono-culture systems make up the majority (Skjermo et al., 2014). Further, the development must consider the use and value of natural marine resources and ensure the stability of the ecosystems (Campbell et al., 2019).

The environmental cost of macroalgae cultivation depends on the scale of production and the carrying capacity of the ecosystem (Campbell et al., 2019). Several aspects of production should be of concern when risk assessment and managemental regulations are imposed. These include spatial planning to minimize damage, the use of native seedlings, disease-prevention measures, restricted use of chemicals, and durable structure materials (Campbell et al., 2019). The most significant risks associated with macroalgae farming include introducing invasive species and pathogens and changing the genetics of local populations (Grebe et al., 2019; Norderhaug et al., 2021). While the current small-scale macroalgae farms in Europe may pose low risks to the shared ecosystem, a more extensive expansion could damage the environment without proper risk assessment (Campbell et al., 2019; Cottier-Cook et al., 2016). Fitting to the perception of the informants as well, where several emphasized that they are not dependent on up-scaling before they have adequately assessed the benefits and harmful outcomes.

5.2.2 Social and economic sustainability

Aquaculture activity promotes livelihood in coastal communities as a prospect for employment in marine biomass production (Grebe et al., 2019; Araújo et al., 2021). The industry contributes to closing the gender inequality gap, as an expanding industry calls for new employment with a secure income, which will contribute to economic growth in coastal communities, especially in low-income societies (Rebours et al., 2014; Seaweed Manifesto,

2020). As local capacity and knowledge could be invaluable for the industry growth, involving stakeholders and other local interests in the decision-making of this industry is vital to ensure positive social outcomes (Broch et al., 2016; Seaweed Manifesto, 2020). In contrast, an expansion at the expense of established industries and shared resources involved, such as local fisheries and tourism businesses, could cause conflict between other ventures' economic sustainability and the community's well-being (Hoegh-Guldberg et al., 2019). Therefore, macroalgae producers should include stakeholders to minimize potential conflicts. However, as the production capacity develops and companies experience profitability in their operations, this could impact the connection to the community. The focus on benefiting local communities is fundamental for the producers. Still, an upscaling and potential industrialization could mean more considerable export or moving parts of production to other places to lower production costs. This would potentially cause negative effects on the coastal communities. Therefore, it is crucial to recognize that macroalgae producers are trying to run successful businesses and are dependent on economic yield.

Small-scale macroalgae farms and start-ups do not require significant investments such as salmon aquaculture (Grebe et al., 2019). However, significant investments will be needed to develop the technology and strengthen the supply chain to grow the production (Seaweed Manifesto, 2020). This will enable co-benefits or opportunities for improved technology design transferable to other areas of use, creating a larger impact and possibilities for further economic growth (Hoegh-Guldberg et al., 2019). Still, the informants state that the current absence of operationalized standards for macroalgae products limits the marked access. Development in the supply chain is necessary to meet the demands of collaborative efforts from research, governance, and the farmers.

Further, it could be argued that the economic prospects of macroalgae aquaculture rely on upscaling production and technological innovations in monitoring, harvesting, and processing, as these advances will enhance the possibility of a sustainable economic industry (Araújo et al., 2021). An increase in production could decrease production costs, as the cost influences the price and impacts market access. Generating added value by extending biomass utilization could reduce the product price in the market (Skjermo et al., 2014). Still, similar biobased products could be cheaper and more beneficial for application in other industries. Therefore, identifying the characteristics and possible areas of use is essential for expanding the industry's commercial value and economic feasibility (Araújo et al., 2021). Another prospect

is to develop consumer attitudes towards macroalgae products using labels such as superfood or organic (Norderhaug et al., 2020).

5.2.3 Prospects for the supply chain

There is widespread agreement amongst the macroalgae producers that the supply chain is underdeveloped and not optimized for the current production. Profitability is a prerequisite, and the focus for producers is to enable a more efficient chain of production to produce a stable and predictable yield. As reported through the interviews, this entails decreasing production costs and gaining market accessibility by improving seedling production and handling and stabilizing biomass. Stévant et al. (2017) report that the conditions along the Norwegian coast are ideal for the prospects of upscaling production; however, producers are careful when discussing the growth. They have reflected on and are aware there will be challenges to face when seeking to deliver higher biomass. Some state that they do not have enough information about potential consequences, even though risk factors have been identified. Precautionary measures, exploring risk and outcomes, must be done to transition from small-scale to large-scale industry (Skjermo et al., 2014).

Challenges encountered in the supply chain are associated with the level of operations. During the interviews, apparent issues depended on their daily operational procedures and end-market product. Due to the possible collaboration with salmon producers, integrated multitrophic aquaculture (IMTA) producers do not face the same challenges as mono-culture producers concerning equipment, vessels, and personnel (Knowler et al., 2020). Moreover, macroalgae producers stated that it would be beneficial for the industry to develop a variety of macroalgae species for aquaculture purposes to reduce the risks associated with monoculture. However, others predict that only a few species will be involved in up-scaling, at least in the short run (Skjermo et al., 2014). Reasons include knowledge about current production methods established for cultivation and the continued development of these practices to guarantee high biomass yield and profit for the producers.

5.3 Innovation for sustainability

Recent development has called for transitions in organizational practices to include a broader set of values than simply economic ones. Innovation is considered the main driver for sustainability, as change is a prerequisite for sustainable development (Baregheh et al., 2009), and these changes must be initiated on multiple levels, including governmental, industrial, and societal (Adams et al., 2016). Several perspectives on innovation have emerged to

accommodate the dimensions of sustainability, for instance, social innovations and green innovation, which strongly emphasize the social and the environmental dimensions, respectively (Silvestre & Ţîrcă, 2019). Sustainable innovations focus on the balance between the dimensions of sustainability and include interactions between the dimensions.

Sustainable innovation is a broad term that involves creating and growing new or improved products and services, or entire systems, which include social and environmental benefits that exceed prior advances (Adams et al., 2016). Working with such initiatives can improve the organization's sustainability performance (Boons et al., 2013). As innovation is such a fundamental part of macroalgae producers' work to face and solve challenges they encounter, they work continuously with development both internally in the organization and with external stakeholders in networks.

5.3.1 Organizational structures enable the initiatives

Even though the macroalgae organizations mainly consist of a few employees, the hierarchical structure and interaction between the internal stakeholders enable knowledge-sharing and creative efforts. The management position provides a clear overview of the organization, which could facilitate change easier. Further, the integration of good practices, even for small endeavours like waste management, is fundamental to the organization's values. The attitudes displayed and shared within the organization are essential to reach wider opportunities and involve external stakeholders in the processes. Because knowledge and innovation are linked, and that trade offs between them entail product or service innovations that can contribute outside of the organization (Quintane et al., 2011).

Change is a fundamental trait for small and entrepreneurial organizations within the macroalgae sector as they must adapt and innovate to realize their competitive edge and ensure profitability. The characteristics of the changes must also be considered, as they can be either continuous, leading to gradual changes in the organization, or disruptive to the current state of operations (Inigo et al., 2017). To face the call for sustainable development, gradual changes will not be sufficient, and systemic change in the organization entails disruptive transformations toward new standards and markets (Hall & Vredenburg, 2003). A prerequisite for these organizational changes is the understanding and perception of sustainability, which could enhance or limit the possibilities (Cillo et al., 2019). For instance, macroalgae producers show a varied understanding of sustainability. They all offer knowledge about their contribution to the more extensive system and define the need for change and development.

However, their account is limited to the level of what they perceive is possible for the future production of macroalgae.

5.3.2 Stakeholders and collaboration

Based on the organizational structures and responsibilities, the need for collaboration can be discussed. This level of interaction can be distinguished by the networks and external forces that influence and relate to the organization, including the research and regulatory sector (Cillo et al., 2019). Discovering solutions to common issues is essential to the macroalgae producers, establishing relations that contribute to brainstorming and creative findings to further coordinate investments. Stating that many show interest in the industry's progress, the informants further elaborate that collaboration supports strategies for development and innovation. Additionally, as they operate within a more extensive system, Dodgson et al. (2013) consider that an organizational approach to sustainable innovations is a part of a collaborative process based on their connections within the network.

Although there are multiple challenges facing further development and growth in the macroalgae sector, the informants are conscious of this and work diligently to solve them. Through the interviews, the majority described the same fundamental issues. They are mainly small actors in a novel industry, but they supposedly encounter the same challenges. However, they are also part of the same networks and often collaborate and discuss with other stakeholders. This could create difficulties because they have limited grounds for new radical ideas, meaning that the networks could facilitate the recycling of knowledge between the stakeholders, creating homogeneous voices.

Knowledge-sharing and experience with established practices from other industries could provide macroalgae producers with advantages. The transfer of production methods from industrialized macroalgae production in Asian countries has supported the foundation of marine biomass production in Europe. Thus, this established insight also provides knowledge of pitfalls and yields opportunities to overcome barriers related to potential diseases, ecosystem impact, and technological advances (Stévant et al., 2017). In addition, Norway has long-standing traditions of being a frontrunner in maritime industries. To benefit the growth of the macroalgae sector, utilizing the competence of the aquaculture and petroleum industry could be a success (Norderhaug et al., 2020).

5.4 Performance evaluation

Initiating change within complex adaptive systems, where economy, environment, and society are fundamentally interconnected, can be challenging. But macroalgae producers pursue innovative ideas to develop the industry further. However, to uncover the change needed and how this impacts the larger system, they must find and assess adverse outcomes and positive synergies (Leach et al., 2012). Further, interdisciplinarity and diversity facilitate knowledge-sharing and collaboration outside the organization while balancing stakeholders' interests to avoid conflict (Cillo et al., 2019). Producing food and biomass for the growing population also entails taking responsibility and participating in creating shared value (Latapí Agudelo et al., 2019). Elaborate monitoring systems that can be applied to evaluate initiatives, supported by the sustainability dimensions, could facilitate the assessment of initiatives and how they transform the operations. However, this entails identifying thoroughly selected indicators to inform the organization and its stakeholders about the situation. Producers perceive the production of macroalgae as fundamentally positive compared to relatable industries, but they are dependent on economic profitability. Linking the organization's sustainability performance to financial success could provide the macroalgae industry with a profitable outcome (Schaltegger & Wagner, 2011).

The initiatives implemented in the organization are scale-dependent and based on the nature of the change, one can assess the implications. Still, small organizations design their entire operation on the objective that macroalgae production is a sustainable alternative to other industries, and coordinate their operations to enable adjustments as it evolves. Building the process on this intentional design means that they are ready for disruptive changes necessary for transformation, even though they experience continuous change daily (Bocken et al., 2019). However, entrepreneurial organizations with limited budgets, and a fiduciary responsibility towards their shareholders, could find it challenging to finance sustainability initiatives. Therefore, it is essential that their responsibility also entails environmental impact and social obligation to pursue sustainability work.

Further, the involvement of stakeholders in transformation processes must be facilitated by balancing their needs and demands against the dimensions of sustainability and organizational goals, as a change in one part of the system could create potential positive or negative effects in the larger system (Ritala, 2019). However, discussing the balance between the dimensions also entails a broad focus on comprehending the three perspectives and their subsystems, which is contradictory and requires compromise (Silvestre & Ţîrcă, 2019). Accordingly, it is

unlikely for an organization to achieve greater sustainability without innovation, as progress in sustainable practices demands change and adaption in daily operations, including management and policy (Hall & Vredenburg, 2003). And even though sustainable innovations are complex and ambiguous processes with internal and external collaborators, they provide the organization with a holistic approach to sustainable development (Silvestre & Ţîrcă, 2019).

5.4.1 Contribution to the United Nations sustainable development goals

Contribution to the UN's sustainable development goals (SDG) is identified through macroalgae production's operations and impacts. Farmers accentuate that their production provides food security, in line with SDG 2, and has a greater societal impact by ensuring nutritious and sustainably grown food based on local production. Further, the production of renewable biomass on nature's terms and without destroying the planet offers an alternative to terrestrial resources facilitating responsible consumption, in line with SDG 12. SDG 14 supports life below water, and is the main focus for the producers. Macroalgae production contributes to natural ecosystems, providing shelter for marine life and protecting exposed coastal regions (Barbier et al., 2019). Through bioremediation, the production ensures upcycling of nutrients, also taking responsibility for other industries' emissions.

Through job-creation the macroalgae industry provides new sources of revenue in coastal communities and promotes SDG 8. However, profitability is a prerequisite for contributing to a sustainable economy and societal dimensions. Developing technology through sustainable, innovative efforts and building suitable infrastructure to support the logistical challenges of macroalgae production (Stévant et al., 2017), facilitate contribution to SDG 9. The macroalgae producers also promote SDG 17 through knowledge-sharing and networks with actors from government, industry, and the public for collaboration toward the goals. Still, the collaborative measures should focus on a few of the SDGs, because to focus broad is a paradox. The goals are interconnected, and contributions of change could also prove beneficial for unintended targets due to the properties of complex adaptive systems.

Figure 5. *Presenting the sustainable development goals: 2: Zero hunger, 8: Decent work and economic growth, 9: Industry, innovation and infrastructure, 12: Responsible consumption and production, 14: Life below water, 17: Partnerships for the goals (UN, 2022a).*

6 Concluding remarks

Macroalgae producers are dedicated to creating new foundations for livelihood in coastal communities, supported by local management and employment while paving the way for biomass production on nature's terms. They are designing their operations based on the perception of macroalgae production being fundamentally sustainable compared to other biomass producers and their contribution to reaching the larger sustainable development goals. Stakeholder engagement and network collaboration provide direction when facing challenges and aid in uncovering solutions. As most macroalgae companies in Norway are small organizations, they rely on relative contribution and support from research institutions, other producers, regulatory sectors, and network members. These interactions allow to discover practices to make the production profitable. While also accounting for their impact on the surrounding environment and the society they are part of.

The macroalgae sector contributes to local value creation, and producers are aware of their responsibility toward the dimensions of sustainability. The production operates in vulnerable marine environments, and the farmers implement initiatives that safeguard the biodiversity of the native ecosystems. Further, the industry provides employment and, thus, has positive implications for coastal communities. These are significant impacts for small organizations that can contribute to more positive synergies in the wider system.

As industry growth could provide more opportunities for the macroalgae sector, issues related to stable economic profit and supply chain optimization are most pressing for an upscaling of the production. Facing these challenges is tough for small organizations alone, but external collaboration is part of the solution. Initiating creative thinking and discourses stimulate innovation, and while some stakeholders can drive the process, others can follow. However, several questions need to be answered, and being an interdisciplinary sector, macroalgae production requires further collaborative work between various fields of research to assess impact, identify indicators, and provide the industry producers with knowledge and tools for successful innovations that facilitate beneficial interaction with the dimensions of sustainability.

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Appendix

Appendix A: Interview guide

Intervjuguide
Introduksjon o Presentasjon av prosjektet, intervjuutforming og databehandling (samtykke til lydopptak, frivillig deltakelse og mulighet til å trekke seg). o Eventuelle andre spørsmål fra deltaker.
Informasjon om intervjudeltaker o Kan du fortelle litt om din bakgrunn? o Kan du beskrive hvilken funksjon og arbeidsoppgaver du har i din organisasjon? o Hvor lenge har du arbeidet med dette?
Bærekraft i organisasjonen o Hva betyr bærekraft for deg og din organisasjon? o Kan du beskrive organisasjonens arbeid med bærekraft (i ulike deler av verdikjeden)? o Har du noen konkrete eksempler? o Hvem etterlyser bærekraft og bærekraftige løsninger? o Hvem og hvorfor? Hva spør de om? o På hvilken måte må bedriften følge (offentlige/statlige/bransjemessige) reguleringer i arbeidet med bærekraft? o Eller er det mangel på slike reguleringer? o Hvilke ambisjoner har dere for å sikre en bærekraftig utvikling i organisasjonen? o Har organisasjonen konkrete bærekraftmål, eventuelt hvilke mål? o Hvordan identifiserer dere spesifikke mål, og hvordan arbeider dere mot disse? o Har dere systemer for registrering og rapportering av mål?
Bærekraft i norsk makroalgenæring o I lys av det vi har pratet om, hvordan synes du makroalgenæringen i Norge bør utvikles? o Hva tror du er toneangivende for den bærekraftige utviklingen i næringen? *Samfunnsmessige og statlige krav?* o *Miljø* – Kan du si noe om hvordan produksjonen påvirker miljøet, positive og negative følger? *Økosystemtjenester, opptak av næringsstoffer* o I hvilke deler av verdikjeden oppstår de største utfordringene knyttet til miljø?

- Hvordan arbeider næringen det med å fremme/løse disse utfordringene, på hvilket nivå (bedrift, næring, lokalt, nasjonalt og globalt)?
- *Samfunn* – Kan du si noe om hvordan makroalgeproduksjon påvirker eller bidrar til et mer bærekraftig samfunn?
  - Hvilke utfordringer mener du makroalgeproduksjonen har mtp. bærekraftig samfunnsutvikling?
  - Hvordan arbeides det med å fremme/løse disse utfordringene, på hvilket nivå (bedrift, næring, lokalt, nasjonalt og globalt)?
- *Økonomi* – Kan du si noe om hvordan produksjonen bidrar til en bærekraftig økonomi?
  - I hvilke deler av verdikjeden oppstår de største utfordringene knyttet til å føre en bærekraftig økonomi?
  - Hvordan arbeides det med å fremme/løse disse utfordringene, på hvilket nivå (bedrift, næring, lokalt, nasjonalt og globalt)?

Innovasjon og utvikling

- Hvilke mål mener du er viktige for utvikling og verdiskaping i denne næringen?
  - Hvorfor er disse viktige?
- Hva vurderer du som de viktigste utfordringene å belyse per nå, og hvorfor? Går sammen med det over.
  - Hvordan mener du at disse utfordringene kan løses/utforskes?
- Hvordan jobber organisasjonen din med innovasjon?
  - Har du noen konkrete eksempler? (produkter, prosesser, salg og markedsføring, kommunikasjon)
  - Hvordan forbedringer har din organisasjon arbeidet med i det siste?
  - Hvilke ambisjoner har organisasjonen for videreutvikling og innovasjon?
- På hvilken måte er forskning nyttig for bærekraftig utvikling og innovasjon?
  - På hvilke områder bidrar forskning? Kunnskapsutvikling, konkurransedyktighet?
  - Er det noe som mangler i forskningen i dag?

Avslutning

- Oppsummering av intervjuet – Har du noe mer å tilføye?
- Kan du kontaktes igjen dersom det er behov for oppfølging?
- Hvis det er av interesse for deg, ønsker du å få tilsendt oppgaven når den er ferdig?
- Har du noen spørsmål helt til slutt?